WaterLegacy September 22, 2025 Comments on U.S. Steel Corp NPDES/SDS Permits for Keetac Mining Area (MN0031879) and Keetac Tailings Basin (MN0055948) and on U.S. Steel Corp Application for Variance from Wild Rice Sulfate Standard

EXHIBIT 31

U.S. Steel Corp., Minnesota Ore Operations, Keetac Tailings Basin
NPDES/SDS Permit Application, December 2009.

UNITED STATES STEEL CORPORATION
MINNESOTA ORE OPERATIONS-KEETAC TAILINGS BASIN
NPDES/SDS PERMIT APPLICATION
PERMIT #MN0055948

Prepared for:

UNITED STATES STEEL CORPORATION

December 2009

Prepared by:

Liesch Companies

Minneapolis • Chicago • Los Angeles • Madison • Milwaukee • Phoenix

UNITED STATES STEEL CORPORATION
MINNESOTA ORE OPERATIONS
KEETAC

TAILINGS BASIN
NPDES/SDS PERMIT APPLICATION
PERMIT #MN0055948

December 2009

Prepared by:
Liesch Associates, Inc.
for
United States Steel Corporation

This application was prepared by me or under my direct supervision:

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1.0 INTRODUCTION

Liesch Associates, Inc. (Liesch) was retained by United States Steel Corporation (U. S. Steel) to assist Minnesota Ore Operations - Keetac (Keetac) in preparation of this application to modify their existing National Pollution Discharge Elimination System/State Disposal System Permit (NPDES/SDS Permit #MN0055948). This NPDES/SDS Permit was issued on March 10, 2006 by the Minnesota Pollution Control Agency (MPCA) and is associated with discharges from Keetac's Tailings Basin operations. Keetac is located just north of the town of Keewatin, Minnesota (see Figure 1 in Appendix A for a site overview). The application to modify this permit is being submitted to request construction associated with, and discharge authorization from the tailings basin system following, a proposed expansion at Keetac that will increase pellet production from 6.0 million tons per year (MTY) to 9.6 MTY. The expansion is planned for 2012. An Environmental Impact Statement (EIS) for the proposed expansion is currently being developed.

There are two significant changes the expansion will have on discharge waters and water quality from the tailings basin system. The first is an increase in tailings slurry flow associated with the increased taconite pellet production. This increased tailings slurry flow will result in increased treated surface water discharge volumes from the tailings basin system. The second significant change is the proposed installation of additional sulfate treatment on the existing scrubber blow-down treatment system. The additional sulfate treatment will reduce the sulfate loadings into the tailings basin system and consequently will reduce the tailings basin sulfate concentration. More detailed information regarding the proposed additional sulfate treatment system and non-degradation review can be found in Section 6.0. The proposed expansion includes dry-scrubber technology on the exhaust from the expanded operations and will therefore not contribute additional sulfate to discharge waters.

Information provided for this NPDES/SDS permit application is associated primarily with the proposed Keetac expansion project with a focus on constituents of concern identified by MPCA. However, modeling of facility discharge rates, sulfate concentrations, and mercury concentrations were conducted for studies required during the EIS process for the next 25 years (2012 through 2036). Information on anticipated flow rates, sulfate concentrations/loadings, and mercury concentrations/loadings throughout the 25 year timeframe were included within this permit application where relevant.

Keetac maintains a separate NPDES/SDS Permit (#MN0031879) for discharges associated with mining and processing activities. An application for permit modification to this permit has also been submitted to the MPCA to address the changes associated with the proposed facility expansion on those discharges.

U. S. Steel conducted various projects in support of the environmental review and permitting process in preparation for the proposed expansion. Many of the projects/studies have been conducted to support the EIS being developed cooperatively by the Minnesota Department of Natural Resources (MNDNR) and the United States Army Corps of Engineers (USACE) with the Bois Forte Band of Chippewa acting as a cooperating agency. Through the EIS process, a significant amount of work was been conducted to better understand and predict the potential impacts of the proposed plant expansion on surface water discharges and receiving water bodies. Results from this work that are directly related to the NPDES/SDS permit application process are included/referenced within this application. However, there is a significant amount of data available for review from the EIS process that can provide more detail (if required) regarding specific aspects of the proposed expansion to evaluate this permit application. This information can be made available by a request for public documents from the MNDNR. Documents that provide additional information regarding water use, facility discharges, downstream receiving waters, sampling results, and predicted downstream impacts include:

- *Water Balance/Mine Yield Study – Keetac Expansion Project (Liesch, February 2009)*
- *Keetac Expansion Project Predicted Water Quantity and Quality Cumulative Impacts Evaluation (Liesch, April 2009)*
- *No Action Alternative Analysis for the Keetac Expansion EIS Memorandum (Liesch, August 2009)*
- *2009 Water Quality, Hydrology, and Wild Rice Monitoring - Swan Lake, Hay Lake, Moose Lake, Hay Creek, and Hart Creek (Barr, September 2009)*

This application is being submitted for modifications that will occur due to the Keetac Expansion Project.

This application is organized as follows:

Section 1: Summarizes significant modifications / requested changes.

Section 2: Provides a regulatory review of applicable MN Rules.

Section 3: Provides a description of the process being permitted, details regarding activities impacting the discharges, discharge locations, and other pertinent information required by the NPDES/SDS Permit Application.

Section 4: Provides information regarding water quality standards review.

Section 5: Provides information regarding non-degradation review.

Section 6: Provides information regarding discharges to impaired waters.

Section 7: Includes the required MPCA NPDES/SDS Permit Application forms.

Appendices: Provide figures, tables, and other supporting information.

1.1 SUMMARY OF SIGNIFICANT MODIFICATIONS / REQUESTED CHANGES

U. S. Steel is requesting to modify their current NPDES/SDS Permit authorization to discharge process wastewater and associated stormwater from the tailings basin facility following the proposed expansion of the Keetac facility. Changes in discharge flow rates and water quality characteristics are expected due to the expansion of the plant. However, the existing limits in the NPDES/SDS permit for the tailings basin for both water quantity and quality do not require modification based on predicted discharge rates and water quality characteristics throughout the 25-year timeframe of the project. U. S. Steel is proposing the following significant changes to current operations that may impact discharges from the tailings basin due to the proposed Keetac expansion project:

- A second taconite processing line will be started and expand plant production capabilities from 6 million tons per year to 9.6 million tons per year.
- The existing sulfate wastewater treatment system will be upgraded to remove 50% of the sulfate load in the effluent from the existing system. This installation

will occur concurrent with the Keetac expansion project and will address nondegradation concerns.

- Dry scrubbers are planned to be installed on the expanded line and will not increase sulfate discharge loadings.
- The expansion will increase water discharge rates, although the predicted rates are expected to stay within existing permit limits. Increased mining depth and extent will require higher dewatering rates in the future which will result in higher discharge rates from the tailings basin system.
- Chemical usage associated with taconite processing will increase due to the increased production.
- A third tailings discharge line will be added to facilitate greater tailings slurry discharge rates associated with the increased production.
- Increased return water volumes will be pumped back to the plant as needed for the increased production rates.
- A new discharge point into Reservoir 2 will be created to provide the option of routing mine dewatering discharges from the Sargent Pit to Reservoir 2. This outfall will include a new monitoring location for this permit. This will provide flexibility in the Sargent Pit dewatering discharge location based on operational needs. Sargent Pit would have the potential to discharge to Mesabi Chief Pit, Russell Pit, or Reservoir 2 (with the Mesabi Chief Pit and Russell Pit discharges being covered under NPDES/SDS Permit MN0031879).

2.0 REGULATORY REVIEW

The following subsections provide a detailed review of applicable Minnesota Administrative Rules in regards to this NPDES/SDS permit application. Specific citation of the applicable rule is provided along with a brief discussion regarding the applicability or further information regarding each requirement. The applicable Minnesota Rules included within this section are:

- MN Rules Chapter 7001.0050 (Permits and Certifications – Written Applications)
- MN Rules Chapter 7001.1050 (Permits and Certifications – NPDES/SDS Permits)
- MN Rules Chapter 7050.0185 (Waters of the State – Nondegradation for All Waters)
- MN Rules Chapter 7050.0180 (Waters of the State – Nondegradation for Outstanding Resource Value Waters)

Please note that a water quality standards review is provided in Section 3.0 of this application (MN Rules 7050.0220-.7050.0227) and an impaired waters review is provided in Section 4.0 of this application (40 CFR, Chapter 122).

2.1 MN RULES 7001.0050 – WRITTEN APPLICATION

A person who requests the issuance, modification, revocation and reissuance, or reissuance of a permit shall complete, sign, and submit to the commissioner a written application. The person shall submit the written application in a form prescribed by the commissioner. The application shall contain the items listed in items A to I unless the commissioner has issued a written exemption from one or more of the data requirements. After receiving a written request for an exemption from a data requirement, the commissioner shall issue the exemption if the commissioner finds that the data is unnecessary to determine whether the permit should be issued or denied. The application must contain:

A. the name, address, and telephone number of the owner of the facility for which the application is submitted and identification of the status of the owner as a federal, state, public, private, or other entity;

B. if the operator of the facility for which the application is submitted is different from the owner, the name, address, and telephone number of the operator and identification of the status of the operator as a federal, state, public, private, or other entity;

C. the name, address, and telephone number of the person who prepared the application;

This information is included in the MPCA "Water Quality Transmittal Form" included in Section 7.0.

D. a description including the location of the business, plant, system, facility, or activity for which a permit is sought;

This information can be found in the MPCA forms included in Section 7.0 as well as within the facility description in Section 3.0.

E. a general description of the materials handled, processed, stored, or disposed of by the applicant that are pertinent to the application; and a statement of the nature and quantity of the materials proposed to be stored, processed, discharged, emitted, or disposed of during the period of the required permit, and proposed methods for control of these materials;

This information can be found on the MPCA forms included in Section 7.0 as well as within the facility description in Section 3.0. In addition, material safety data sheets for products discussed in the facility description are included within Appendix C.

F. a topographic map, or other map if a topographic map is unavailable, that shows the facility and the area surrounding the facility for a distance of at least one mile in all directions of the facility; and all structures that relate to the proposed discharge, emission, storage, processing, or disposal activity;

This information is included on Figure 4 and Figure 5 in Appendix A.

G. a copy of a draft or final environmental impact statement that has been prepared under the National Environmental Policy Act, United States Code, title 42, sections 4331 et seq. as amended through December 31, 1982, or a copy of an environmental assessment or environmental impact statement prepared under the rules of the Minnesota Environmental Quality Board, chapter 4410;

As mentioned in Section 1.0, the MNDNR (in cooperation with the USACE and the Bois Forte Band of Chippewa) is currently drafting an EIS for the proposed Keetac expansion project. The Draft EIS is being prepared concurrently with this NPDES/SDS Permit application. Due to the size of the Draft EIS, it is not included with this application, but is available upon request.

H. additional information determined by the commissioner to be relevant to a decision as to permit issuance, including but not limited to plans, specifications, or other technical information that is necessary to determine whether the facility will meet all applicable Minnesota and federal statutes and rules; and

Information regarding compliance with water quality standards is included in Section 4.0. A non-degradation review is included in Section 5.0. A review of potential impacts to downstream impaired waters is included in Section 6.0. The MPCA has indicated during meetings and conference calls that additional information (not already included in this application) is not required at this time for their permit application review.

I. other information relevant to the application as required by parts 7001.0550 to 7001.0640, 7001.1050, 7001.1290, 7001.3175 to 7001.3475, 7001.4200, or 7041.0700.

MN Rules 7001.0550 to 7001.0640 apply to hazardous waste storage, treatment, or disposal facility permit applications and are therefore not applicable to this permit application.

MN Rule 7001.1050 is discussed below within this section.

MN Rule 7001.1290 was renumbered as MN Rule 7023.9020 has been repealed.

MN Rules 7001.3175 to 7001.3475 apply to land treatment and disposal and to solid waste management facility permit applications and therefore are not applicable to this permit application.

MN Rule 7001.4200 applies to above ground storage tank permit applications and is therefore not applicable to this permit application.

MN Rule 7041.0700 applies to sewage sludge land application permit applications and is therefore not applicable to this permit application.

2.2 MN RULES 7001.1050 – CONTENTS OF NPDES PERMIT APPLICATIONS

Subpart 1. Publicly owned treatment works. If the applicant is requesting the issuance, modification, revocation and reissuance, or reissuance of a national pollutant discharge elimination system permit for a publicly owned treatment works, the applicant shall submit the following information to the commissioner: [further Subpart 1 omitted]

Not applicable. This application is not for a publicly owned treatment works.

Subp. 2. Manufacturing, commercial, mining, and silvicultural discharges. If the applicant is requesting the issuance, modification, revocation and reissuance, or reissuance of a national pollutant discharge elimination system permit for a manufacturing, commercial, mining, or silvicultural discharge, the applicant shall submit the following information to the commissioner:

A. The information required by part 7001.0050.

The required information from 7001.0050 is previously discussed within this section.

B. The name of the receiving water of the discharge.

The permit application requests discharge authorization to Reservoir 2. Further information is included in the *MPCA Attachment for Industrial Surface Water Discharge Wastewater Treatment Facilities NPDES Permit Form* included in Section 7.0 and within the facility description in Section 3.0.

C. The exact location of the outfall, including the latitude and longitude of the location to the nearest 15 seconds.

This information is included on Figure 4 in Appendix A.

D. A line drawing of the water flow through the facility with a water balance, showing process and treatment operations contributing to the effluent. The water balance must show approximate average flows at intake and discharge points and between units, including treatment units. If a water balance cannot be determined, the applicant shall provide a pictorial description of the nature and amount of the sources of water and the collection and treatment measures.

This information is included on Figure 2 and Figure 3 in Appendix A.

E. A narrative identification of each type of process, operation, or production area which contributes or will contribute wastewater to the effluent for each outfall. This identification must include process wastewater, cooling water, and storm water runoff contributions to each outfall; the average flow that each process contributes; a description of the treatment the wastewater receives; a discussion of any disposal, other than by discharge, of solid or fluid wastes generated in the process; and the discharge frequency.

This information is included within the facility description in Section 3.0 and in the *MPCA Attachment for Industrial Surface Water Discharge Wastewater Treatment Facilities NPDES Permit Form* included in Section 7.0. A brief discussion of other disposal/re-use option other than discharge is provided in the MPCA *NPDES Permit Application – Appendix A* Form in Section 7.0.

F. A statement as to the product that is or will be manufactured, processed, or produced at the facility and a statement as to the quantity of the product actually manufactured, processed, or produced at the facility. If a technology-based effluent guideline is applicable to the discharge, the applicant shall express the quantity of product in the same measure as that used in the applicable effluent limitation guideline.

This information is included in the *MPCA Attachment for Industrial Surface Water Discharge Wastewater Treatment Facilities NPDES Permit Form* included in Section 7.0.

G. If the applicant is subject to a requirement or compliance schedule for construction, upgrading, or operation of waste treatment equipment, an identification of the requirement, a description of the project, and a listing of the required and projected final compliance dates.

Not applicable. There is no compliance schedule requirement for the facility associated with this NPDES/SDS Permit.

H. The results of analyses and other information required by part 7001.1060.

MN rule 7001.1060 establishes the required parameters for permit applicants to sample for inclusion within the permit application. The MPCA was consulted during the development of the permit modification application and specific parameters were

identified by the MPCA that were required for review of this application. The MPCA indicated that a minimum of three samples from the discharge outfalls would be required for each of the identified parameters. The results from the sampling events are included in Table 3 and Table 4 in Appendix B.

The Sargent Pit dewatering water quality characteristics were assumed to be similar to the Mesabi Chief Pit dewatering. The Mesabi Chief dewatering discharges were sampled the requisite three times and those results are included in Table 3 and Table 4 of the Plant/Mine NPDES/SDS Permit #MN0031879 application submitted concurrently with this application. The MPCA requested that one sample be collected from the Sargent Pit to confirm the similarity of water quality between the two dewatering discharges. The results from Sargent Pit sampling validated this assumption and are included in Table 3 and Table 4.

Sargent Pit information is included in this application as Keetac is proposing to have the capacity to discharge to Reservoir 2 under this permit authorization. This will provide flexibility in the Sargent Pit dewatering discharge location based on operational needs. Sargent Pit would have the potential to discharge to Mesabi Chief Pit, Russell Pit, or Reservoir 2 (with the Mesabi Chief Pit and Russell Pit discharges being covered under NPDES/SDS Permit MN0031879).

I. If the analyses required by part 7001.1060 were performed by a contract laboratory or consulting firm, the name and address of the laboratory or firm, and an identification as to which analyses were performed by the laboratory or firm.

All analyses provided in Table 3 and Table 4 in Appendix B of this application were performed by Northeast Technical Services, Inc., 315 Chestnut Street, Virginia, MN 55792 (MDH Lab Certification #027-137-157).

J. A list of any toxic pollutants that the applicant uses or manufactures or expects that it will use or manufacture during the next five years, including manufacturing as an intermediate or final product or by-product.

Information regarding chemical products used during taconite processing that have the potential to impact wastewater flowing to the tailings basin is included in the facility description in Section 3.0 and within the material safety data sheets included in Appendix C.

K. A description of the expected levels of and the reasons for any discharge of pollutants that the applicant knows or has reason to believe will in the next five years exceed two times the values reported under part 7001.1060.

No current discharge pollutants are anticipated to increase two times the values reported in this application.

L. An identification of biological toxicity tests that the applicant knows or has reason to believe have been made within the last three years on any of the applicant's discharges or on a receiving water related to the applicant's discharge.

There are no known toxicity tests within the past the three years.

M. If the applicant proposes to construct or operate a new or existing concentrated animal feeding operation or aquatic animal production facility, the information required in Code of Federal Regulations, title 40, section 122.21(h).

Not applicable. This application is not for any of these listed activities.

N. If the applicant wishes to request that the commissioner, in establishing a technology-based effluent limitation to be included in the conditions of the permit, establish an effluent limitation which is different than the effluent limitation which would result from the normal application of the relevant effluent limitation guideline, then the applicant shall submit, either in the application or in a supplement to the application filed no later than the last day of the comment period established in part 7001.0100, subpart 4, the following information: [remainder omitted]

Not applicable. The applicant is not requesting a variance from applicable effluent limitation guidelines.

O. If the applicant desires to request an extension from the statutory deadline established in section 301(b)(2)(A) of the Clean Water Act, United States Code, title 33, section 1311(b)(2)(A), on the grounds that the applicant proposes to replace existing production capacity with an innovative production process which will meet the standards in section 301(k) of the Clean Water Act, United States Code, title 33, section 1311(k), the applicant shall submit an explanation and documentation supporting this claim.

Not applicable. The applicant is not requesting a variance.

2.3 MN RULES 7050.0185 - NONDEGRADATION FOR ALL WATERS

The intent of Minnesota nondegradation rules is to "protect all waters from significant degradation from point and nonpoint sources and wetland alterations and to maintain existing water uses and aquatic and wetland habitats." It is the policy of the MPCA that water quality conditions must be maintained and protected when possible, even when those conditions are better than applicable water quality standards or better than levels necessary to support the beneficial uses.

Subp. 3. Minimum treatment. Any person authorized to maintain a new or expanded discharge of sewage, industrial waste, or other waste, whether or not the discharge is significant, shall comply with applicable

water quality standards of this chapter and effluent limits in chapter 7053 and other applicable federal and state point source treatment requirements. Nonpoint sources of pollution shall be controlled as required by this chapter, chapters 7020 and 7080, and any other applicable federal or state requirements. All existing beneficial uses shall be maintained in the receiving waters.

A water quality standards review is included in Section 4.0. An impaired waters review is included in Section 6.0. Discharges from the Keetac facility must comply with federal effluent limitation guidelines (ELGs) established under 40 CFR 440 (Ore Mining and Dressing Point Source Category, Subpart A – Iron Ore). Three parameters have ELGs established for this category, which are:

- Iron, dissolved – 2.0 mg/l daily maximum/1.0 mg/l 30-day average
- Total Suspended Solids (TSS) – 30 mg/l daily maximum/20 mg/l 30-day average
- pH – Between 6.0 and 9.0

As can be seen in Table 1 and Table 2 in Appendix B, historic monitoring of these parameters has indicated that discharges from the Keetac facility have been in compliance with the federal ELGs. The proposed expansion is not anticipated to affect compliance with these parameters, therefore it is expected that Keetac will continue to comply with the ELGs.

Additional detailed information regarding the proposed Keetac expansion project and the potential effects on waters of the state is included with the draft EIS developed by the MNDNR and available to the MPCA upon request.

Subp. 4. Additional requirements for significant discharges. If a person proposes a new or expanded significant discharge from either a point or nonpoint source, the agency shall determine whether additional control measures beyond those required by subpart 3 can reasonably be taken to minimize the impact of the discharge on the receiving water. In making the decision, the agency shall consider the importance of economic and social development impacts of the project, the impact of the discharge on the quality of the receiving water, the characteristics of the receiving water, the cumulative impacts of all new or expanded discharges on the receiving water, the costs of additional treatment beyond what is required in subpart 3, and other matters as shall be brought to the agency's attention.

Subp. 5. Determination of significance. A person proposing a new or expanded discharge of sewage, industrial waste, or other wastes shall submit to the commissioner the information required to determine whether the discharge is significant under subpart 2. If the discharge is sewage, the flow rate used to determine significance under this part is the design average wet weather flow for the wettest 30-day period. For discharges of industrial and other wastes, the flow rate to be used is the design maximum daily flow rate. In determining the significance of a discharge to a lake or other nonflowing receiving water, a mixing zone may be established under the guidelines of part 7050.0210, subpart 5.

The discharge associated with the Keetac Expansion Project from the tailings basin facility is not considered a “new” or an “expanded” discharge as defined in MN Rules

7050.0185 Subp.2. A ("New Discharge") & B ("Expanded discharge"). This is largely due to the proposed upgrade to the existing scrubber wastewater treatment system. See Section 5.0 for a detailed review of non-degradation applicability.

Subp. 6. Baseline quality. If an existing discharge to a water of the state is eliminated or significantly reduced, baseline quality for purposes of this part shall be adjusted to account for the water quality impact associated with that particular discharge. If no data are available to determine baseline quality or the data collected after January 1, 1988, are of better quality, then the commissioner shall authorize the use of data collected after January 1, 1988. If no data are available, the person proposing the discharge may collect new data in accordance with agency protocols.

Not applicable. No existing discharges to waters of the state are anticipated to be eliminated or significantly reduced to the Keetac Expansion Project.

Subp. 7. Incremental expansions. If a new or expanded discharge is proposed in increments, the increments must be added together to determine whether the discharge is a significant discharge. Once the criteria for a significant discharge are satisfied by adding together the increments, the requirements of this part shall apply to the discharge.

Not applicable. The discharge associated with the Keetac Expansion Project from the tailings basin facility is not considered a "new" or an "expanded" discharge as defined in MN Rules 7050.0185 Subp.2. A ("New Discharge") & B ("Expanded discharge"). This is largely due to the proposed upgrade to the existing scrubber wastewater treatment system. See Section 5.0 for a detailed review of non-degradation applicability, which included analysis through all five phases of the mining expansion project (2012-2036).

Subp. 8. Determination of reasonable control measures for significant discharges. The person proposing a new or expanded significant discharge of sewage, industrial waste, or other wastes shall submit to the commissioner information pertinent to those factors specified in subpart 4 for determining whether and what additional control measures are reasonable. The commissioner shall provide notice and an opportunity for a public hearing in accordance with the permit requirements in chapter 7001 before establishing reasonable control requirements for a new or expanded significant discharge.

Not applicable. The discharge associated with the Keetac Expansion Project from the tailings basin facility is not considered a "new" or an "expanded" discharge as defined in MN Rules 7050.0185 Subp.2. A ("New Discharge") & B ("Expanded discharge"). This is largely due to the proposed upgrade to the existing scrubber wastewater treatment system. See Section 5.0 for a detailed review of non-degradation applicability.

Subp. 9. Physical alterations of wetlands. The permit or certification applicant shall comply with part 7050.0186 if there is a proposed physical alteration that has the potential for a significant adverse impact to a designated use of a wetland and that is associated with a project that requires a National Pollutant Discharge Elimination System (NPDES) permit, a 401 certification under parts 7001.1400 to 7001.1470, or a state disposal system permit.

Future mining activities planned with the Keetac Expansion Project will require physical alterations of wetlands. Keetac will comply with MN Rule 7050.0186 when mining activities progress to the extent that wetland impacts are required. Additional information regarding wetland impacts due to the proposed expansion can be found in the Draft EIS document previously referenced.

2.4 MN RULES 7050.0180 - NONDEGRADATION FOR OUTSTANDING RESOURCE VALUE WATERS

Subp. 3. Prohibited discharges. No person may cause or allow a new or expanded discharge of any sewage, industrial waste, or other waste to waters within the Boundary Waters Canoe Area Wilderness; those portions of Lake Superior north of latitude 47 degrees, 57 minutes, 13 seconds, east of Hat Point, south of the Minnesota-Ontario boundary, and west of the Minnesota-Michigan boundary; Voyageur's National Park; or Department of Natural Resources designated scientific and natural areas; or to federal or state wild river segments.

Subp. 6. Restricted discharges. No person may cause or allow a new or expanded discharge of any sewage, industrial waste, or other waste to any of the following waters unless there is not a prudent and feasible alternative to the discharge:

A. Lake Superior, except those portions identified in subpart 3 as a prohibited discharges zone;

B. those portions of the Mississippi River from Lake Itasca to the southerly boundary of Morrison County that are included in the Mississippi Headwaters Board comprehensive plan dated February 12, 1981;

C. lake trout lakes, both existing and potential, as determined by the agency in conjunction with the Minnesota Department of Natural Resources, outside the boundaries of the Boundary Waters Canoe Area Wilderness and Voyageurs National Park and identified in parts 7050.0460 to 7050.0470;

D. federal or state designated scenic or recreational river segments; and

E. calcareous fens identified in subpart 6b.

Subp. 6a. Federal or state designated scenic or recreational river segments.

Subp. 6b. Calcareous fens.

Subp. 7. Unlisted outstanding resource value waters.

Subp. 8. Public hearing.

No sewage, industrial waste, or other waste from the Keetac facility directly discharges to an outstanding resource value water (ORVW). Therefore, the limitations under Subpart 3 (prohibited discharges) and Subpart 6 (restricted discharges) do not apply. The subparts

not listed or not listed in their entirety include definitions, ORVW designated waters, and information on requesting a public hearing for ORVW nondegradation concerns.

Subp. 9. Impact from upstream discharges. The agency shall require new or expanded discharges to waters that flow into outstanding resource value waters be controlled so as to assure no deterioration in the quality of the downstream outstanding resource value water.

All discharges from Keetac flow into the O'Brien Diversion Channel, then Hay Creek (and pass through Hay Lake), then Swan Lake, then Swan River, and ultimately the Mississippi River. This portion of the Mississippi is identified as an ORVW. The discharges from Keetac are not expected to adversely impact this downstream ORVW with the modifications requested in this application. Additional information regarding the impact of Keetac discharges on downstream impaired waters is included in Section 6.0 of this application.

Subp. 10. Thermal discharges. If a thermal discharge causes potential water quality impairment, the agency shall implement the nondegradation policy consistent with section 316 of the Clean Water Act, United States Code, title 33, section 1326.

Keetac discharges will not cause potential water quality impairment for thermal conditions.

3.0 FACILITY DESCRIPTION

3.1 EXISTING CONDITIONS

The Keetac tailings basin facility provides the primary method of process water treatment as well as the majority of make-up water for the plant process. This system consists of the Keetac inner tailings basin, outer tailings basin, 2nd Stage Pond, Reservoir 6, a small maintenance building, the drainage areas contributing surface run-off to these basins/reservoirs, and all non-sewage wastewater disposal systems contributing flow to the tailings discharge. The principal activity at the facility is the disposal of taconite tailings and treatment of process water from the Keetac plant. See Figure 1 in Appendix A for a site overview.

Currently, the plant can produce approximately 6.0 million tons per year (MTY) of taconite pellets. The proposed expansion discussed in Section 3.2 below will increase this production to 9.6 MTY.

The tailings and related process water that is treated in the tailings basin are generated by the Keetac plant, which is located north of the town of Keewatin. The plant consists of a series of crushers and screens, a concentrator, and an agglomerator. Information on these processes and the associated chemical usage is provided below as these activities impact the influent to the tailings basin system covered under this NPDES/SDS permit.

The concentrator consists of a series of mills, magnetic separators, hydro separators, hydro clones, screens, and thickeners. A flocculent is added to the concentrator tailings slurry before the thickening stage.

The agglomerator receives the concentrate, which is mixed with limestone/dolomite then dewatered by disc filters. The filter cake is then mixed with bentonite and formed into pellets in balling drums. The agglomerator wastewater, as well as wet scrubber, recirculating non-contact cooling water, and normal floor drain wastewater that is generated at the plant, is recirculated as process water within the plant. The make-up water for the recirculating non-contact cooling water system in the plant is softened. Additional chemicals, such as a corrosion inhibitor, a microbiocide, and a water softener are also added. A corrosion inhibitor/descaler is used in the vacuum seal water system.

Chemicals used in the wet scrubber system include calcium hydroxide for pH control and a clarification/coagulation aid. Diluted hydrochloric acid is used to clean pH. Two types of lime descaler are used to clean lime deposits.

The process water flow to the tailings basin consists of the tailings slurry (which includes associated process water as described above). The current average tailings slurry flow rate is 20 million gallons per day (MGD). The tailings slurry and plant process water is piped under pressure from the plant across Highway 169 and is spigotted into the tailings basin. The dual tailings pipelines have several gravity flow drainage points along their route that are used during routine maintenance, winter operations, and emergency situations such as pump failure. Tailings pipe dump valve drainage points 4, 5, 6W, 6E, 7, and 8 flow by gravity directly to the tailings basin. An average of 13 million long tons per year (MLTY) of dry tailings is disposed of each year in the basin.

Keetac's Tailings Basin is divided into two parts; the inner tailings basin and the outer tailings basin. The tailings slurry is discharged into the inner tailings basin via a spigot system such that course tails are deposited near the outer areas (used to build the containment dike) and fine tails are deposited further from the outer edge and settle out within the tailings pond. The inner tailings basin clear pool is currently being expanded to increase the surface area which will assist with dust suppression. The final extent of the surface area is anticipated to cover approximately 2,000 acres (approximately 80% of the inner tailings basin surface area). This final surface area coverage is expected to be reached in 2011. The elevation of the inner tailings basin increases with time as tails settle within the pond and increase the pond bottom elevation.

Chemical dust suppressants are occasionally used at the facility. Currently, magnesium chloride is used, however, this does not restrict the use of other acceptable dust suppressants at the facility.

Water discharges from the inner tailings basin via a decant tower into the outer tailings basin where it flows to the 2nd stage pond for additional sedimentation. The outer tailings basin dikes are constructed of clay starter dikes with a coarser sand and gravel chimney drain. The tailings basin (outer and inner) is principally underlain by glacial till and glaciofluvial deposits.

Water from the 2nd stage pond is discharged to Reservoir 6 via a discharge structure located in the southwest corner. The majority of the water discharged into Reservoir 6 is re-circulated back to the plant as make-up water. Surface water from Reservoir 6 discharges through Outfall SD005 into a drainage swale and then into Reservoir 2 (Class 2B, 3C, 4A, 4B, 5, and 6). Depending on water elevations, water can flow in reverse through the drainage swale, which will convey water from Reservoir 2 North (Class 2B,

3C, 4A, 4B, 5, and 6) into Reservoir 6. Reservoir 2 North receives water from Welcome Creek (Class 2C, 3C, 4A, 4B, 5, and 6).

Water is occasionally pumped from Reservoir 2 to Reservoir 6 for water-level maintenance at an average rate of 668 million gallons per year (based on data from 2001-2007). This permit application includes the potential for Sargent Pit dewatering discharges to be directed into Reservoir 2, which can then be pumped into Reservoir 6 to augment plant make-up requirements. Figure 2 in Appendix A provides a detailed water flow schematic for the Keetac facility in its current configuration (includes Reservoir 5).

Reservoir 6 is equipped with emergency overflow to Reservoir 2 via siphon outlet SD001 (consists of Outfalls 010, 011, 012, and 013). This discharge point is above the typical water elevation in Reservoir 6 and has not discharged in over eight years. Reservoir 2 discharges into the O'Brien Diversion Ditch (Class 2B, 3C, 4A, 4B, 5, and 6), which flows into Hay Creek (Class 2B, 3C, 4A, 4B, 5, and 6) and ultimately to Swan Lake (Class 2B, 3C, 4A, 4B, 5, and 6). The discharge from Reservoir 6 at SD005 represents the tailings basin system's primary regulatory compliance point from an NPDES/SDS permitting perspective.

Surface water station SW001 is located at the weir outlet of Reservoir 2 and was established at the request of the Permittee. No limits are associated with the SW001 monitoring station.

Precipitation that falls on the outer edge of the exterior tailings basin dike flows as surface runoff away from the basin and has the potential to discharge to various surface waters, including the West Swan River (Class 2C, 3C, 4A, 4B, 5, and 6), unnamed wetlands (Class 2D, 3D, 4C, 5, and 6), Hay Creek, Reservoir 2, Reservoir 2 North, and Welcome Creek.

Repair shops and a garage are located in the southwest ¼ of the southeast ¼ of Section 36, Township 57N, Range 22W. Vehicle and/or equipment maintenance is conducted indoors. Sewage generated at this site is contained in portable units and disposed of in a nearby municipal wastewater treatment facility.

The location of the facility, designated monitoring sites, and water flow schematics are shown in Appendix A. Please also refer to the "Water Balance/Mine Yield Study – Keetac Expansion Project" (Liesch, February 2009) for additional information regarding existing process water flows.

3.2 CHANGES ASSOCIATED WITH PROPOSED EXPANSION

U. S. Steel is proposing to expand the Keetac facility beginning in 2012. As part of the expansion project, an additional production line is being started to increase plant capacity. The proposed expansion would increase taconite pellet production by 3.6 MTY to a total output of 9.6 MTY. The additional increase in mining and processing will result in increased flow to the tailings basin system. The tailings slurry flow is projected to be 29 MGD following the expansion. This will result in approximately 22 MLTY of dry tailings deposition in the tailings basin following expansion. This increase in tailings deposition increases the water loss due to lock-up within the tailings voids. Keetac intends to add an additional tailings discharge line as part of the expansion project.

The production line associated with the expansion will be equipped with dry scrubber technology. Therefore, the scrubber associated with the expansion will not contribute additional sulfate loadings to the system.

This permit application also includes potential discharges from Sargent Pit mine dewatering into Reservoir 2. This has been included in this permit to provide flexibility of discharge from the Sargent Pit and to provide potential make-up water into Reservoir 6 (via Reservoir 2). Figure 6 in Appendix A provides the proposed discharge route from Sargent Pit to Reservoir 2. As mentioned above, water from Reservoir 2 is occasionally pumped to Reservoir 6 to provide additional make-up water for the plant.

Reservoir 5 is planned to be removed, with mine dewatering previously conveyed to Reservoir 5 being routed directly to the plant as make-up water. Figure 3 in Appendix A provides a detailed water flow schematic for the Keetac facility following the removal of Reservoir 5.

A summary table of estimated usages for all approved chemicals is included in Appendix C along with each individual MSDS.

Predicted average and maximum flow rates for the discharge points discussed above are provided within Section 7.0 (MPCA NPDES/SDS Application Forms).

4.0 WATER QUALITY STANDARDS REVIEW

Water quality standards are determined for each of the receiving waters based on appropriate water use classifications, as defined in MN Rules 7050. Table 1 (SD001 – Siphon outfalls from Reservoir 6) and Table 2 (SD005 – Outfall 015 from Reservoir 6) in Appendix B provide Discharge Monitoring Report results from 2001 through 2009 for the discharge monitoring locations covered under the Tailings Basin NPDES/SDS Permit. Table 3 (metals) and Table 4 (non-metals) in Appendix B provide sampling results regarding parameters of concern, as identified by MPCA personnel for the purposes of this permit application.

The MPCA provided U. S. Steel with a list of parameters that were required for the NPDES/SDS Permit application and indicated that three sampling data points would be sufficient to document the concentrations of the identified parameters, unless sampling results indicated a specific concern. The MPCA has reviewed the results from the sampling and agreed that the three sampling events adequately characterized the discharge water quality. Tables 3 and 4 also list the applicable water quality standards for the most stringent water use classification in the downstream receiving waters for each parameter. The concentration for each parameter sampled is below the applicable water quality standard based on the water use classification of the receiving streams, with the exception of the sulfate standard for wild rice. The applicability of the wild rice standard is discussed further below.

4.1 WILD RICE

There are no downstream receiving bodies that are designated as wild rice in MN Rule 7050.0470 However, stands of wild rice have been identified in Hay Lake and Swan Lake. These lakes are downstream of Keetac discharges. MN Rule 7050.0224 states that the sulfate water quality standard of 10 mg/l is to be used as a guide and applies to waters that are used for irrigation of wild rice. The standard is applicable to periods when the wild rice may be susceptible to damage by high sulfate levels. A compilation of scientific studies available from the literature (Walker, 2009[1]) and the existing wild rice stands in Swan and Hay Lakes indicate that wild rice grows in sulfate concentrations considerably higher than the 10 mg/l standard. U. S. Steel is proposing to upgrade the existing sulfate wastewater treatment system to significantly reduce sulfate discharge loadings on

[1] Walker, 2009, Wild Rice and Sulfate References, Barr Engineering, November 11, 2009

downstream receiving waters. Dry scrubbers are planned to be installed on the expanded line and will not increase sulfate discharge loadings. U. S. Steel requests that the MPCA consider these factors when evaluating the applicability of the sulfate standard on Keetac's discharge.

An EIS is being prepared by the MNDNR for the Keetac Expansion Project. Barr Engineering, on behalf of U. S. Steel, has prepared a wild rice study to support the EIS process (*2009 Water Quality, Hydrology, and Wild Rice Monitoring, Barr Engineering, September 2009*). This study includes greater detail and discussion on the wild rice issue and should be reviewed to better understand the current and future predicted conditions due to the proposed expansion. Information regarding this study has been submitted previously to the MPCA as part of the Perry Pit NPDES/SDS permit application.

5.0 NON-DEGRADATION REVIEW

A non-degradation review for an NPDES/SDS permit modification requires a determination of whether previously allowable discharge loadings of certain parameters will be exceeded. Parameters that have current limits in the facility's permit or that hold a special interest to the public are typically required to be analyzed in a non-degradation review. The allowable loading for each parameter is determined by permit limits that were in effect at a specified date depending upon the type of receiving waters. Flow rate limits and/or concentration limits for specific parameters in that permit are used to determine the allowable load. In the absence of specific limits, maximum observed flow rates or concentrations of parameters expected at the specified permit date can be used to determine allowable loads.

The discharge from the Keetac tailing basin is to waters that are classified as "all waters" under Minnesota Rules 7050.0185. There are no outstanding resource value (ORV) classified waters in the direct receiving body or downstream until the water reaches the Mississippi River, which is a substantial distance downstream from the Keetac discharges. As a result, Keetac's contribution to overall flow and load would be negligible. In meetings regarding this permit modification application, MPCA personnel indicated that for the purposes of this application, the MPCA would not apply ORVW non-degradation review, but would rely on the "all waters" classification of the water bodies discharged into and nearby downstream points. Therefore, the permit that was in effect on January 1, 1988 determines the allowable discharge loading from a non-degradation perspective.

After reviewing conditions from the NPDES/SDS permit issued in July of 1986 (and in effect on January 1, 1988), it has been determined that discharge loadings from the Keetac tailings basin following the proposed expansion will be less than the allowable loadings on January 1, 1988 for the parameters reviewed. Therefore a non-degradation analysis on these discharges is not required. Further details regarding this review are included below.

5.1 ALLOWABLE DISCHARGE FLOW RATE

Federal regulations (40 CFR Part 440 Subpart A) specifically allow a discharge volume from taconite plant tailings basins on the Mesabi Iron Range of precipitation minus evaporation (P-E). However, a condition in the 1986 NPDES/SDS Permit that regulated

Keetac's tailings basin discharges on January 1, 1988 limited the tailings basin discharge to less than P-E levels, but also allowed a carry-over volume from the previous year.

For this non-degradation review the maximum allowable annual discharge flow rate was calculated using data from the highest annual precipitation event observed minus the calculated evaporation. Although this high precipitation year may not have occurred in 1988, the permit in effect at that time would have allowed this discharge had those conditions occurred in 1988. The highest precipitation year was observed in 1999. Both the P-E method and the 1986 permit limits were used to calculate the maximum allowable annual discharge flow rate. Table 1 in Appendix D shows the allowable discharge volumes calculated by both methods.

For the typical P-E calculation, the allowable discharge volume was determined based on 1999 precipitation and evaporation values. The P-E allowable discharge flow rate was calculated to be 6,265 million gallons per year. Due to the allowable carry-over component in the 1986 permit, the allowable discharge volume was determined based on year 2000 conditions and utilizing carry-over results from 1999. The 1986 permit allowable discharge flow rate was calculated to be 5,297 million gallons per year. The lower of the two calculated discharges flow rates, the 1986 permit limit, was used to determine the maximum allowable flow rate within the non-degradation review.

5.2 PARAMETER SELECTION

The current NPDES/SDS tailings basin permit contains limits on dissolved iron and suspended solids. An analysis is required to determine if the predicted discharge loadings following expansion would exceed allowable loadings for dissolved iron and suspended solids. In addition, other parameters without specific limits in the current permit that may hold a special interest to the public also require analysis. The anticipated discharge loading of chloride, fluoride, hardness, mercury, sulfate, phosphate, and trace metals were also evaluated against the allowable discharge loadings.

The large size and residence time of the tailings basin system coupled with high dissolved oxygen concentrations allows ample time for iron oxidation to occur. The large residence time promotes effective settling of iron and other suspended solids. Therefore it is anticipated that the tailings basin will continue to discharge water with low levels of dissolved iron and suspended solids. The tailings basin system, which consists of three large pools/ponds in series, will continue to remove dissolved iron and total suspended solids and remain well below the allowable loadings in the effluent.

The proposed expansion will utilize a taconite production process that is very similar to the existing process in terms of impacts to the water except that a dry scrubber is planned. The dry scrubber will not result in the introduction of certain contaminants into the water. Therefore, concentrations of chloride, fluoride, mercury, phosphate, and trace metals are expected to be at or less than current levels in the tailings basin effluent. In addition, modeling has shown the discharge volume from Reservoir 6 will not exceed the allowable discharge flow rate of 5,297 million gallons per year (*Water Balance/Mine Yield Study – Keetac Expansion Project, Liesch, February 2009*). Therefore, the mass loadings of these parameters are expected to remain below the loadings that would have been allowed under the 1986 permit.

Sulfate is a parameter of concern due to the current increases observed in the tailings basin system and the potential impact to downstream water quality. In addition, hardness levels could increase due to the use of hydrated lime within the scrubber wastewater treatment system Therefore a more detailed review of potential non-degradation was conducted on these two parameters and is detailed below.

5.3 SULFATE NON-DEGRADATION REVIEW

Sulfate concentrations have been increasing in the tailings basin. The increase is due to the installation of a wet scrubber on the existing taconite process in 2006 to satisfy maximum achievable control technology (MACT) standards for air quality. The increase has occurred despite a lime precipitation system that was added in 2006 to reduce sulfate concentrations in the scrubber blow-down. Due to the large size of the tailings pond and associated retention time, steady state sulfate concentrations would not be reached for many years after a process change is made, such as the 2006 scrubber addition. Due to the delayed impact of process changes, modeling of the tailings pond sulfate concentrations and discharge loadings was conducted beyond the typical 5 year NPDES/SDS permit term to 2036 (the final phase of the proposed mining plan). This proactive measure was undertaken to determine if a build-up of sulfate in the tailings pond would cause discharge sulfate loadings in the future above the non-degradation threshold allowed based on the 1986 permit. The possible impact of the treatment chemical (lime) from the addition of the 2006 scrubber blow-down treatment system was also evaluated for calcium concentrations, and thus hardness levels, in the tailings basin discharge.

Modeling indicated that sulfate concentrations would build-up slowly in the tailings pond with the operation of the wet scrubbers and the current scrubber wastewater treatment

system. As the mine expands and dewatering flow rates increase, the discharge loading of sulfate during a high precipitation year could cause sulfate loadings in the discharge to exceed what was allowed based on the 1986 permit. It should be noted that, without modifications to the current scrubber wastewater treatment system, modeling indicated that the anticipated sulfate discharge loadings could not have exceeded the allowable discharge loadings until at least 15 years after plant expansion, and even then only during the highest precipitation year evaluated in the water balance study.

To prevent the build-up of sulfate in the tailings basin to these levels, U. S. Steel has proposed to install additional treatment equipment to the scrubber wastewater treatment system that was installed in 2006. A 50 percent reduction in the sulfate load from the existing scrubber wastewater treatment system was determined to be sufficient to prevent future maximum sulfate discharge loads from exceeding the non-degradation threshold.

To determine the allowable sulfate loading, the concentration of sulfate that existed in the discharge from the tailings basin in 1988 was determined. The concentration of sulfate reported in Keetac's tailing basin discharge in 1988 was 58.4, 54, 59, and 77 mg/l resulting in an average concentration 62.1 mg/l (see 1988 Discharge Reports in Appendix D). Using the maximum allowable discharge from the tailings basin of 5,297 million gallons per year, the maximum allowable discharge of sulfate is 1370 tons per year.

Table 2 in Appendix D shows the model outputs for the predicted sulfate concentrations in the tailings basin under normal precipitation years using a 50 percent reduction in the sulfate load being discharged from the existing scrubber wastewater treatment system. Since a request to discharge Sargent Pit dewatering into Reservoir 2 (the outfall receiving water from Reservoir 6) has been made in this application, the loading from that source has been added to the loading from Reservoir 6 for this review. Adding the Reservoir 6 w/out Sargent flow rates (Table 2 in Appendix D) to the Sargent Pit flow rate and using the predicted sulfate concentration for each year, it was determined that the maximum predicted sulfate discharge loadings will be well below the maximum allowable sulfate discharge loadings of 1,370 tons per year.

However, this analysis assumed an average precipitation year, and a high precipitation year would cause an increase in the discharge flow rate, and therefore an increase in sulfate discharge loadings. An analysis of the sulfate discharge loadings that could occur from the tailings pond during a year with high precipitation rates was also conducted. The concentration in the tailings pond would be expected to decrease during a high precipitation year due to the dilution effect of the precipitation. The concentration of

sulfate in the tailings basin was modeled during each of the 5 phases of the expansion (each phase spans 5 years) assuming a high precipitation year occurred. The results of that modeling can be seen in Table 3 through Table 7 in Appendix D. The modeled sulfate concentrations and maximum Reservoir 6 discharge flow rates can be seen in Table 8 in Appendix D for each of the phases. It was determined that removing 50 percent of the existing sulfate load in the discharge from the scrubber wastewater treatment system will enable the worst case sulfate discharge from the tailings basin to stay below the allowable sulfate discharge loading of 1370 tons per year.

5.4 HARDNESS NON-DEGRADATION REVIEW

Hardness is also expected to increase in concentration following the addition of the 2006 scrubber due to the lime addition as a precipitating agent in the associated treatment system. This anticipated increase in hardness concentration requires a more detailed review of potential non-degradation issues.

The baseline concentration of hardness in Keetac's tailings basin discharge in 1988 was 223, 195, 235, and 290 mg/l resulting in an average concentration of 235.8 mg/l. Utilizing the maximum allowable discharge flow rate of 5,297 million gallons per year and the baseline concentration, the maximum allowable hardness discharge loading (from a non-degradation review perspective) is 5,200 tons per year.

Prior to the addition of the scrubber in 2006, no changes were made to the Keetac site that had the potential to significantly affect the hardness concentration in the tailings basin discharge. As a result, the future predicted maximum hardness loading for the expansion is the baseline hardness concentration (235.8 mg/l in 1988) multiplied by the highest predicted flow rate in 2036 plus the estimated hardness loading due to the calcium discharges from the scrubber wastewater treatment system following the planned upgrade. The highest predicted flow was determined by modeling a high precipitation year occurring in 2036 when mine dewatering volumes are at their peak. This resulted in a peak flow rate of 4,160 million gallons per year, as shown in Table 8 in Appendix D. The peak future hardness loadings without the loadings from the scrubber were therefore calculated to be 4,084 tons per year. The existing scrubber and wastewater treatment system adds 596 tons of hardness per year. The wastewater treatment system upgrade will remove 50 percent of the current sulfate ions and it is anticipated that calcium ions would be removed at the same efficiency. The estimated increase in hardness loading due to the scrubber wastewater treatment system with planned upgrades is 298 tons per year (Water Balance/Mine Yield Study – Keetac Expansion Project, Liesch, February 2009). This

predicts a maximum future hardness loading of 4,382 tons per year. This is less than the maximum allowable hardness discharge loading of 5,200 tons per year. It should be noted that, even without the 50 percent calcium removal from the planned wastewater treatment system upgrade, the highest hardness discharge loading over the next 25 years is predicted to be less than the maximum allowable hardness discharge loading of 5,200 tons per year.

5.5 CONCLUSION

The discharge loading of parameters with permit limits will be below levels that were allowed in the permit that was in effect in 1988. In addition, the predicted discharge loading of other parameters of concern such as chloride, fluoride, mercury, phosphate, and trace metals will be below maximum allowable discharge loads without further wastewater treatment. Upgrades to the 2006 scrubber wastewater treatment system are expected to remove 50 percent of the sulfate load being discharged currently. This will ensure that future discharge loadings will be below allowable sulfate loadings, from a non-degradation perspective. Maximum potential hardness discharge loadings have also been shown to be below allowable discharge loadings, from a non-degradation perspective. Based on this information, parameters of concern do not exceed the threshold that would require a formal non-degradation analysis.

6.0 IMPAIRED WATERS REVIEW

There are currently eight impairments identified by the MPCA in various downstream receiving waters from the Keetac facility. None of the impaired waters receive direct discharge from the tailings basin system. The water body and associated impairment are as follows:

- Swan Lake (Main Basin)
  - Mercury in Tissue
- Swan River (to Mississippi)
  - Mercury in Tissue
  - Dissolved Oxygen
- Mississippi River
  - Mercury in Tissue
  - Mercury in Water Column
  - Turbidity
  - Dissolved Oxygen
  - PCB in Fish Tissue
  - Fecal Coliform
  - Fish Bioassessments
  - Perfluorooctane Sulfonate (PFOS) in Fish Tissue

The discharge from the Keetac tailings basin system will meet the water quality standards of the receiving waters for the impairments at the point of discharge and will not cause or contribute to further impairments. Further discussion regarding each of the impairments list above is provided below.

6.1 MERCURY

All three water bodies listed above are impaired for mercury in fish tissue. The Mississippi River is also impaired for mercury in the water column. A total maximum daily load (TMDL) has been approved for these impairments.

The fine tails deposited in the tailings basin adsorb mercury from the wastewater in the tailings slurry. The tailings basin system acts as an extremely efficient mercury removal system due to adsorption and subsequent particle settling. The average mercury concentration measured in Reservoir 6 discharge was less than 1.3 nanograms per liter.

The mercury concentration measured in the Sargent Pit discharge was 1.2 nanograms/liter (see Table 3 in Appendix B). These mercury concentrations are a fraction of typical mercury concentrations observed in rainwater in this area.

The water quality standard for mercury for this area of the state is 6.9 ng/l. The EPA has approved a mercury TMDL for all mercury impaired waters in this region. The increased flow rates predicted from the tailings basin over the five phases of the proposed expansion are included in the table below. The increased mass in mercury discharged from the tailings basin over the timeframe of the proposed expansion has been calculated and is included below, based on the 1.3 ng/l Reservoir 6 concentration.

Increase in Mercury Loadings from Tailings Basin Discharges

	Predicted Reservoir Six Flow Rate* (MGY)	Hg Concentration (ng/l)	Increase in Reservoir Six Discharge Loadings (grams Hg/year)
Pre-expansion	756	1.3	-
Phase I (2012-2016)	1,126	1.3	1.8
Phase II (2017-2021)	1,213	1.3	2.3
Phase III (2022-2026)	1,294	1.3	2.7
Phase IV (2027-2031)	2,156	1.3	6.9
Phase V (2032-2036)	2,247	1.3	7.3

*Pre-expansion rate does not include Sargent Pit water discharging to Reservoir 2 (and ultimately pumped to Reservoir 6), post-expansion flow rates do include Sargent Pit flow.

Effluent monitoring for mercury in the Reservoir 6 discharge is already required and will continue to be conducted. A new monitoring point will be required for the Sargent Pit discharge to Reservoir 2. The effluent from the tailings basin system and Sargent Pit is expected to be consistently below the water quality standard of 6.9 ng/l. The discharge of water from the Keetac tailings basin system or Sargent Pit is not reasonably expected to cause or contribute to mercury impairment in downstream receiving waters.

6.2 DISSOLVED OXYGEN

A TMDL has not been approved for this impairment. Dissolved oxygen is typically depleted in rivers and streams due to elevated phosphorous (which can lead to excessive eutrophication) and/or biological oxygen demand (BOD) levels. Phosphorous concentrations in the tailings basin averaged 15 micrograms/liter. Phosphorous concentrations in the Sargent Pit discharge were measured at less than 4.3 micrograms/liter. The phosphorus water quality standard for the receiving waters are all at or above 30 micrograms/liter. BOD levels were below detection limits for all three

samples taken from the tailings basin and were also non-detect from the Sargent Pit discharge. The increase in low-phosphorus and low-BOD discharges from the proposed expansion project into upstream receiving waters will likely help to increase dissolved oxygen concentration in downstream impaired waters. This is due to the increased flows (with low BOD/phosphorus) that will effectively dilute the downstream oxygen demand from other sources.

6.3 TURBIDITY

A TMDL has not been approved for this impairment. The Reservoir 6 discharge sampling average turbidity was 2.0 NTU. The Sargent Pit discharge sampling turbidity was 0.30 NTU. The receiving waters have a water quality standard of 25 NTU. In addition, the extremely low phosphorous and non-detectable levels of BOD are good indicators that the discharge from the tailings basin system or Sargent Pit will not contribute or cause turbidity impairments downstream. It is likely that the increased flows from the proposed expansion project will help decrease turbidity in the downstream receiving waters.

6.4 FISH BIOASSESSMENTS

A TMDL has not been approved for this impairment. Turbidity would be a likely candidate as a surrogate parameter for fish bioassessments. The impaired water for fish bio-assessments is on the Mississippi water just north of Minneapolis which is several hundred miles away. As is explained in the turbidity section, Keetac discharge water is not expected to contribute to turbidity impairments. Therefore, it is not expected to cause or contribute to fish bioassessment impairments downstream.

6.5 PCBS

A TMDL has not been approved for this impairment. PCBs are not reasonably expected to be present in the effluent from the Keetac tailings basin or from Sargent Pit.

6.6 FECAL COLIFORM

A TMDL has not been approved for this impairment. Fecal coliform is not reasonably expected to be present in the effluent from the Keetac tailings basin system or from Sargent Pit.

6.7 PERFLUOROOCTANE SULFONATE

A TMDL has not been approved for this impairment. Perfluorooctane sulfonate is not reasonably expected to be present in the effluent from the Keetac tailings basin or from Sargent Pit.

7.0 MPCA NPDES/SDS APPLICATION FORMS

Included with this section are the MPCA NPDES/SDS Permit Modification Application Forms required. The forms included are:

- MPCA Water Quality Transmittal Form
- MPCA NPDES/SDS Permit Application – Appendix A
- MPCA Attachment for Industrial Surface Water Discharge Wastewater Treatment Facilities National Pollutant Discharge Elimination System (NPDES/SDS) Permit

W:\ww\94213\NPDES Permit Applications\Tailings Basin\FINAL APPLICATION\Application Tailings Basin 12-23-09.doc

Minnesota Pollution Control Agency

Tailings Basin
WATER QUALITY TRANSMITTAL FORM

MPCA USE ONLY Application Number		
MN		
Date Received		
Month	Day	Year

COMPLETE APPLICATION BY PRINTING OR TYPING.
PLEASE MAKE A PHOTOCOPY FOR YOUR RECORDS.

FACILITY INFORMATION

Facility Owner [X] and/or Operator [X] (Public Entity, City or Business Firm legally responsible for facility operation) [see Minn. R. 7001.0050]

Permittee Name: United States Steel Corporation Phone: ( ) FAX: ( )

Mailing Address: 600 Grant Street City: Pittsburgh

State: PA Zip: 15219 Type of ownership Public [ ] / Private [X]

Facility Location No Post Office Boxes allowed. Actual physical location of facility -- must use actual street or highway address (or Section/Township/Range coordinates). *If applying for a permit that can cover more than one site (e.g. aggregate and/or hot mix asphalt operations), write NA.*

Facility Name: United States Steel Corporation, Minnesota Ore Operations - Keetac Phone: (218)778-8672

Location Address: 1 Mine Road

Facility is located in the N/A quarter of the N/A quarter of section N/A township Various

of Itasca & St. Louis county. Township # 56, 57 Range # 21-22 East [ ] West [X]

City: Keewatin State: MN Zip: 55753

Is the facility located on tribal land? [ ] yes [X] no If yes, apply to EPA Region V, John Coletti; (312) 886-6106.

Technical Agent or Consulting Engineer Michael Johnson, P.E. Title: Sr. Project Engineer

Name of firm or organization: Liesch Associates, Inc.

Mailing Address: 13400 15th Avenue N Phone: (763)489-3100

City: Plymouth State: MN Zip: 55441

Contact Person (Operator, Plant Manager, City Official): Title:

APPLICATION INFORMATION

Reason for Application (check all that apply):

[ ] Expiration of existing permit (reissue) [X] Modification to existing permit [ ] Agency request
[ ] New permit/facility [ ] Land Application Site Approval [ ] Other, please specify

Type of Application (check all that apply):

[ ] Municipal/Domestic / [ ] Sanitary Sewer / [ ] Biosolids / [ ] Pretreatment / [X] Industrial Process Wastewater /
[ ] Industrial By-product Land Application / [ ] Land Disposal Site Approval for Wastewater /
[X] Stormwater / [ ] Water Treatment Plant / [ ] Non-contact Cooling Water / [ ] Ground Water Pump Out /
[ ] Dredge / [ ] Feedlot / [ ] Aquaculture / [ ] Aggregate/Hot Mix

Have you ever applied for, or do you currently have a National Pollutant Discharge Elimination System (NPDES) or State Disposal System (SDS) permit for this facility? ☒ yes ☐ no

If yes, please list permit number(s) MN0055948

Name on existing permit U. S. Steel Corporation

List all current MPCA permits or certificates, and their numbers, which also may apply to this facility:
NPDES/SDS MN0031879 applies to the mining and plant operations; Title V Permit: 13700063-003; Wetland Permits: 96-04859-TWP, 04-00215-TWP, 2006-69-TWP; AST Major Facility Permit: 11153; Waste Tire Storage Permit: WTSF-115; Hazardous Waste Generator ID# MND071344733

If this is a new or expanded facility, has an Environmental Impact Statement or an Environmental Assessment Worksheet been prepared?

yes ☒ no ☐ If yes, note the title and date: Currently in process with DNR

Annual Permit fee invoice should be mailed to ☐ Owner/operator address ☒ Facility location address ☐ Not applicable

Discharge Monitoring Report forms should be mailed to ☐ Owner/operator address ☒ Facility location address ☐ Not applicable

APPLICATION FEES

An application fee is required under Minn. Stat. § 116.07, subd. 4d (1990) and Minn. R. ch. 7002 (Permit Fee Rules). This application fee must be submitted with the application. **The application fee is $350.**

Reminder:

✓ ***Did you sign attachment form(s)?***
✓ ***Attach your $350 application fee?***
✓ ***Enclose completed attachments?***

Applications that are submitted without an authorized signature, the required application fee, and attachments will be returned. Please make your check payable to the Minnesota Pollution Control Agency. Send the completed permit application, attachments (including plans and specifications, if applicable) and check to:

Minnesota Pollution Control Agency
Beckie Olson, MAR/MAJ
520 Lafayette Road North
St. Paul, Minnesota 55155-4194

For more information please contact the Customer Assistance Center at:

In Metro Area: (651) 297-2274
Outside Metro Area: (800) 646-6247

Minnesota Pollution Control Agency

NPDES PERMIT APPLICATION - APPENDIX A

The 1993 Legislature revised the Minnesota Pollution Control Agency's responsibilities in Minn. Stat. § 115.03, subd. 1(e)(10) "Requiring that applicants for wastewater discharge permits evaluate in their applications the potential reuses of the discharged wastewater;"

As a result of this 1993 Law, the Minnesota Pollution Control Agency has been charged with requiring permit applicants to evaluate the reuse potential of their wastewater prior to discharge.

Therefore, please provide in narrative form in the space below, an evaluation of reuse potential of your wastewater prior to discharge to a receiving stream, lake, or storm sewer. Some ideas include water conservation measures, use of cooling tower blowdown for thermal discharges, lawn watering or irrigation of parks and public property, wetland reclamation/development/recharge.

The tailings basin facility serves to provide a means of depositing fine and course tails as well as treating wastewater so that it may be recycled and returned to the main plant operations for re-use. The vast majority of water discharged to the tailings basin in the tailings slurry is re-used within the plant as make-up water.

At the time of permit submittal, Keetac is also in the process of expanding the surface area of the tailings basin inner pool to minimize dusting issues. Therefore, the tailings slurry discharge water is being utilized as a control option to address dusting issues.

Minnesota Pollution Control Agency, 520 Lafayette Road North, St. Paul, Minnesota 55155-4194
(651) 296-6300, toll-free (800) 657-3864, TTY (651) 282-5332 or (800) 657-3864

Tailings Basin

ATTACHMENT FOR

Industrial Surface Water Discharge
Wastewater Treatment Facilities
National Pollutant Discharge Elimination System
(NPDES) Permit

Minnesota Pollution Control Agency

MPCA USE ONLY Application Number		
MN		
Date Received		
Month	Day	Year

COMPLETE APPLICATION BY PRINTING OR TYPING. PLEASE MAKE A PHOTOCOPY FOR YOUR RECORDS.

PERMITTEE:	United States Steel Corporation, Minnesota Ore Operations - Keetac

BASIC INFORMATION

1. Principal Facility Activity:

If established, please indicate what you believe to be the applicable federal effluent limitation guideline(s) for your waste stream(s): 40 CFR Part 440, Subpart A - Iron Ore Subcategory	
Product(s) Produced:	Iron taconite pellets
Raw Material(s) Consumed:	Iron ore taconite, limestone, dolomite, bentonite
*Average and maximum amount of product produced per Unit Time (such as tons/year, kilograms/day):	
Post expansion: 8.1 million tons average, 9.6 million tons max	
*Average and maximum amount of raw material consumed per Unit Time (such as tons/year, kilograms/day):	
Post expansion: 30 million long tons average, 32.7 million long tons max	
Standard Industrial Classification (SIC) Code Number:	1011
*Provide both daily maximum and long-term monthly average expected during the five-year permit term. If an effluent limitation guideline applies and is expressed in terms of production (or other measure of operation) please report the expected actual production rates in the units used in the applicable effluent guideline. Consumptive use and/or production rates should be in sufficient detail so as to aid in the development of technology-based effluent limitations. For new discharges, actual production shall be estimated using projected production.	

STORM WATER

2. Is the facility now covered by an MPCA storm water NPDES permit? ☒ Yes ☐ No
If yes, indicate the permit number (if storm water discharges are authorized under the storm water general permit give unique identifying number rather than general permit number): MN0055948

3. Does storm water contact ANY raw or processed materials, finished products, industrial waste, byproducts, or any other type of significant materials at the facility? ☒ Yes ☐ No

If yes, describe these materials: **Precipitation within tailings basin contacts deposited coarse and fine tails**

4. Is any vehicle maintenance, transportation equipment cleaning, or airport deicing conducted at the facility?
☒ Yes ☐ No

Vehicle maintenance performed indoors

5. Indicate the name of the receiving water body(ies) to which storm water from the facility discharges and attach a site map showing discharge drainage path(s). If storm water discharges to a storm sewer, include a map showing storm sewer route to receiving water body: Reservoir #2, See Application, Appendix A for Figures

WATER SUPPLY

6. What is the source of the intake water supply for the facility?		Rate of supply (gallons/day)?
☐ Municipal water supply, city name:		
☐ Ground water, intake location:	Mine dewatering via tailings slurry	Various
☒ Surface water, name:	Welcome Creek via Reservoir 2 North, Reservoir 2	Various

If this is a surface or ground water intake, please given the
DNR Water Appropriation Permit Number 65-1138, 65-0351
Is the intake water supply chlorinated or otherwise disinfected? ☐ Yes ☒ No

INDUSTRIAL PROCESS WASTEWATER

7. Does the facility generate industrial process wastewater? ☒ Yes ☐ No

8. If yes, the industrial process wastewater from the facility is discharged to: (check all that apply)

☐ Surface water via municipal storm sewer	☐ Surface Water via applicant owned and operated wastewater treatment system
☒ Direct to surface water	☐ Publicly owned treatment works, provide owner/operator name:
☐ On-Site Storm water retention basin	☐ Septic tank/drain field
☐ Land Application (if checked you must complete the Land Application Disposal form)	☐ Other, please describe _____

9. Is the applicant requesting authorization to discharge industrial process wastewater? ☒ yes ☐ no

Provide flow information specific to the industrial process wastewater waste stream:

Maximum flow rate in gallons per day	Average flow rate in gallons per day	Discharge frequency**	Receiving Water/ Disposal Point
3.1 MGD	40 MGD	Continuous	Reservoir 2

Additionally, provide a list of what pollutants are known or can reasonable be expected to be present. All levels (except discharge flow, temperature, and pH) must be given as concentration and total mass.

DISCHARGE FROM INCOMING WATER TREATMENT PROCESSES

10. Does the facility generate wastewater from water treatment process(es) for which discharge authorization is requested? ☐ Yes ☒ No **If no, skip to item 14.**

11. If yes, check all waste stream types that apply: ☐ Reverse Osmosis ☐ Softener ☐ Deionization ☐ Multi-media Filter ☐ Other, explain:

On the water balance (described on page 4 of 6), be sure to provide actual (or estimated for new sources) individual flow contributions for each of these processes.

12. Please indicate to where wastewater from the water treatment process(es) will be discharged: (check all that apply)

☐ Publicly owned treatment works, provide owner/operator name:	☐ Surface Water via applicant owned and operated wastewater treatment system
☐ Direct to surface water	☐ Surface water via municipal storm sewer
☐ On-Site Storm water retention basin	☐ Septic tank/drain field
☐ Land Application (if checked you must complete the Land Application Disposal form)	☐ Other, please describe _____

Provide flow information specific to the water treatment waste stream:

Maximum flow rate in gallons per day	Average flow rate in gallons per day	Discharge frequency**	Receiving Water/ Disposal Point

13. Include as an attachment, test results (new dischargers should provide reasonable estimates) for the following pollutants unless otherwise waived by the permitting authority: pH, Total Chlorides, Specific Conductivity, Total Dissolved Solids, Total Sulfates, Hardness (as CaCO3), Bicarbonates (as HCO3 in meq/L), Boron, Sodium, Total Salinity.

NON-CONTACT COOLING WATER

14. Does the facility generate non-contact cooling water (e.g., power generation, refrigeration, boilers, etc.) for which discharge authorization is requested? ☐ Yes ☒ No

If yes, is this once-through ☐ or recirculating (i.e., cooling towers) ☐ ?

If this is recirculating, what is recycling time and ratio of bleedoff, to evaporation, to make-up?

Are any chemical additives used in conjunction with the cooling operation? ☐ No ☐ Yes **(be sure to complete item 15)**

14a. Provide test results (new dischargers should provide reasonable estimates) for the following pollutants unless otherwise waived by the permitting authority: temperature, pH, total residual chlorine (TRC), total phosphorus, chemical oxygen demand (COD), total organic carbon (TOC), and total dissolved solids (TDS).

Cooling Process (describe the type cooling towers, contact, etc.:	Flow Rate Average (specific to cooling waste stream)	Flow Rate Maximum (specific to cooling waste stream)	Discharge Frequency (if seasonal list months)	Receiving Water (or other disposal point)
N/A				

CHEMICAL ADDITIVES

15. List below all chemical additives that are used or proposed to be used in the waste stream(s) for which discharge authorization is requested.

Product Name	Process in which Used and Purpose for Use	Dosage Frequency (e.g. continuous, slug dosed 2x/week)	Maximum Rate of Use	Average Rate of Use
See Application, Appendix C				

You must attach Material Safety Data Sheets (MSDS) and complete product labels for each additive. If the MSDS does not include information on chemical composition, including percentages for each ingredient totaling to 100%, and aquatic toxicity, human health, and environmental fate for each proposed chemical additive, you must contact the supplier and have the information forwarded to the MPCA. Please note that it is not unusual for MSDSs only to contain ingredients considered hazardous by OSHA for transport and therefore may not list a nonhazardous ingredient such as polyphosphonate commonly used for scale and corrosion control.

WASTEWATER TREATMENT AND/OR WASTE STREAM DISCHARGE(S)

16. How do you dispose of sewage (sanitary wastewater) at the facility? Trucked away to POTW

17. Identify the discharge rate (gallons per day) and other information for each wastewater outfall discharge point:

Outfall point	Type of	Discharge flow	Discharge flow rate,	Discharge Frequency	Route

number	wastewater/ waste stream	rate, average	maximum		to receiving waters
SD001	Tailings Basin Discharge	0 MGD	9.4 MGD	Emergency Overflow	Siphon Outlet to Reservoir 2
SD005	Tailings Basin Discharge	3.1 MGD	40 MGD	Continuous	Drainage Ditch/Creek to Reservoir 2
Sargent Pit	Mine Dewatering	1.3 MGD	4.75 MGD	Continuous	Drainage Ditch to Reservoir 2

18. As an attachment to this application, provide a narrative description of the treatment the wastewater will receive along with all operations contributing wastewater to the effluent, average flow contributed by each operation, and the ultimate disposal of any solid or liquid wastes not discharged (Describe how and where the sediments and sludges removed from the wastewater treatment system at the facility are disposed). Highlight any changes made since permit issuance. Provide a diagram of the wastewater treatment process. See Application, Section 3.0 for Facility Description
See Application, Appendix A, Figure 2 & Figure 3 for Diagram

19. Attach a diagram, chart, or line drawing showing the water flow through the facility, showing operations contributing wastewater to the effluent and treatment units. The water balance must show approximate average flows at the intake, proceed through the plant processes, the wastewater treatment system (if any) and to each discharge point. The line balance should account for any loss between intake and discharge points.

See Application, Appendix A, Figure 2 & Figure 3

20. Attach a U.S. Geological Survey map showing the location of the facility, the wastewater treatment system, each of the discharge outfalls, other surface and ground water sampling points, and the route to the receiving waters. If this a discharge to a storm sewer, you must show the route of the storm sewer to a receiving water body. A map showing only the discharge to a storm sewer is unacceptable. The MPCA must receive a map which shows how and where the facility's waste stream(s) enter a receiving water body.

See Application, Appendix A, Figure 4

GROUND WATER MONITORING

21. Are there ground water monitoring wells or lysimeters at your facility? ☒ Yes ☐ No

If yes, describe where and why they were installed

17 Monitoring wells are located at southwest corner of the tailing pond exterior. These wells were installed to monitor along the clay perimeter dike. Six monitoring wells are located at south and east side of the tailings pond interior. These wells were installed to monitor water elevations in the coarse tailings dike of the interior pond. Five piezometers are located at south and east side of the tailings pond interior. These piezometers were installed to monitor water elevations in the coarse tailings dike.

WATER QUALITY TEST RESULTS

22. In an attachment to this application, please provide test results for all pollutants known or reasonably believed to be present at each of the facility discharge points. Such pollutants may include total suspended solids, biochemical oxygen demand, pH, fecal coliform, temperature (heat), nutrients (phosphorus, ammonia, nitrate, nitrite), metals, salts, cyanide, residual chlorine, fluoride, oil and grease, polychlorinated biphenyls, phenols, polynuclear aromatic hydrocarbons, volatile organic compounds, pesticides and/or radioactivity. Please clearly indicate, with all test results, the specific dates, location where sample was taken, types of wastewater sampled, and method(s) of sampling (e.g. grab, composite).
At a minimum provide test results for total suspended solids (TSS), biochemical oxygen demand (BOD), fecal coliform (if believed present or sanitary wastes will be discharged), pH, and total phosphorus, irrespective of what

might be required by an existing permit.
If this is an application for reissuance of an existing permit, review your existing NPDES/SDS permit to see if it has special testing requirements as part of the application for reissuance process.

23. Name of the laboratory that analyzed samples:	Northeast Technical Services
Indicate the Minnesota Department of Health Laboratory Certification Number for this laboratory:	027-137-157

24. If the system is currently covered under an NPDES/SDS permit, has the system been in compliance with the permit limits during the past five years?

☒ yes	☐ no	If no, please explain.	

MONITORING RESULTS (Checklist)

- ☒ Test results for all other pollutants known or reasonably believed to be present. (See item 9a)
- ☐ Test results from water treatment processes. (See item 13)
- ☐ Test results for BOD, TSS, COD, TOC, fecal, total phosphorus & pH. (See item 22)
- ☐ Test results from cooling water processes (temperature, pH, TRC, total phosphorus, COD, TOC, and TDS). (See item 14a)

ATTACHMENTS (Checklist)

- ☒ Narrative description of the treatment process. (See item 18)
- ☒ Information on chemical composition for all water treatment/chemical additives.
- ☒ MSDS sheets & product labels for all water treatment/chemical additives.

MAPS (Checklist)

- ☒ U.S. Geologic Survey topographic map. (See item 20)
- ☐ Site Map showing storm water conveyance from facility site. (See item 5)

FLOW CHART/DIAGRAMS (Checklist)

- ☒ Route of water flow/water balance from intake through facility and all treatment processes. (See item 19)
- ☐ Wastewater Treatment System. (See item 18)
- ☐ Other, Please list:

**** Discharge frequency shall be given as continuous, controlled, intermittent, or periodic/ seasonal. A year-round, daily discharge (excepting possibly weekends & holidays) is considered a continuous discharge. A controlled discharged is defined as a discharge from a stabilization pond. If the discharge rate given above is other than continuous or controlled, you must please provide an explanation for discharge frequency.**

CERTIFICATION

Federal regulations (Section 309(c)(2) of the Clean Water Act and State regulations (Minn. R. 7001.0070) require the authorized signer to be one of the following:

A. **For corporation, a principal executive officer of at least the level of vice president;**
B. **For a partnership or sole proprietorship, a general partner or the proprietor, respectively; or**
C. **For a municipality, State, Federal, or other public facility, either a principal executive officer or ranking executive official.**
D. **If the operator of the facility is different than the owner, both the operator and the owner according to items A to C.**

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person, or persons, who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment."

PRINTED NAME Jeremy Smolich TITLE Plant Manager

AUTHORIZED SIGNATURE _____ DATE _____

STATE TAX I.D. # 5738839 FEDERAL TAX I.D. # 25-1897152

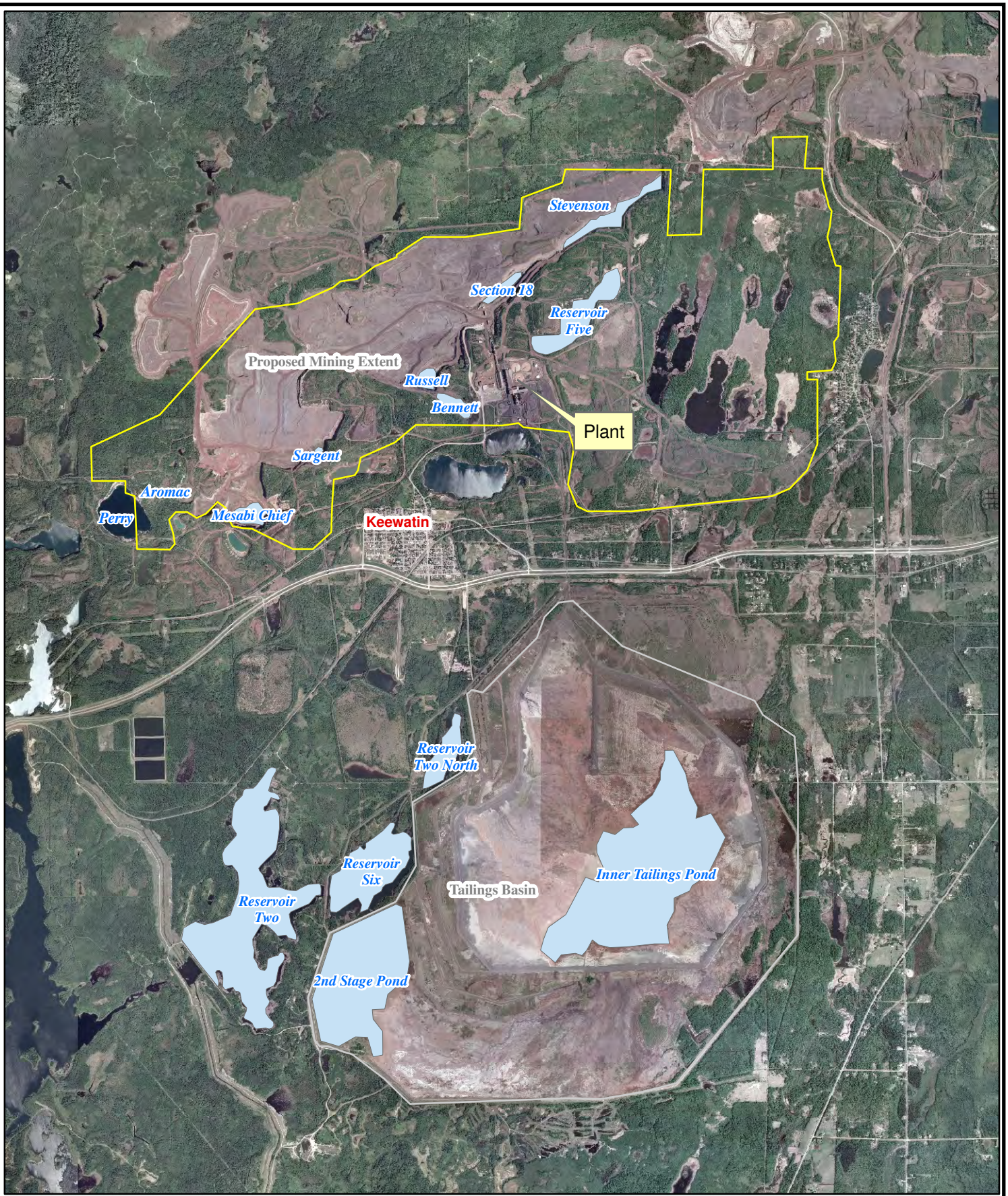
Reminder:

✓Did you enclose the Transmittal Form?
✓Did you enclose all necessary attachments?
Did you enclose the $350 app fee?

Applications submitted without an authorized signature, the required application fee and attachments, will be returned. Please make your check payable to the Minnesota Pollution Control Agency and mail to:

Minnesota Pollution Control Agency
Beckie Olson
520 Lafayette Road North
St. Paul, Minnesota 55155-4194

APPENDIX A – FIGURES



Source: 2003 NAIP Orthophoto, MnDOT
Projection: NAD83 UTM Zone 15N

0 5,000 10,000 Feet

1:60,000
1 Inch = 5,000 Feet

N

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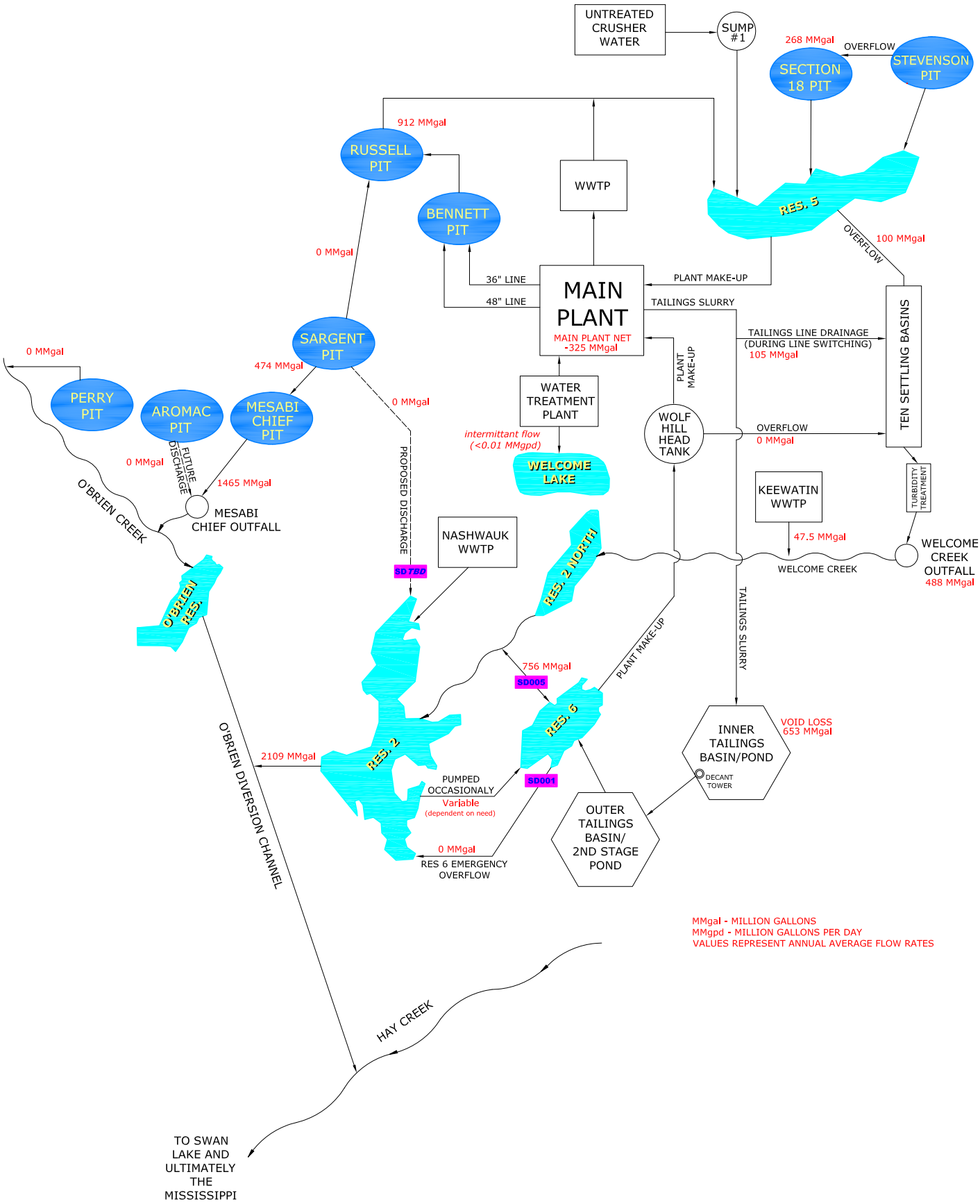
U.S. Steel - Keetac

Feb 09

Site Location

Figure 1



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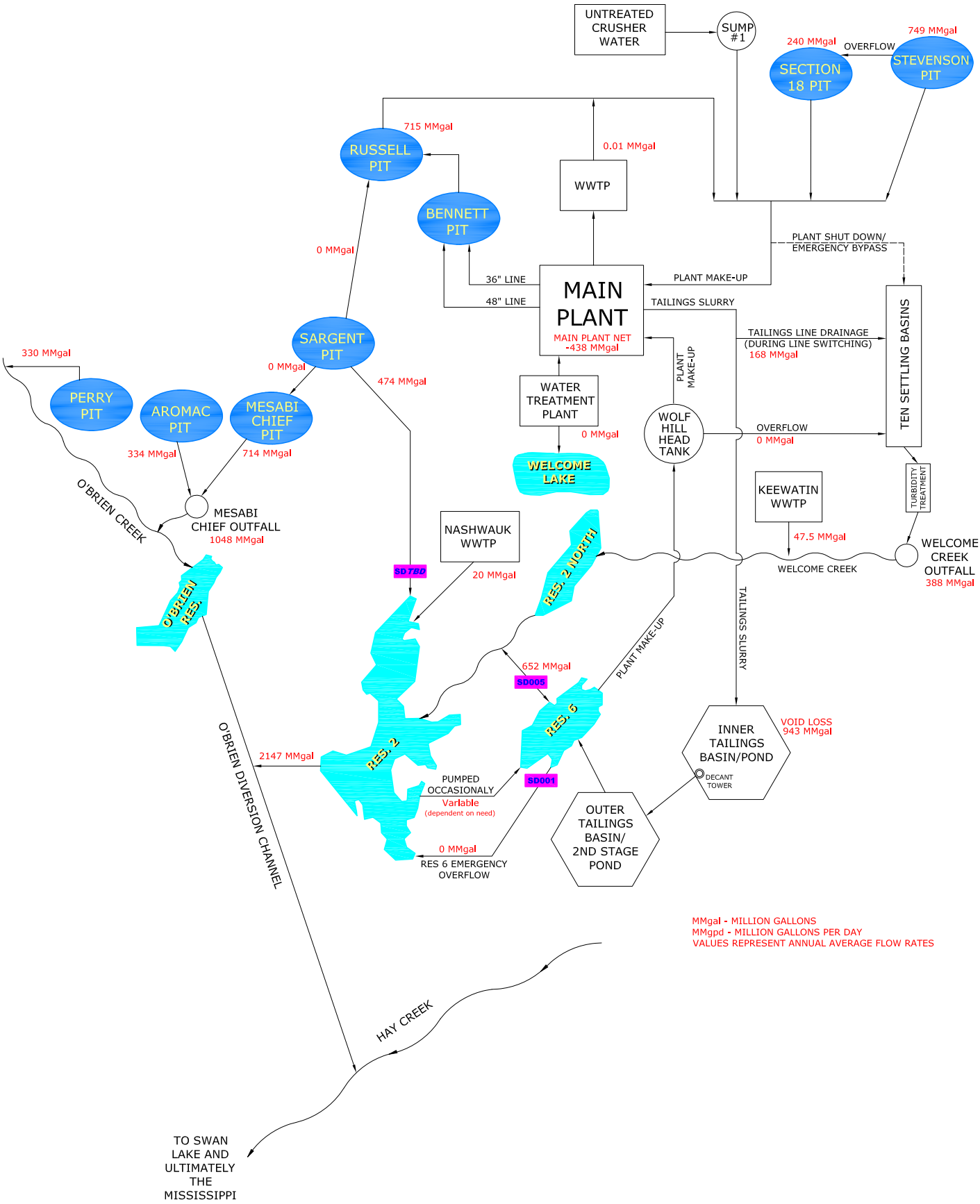
4300 N. Miller Rd., Suite 211
Phoenix, Az 85251
(480) 421-0853

U. S. Steel - Keetac

Oct 09

Predicted Pre-Expansion Water Flow Rates Prior to Reservoir 5 Removal

FIGURE 2



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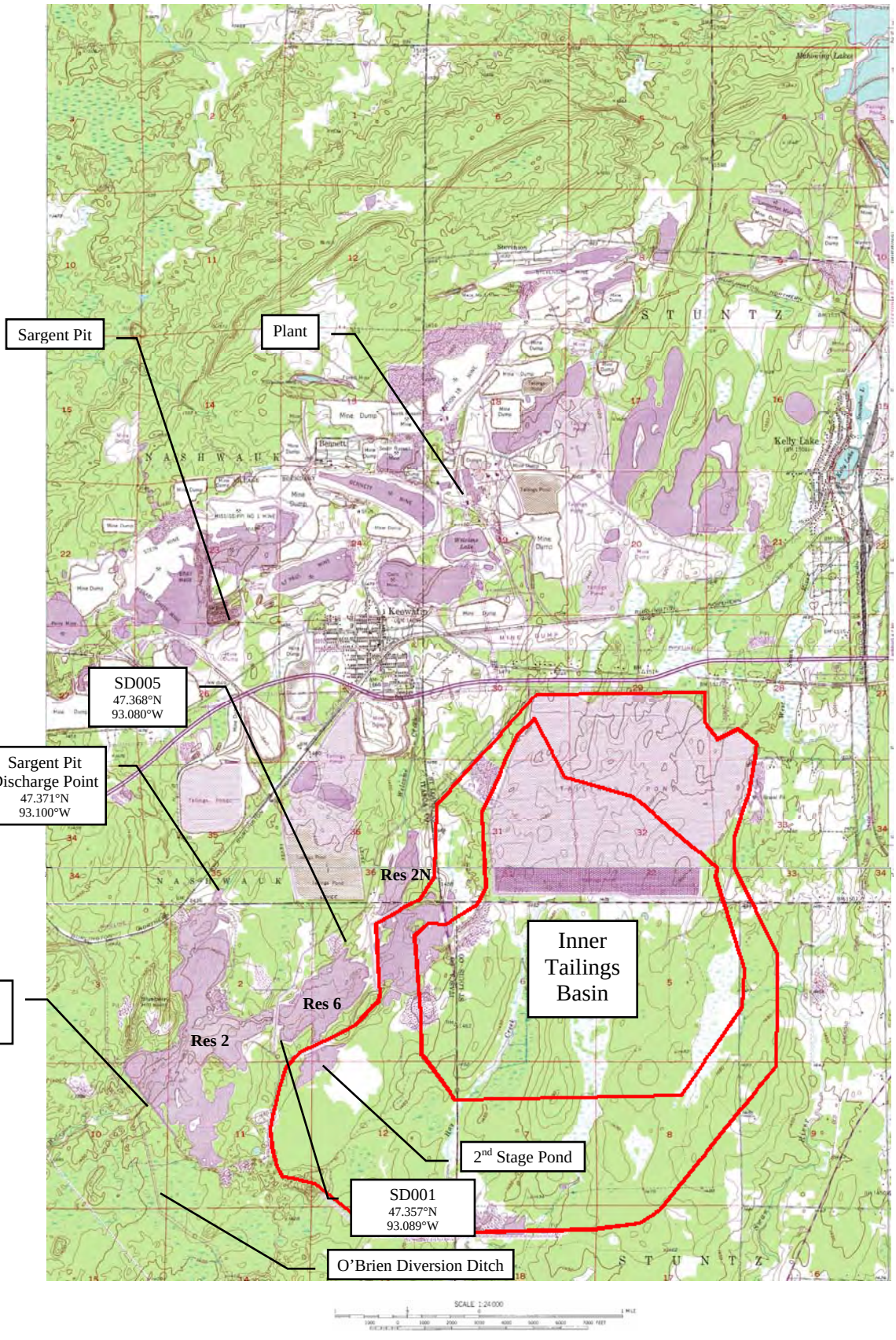
Predicted Post-Expansion Water Flow Rates Following Reservoir 5 Removal

FIGURE 3



Source:USGS 7.5 minute topographic – Composite of Keewatin, MN and Silica, MN quadrangle

W:\ww\94213\NPDES Permit Applications\Tailings Basin\USGS Map.doc

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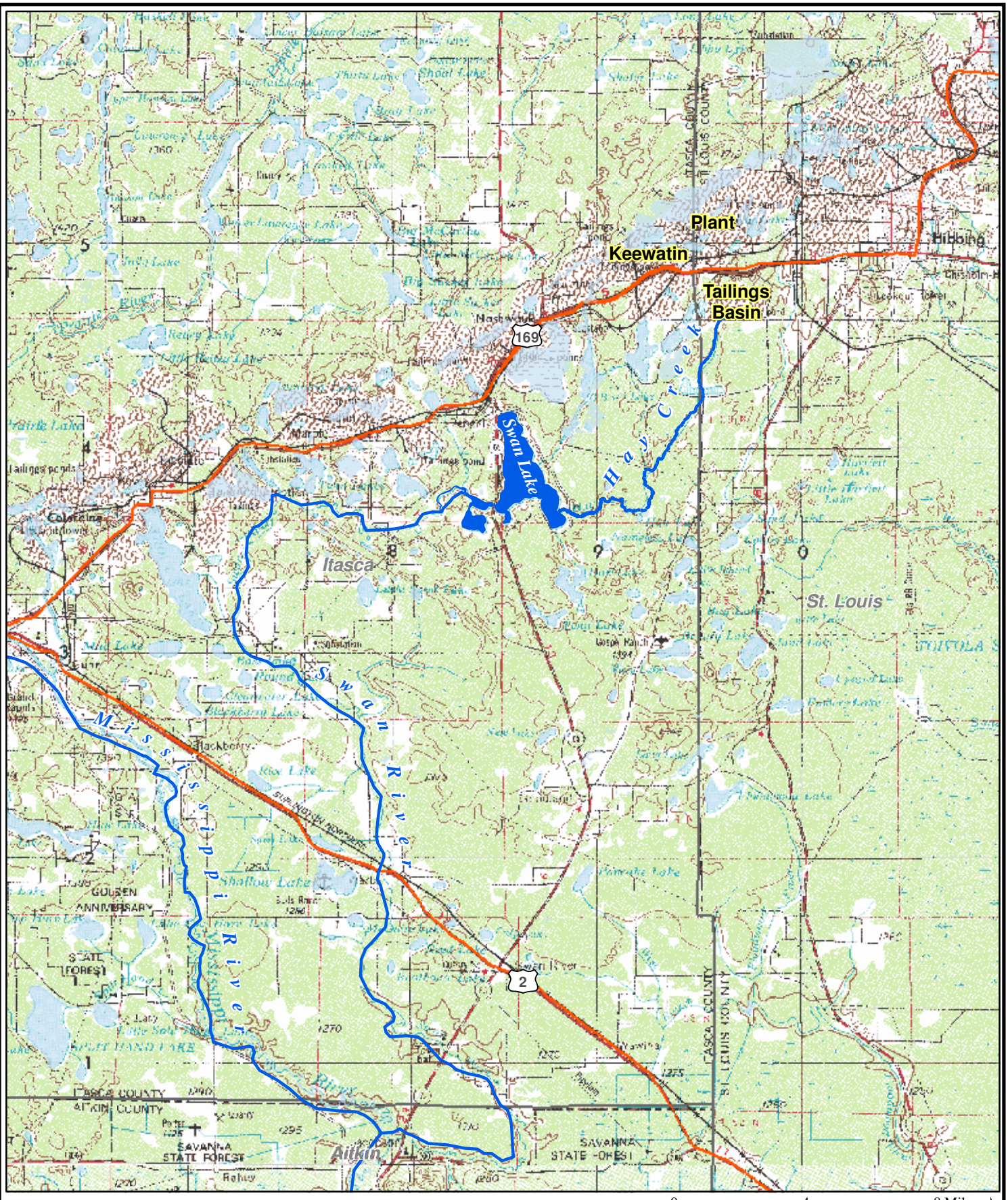
U. S. Steel - Keetac	**Oct 09**
USGS Topographic Map Facility Overview	**Figure 4**



Source: Microsoft Virtual Earth Topos
Projection: NAD83 UTM Zone 15N

0 4 8 Miles
1:250,000
N

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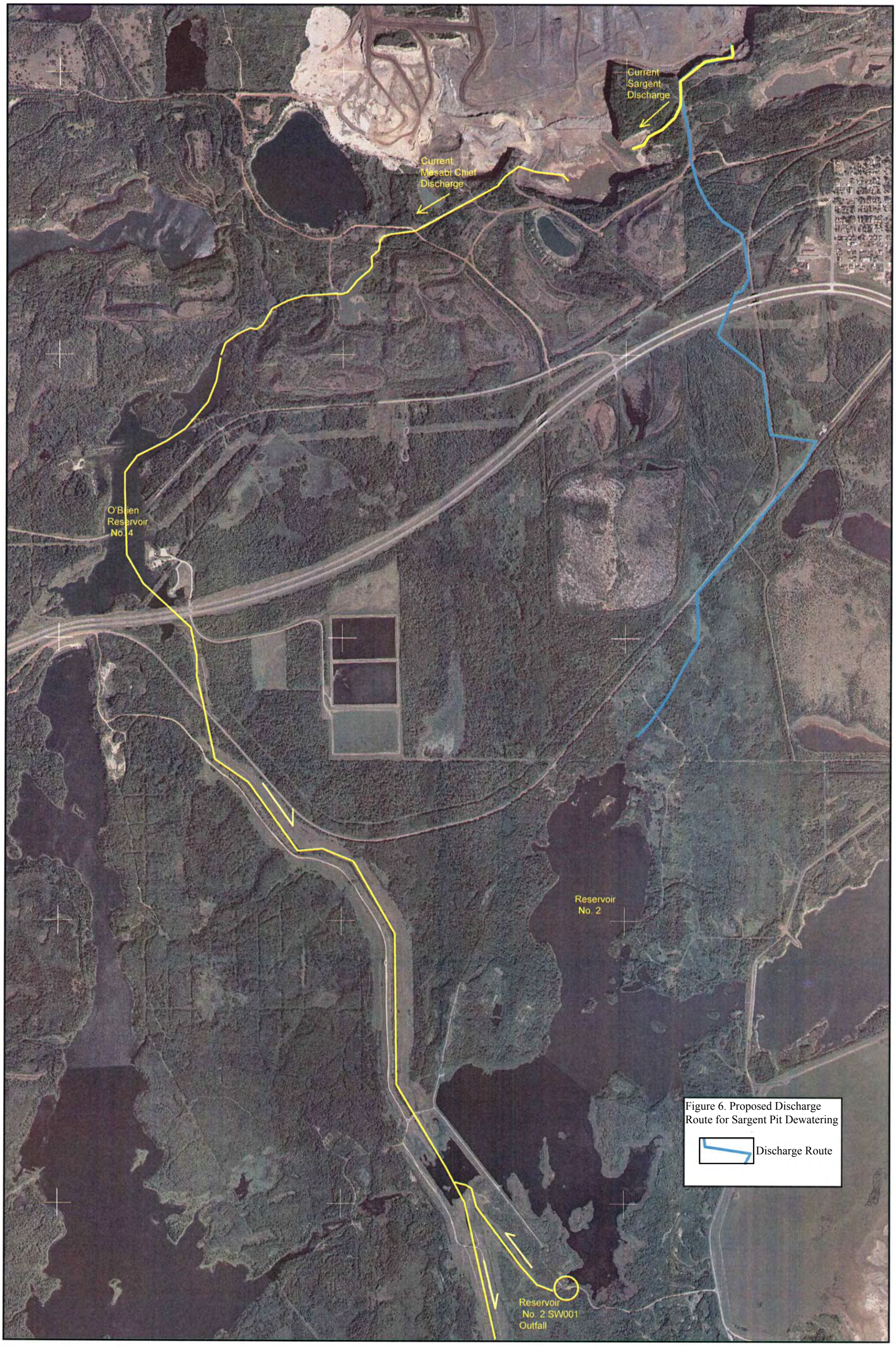
U.S. Steel - Keetac	Nov 09
USGS Topographic Map Regional Overview	Figure 5


Current
Sargent
Discharge
Current
Mesabi Chief
Discharge
O'Brien
Reservoir
No. 4
Reservoir
No. 2
Reservoir
No. 2 SW001
Outfall
Figure 6. Proposed Discharge
Route for Sargent Pit Dewatering
Discharge Route

APPENDIX B – WATER QUALITY SAMPLING RESULTS

Table 1: SD001 Reservoir 6 Siphon Outfalls (Overflow) DMR Data

		Total Flow MG	Max Daily Flow mgd	Cobalt, Total (as Co) ug/L	Fluoride, Total (as F) mg/L	Iron, Dissolved (as Fe) CalMoAvg mg/L	Iron, Dissolved (as Fe) Max mg/L	Molybdenum, Total (as Mo) ug/L	Nitrite Plus Nitrate, Total (as N) mg/L	TSS CalMoAvg mg/L	TSS Max mg/L	Specific Cond. umh/cm	Strontium, Total (as Sr) ug/L	Sulfate, Total (as SO4) Max mg/L	pH Minimum s.u.	pH Maximum s.u.
2006-2009	DEC	No flow in 2006-2009														
	NOV															
	OCT															
	SEP															
	AUG															
	JUL															
	JUN															
	MAY															
	APR															
	MAR															
	FEB															
	JAN															
2005	DEC															
	NOV															
	OCT															
	SEP															
	AUG															
	JUL															
	JUN															
	MAY															
	APR															
	MAR			<1	1.4	<0.03	<0.03	47.6	0.77	<1	<1	686	66.6	68.4	8.2	8.2
	FEB															
	JAN															
2004	DEC			<1	1.1	<0.03	<0.03	33.4	0.14	8	8	637	83.3	67	8.7	8.7
	NOV															
	OCT															
	SEP			<1	1.3	0.03	0.03	35.4	0.59			561	63.9	64.9		
	AUG															
	JUL															
	JUN			<1	0.35	0.432	0.52	6.5	0.84			640	120	63.2		
	MAY															
	APR															
	MAR															
	FEB															
	JAN															
2003	DEC			<1	0.93			26.6	0.29			597	88.1	57.1		
	NOV															
	OCT															
	SEP			<1	1.3			28	5.1			625	56.6	77.6		
	AUG															
	JUL															
	JUN															
	MAY															
	APR															
	MAR															
	FEB															
	JAN															
2002	DEC			<1.0	1	<0.03	<0.03	26.2	2	5.3	5.3	542	77.5	52	8.2	8.2
	NOV															
	OCT															
	SEP			<1.0	1.2	<0.03	<0.03	32	1.5	4	4	534	60.7	62.4	8.56	8.56
	AUG															
	JUL															
	JUN			<1.0	1.7	<0.03	<0.03	47.6	2.8	<1.0	<1.0	546	73.7	63.7	8.1	8.1
	MAY															
	APR															
	MAR			<5.0	1.1	<0.03	<0.03	52	1.3	<1.0	<1.0	572	95.2	63.5	8.11	8.11
	FEB															
	JAN															
2001	DEC	No flow in 2001														
	NOV															
	OCT															
	SEP															
	AUG															
	JUL															
	JUN															
	MAY															
	APR															
	MAR															
	FEB															
	JAN															

Table 2: SD005 Reservoir 6 Weir Outfall 015 DMR Data

		Total Flow MG	Max Daily Flow mgd	Cobalt, Total (as Co) ug/L	Fluoride, Total (as F) mg/L	Iron, Dissolved (as Fe) CalMoAvg mg/L	Iron, Dissolved (as Fe) Max mg/L	Mercury, Total (as Hg) ng/L	Molybdenum, Total (as Mo) ug/L	Nitrite Plus Nitrate, Total (as N) mg/L	TSS CalMoAvg mg/L	TSS Max mg/L	Specific Cond. umh/cm	Strontium, Total (as Sr) ug/L	Sulfate, Total (as SO4) Max mg/L	Sulfate, Total (as SO4) CalMoAvg mg/L	pH Minimum s.u.	pH Maximum s.u.
2009	DEC																	
	NOV																	
	OCT																	
	SEP																	
	AUG																	
	JUL																	
	JUN				1.53			1.6		0.88								
	MAY	107.79	10.97			0.05	0.05				2	2	573			111	8.3	8.3
	APR	171.38	13.79			<0.05	<0.05				5.6	5.6	475			106	8.2	8.2
	MAR	138.2	6.77		0.67	<0.05	<0.05	0.5		1.09	1.6	1.6	596			135	8	8
	FEB	98	6.07			0.05	0.05				1	1	820			137	8.1	8.1
	JAN	6.89	0.49			0.091	0.091				1.3	1.3	845			107	7.5	7.5
2008	DEC																	
	NOV																	
	OCT																	
	SEP																	
	AUG																	
	JUL																	
	JUN	4.92	0.66		0.98	0.05	0.05	0.9		1.1	1	1	672			119	8	8
	MAY	31.2	4.92			0.05	0.05				1.6	1.6	658			122	8.4	8.4
	APR	147.49	10.62			0.05	0.05				1.6	1.6	795			115	7.9	7.9
	MAR																	
	FEB																	
	JAN																	
2007	DEC																	
	NOV																	
	OCT																	
	SEP																	
	AUG																	
	JUL																	
	JUN																	
	MAY	57.86	7.67			<0.05	<0.05				4	4	850			94.5	7.8	7.8
	APR	109.46	3.65			<0.05	<0.05				5.5	5.5	952			99.9	7.7	7.7
	MAR	16.7	0.54		1.73	<0.05	<0.05	2.2		1.47	6.4	6.4	880			109	7.6	7.6
	FEB																	
	JAN																	
2006	DEC																	
	NOV																	
	OCT																	
	SEP																	
	AUG																	
	JUL																	
	JUN				1.7			<0.2		1.5								
	MAY	38.2	5.7			<0.05	<0.05				4.8	4.8	615			87.3	8.7	8.7
	APR	54.7	7.81			0.05	0.05				3	3	463			82	7.8	7.8
	MAR																	
	FEB																	
	JAN																	
2005	DEC																	
	NOV																	
	OCT																	
	SEP																	
	AUG																	
	JUL																	
	JUN																	
	MAY																	
	APR	73.99	10.32			0.03	0.03				11.4	12	958		59.7		7.5	8.5
	MAR	18.29	7.84	<1	1.4	<0.03	<0.03		47.6	0.77	1.5	1.5	686	66.6	72.5		8.1	8.1
	FEB																	
	JAN																	
2004	DEC			<1.0	1.1	<0.03	<0.03		33.4	0.14	8	8	627	83.3	67		8.7	8.7
	NOV																	
	OCT					<0.03	<0.03				8	8	627		67		8.7	8.7
	SEP			<1	1.3	0.03	0.03		35.4	0.59			561	63.9	64.9			
	AUG																	
	JUL																	
	JUN	41.6	7.84	<1	0.35	0.432	0.52		6.5	0.84	6.23	7	640	120	63.2		8.7	8.9
	MAY	3.2	2.21															
	APR	25.18	2.95			0.29	0.52				4.5	5	536		63.2		7.1	7.6
	MAR	6.24	2.95	<1.0	1.3	<0.03	<0.03		36.2	1.2	6.7	6.7	758	86.4	87.4		8	8
	FEB																	
	JAN	0	0			<0.03	<0.03				2.4	2.4	682		71.7		8.2	8.2
2003	DEC			<1.0	0.93				26.6	0.29			597	88.1	57.1			
	NOV																	
	OCT																	
	SEP			<1	1.3				28	5.1			625	56.6	77.6			
	AUG																	
	JUL																	
	JUN	1.15	0.66	<1	1.2				31.8	2.3			627	81.8	67			
	MAY	21.04	2.3			<0.03	<0.03				1.5	2	620		67.7		8.3	8.5
	APR	66.41	4.04			<0.03	<0.03				3.9	6	627		67		8	8.4
	MAR			<1	1.2	<0.03	<0.03		34.6	2.3	2.7	2.7	622	81.5	68.7		8.2	8.2
	FEB																	
	JAN																	
2002	DEC	5.72	1.76	<1.0	1	<0.03	<0.03		26.2	2	3.3	5.6	566	77.5	56		8	8.2
	NOV	11.32	1.76			<0.03	<0.03				5.3	5.3	542		52		8.2	8.2
	OCT																	
	SEP			<1.0	1.2	<0.03	<0.03		32	1.5	4	4	534	60.7	62.4		8.56	8.45
	AUG																	
	JUL	36.55	9.54			<0.03	<0.03				1.75	2	551		85.6		8.2	8.5
	JUN	21.18	10.37	<1.0	1.7	<0.03	<0.03		47.6	2.8	<1.0	<1.0	546	73.7	63.7		8.1	8.1
	MAY	6.02	1.14			0.05	0.07				2.5	4	583		70.7		8.08	8.16
	APR	7.58	2.48			<0.03	<0.03				2.8	3.6	613		61.1		8.05	8.08
	MAR			<5.0	1.1	<0.03	<0.03		52	1.3	<1.0	<1.0	572	95.2	63.5		8.11	8.11
	FEB																	
	JAN																	
2001	DEC	9.38	0.71	<1.0	1.1	<0.03	0.03		27.9	0.71	2.27	2.8	548	69.2	56.9		7.72	7.7
	NOV	2.32	0.39			0.04	0.04				1.8	2	536		57.7		7.92	7.94
	OCT																	
	SEP																	
	AUG																	
	JUL																	
	JUN	142.33	11.27	<1.0	1.9	0.08	0.1		35.7	3.41	3.1	5.2	500	92.5	53.6		7.46	8.08
	MAY	187.23	15.51			0.048	0.06				6.48	14.4	529		61.2		7.85	8.1
	APR	676.6	28.46			0.065	0.11				5.8	9.2	664		77.4		7.86	8
	MAR	29.74	4.49	<1.0	0.97	0.03	0.03		28.5	2	1.75	2.5	589	94.2	70.8		7.41	7.69
	FEB	13.85	3.18			0.04	0.04				2.25	3.3	549		63.6		7.77	7.81
	JAN	27.02	1.1			<0.03	<0.03				1.7	2.4	531		74.4		6.48	7.87

Table 3. NPDES Permit Application Sampling Results - Metals

Metals

Sample Date	Aluminum ug/L	Antimony ug/L	Arsenic ug/L	Barium ug/L	Boron ug/L	Cadmium ug/L	Calcium mg/L	Chromium ug/L	Cobalt ug/L	Copper ug/L	Iron mg/L	Lead ug/L	Magnesium mg/L	Manganese ug/L	Mercury ng/L	Molybdenum ug/L	Nickel ug/L	Selenium ug/L	Tin ug/L	Titanium ug/L	Vanadium ug/L	Zinc ug/L
Applicable Water Quality Standard	**125**	**31**	**53**	**-**	**500**	**2.7***	**-**	**11**	**5**	**19***	**-**	**13***	**-**	**-**	**6.9**	**-**	**399***	**5**	**-**	**-**	**-**	**269***
SD-005 Res 6 Discharge																						
Sep 2004									<1							35.4						
Dec 2004									<1							33.4						
Mar 2005									<1							47.6						
Mar 2007											<0.05											
Apr 2007											<0.05											
May 2007											<0.05											
6/13/2008	29.1	<10	2.2	12.6	104	0.41	30.3	<2		<2		<1	55.3	49.3	<0.5		<2	<2	<25	<10	<10	<25
6/30/2008	<25	<10	<2	10.2	99.9	<0.2	29.1	<2		<2		<1	55.6	37.4	1		<2	2.3	<25	<10	<10	<25
8/1/2008	<25	<10	2.5	11.5	97.4	<0.2	27.6	<2		<2		<1	52.8	23	2.4		<2	<2	<25	<10	<10	<25
8/18/2008																						
AVERAGE	**< 26**	**< 10**	**< 2.23**	**11**	**< 100**	**< 0.27**	**29**	**< 2.0**	**< 1.0**	**< 2.0**	**< 0.05**	**< 1.0**	**55**	**37**	**< 1.30**	**39**	**< 2.0**	**< 2.10**	**< 25**	**< 10**	**< 10**	**< 25**
Sargent Pit																						
8/18/2008	<25	<10	4.7	35.6	<50	<0.2	61	<2	<2	<2	<0.05	<1	43.5	480	1.2	<5	<2	2.9	<25	<10	<10	<25

*Water quality standard variable depending on hardness. A hardness value of 300 mg/l was used to determine applicable standard.

Table 4. NPDES Permit Application Sampling Results - Non Metals

Non-Metals

Sample Date	Oil & Grease mg/L	BOD mg/L	Bromide mg/L	Chloride mg/L	COD mg/L	Fluoride mg/L	Nitrogen, Ammonia mg/L	Low-Level Phosphorus, Total mg/L	Solids, Filterable (TDS) mg/L	Solids, Nonfilterable (TSS) mg/L	Specific Conductance umhos	Sulfate mg/L	Turbidity NTU
Applicable Water Quality Standard	**-**	**-**	**-**	**230**	**-**	**-**	**-**	**0.03**	**700**	**-**	**1000**	*****	**25**
SD-005 Res 6 Discharge													
Mar 2005						1.4							
Jun 2006						1.7							
Mar 2007						1.7							
6/13/2008	<2	<3	<0.5	25.9	35.8		<0.1		394	2.8	914	120	2.7
6/30/2008	<2	<3	<0.5	24.4	29.2		0.42		403	1.6	720	106	1.6
8/1/2008	<2	<2.4	<1	22.9	21.5		0.19		378	2.4	714	106	1.8
8/18/2008								0.007					
9/26/2008								0.017					
10/17/2008								0.021					
Average	**< 2.0**	**< 2.8**	**< 0.67**	**24.4**	**28.8**	**1.6**	**< 0.24**	**0.015**	**392**	**2.3**	**783**	**111**	**2.0**
Sargent													
8/18/2008	<2	<2.4	<0.5	8.84	13.0	<0.1	0.19	<0.004	421	<1	660	113	0.3
9/26/2008								0.004					
10/17/2008								0.005					
Average	**< 2.0**	**< 2.4**	**< 0.50**	**8.8**	**13**	**< 0.10**	**< 0.19**	**< 0.0043**	**421**	**< 1.0**	**660**	**113**	**0.30**

* Class 4A waters include a 10 mg/l sulfate standard applicable to water used for production of wild rice. This limit is discussed in more detail in Section 6.0.

APPENDIX C – MATERIAL SAFETY DATA SHEETS (MSDS)

A summary table of estimated usages and MSDSs are included within this appendix for products utilized at Keetac that have the potential to impact discharges for which Keetac is requesting authorization under this NPDES Permit Application. The individual MSDSs follow the summary table.

The only compound not used within the taconite processing plant is the magnesium chloride solution used for dust suppressant at the facility. The remaining MSDSs included in this appendix are utilized within the processing plant. The process wastewater from the plant is discharged within the tailings slurry into the tailings basin, and therefore the tailings basin discharge has the potential to be impacted by these compounds.

U. S. Steel Keetac: Tailings Basin System NPDES Permit MSDS Review

Chemical List	Usage Estimate	Max Usage Estimate	Comment
Zetag 7130	460,000 lbs/yr	550,000 lbs/yr	flocculent added to the concentrator tailings slurry before the thickening stage
CL-2840	10,100 lbs/yr	12,120 lbs/yr	corrosion inhibitor used in closed-loop treated water system
CL-4074	9,200 lbs/yr	11,040 lbs/yr	corrosion inhibitor/descaler in vacuum pump
CL-2150	1,700 lbs/yr	2,040 lbs/yr	microbiocide used in closed-loop treated water system
Hydrated Lime	1,000 tons/yr	1,200 tons/yr	pH control in scrubber water system
P-817E	10,000 lbs/yr	12,000 lbs/yr	clarification and coagulation aid in scrubber
CL-16	16 gal/yr	19 gal/yr	water softener resin cleaner for the closed-loop water system
Diluted HCl*	16 gal/yr	19 gal/yr	used to clean pH probes
Rydlime*	240 gal/yr	288 gal/yr	used to clean lime handling systems
Super Gold	14 gal/yr	17 gal/yr	used to clean off heavy lime deposits
Magnesium Chloride Solution	4 tons/yr	4 tons/yr	dust suppression used at facility

* New chemical requesting authorization for discharge through this permit modification application.

CIBA ZETAG 7130 COAGULANT

NFPA Hazard codes:

Health: 1	Fire: 0	Reactivity: 0	Special: -

HMIS III rating

Health: 1	Flammability: 0	Physical hazard: 0	Personal protection: X

HMIS Note: * Indicates possible chronic health effects.

1. Identification of the Substance/Preparation and of the Company/Undertaking

Company Information

Company: Ciba Specialty Chemicals Corporation
2301 Wilroy Road
P.O.Box 820
Suffolk,VA 23434-0820
U.S.A.
Customer Service / Product Information: 1-800-322-3885
MSDS Request Line: 1-800-431-2360

Emergency information

Emergency 24-Hour Health/Environmental Phone: (24h) +1-800-873-1138

CHEMTREC: (800) 424-9300 (24hrs) or (703) 527-3887

Product information

Product: ZETAG 7130

Use: Coagulant.

2. Hazards Identification

Emergency overview

Signal word:	NOTICE! !
Colour:	straw yellow
Appearance:	liquid
State of matter:	liquid
Odour:	Slightly amine
Health:	Repeated or prolonged contact can cause skin irritation.
Physical/Chemical hazards:	Spills are very slippery.

Potential health effects

Primary routes of entry:

Skin, Eyes, Inhalation, Ingestion

3. Composition/Information on Ingredients

Chemical name	CAS Number	Content (Weight)	Hazardous
Poly-diallyl-dimethylammonium chloride Homopolymer	26062-79-3	33.0 - 37.0 %	Y

This material is classified as hazardous under OSHA regulations.

4. First-aid Measures

Inhalation:

Remove to fresh air, if not breathing give artificial respiration. If breathing is difficult, give oxygen and get immediate medical attention.

Skin:

If clothing is contaminated, remove and launder before reuse.
After contact with skin, wash immediately with plenty of water and soap.
Get medical attention if irritation occurs.

Eyes:

Immediately flush the eye(s) with lukewarm, gently flowing water for 15 minutes or until the chemical is removed.
Get immediate medical attention if irritation persists.

Ingestion:

Do not induce vomiting. If vomiting occurs naturally, have casualty lean forward to reduce the risk of aspiration.
Seek medical attention immediately.

5. Fire-fighting Measures

Suitable extinguishing media:

carbon dioxide, dry powder, foam, water fog

Unsuitable Extinguishing Media:

If water is used, restrict pedestrian and vehicular traffic in areas where slip hazard may exist.

Hazardous combustion products:

Carbon and nitrogen oxides., Ammonia., Hydrogen chloride.

Hazards during fire-fighting:

Standard procedure for chemical fires.
Cool fire-exposed containers with water.
Spills can cause very slippery conditions on floors.
Restrict pedestrian and vehicular traffic in areas where slip hazard may exist.

Protective equipment for fire-fighting:

Wear self-contained breathing apparatus and chemical-protective clothing.

6. Accidental Release Measures

Cleanup:

Pick up with inert absorbent material (e.g. sand, earth etc.).
Place into approved waste containers.
Wear suitable protective equipment.
Should not be released into the environment.

7. Handling and Storage

Handling

General advice:

As with all industrial chemicals, use good industrial practices when handling. Avoid eye, skin, and clothing contact. Do not inhale. Do not taste or swallow. Use only with adequate ventilation.

General advice:

Keep container tightly closed in a dry, cool and well-ventilated place.
Avoid extremes of temperature.
Temperature toleranceKeep from freezing.
Product will freeze but should recover upon warming and mixing.

> for industrial use only <

8. Exposure Controls and Personal Protection

Engineering Controls:

Work in well ventilated areas. Do not breathe vapors or mist.

Personal protective equipment

Respiratory protection:

Wear a NIOSH-certified respirator as necessary.

Eye protection:

Tightly fitting safety goggles (splash goggles) (EN 166)

Body protection:

Wear chemical resistant gloves and protective clothing.

General safety and hygiene measures:

There are no OSHA or ACGIH exposure guidelines available for component(s) in this product.
Eye wash station and safety shower should be available in immediate work area., Select additional protective equipment based upon potential for exposure.

9. Physical and Chemical Properties

Colour:	straw yellow	
Form:	liquid	
State of matter:	liquid	
Odour:	Slightly amine	
pH value:	5.5	
Evaporation rate:		Not tested
Flash point:	> 100 °C	
Self-ignition temperature:		Not tested
		Not tested
Boiling point:	> 100 °C	
Vapour pressure:		Not tested
Density:	1.1 g/cm3	
Vapour density:		Not tested
Partitioning coefficient n-octanol/water (log Pow):		Not applicable
Viscosity, dynamic:		Not tested
% Volatiles:		not determined
Solubility in water:		miscible
Solubility in other solvents:		Not tested

10. Stability and Reactivity

Stability:

Stable.

Conditions to avoid: Avoid temperature extremes, especially frost and freezing conditions.

Substances to avoid: Strong oxidizing agents., May react slowly with iron, copper, and aluminium resulting in corrosion and discoloration of product.

Possibility of Hazardous Reactions: No hazardous reactions known.

Hazardous decomposition products: No decomposition expected under normal storage conditions.

11. Toxicological Information

Acute oral toxicity:

LD50 / oral / rat: > 2,000 mg/kg
By analogy with a product of similar composition

Acute inhalation toxicity:

by inhalation:
not determined

Acute dermal toxicity:

dermal:
not determined

Skin irritation:

not determined

Eye irritation:

not determined

Skin Sensitization:

not determined

Subacute toxicity:

not determined

Chronic toxicity:

not determined

Subchronic Toxicty:

not determined

Genetic toxicity:

Not determined.

Carcinogenicity:

None of the components in this product at concentrations greater than 0.1% are listed by IARC; NTP, OSHA or ACGIH as a carcinogen.

Reproductive toxicity:

not determined

Developmental toxicity/teratogenicity:

not determined

12. Ecological Information

Toxicity to fish:

96 h/LC50: > 10 mg/l
By analogy with a product of similar composition

Toxicity to aquatic invertebrates:

48 h/EC50: > 10 mg/l
By analogy with a product of similar composition

Toxicity to aquatic plants:

Not tested

Toxicity to microorganisms:

Not tested

Biodegradation:

Not tested

13. Disposal Considerations

Waste disposal of substance:

Dispose of in accordance with national, state and local regulations.

Resource Conservation and Recovery Act (RCRA): Not a hazardous waste under RCRA (40 CFR 261).

14. Transport Information

U.S. Department of Transportation

The listed Transportation Classification does not address regulatory variations due to changes in package size, mode of shipment or other regulatory descriptors.

Road transport:

Special shipping information: Not classified as a dangerous good under transport regulations.

Air transport:

Special shipping information: Not classified as a dangerous good under transport regulations.

Inland-waterway transport:

Special shipping information: Not classified as a dangerous good under transport regulations.

15. Regulatory Information

US: Toxic Substances Control Act (TSCA):	All component(s) comprising this product are either exempt or listed on the TSCA inventory
Canada: Domestic Substances List (DSL):	All components either exempt or listed on the DSL

United States - Regulations

SARA Section 311/312 Hazard Communication Standard:

Acute Health:	Y	Fire:	N
Chronic Health:	N	Reactivity:	N
		Sudden release of pressure:	N

SARA Section 313 Toxic Chemical List:

This product does not contain any components reportable under Sec 313 (40 CFR 372).

OSHA hazard category:

This material is classified as hazardous under OSHA regulations.

Toxic Substances Control Act (TSCA) Significant New Use Rule (SNUR):

This product is not subject to a Significant New Use Rule (SNUR).

Toxic Substances Control Act (TSCA) Section 5(e) Consent Orders:

This product is not subject to a Section 5(e) Consent Order.

Toxic Substances Control Act (TSCA) Section 5(f):

This product is not subject to a Section 5(f)/6(a) rule.

Toxic Substances Control Act (TSCA) Section 12(b) Export Notification:

No components listed.

Clean Air Act - Hazardous Air Pollutants (HAP):

This product does not contain any Hazardous Air Pollutants (HAP), as defined by the U.S. Clean Air Act Section 112 (40 CFR 61).

Clean Air Act 111 - Volatile Organic Compounds (VOC):

This product does not contain any SOCMI Intermediate or Final VolatileOrganic Compounds (VOC), as defined by the U.S. Clean Air Act Section 111 (40 CFR 60.489).

Clean Air Act 602 - Ozone Depleting Substances (ODS):

This product neither contains, nor was manufactured with, a Class I or Class II ozone depleting substance (ODS), as defined by the U.S. Clean Air Act Section 602 (40 CFR 82, Subpt. A, App. A+B).

Clean Water Act - Priority Pollutants (PP):

This product does not contain any priority pollutants listed under the U.S. Clean Water Act Section 307(2)(1) Priority Pollutant List (40 CFR 401.15).

Pennsylvania Right to Know:

This product does not contain any components that are subject to the Pennsylvania Right-To-Know disclosure requirement.

California Proposition 65 - Chemicals Known to the State to Cause Cancer:

No components listed.

California Proposition 65 - Chemicals Known to the State to Cause Reproductive Toxicity:

No components listed.

International Regulations

Chemical Weapons Convention:

This product does not contain any component(s) listed under the Chemical Weapons Convention Schedule of Chemicals.

16. Other Information

Disclaimer:

The information contained herein is based upon data believed to be correct. However, no guarantee or warranty of any kind, expressed or implied, is made with respect to such data or information. The user is responsible for determining whether the product is suitable for its intended conditions of use.

END OF DATA SHEET

CHEMTREAT CL-2840

ChemTreat, Inc.

MATERIAL SAFETY DATA SHEET

Section 1. Chemical Product and Company Identification

Product Name:	**ChemTreat CL-2840**
Manufacturer's Name:	ChemTreat, Inc.
Emergency Telephone Number:	(800) 424-9300
Address (Corporate Headquarters)	4461 Cox Road, Glen Allen, VA 23060
Telephone Number for Information:	(800) 648-4579
Date of MSDS:	September 11, 2007

Section 2. Composition/Hazardous Ingredients

Component	CAS Registry #	Wt. %
Sodium nitrite	7632-00-0	30 - 60
Tolyltriazole, sodium salt	64665-57-2	0.5 – 1.5
Sodium hydroxide	1310-73-2	1 - 5

Section 3. Hazards Identification

Emergency Overview: Yellow colored liquid; mild odor; not flammable. Corrosive to eyes and skin.
Potential Health Effects:
Eyes – Will cause corrosive effects (burns or irreversible damage) to the eyes.
Skin – Will cause corrosive effects (burns or irreversible damage) to the skin.
Inhalation – Will cause corrosive effects (burns or irreversible damage) to the lungs, upper respiratory tract, and nose.
Ingestion – Will cause corrosive effects (burns or irreversible damage) to the mouth, throat, or digestive tract.
Chronic Effects/Carcinogenicity: Overexposure to sodium nitrite may produce low blood pressure, nausea, headache, weakness, and cyanosis. Persons with pre-existing diseases of the cardiovascular system or bone marrow or skin disorders or impaired pulmonary function may be more susceptible to the effects of this product.

Section 4. First Aid Measures

Inhalation: Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get immediate medical attention.
Eyes: Immediately flush eyes with plenty of water for at least 15 minutes, holding eyelids apart to ensure flushing of entire eye surface. Get medical attention.

Skin: In case of contact, immediately wash with plenty of water while removing contaminated clothing. Seek medical advice. Wash and decontaminate clothing before reuse.
Ingestion: Do not induce vomiting. Call a physician or poison control center immediately. Never give anything by mouth to an unconscious person.

Section 5. Fire Fighting Measures

Flammable Properties: Not flammable
Suitable Extinguishing Media: Use extinguishing media appropriate to surrounding fire.
Fire & Explosion Hazards: Although product will not burn, high temperatures (above 900F) can result in decomposition and the release of nitrogen oxides.
Protective Equipment: If product is involved in a fire, wear full protective clothing including a positive-pressure, NIOSH-approved, self-contained breathing apparatus.

Section 6. Accidental Release Measures

Small Spill: Construct temporary dikes of dirt, sand, or any readily available inert material to prevent spreading of the material. Wearing appropriate personal protective equipment, move the leaking container to a containment area or plug the leak. Absorb on inert material, then shovel up and dispose of according to local, state, federal regulations.
Large Spill: Construct temporary dikes of dirt, sand, or any readily available inert material to prevent spreading of the product. Wearing appropriate personal protective equipment, close or cap valves and/or block or plug hole in leaking container and transfer to another container for proper disposal.

Section 7. Handling and Storage

Keep away from heat and oxidizers. Keep away from acids and reducing agents. Use only with adequate ventilation. Do not get in eyes, or on skin and clothing. Wash thoroughly after handling. Avoid breathing mists. Do not ingest. Store at ambient temperatures. Keep container securely closed when not in use. Label precautions also apply to empty container. Recondition or dispose of empty containers in accordance with government regulations. For industrial use only.

Section 8. Exposure Controls/Personal Protection

Use protective equipment in accordance with 29 CFR 1910 Subpart I. Good general ventilation should be sufficient to control airborne levels. Wear chemical splash goggles or safety glasses with full-face shield. Wear rubber gloves. Wash them after each use and replace as necessary. If conditions warrant, wear protective clothing such as boots, aprons, and coveralls to prevent skin contact. Maintain eyewash fountain and quick-drench facilities in work area.

Section 9. Physical and Chemical Properties

Appearance: Clear, yellow	Physical state: Liquid
Boiling Point: ~212°F	Solubility in Water: Complete
Evaporation Rate: 1	Specific Gravity: ~1.321
Freezing Point: <-9°F	Vapor Density: N/A

Melting Point: N/A	Vapor Pressure: <17.5
Molecular Weight: N/A	Viscosity: N/A
Odor: Mild	% VOCs: 0
pH: ~13.1	Flash Point: Not flammable

Section 10. Stability and Reactivity

Chemical Stability: Stable at normal temperatures and pressures.
Incompatibility: Cyanides, organics, ammonium salts, acids, reducing agents, and activated carbon
Hazardous Decomposition Products: Oxides of nitrogen and carbon
Hazardous Polymerization: Will not occur

Section 11. Toxicological Information

Nitrous acid, sodium salt: Oral LD50 (rats) = 85 mg/kg
Tolytriazole, sodium salt: Oral LD50 (female rats) = 640 mg/kg; Dermal LD50 (rabbits) = >2 g/kg;
TLV = 10 mg/m3 Nuisance Dust ACGIH

Section 12. Ecological Information

Fathead Minnow 96h LC50 = 76.6 mg/l; Ceriodaphnia Dubia 48h LC50 = 6.43 mg/l

Section 13. Disposal Considerations

Observe all federal, state and local regulations during disposal. In the original form, this material will have a Corrosivity hazardous waste characteristic (D002).

Section 14. Transport Information (not meant to be all inclusive)

D.O.T. Shipping Name: Corrosive liquid, n.o.s.
Technical Name: (Sodium nitrite; Sodium hydroxide)
Hazard Class 8 (Corrosive); UN1760; PG II

Section 15. Regulatory Information (*Not meant to be all inclusive – selected regulation represented)*

TSCA Status: All ingredients listed
CERCLA Reportable Quantity: Sodium hydroxide - 1,000 lbs.; Sodium nitrite - 100 lbs.
SARA Title III:
Section 302 Extremely Hazardous Substances: None
Section 313 Toxic Chemicals: Yes – Sodium nitrite
CALIFORNIA PROPOSITION 65: None known.

Section 16. Other Information

HMIS Hazard Rating:

Health: 2	Flammability: 0	Physical Hazard: 1	PPE: X (see note)

Note: PPE rating depends on circumstances of use. See Section 8 for recommended PPE.

SARA Hazard Categories - Section 311/312

Acute - Yes Chronic - No Fire - No Reactive - No Sudden Release - No

Prepared by Regulatory Affairs

CHEMTREAT CL-4074

ChemTreat, Inc.

MSDS

MATERIAL SAFETY DATA SHEET

Section 1. Chemical Product and Company Identification

Product Name:	**ChemTreat CL-4074**
Manufacturer's Name:	ChemTreat, Inc.
Emergency Telephone Number:	(800) 424-9300
Address (Corporate Headquarters)	4461 Cox Road, Glen Allen, VA 23060
Telephone Number for Information:	(800) 648-4579
Date of MSDS:	April 5, 2007

Section 2. Composition/Hazardous Ingredients

Component	CAS Registry #	Wt. %
Aminotri(methylenephosphonic acid), hexapotassium salt	40588-62-3	40 - 70

Section 3. Hazards Identification

Emergency Overview: Clear light straw liquid; mild odor; Not flammable.
Potential Health Effects:
Eyes: May cause significant eye irritation.
Skin: May cause significant skin irritation.
Inhalation: May cause significant irritation to lungs, upper respiratory tract, and nose.
Ingestion: May cause significant irritation to digestive tract.
Chronic Effects/Carcinogenicity: Not listed by NTP, IARC, or OSHA. Not expected to be a reproductive toxic or a teratogen.

Section 4. First Aid Measures

Inhalation: Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get immediate medical attention.
Eyes: Immediately flush eyes with plenty of water for at least 15 minutes, holding eyelids apart to ensure flushing of entire eye surface. Get medical attention.
Skin: In case of contact, immediately flush skin with plenty of water for at lest 15 minutes while removing contaminated clothing and shoes. Get medical attention immediately. Thoroughly wash or discard clothing and shoes before reuse.
Ingestion: If swallowed, induce vomiting immediately as directed by medical personnel. Never give anything by mouth to an unconscious person. Get medical attention immediately.

Section 5. Fire Fighting Measures

Flammable Properties: Not flammable.
Suitable Extinguishing Media: Use water, carbon dioxide, dry chemical, or foam.
Fire & Explosion Hazards: Keep containers cool with water spray to minimize the potential of decomposition.
Protective Equipment: If product is involved in a fire, wear full protective clothing including a positive-pressure, NIOSH-approved, self-contained breathing apparatus.

Section 6. Accidental Release Measures

Small Spill: Construct temporary dikes of dirt, sand, or any readily available inert material to prevent spreading of the material. Wearing appropriate personal protective equipment, move the leaking container to a containment area or plug the leak. Absorb on inert material, then shovel up and dispose of according to local, state, federal regulations.
Large Spill: Construct temporary dikes of dirt, sand, or any readily available inert material to prevent spreading of the product. Wearing appropriate personal protective equipment, close or cap valves and/or block or plug hole in leaking container and transfer to another container for proper disposal.

Section 7. Handling and Storage

Keep away from heat and oxidizers. Use with adequate ventilation. Do not get in eyes, or on skin and clothing. Wash thoroughly after handling. Avoid breathing mists. Do not ingest. Store at ambient temperatures. Keep container securely closed when not in use. Label precautions also apply to empty container. Recondition or dispose of empty containers in accordance with government regulations. For industrial use only.

Section 8. Exposure Controls/Personal Protection

Use protective equipment in accordance with 29 CFR 1910 Subpart I. Good general ventilation should be sufficient to control airborne levels. Wear chemical splash goggles or safety glasses with full-face shield. Wear rubber gloves. Wash them after each use and replace as necessary. If conditions warrant, wear protective clothing such as boots, aprons, and coveralls to prevent skin contact. Maintain eyewash fountain and quick-drench facilities in work area.

Section 9. Physical and Chemical Properties

Appearance: Clear light straw
Boiling Point: ~226°F
Evaporation Rate: N/D
Freezing Point: ~9°F
Melting Point: N/A
Molecular Weight: N/A
Odor: Mild
pH: ~ 1.6
Physical state: Liquid
Solubility in Water: Miscible
Specific Gravity: ~1.336
Vapor Density: N/D
Vapor Pressure: N/D
Viscosity: N/A
% VOCs: N/D
Flash Point: Not flammable

Section 10. Stability and Reactivity

Chemical Stability: Stable at normal temperatures and pressures.
Incompatibility: Strong oxidizing agents
Hazardous Decomposition Products: Oxides of phosphorus and of carbon; acids of phosphorus.
Hazardous Polymerization: Will not occur.

Section 11. Toxicological Information

Dermal LD50 = 2000 mg/kg (rabbit); Oral LD50 = 5000 mg/kg (rat).

Section 12. Ecological Information

Ceriodaphnia Dubia: 48h LC50 = 732 mg/L
Pimephales promelas: 96h LC50 = 5,657 mg/L

Section 13. Disposal Considerations

Dispose of in accordance with local, state and federal regulations.

Section 14. Transport Information (not meant to be all inclusive)

D.O.T. Shipping Name: Corrosive liquid, acidic, organic, n.o.s.
D.O.T. Technical Name: Amino-Tri (Methylenephosphonic acid)
Hazard Class 8; UN3265; PG II; NAERG #153

Section 15. Regulatory Information (*Not meant to be all inclusive – selected regulation represented*)

TSCA Status: All ingredients listed
CERCLA Reportable Quantity: None
SARA Title III:
Section 302 Extremely Hazardous Substances: None
Section 313 Toxic Chemicals: None
CALIFORNIA PROPOSITION 65: None known.

Section 16. Other Information

HMIS Hazard Rating:
Health: 3 Flammability: 1 Physical Hazard: 1 PPE: X (see note)

Note: PPE rating depends on circumstances of use. See Section 8 for recommended PPE.

SARA Hazard Categories – Section 311/312
Acute – Yes Chronic – No Fire – No Reactive – No Sudden Release – No

Prepared by Regulatory Affairs

CHEMTREAT CL-2150

IHS Number: 28693

MATERIAL SAFETY DATA SHEET

Section 1. Chemical Product and Company Identification

Product Name:	ChemTreat CL2150
Product Use:	Cooling Water Microbiocide and Paper Slimicide
Manufacturer's Name:	ChemTreat, Inc.
Emergency Telephone Number:	(800) 424–9300
Address (Corporate Headquarters):	4461 Cox Road Glen Allen, VA 23060
Telephone Number for Information:	(800) 648–4579
Date of MSDS:	May 29, 2008

Section 2. Hazard(s) Identification

Signal Word: **DANGER!**

Hazard Statement(s):

Causes severe skin burns and eye damage.
Causes serious eye damage.
Harmful in contact with skin.
Harmful if inhaled.
Harmful if swallowed.
Harmful to aquatic life.

Precautionary Statement(s):

Wear protective gloves/clothing and eye/face protection. Do not breathe dust/fume/gas/mist/vapors/spray. Do not eat, drink or smoke when using this product. Wash hands thoroughly after handling. Use only outdoors or in a well–ventilated area.

Section 3. Composition/Hazardous Ingredients

Component	CAS Registry #	Wt.%
5–chloro–2–methyl–4–isothiazolin–3–one	26172–55–4	1.11
2–methyl–4–isothiazolin–3–one	2682–20–4	0.39

Section 4. First Aid Measures

Inhalation:	Remove victim to fresh air and keep at rest in a position comfortable for breathing. Immediately call a poison center or doctor/physician.
Eyes:	Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Immediately call a poison center or doctor/physician.
Skin:	Immediately remove/take off all contaminated clothing. Rinse skin with water/shower. Wash contaminated clothing before re–use. Immediately call a poison center or doctor/physician.
Ingestion:	DO NOT INDUCE VOMITING. Rinse mouth. Call a POISON CENTER or doctor/physician.
Notes to Physician:	Probable mucosal damage may contraindicate the use of gastric lavage.
Additional First Aid Remarks:	Have the product container, label or MSDS with you when calling a poison control center or doctor, or when going for treatment.

Section 5. Fire Fighting Measures

Flammability of the Product:	Not flammable.
Suitable Extinguishing Media:	Use extinguishing media suitable to surrounding fire.
Specific Hazards Arising from the Chemical:	Use water spray to keep containers cool.
Protective Equipment:	If product is involved in a fire, wear full protective clothing including a positive–pressure, NIOSH approved, self–contained breathing apparatus.

Section 6. Accidental Release Measures

Personal Precautions:	Use appropriate Personal Protective Equipment (PPE).
Environmental Precautions:	This pesticide is toxic to fish and aquatic organisms. Do not discharge effluent containing this product into lakes, ponds, streams, estuaries, oceans or public waters unless in accordance with the requirements of a National Pollutant Discharge Elimination System (NPDES) permit, and the permitting authority has been notified in writing prior to discharge. Do not discharge effluent containing this product to sewer systems without previously notifying the local sewage treatment plant authority. For guidance contact your State Water Board or Regional Office of the EPA.

Methods for Cleaning up: Contain and recover liquid when possible. Flush spill area with water spray.

Other Statements: If RQ (Reportable Quantity) is exceeded, report to National Spill Response Office at 1-800-424-8802.

Section 7. Handling and Storage

Handling: Wear appropriate Personal Protection Equipment (PPE) when handling this product. Do not get in eyes, or on skin and clothing. Wash thoroughly after handling. Do not ingest. Avoid breathing vapors, mist or dust.

Storage: Store away from incompatible materials (see Section 10). Store at ambient temperatures. Keep container securely closed when not in use. Label precautions also apply to empty container. Recondition or dispose of empty containers in accordance with government regulations. For Industrial use only.
Store in corrosive resistant container with a resistant inliner.

Section 8. Exposure Controls/Personal Protection

Exposure Limits

Component	Source	Exposure Limits
5-chloro-2-methyl-4-isothiazolin-3-one		N/E
2-methyl-4-isothiazolin-3-one		N/E

Carcinogenicity Category

Component	Source	Code	Brief Description
5-chloro-2-methyl-4-isothiazolin-3-one			N/E
2-methyl-4-isothiazolin-3-one			N/E

Engineering Controls: Use only with adequate ventilation. The use of local ventilation is recommended to control emission near the source.

Personal Protection

Eyes: Wear chemical splash goggles or safety glasses with full-face shield. Maintain eyewash fountain in work area.

Skin: Maintain quick-drench facilities in work area.
Wear butyl rubber or neoprene gloves. Wash them after each use and replace as necessary. If conditions warrant, wear protective clothing such as boots, aprons, and coveralls to prevent skin contact.

Respiratory: If misting occurs, use NIOSH approved organic vapor/acid gas dual

cartridge respirator with a dust/mist prefilter in accordance with 29 CFR 1910.134.

Section 9. Physical and Chemical Properties

Physical State and Appearance:	Liquid, Green, Clear
Specific Gravity:	1.0290
pH:	3.6
Freezing Point:	32°F
Flash Point:	N/D
Odor:	Mild
Melting Point:	N/A
Boiling Point:	N/D
Solubility in Water:	Complete
Evaporation Rate:	<1
Vapor Density:	N/D
Molecular Weight:	N/D
Viscosity:	N/A
Flammable Limits:	N/A
Autoignition Temperature:	N/A
Density:	8.58 lb/ga
Vapor Pressure:	N/D
% VOC	0

Section 10. Stability and Reactivity

Chemical Stability: Stable at normal temperatures and pressures.

Incompatibility with Various Substances: Strong oxidizers, Strong bases

Hazardous Decomposition Products: Oxides of nitrogen, Oxides of sulfur, Oxides of carbon, Halogenated compounds

Possibility of Hazardous Reactions: None known.

Section 11. Toxicological Information

Chemical Name	Exposure	Type of Effect	Concentration	Species
ChemTreat CL2150	Oral	LD50	3810 mg/kg	Rat
	Dermal	LD50	>5000 mg/kg	Rabbit
	Inhalation	LD50	13.7 mg/l	Rat

Comments: None.

Section 12. Ecological Information

Species	Duration	Type of Effect	Test Results
Daphnia magna	48h	LC50	10.7 mg/l
Bluegill Sunfish	96h	LC50	18.6 mg/l
Ceriodaphnia dubia	48h	EC50	10.7 mg/l
Rainbow Trout	96h	LC50	12.6 mg/l
Sheepshead Minnow	96h	LC50	70.7 mg/l
Mysid Shrimp	48h	LC50	46.1 mg/l

Comments: None.

Section 13. Disposal Considerations

PESTICIDE DISPOSAL: Pesticide wastes are toxic. Improper disposal of excess pesticide, spray mixture, or rinsate is a violation of Federal Law. If these wastes cannot be disposed of by use according to label instructions, contact your State Pesticide or Environmental Control Agency, or the Hazardous Waste representative at the nearest EPA Regional Office for guidance. CONTAINER DISPOSAL: Triple rinse (or equivalent). Then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill, or incineration, or if allowed by state and local authorities, by burning. If burned, stay out of smoke.

Section 14. Transport Information

DOT Classification

DOT Name: CORROSIVE LIQUIDS, N.O.S.
Technical Name: (5-CHLORO-2-METHYL-4-ISOTHIAZOLIN-3-ONE; 2-METHYL-4-ISOTHIAZOLIN-3-ONE)
Hazard Class: Corrosive
UN/NA#: UN1760
Packing Group: PGII

Section 15. Regulatory Information

Inventory Status

United States (TSCA): All ingredients listed.
Canada (DSL/NDSL): All ingredients listed.

Federal Regulations

SARA Title III Rules

Sections 311/312 Hazard Classes

Fire Hazard:	No
Reactive Hazard:	No
Release of Pressure:	No
Acute Health Hazard:	Yes
Chronic Health Hazard:	No

Other Sections

Component	Section 313 Toxic Chemical	Section 302 EHS TPQ	CERCLA RQ
5-chloro-2-methyl-4-isothiazolin-3-one	N/A	N/A	N/A
2-methyl-4-isothiazolin-3-one	N/A	N/A	N/A

State Regulations

California Proposition 65: None known.

Special Regulations

Component	States
5-chloro-2-methyl-4-isothiazolin-3-one	None
2-methyl-4-isothiazolin-3-one	None

International Regulations

Canada

WHMIS Classification: N/A

Controlled Product Regulations (CPR): N/A

Section 16. Other Information

HMIS Hazard Rating

Health:	3
Flammability:	0
Physical Hazard:	0
PPE:	X

Notes: The PPE rating depends on circumstances of use. See Section 8 for recommended PPE.
The Hazardous Material Information System (HMIS) is a voluntary, subjective alpha–numeric symbolic system for recommending hazard risk and personal protection equipment information. It is a subjective rating system based on the evaluator's understanding of the chemical associated risks. The end–user must determine if the code is appropriate for their use.

NSF: N/A

FDA: All ingredients in this product are authorized in 21 CFR 176.170 and 21 CFR 176.180.

KOSHER: This product is certified by the Orthodox Union as kosher pareve.

FIFRA: This product is an EPA registered biocide. 15300–24

Other: None

Abbreviations

Abbreviation	Definition
<	Less Than
>	Greater Than
ACGIH	American Conference of Governmental Industrial Hygienists
EHS	Environmental Health and Safety Dept
N/A	Not Applicable
N/D	Not Determined
N/E	Not Established
OSHA	Occupational Health and Safety Dept
PEL	Personal Exposure Limit
STEL	Short Term Exposure Limit
TLV	Threshold Limit Value
TWA	Time Weight Average
UNK	Unknown

Prepared by: Regulatory Affairs Department

Disclaimer

Although the information and recommendations set forth herein (hereinafter "information") are presented in good faith and believed to be correct as of the date hereof, ChemTreat, Inc. makes no representations as to the completeness or accuracy thereof. Information is supplied upon the condition that the persons receiving same will make their own determination as to its suitability for their purposes prior to use. In no event will ChemTreat, Inc. be responsible for damages of any nature whatsoever resulting from the use or reliance upon information. No representation or warranties, either expressed or implied, of merchantability, fitness for a particular purpose, or of any other nature are made hereunder with respect to information or the product to which information refers.

HYDRATED LIME (CUTLER-MAGNER)

Cutler-Magner Company
12th Avenue West and Waterfront
P.O. Box 16807
Duluth, Minnesota 55816-0807

IHS Number: 56784

Material Safety Data Sheet

PRODUCT IDENTIFICATION	CHEMICAL ABSTRACT NO.	DATE REVISED
CALCIUM HYDROXIDE - HYDRATED LIME	**CAS No. 1305-62-0**	**08/01/2005**

Section I

MANUFACTURER		HMIS II RATING
Cutler-Magner Company Foot of Hill Avenue Superior, WI 54880	24 Hour Emergency Contact Number: (715) 392-5146 Ask for Supervisor On Call Telephone Number for Information: (800) 232-1302	Health - **3** Flammability - **0** Physical Hazard - **1** Personal Protective Equip - **E**
	Other Common Names: Hydrate, Slaked Lime Trade Name(s): Rockport, Cutler's Barn & Ag, Kelly Island	

Section II – Hazardous Ingredients / Identity Information

Specific Chemical Identity; Common Names	OSHA PEL	ACGIH TLV	Other Limits Recommended	% (Optional)
Calcium Hydroxide - Total Calcium Hydroxide - Respirable	15 mg/m^3 5 mg/m^3	5 mg/m^3		
Crystalline Silica (Quartz)	0.1 mg/m^3	0.05 mg/m^3	OSHA Calculation	< 0.10 %

Calcium Hydroxide is not listed on the NTP, IARC, or OSHA lists of carcinogens. Cutler-Magner Company recommends using personal protection equipment when handling this product.

Section III – Physical / Chemical Characteristics

Boiling Point (Calcium Oxide)	2850 °C	Specific Gravity (H_2O = 1)	2.2-2.3
Vapor Pressure (mm Hg)	NA	Melting Point	NA
Vapor Density (Air = 1)	NA	Evaporation Rate	NA
Solubility in Water	0.185 % @ 0 ° C; 0.077 % @ 100 ° C		
Appearance and Color	White powder; faint earthy odor		

Section IV – Fire and Explosion Hazard Data

Flash Point	NA	Flammable Limits – NA
Extinguishing Method	NA	
Special Fire Fighting Procedures	NA	
Unusual Fire and Explosion Hazards	NA	

Section V – Reactivity Data

Stability	Unstable		Conditions to Avoid – NA
	Stable	X	
Incompatibility (Materials to Avoid)		Acids, Reactive Fluoridated or Brominated Compounds, Reactive Powdered Metals, Organic Acid Anhydrides, Nitro-Organic Compounds, Reactive Phosphorous Compounds, Interhalogenated Compounds	
Hazardous Decomposition or Byproducts		None	
Hazardous Polymerization	May Occur		Conditions to Avoid – NA
	Will Not Occur	X	

Section VI – Health Hazard Data

Route(s) of Entry	Inhalation? - YES	Absorption Through Skin? – YES	Ingestion (swallowing)? - YES
Health Hazards	Acute	Corrosive to skin and eyes. Causes irritation and inflammation to mucous membrane and respiratory passages.	
	Chronic		
Toxicological Information	Not listed by MSHA, OSHA, or IARC as a carcinogen, but this product may contain trace amounts of crystalline silica, which has been classified by IARC as (Group 1) carcinogenic to humans when inhaled in the form of quartz or crystobalite. ORL-RAT LD 50: 7340 mg/kg ORL-MUS LD50: 7300 mg/kg		
Signs and Symptoms of Exposure		Irritation of skin, eyes, and respiratory tract.	
Medical Conditions Generally Aggravated by Exposure		Respiratory disease, skin condition.	
Emergency and First Aid Procedures		Remove to fresh air. Wash dust with soap and water. Flush out eyes with generous amounts of water. Drink plenty of water if swallowed. See Physician.	

Section VII – Precautions for Safe Handling

Steps to Be Taken in Case Material is Released or Spilled	Normal clean-up procedures. Care should be taken to avoid causing dust to become airborne. Vacuum cleaning systems are recommended.
Waste Disposal Method	Dispose of product in accordance with Federal, State and Local regulations.
Precautions to Be Taken in Handling	Store away from water and acids.
Other Precautions	None.

Section VIII – Control Measures

Respiratory Protection - Dust filter mask is recommended as minimal protection		
Ventilation	Local Exhaust – To maintain TLV and PEL Mechanical – To maintain TLV and PEL	Special – None Other – None
Protective Gloves – Cloth or leather gloves will protect skin		
Eye Protection – Fitted goggles will reduce eye injury		
Other Protective Clothing – Long sleeve shirts and pants		
Work / Hygienic Practices – Maintain dust exposure limits below TLV and PEL. If not possible – use respiratory protection		

Section IX – Ecological Information

Ecotoxicity: Because of the high pH of this product, in high concentrations it would be expected to produce significant ecotoxicity upon exposure to aquatic organisms and aquatic systems.

Environmental Fate: This material shows no bioaccumulation effect or food chain toxicity.

Section X – Regulatory Information

EPA

RCRA Hazardous Waste Classification (40 CFR 261): Not Listed
RCRA Hazardous Waste Number (40 CFR 261.33): Not Listed
ERCLA Hazardous Substance (40 CFR 302.4): Unlisted specific per RCRA, Sec. 3001; CWA, Sec.311 (b)(4); CWA, Sec. 307(a), CAA, Sec. 112
CERCLA Reportable Quantity (RQ): Not Listed
SARA 311/312 Codes: Not Listed
SARA Toxic Chemical (40 CFR 372.65): Not Listed
SARA EHS (Extremely Hazardous Substance) (40 CFR 355): Not Listed; Threshold Planning Quantity (TPQ): Not Listed
All chemical ingredients are listed on the USEPA TSCA Inventory List

OSHA / MSHA

Air Contaminant (29 CFR 1910.1000, Table Z-1, Z-1-A): 5 mg/M^3 TWA-8
MSHA: Not Listed
OSHA Specifically Regulated Substance (29 CFR 1910): Not Listed

Canada

WHIMS Classification: "E" Corrosive Materials
CANADA DSL: Listed

State Regulations

Consult state and local authorities for guidance

Other

HMIS: Health Risk 3, Flammability 0, Reactivity 1, Personal Protection E
NFPA: Health Hazard 3, Fire Hazard 0, Reactivity 1
DOT: For aircraft transport only, Calcium Oxide is classified as Hazard Class 8
- Corrosive, UN 1910, Packing Group 3

CHEMTREAT P817E

ChemTreat, Inc.

MSDS

MATERIAL SAFETY DATA SHEET

Section 1. Chemical Product and Company Identification

Product Name:	ChemTreat P817E
Product Use:	Water Clarification/Solids Conditioning Agent
Manufacturer's Name:	ChemTreat, Inc.
Emergency Telephone Number:	(800) 424-9300
Address (Corporate Headquarters):	4461 Cox Road Glen Allen, VA 23060
Telephone Number for Information:	(800) 648-4579
Date of MSDS:	March 13, 2008

Section 2. Hazard(s) Identification

Signal Word: WARNING!

Hazard Statement(s): May be harmful in contact with skin.
May be harmful if inhaled.
May be harmful if swallowed.

Precautionary Statement(s): No significant health risks are expected from exposures under normal conditions of use.

Section 3. Composition/Hazardous Ingredients

Component	CAS Registry #	Wt.%
There are no hazardous ingredients in this product as defined in 29 CFR 1910-1200.	Proprietary	N/A

Section 4. First Aid Measures

Inhalation: Remove to fresh air and keep at rest in a position comfortable for breathing. Call a poison center or doctor/physician if you feel unwell.

Eyes: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. If eye irritation persists, get medical advice/attention.

Skin: Wash with plenty of soap and water. Call a poison center or doctor/physician if you feel unwell.

Ingestion: DO NOT INDUCE VOMITING. Rinse mouth. Call a POISON CENTER or doctor/physician if you feel unwell.

ChemTreat, Inc.

MSDS

Notes to Physician:	N/A
Additional First Aid Remarks:	N/A

Section 5. Fire Fighting Measures

Flammability of the Product:	Not flammable.
Suitable Extinguishing Media:	Use extinguishing media suitable to surrounding fire.
Specific Hazards Arising from the Chemical:	None known.
Protective Equipment:	If product is involved in a fire, wear full protective clothing including a positive–pressure, NIOSH approved, self–contained breathing apparatus.

Section 6. Accidental Release Measures

Personal Precautions:	Use appropriate Personal Protective Equipment (PPE).
Environmental Precautions:	Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains, and sewers.
Methods for Cleaning up:	Contain and recover liquid when possible. Flush spill area with water spray.
Other Statements:	None.

Section 7. Handling and Storage

Handling:	Wear appropriate Personal Protection Equipment (PPE) when handling this product. Do not get in eyes, or on skin and clothing. Wash thoroughly after handling. Do not ingest. Avoid breathing vapors, mist or dust. Material is very slippery if spilled.
Storage:	Store away from incompatible materials (see Section 10). Store at ambient temperatures. Keep container securely closed when not in use. Label precautions also apply to empty container. Recondition or dispose of empty containers in accordance with government regulations. For Industrial use only. Keep from freezing. Do not store below 41°F. Do not store above 86°F.

ChemTreat, Inc.

MSDS

Section 8. Exposure Controls/Personal Protection

Exposure Limits

Component	Source	Exposure Limits
There are no hazardous ingredients in this product as defined in 29 CFR 1910–1200.		N/E

Carcinogenicity Category

Component	Source	Code	Brief Description
There are no hazardous ingredients in this product as defined in 29 CFR 1910–1200.			N/E

Engineering Controls: Use only with adequate ventilation. The use of local ventilation is recommended to control emission near the source.

Personal Protection

Eyes: Wear chemical splash goggles or safety glasses with full–face shield. Maintain eyewash fountain in work area.

Skin: Maintain quick–drench facilities in work area.
Wear butyl rubber or neoprene gloves. Wash them after each use and replace as necessary. If conditions warrant, wear protective clothing such as boots, aprons, and coveralls to prevent skin contact.

Respiratory: If misting occurs, use NIOSH approved organic vapor/acid gas dual cartridge respirator with a dust/mist prefilter in accordance with 29 CFR 1910.134.

Section 9. Physical and Chemical Properties

Physical State and Appearance:	Liquid Emulsion, White, Opaque
Specific Gravity:	1.0720
pH:	6.0 – 8.0
Freezing Point:	0°F
Flash Point:	N/D
Odor:	Mild
Melting Point:	N/A
Boiling Point:	N/D
Solubility in Water:	Complete
Evaporation Rate:	N/D
Vapor Density:	N/D
Molecular Weight:	N/D
Viscosity:	N/A
Flammable Limits:	N/A
Autoignition Temperature:	N/A
Density:	8.94 lb/ga

Vapor Pressure:	N/D
% VOC	N/D

Section 10. Stability and Reactivity

Chemical Stability: Stable at normal temperatures and pressures.

Incompatibility with Various Substances: Strong oxidizers

Hazardous Decomposition Products: Oxides of carbon, Oxides of nitrogen

Possibility of Hazardous Reactions: None known.

Section 11. Toxicological Information

Chemical Name	Exposure	Type of Effect	Concentration	Species
ChemTreat P817E	Oral	LD50	>5000 mg/kg	Rat

Comments: None.

Section 12. Ecological Information

Species	Duration	Type of Effect	Test Results
Fathead Minnow	96h	LC50	>1000 mg/l
Algae	72h	EC50	>1000 mg/l
Daphnia magna	48h	LC50	15 mg/l

Comments: None.

Section 13. Disposal Considerations

Dispose of in accordance with local, state and federal regulations.
Not a RCRA–regulated hazardous waste when disposed in the original product form.

Section 14. Transport Information

DOT Classification

DOT Name:	COMPOUND, INDUSTRIAL WATER TREATMENT, LIQUID
Technical Name:	N/A
Hazard Class:	Not D.O.T. Regulated.
UN/NA#:	N/A
Packing Group:	N/A

Section 15. Regulatory Information

Inventory Status

United States (TSCA):	All ingredients listed.
Canada (DSL/NDSL):	All ingredients listed.

Federal Regulations

SARA Title III Rules

Sections 311/312 Hazard Classes

Fire Hazard:	No
Reactive Hazard:	No
Release of Pressure:	No
Acute Health Hazard:	Yes
Chronic Health Hazard:	No

Other Sections

Component	Section 313 Toxic Chemical	Section 302 EHS TPQ	CERCLA RQ
There are no hazardous ingredients in this product as defined in 29 CFR 1910-1200.	N/A	N/A	N/A

State Regulations

California Proposition 65: This product contains chemical(s) known to the State of California to cause cancer and/or to cause birth defects or other reproductive harm: residual acrylamide.

ChemTreat, Inc.

MSDS

Special Regulations

Component	States
There are no hazardous ingredients in this product as defined in 29 CFR 1910-1200.	None

International Regulations

Canada

WHMIS Classification: N/A

Controlled Product Regulations (CPR): N/A

Section 16. Other Information

HMIS Hazard Rating

Health: 1
Flammability: 1
Physical Hazard: 0
PPE: X

Notes: The PPE rating depends on circumstances of use. See Section 8 for recommended PPE.
The Hazardous Material Information System (HMIS) is a voluntary, subjective alpha-numeric symbolic system for recommending hazard risk and personal protection equipment information. It is a subjective rating system based on the evaluator's understanding of the chemical associated risks. The end-user must determine if the code is appropriate for their use.

NSF: N/A

FDA: N/A

KOSHER: This product has not been evaluated for Kosher approval.

FIFRA: N/A

Other: None

ChemTreat, Inc.

MSDS

Abbreviations

Abbreviation	Definition
<	Less Than
>	Greater Than
ACGIH	American Conference of Governmental Industrial Hygienists
EHS	Environmental Health and Safety Dept
N/A	Not Applicable
N/D	Not Determined
N/E	Not Established
OSHA	Occupational Health and Safety Dept
PEL	Personal Exposure Limit
STEL	Short Term Exposure Limit
TLV	Threshold Limit Value
TWA	Time Weight Average
UNK	Unknown

Prepared by: Regulatory Affairs Department

Disclaimer

CHEMTREAT CL-16

ChemTreat, Inc.

MSDS

MATERIAL SAFETY DATA SHEET

Section 1. Chemical Product and Company Identification

Product Name:	**ChemTreat CL-16**
Manufacturer's Name:	ChemTreat, Inc.
Emergency Telephone Number:	(800) 424-9300
Address (Corporate Headquarters)	4461 Cox Road, Glen Allen, VA 23060
Telephone Number for Information:	(800) 648-4579
Date of MSDS:	March 19, 2007

Section 2. Composition/Hazardous Ingredients

Component	CAS Registry #	Wt. %
Citric acid	77-92-9	10 – 30
Hydroxyethylidene-1,diphosphonic acid	2809-21-4	1 - 5

Section 3. Hazards Identification

Emergency Overview: Clear colorless liquid; mild odor; not flammable.
Potential Health Effects:
Eyes – Will cause corrosive effects (burns or irreversible damage) to eyes.
Skin – Will cause corrosive effects (burns or irreversible damage) to skin.
Inhalation – Will cause corrosive effects (burns or irreversible damage) to lungs, upper respiratory tract, and nose.
Ingestion – Will cause corrosive effects (burns or irreversible damage) to mouth, throat, and digestive tract.
Chronic Effects/Carcinogenicity: No information found on significant long-term effects.

Section 4. First Aid Measures

Inhalation: Remove victim to fresh air. If not breathing, give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen. Get immediate medical attention.
Eyes: Hold eyes open and rinse slowly and gently with water for 15 – 20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. Call a poison control center or doctor for treatment advice.
Skin: Take off contaminated clothing. Rinse skin immediately with plenty of water for 15 – 20 minutes. Call a poison control center or doctor for treatment advice.
Ingestion: If swallowed, do not induce vomiting. Give victim a glass of water or milk. Call a physician or poison control center. Never give anything by mouth to an unconscious person.

Section 5. Fire Fighting Measures

Flammable Properties: Not flammable.
Suitable Extinguishing Media: Use extinguishing media appropriate to surrounding fire.
Fire & Explosion Hazards: None known
Protective Equipment: Wear full protective clothing including a positive-pressure, NIOSH-approved, self-contained breathing apparatus.

Section 6. Accidental Release Measures

Small Spill: Construct temporary dikes of dirt, sand, or any readily available inert material to prevent spreading of the material. Wearing appropriate personal protective equipment, move the leaking container to a containment area or plug the leak. Absorb on inert material, then shovel up and dispose of according to local, state, federal regulations.
Large Spill: Construct temporary dikes of dirt, sand, or any readily available inert material to prevent spreading of the product. Wearing appropriate personal protective equipment, close or cap valves and/or block or plug hole in leaking container and transfer to another container for proper disposal.

Section 7. Handling and Storage

Do not get in eyes, or on skin and clothing. Wash thoroughly after handling. Avoid breathing mists. Do not ingest. Store at ambient temperatures. Keep container securely closed when not in use. Label precautions also apply to empty container. Recondition or dispose of empty containers in accordance with government regulations. For industrial use only.

Section 8. Exposure Controls/Personal Protection

Use protective equipment in accordance with 29 CFR 1910 Subpart I. Good general ventilation should be sufficient to control airborne levels. Wear chemical splash goggles or safety glasses with full-face shield. Wear rubber gloves. Wash them after each use and replace as necessary. If conditions warrant, wear protective clothing such as boots, aprons, and coveralls to prevent skin contact. Maintain eyewash fountain and quick-drench facilities in work area.

Section 9. Physical and Chemical Properties

Appearance: Clear colorless
Boiling Point: ~ 212°F
Evaporation Rate: N/D
Freezing Point: ~ 32°F
Melting Point: N/A
Odor: Mild
pH: ~ 1.0
Physical state: Liquid
Solubility in Water: Complete
Specific Gravity: ~1.093
Vapor Density: N/D
Vapor Pressure: N/D
% VOCs: N/D

Section 10. Stability and Reactivity

Chemical Stability: Stable at normal temperatures and pressures.
Incompatibility: Bases; strong oxidizers

Hazardous Decomposition Products: Oxides of phosphorus and carbon.
Hazardous Polymerization: Will not occur.

Section 11. Toxicological Information

Citrus acid Dermal LD50 = 500 mg/kg (rabbits)
Hydroxyethylidene-1,diphosphonic acid Oral LD50 = 2400 mg/kg (rats); Dermal LD50 = 7940 mg/kg (rabbits)

Section 12. Ecological Information

Ceriodaphnia dubia 48 hour LC50 = >1000 mg/L; Fathead minnow 96 hour LC50 = >1000 mg/L

Section 13. Disposal Considerations

Dispose of in accordance with local, state and federal regulations as unlisted hazardous waste, characteristic of corrosivity D002.

Section 14. Transport Information (not meant to be all inclusive)

D.O.T. Shipping Name: Corrosive liquid, acidic, organic, n.o.s. (Citric Acid)
Hazard Class: 8 (Corrosive); UN3265; Packing Group: PG II

Section 15. Regulatory Information (*Not meant to be all inclusive - selected regulation represented*)

TSCA Status: All ingredients listed
CERCLA Reportable Quantity: None known
SARA Title III:
Section 302 Extremely Hazardous Substances: None
Section 313 Toxic Chemicals: None
CALIFORNIA PROPOSITION 65: None
KOSHER: This product is certified by the Orthodox Union as kosher pareve.
USDA: (Federally inspected meat and poultry plants) - product is approved for Category G7.

Section 16. Other Information

HMIS Hazard Rating: Health: 2 Flammability: 0 Reactivity: 1 PPE: X (see note)

NOTE: PPE rating depends on circumstances of use. See Section 8 for recommended PPE.

SARA Hazard Categories – Section 311/312
Acute – Yes Chronic – No Fire – No Reactive – No Sudden Release – No

Prepared by Regulatory Affairs

HYDROCHLORIC ACID, DILUTE (RICCA)

Material Safety Data Sheet

Section 1: Chemical Product and Company Identification

Catalog Number:

3558, 3567.4, 3568, 3569, 3569.4, 3570, 3572, 3573, H-110, H-120, H-133, H-135, H-288, H044710, HCLBLNK, PHACID5, R3571600, SH044675, SH044680, SH044710, SHCLBLNK

Product Identity:
HYDROCHLORIC ACID, 4 - 16.9% (v/v) Aqueous Solutions; HYDROCHLORIC ACID:WATER, 6:94

Manufacturer's Name: RICCA CHEMICAL COMPANY LLC	**Emergency Contact(24 hr) -- CHEMTREC®** Domestic: 800-424-9300 International: 703-527-3887
CAGE Code: 0V553	
Address: 448 West Fork Dr Arlington, TX 76012	**Telephone Number For Information:** 817-461-5601
Date Prepared: 12/8/98	**Revision:** 14 Last Revised: 03/16/2007 Date Printed: 03/21/2007 9:37:32 am

Section 2. Composition/Information on Ingredients

Component	CAS Registry #	Concentration	ACGIH TLV	OSHA PEL
Hydrochloric Acid	7647-01-0	4-16.9	C 5 ppm C 7.5 mg/m3	C 5 ppm C 7 mg/m3
Water, Deionized	7732-18-5	Balance	Not Available Not Available	Not Available Not Available

Section 3: Hazard Identification

Emergency Overview: Mildly corrosive. Wash areas of contact with water for at least 15 minutes. Hazards increase as concentration increases.

Target Organs: eyes, skin, respiratory system.

Eye Contact: May cause irritation, redness, pain, and tearing.

Inhalation: May cause irritation.

Skin Contact: May cause irritation, redness, and pain.

Ingestion: May cause nausea, vomiting, diarrhea and cramps.

Chronic Effects/Carcinogenicity: None

IARC - Hydrochloric Acid is unclassifiable as to carcinogenicity to humans.

NTP - No.

OSHA - No.

Reproductive Information: Reproductive effects cited in 'Registry of Toxic Effects of Chemical Substances' for Hydrochloric Acid.

Teratology (Birth Defect) Information: Mutation data cited in 'Registry of Toxic Effects of Chemical Substances' for Hydrochloric Acid.

Section 4: First Aid Measures - In all cases, seek qualified evaluation.

Eye Contact: Irrigate immediately with large quantity of water for at least 15 minutes. Call a physician if irritation develops.
Inhalation: Remove to fresh air. Give artificial respiration if necessary. If breathing is difficult, give oxygen.
Skin Contact: Wash areas of contact with soap and water for at least 15 minutes. Call a physician if irritation develops.
Ingestion: Dilute with water or milk. Do not induce vomiting. Call a physician if necessary.

Section 5: Fire Fighting Measures

Flash Point: Not Available.
Method Used: Not Available.
LFL: Not Available.
UFL: Not Available.
Extinguishing Media: Use any means suitable for extinguishing surrounding fire.
Fire & Explosion Hazards: Not considered to be a fire or explosion hazard. May react with metals to release flammable Hydrogen gas.
Fire Fighting Instructions: Use normal procedures/instructions.
Fire Fighting Equipment: Use protective clothing and breathing equipment appropriate for the surrounding fire.

Section 6: Accidental Release Measures

Cover the spill with Sodium Carbonate or a soda ash-slaked lime mixture (50:50). Mix and add water to form slurry. Decant the liquid to the drain with excess water. Treat the solid residue as normal refuse. Wash site with soda ash solution. Always dispose of in accordance with local regulations.

Section 7. Handling and Storage

As with all chemicals, wash hands thoroughly after handling. Avoid contact with eyes and skin. Protect from freezing and physical damage.
Safety Storage Code: Corrosive

Section 8: Exposure Control/Personal Protection

Engineering Controls: No specific controls are needed. Normal room ventilation is adequate.
Respiratory Protection: Normal room ventilation is adequate.
Skin Protection: Chemical resistant gloves.
Eye Protection: Safety glasses or goggles.

Section 9: Physical and Chemical Properties

Appearance: Clear, colorless liquid
Odor: Odorless to slightly pungent
Solubility in Water: Inifinite
Specific Gravity: Approximately 1 - 1.03
pH: Not Available.
Boiling Point(°C): Approximately 100
Melting Point(°C): Approximately 0
Vapor Pressure: Not Applicable.

Section 10: Stability and Reactivity

Chemical Stability: Stable under normal conditions of use and storage.
Incompatibility: Most metals, Alkalis, active metals, Cyanides, Sulfides, Sulfites, Metal Oxides, Formaldehyde.
Hazardous Decomposition Products: Fumes of Hydrogen Chloride and Hydrogen in contact with metals, Chlorine gas from Oxidizers.
Hazardous Polymerization: Will not occur.

Section 11. Toxicological Information

LD50, Oral, Rabbit (Hydrochloric Acid) 900 mg/kg; Details of toxic effects not reported other than lethal dose value. LCLo, inhalation, human: 3000 ppm/5 minutes: No toxic effects noted.

Section 12. Ecological Information

Ecotoxicological Information: Hydrogen Chloride has slight acute and chronic toxicity to aquatic life.
Chemical Fate Information: Virtually 100% of Hydrogen Chloride will eventually end up in the air.

Section 13. Disposal Considerations

Cover the spill with Sodium Carbonate or a soda ash-slaked lime mixture (50:50). Mix and add water to form slurry. Decant the liquid to the drain with excess water. Treat the solid residue as normal refuse. Always dispose of in accordance with local, state and federal regulations.

Section 14. Transport Information

Part Numbers: 3558-16, 3567.4-5, 3568-1, 3568-16, 3568-30, 3568-32, 3568-5, 3569.4-16, 3569.4-32, 3570-1, 3570-16, 3570-2.5, 3570-32, 3570-5, 3572-55, H-110 4-LT, H-110 LT, H-120 20-LT, H-120 4-LT, H-120 500ML, H-120 LT, H-133 10-LT, H-133 20-LT, H-133 LT, H-135 20-LT, H-135 200-LT, H-135 4-LT, H-135 500ML, H-135 LT, H-288 20-LT, H-288 4-LT, H-288 LT, PHACID5-1CT, PHACID5-2.5, PHACID5-500, R3571600-1A, R3571600-4A, SH044710-1A, SH044710-4A, SH044710-500A, SHCLBLNK-500N

D.O.T. Shipping Name: Hydrochloric Acid Solution

D.O.T. Hazard Class: 8

U.N. / N.A. Number: UN1789

Packing Group: III

D.O.T. Label: 8

Section 15. Regulatory Information (Not meant to be all inclusive - selected regulation represented)

OSHA Status: These items meet the OSHA Hazard Communication Standard (29 CFR 1910.1200) definition of a hazardous material.
TSCA Status: All components of this solution are listed on the TSCA Inventory or are mixtures (hydrates) of items listed on the TSCA Inventory.

Sara Title III:

Section 302 Extremely Hazardous Substances: Not Applicable.
Section 311/312 Hazardous Catagories: Acute: Yes Chronic, Fire, Pressure, Reactivity: No
Section 313 Toxic Chemicals: Not Applicable.

California: None Reported.
Pennsylvania: Hydrochloric Acid is listed as an Environmental Hazard on the state's Hazardous Substances List.
RCRA Status: Not Applicable.
CERCLA Reportable Quantity: Hydrochloric Acid - 5,000 pounds.

WHMIS: E: Corrosive Material.

Section 16. Other Information

NFPA Ratings:

Health: 2	Flammability: 0	Reactivity: 0	Special Notice Key:None

HMIS Ratings:

Health: 2	Flammability: 0	Reactivity: 0	Protective Equipment:B (Protective Eyewear, Gloves)

Rev 1, 4-16-99: (Section 1) added catalog numbers 3558 and 3569.4, (Section 3) added mutation and reproductive data cited, IARC not classifiable as to carcinogenicity to humans, Oral, Rat corrected to Oral, Rabbit, (Section 15) added Florida and Pennsylvania state information.
Rev 2, 12-10-99: (Section 1) Revised emergency telephone number to CHEMTREC® 800-424-9300.
Rev 3, 2-23-2000: Reformatted from WordPerfect® to Microsoft Word®; (Section 2) revised exposure limits from mg/m3 to ppm, (Section 7) added storage code, (Section 15) added TPQ information.
Rev 4, 10-09-2001: Reformatted to electronic data format.
Rev 5, 03-13-2002: (Section 1) added catalog number 3572.
Rev 6, 09-05-2003: (Section 14) revised DOT name from Corrosive liquid, acidic, nos.
Rev 7, 09-25-2003: (Section 1) added Solutions Plus catalog number H044710.
Rev 8, 02-11-2004: (Section 1) added Solutions Plus catalog number HCLBLNK.
Rev 9, 04-19-2005: (Section 1) added catalog number 3567.4.
Rev 10, 03-01-2006: (Section 1) added Red Bird catalog number H-120.
Rev 11, 03-27-2006: (Section 1) added catalog number PHACID5.
Rev 12, 05-19-2006: (Section 1) added catalog number R3571600 and Red Bird catalog number H-110.
Rev 13, 11-17-2006: (Section 1) added Red Bird catalog number H-133.
Rev 14, 03-16-2007: (Section 1) added Red Bird catalog number H-288.

When handled properly by qualified personnel, the product described herein does not present a significant health or safety hazard. Alteration of its characteristics by concentration, evaporation, addition of other substances, or other means may present hazards not specifically addressed herein and which must be evaluated by the user. The information furnished herein is believed to be accurate and represents the best data currently available to us. No warranty, expressed or implied, is made and RICCA CHEMICAL COMPANY assumes no legal responsibility or liability whatsoever resulting from its use.

RYDLYME (APEX ENGINEERING)

MATERIAL SAFETY DATA SHEET
REVISED AUGUST 2006

APEX ENGINEERING PRODUCTS CORPORATION
1241 Shoreline Drive
Aurora, Illinois 60504
Phone: 800-451-6291 FAX: 630-820-8886

For Chemical Emergency, Spill, Leak, Fire Exposure or Accident
Call CHEMTREC Day or Night
DOMESTIC NORTH AMERICA 800-424-9300
INTERNATIONAL, CALL 703-527-3887 (collect calls accepted)

PRODUCT INFORMATION

TRADE NAMES OR SYNONYMS:	RYDLYME, RID-LIME
FORMULA:	PROPRIETARY, CONFIDENTIALITY REQUIRED
CHEMICAL FAMILY:	WATER SCALE CLEANER

HAZARDOUS INGREDIENTS

MATERIAL OR COMPONENT	TLV (p.p.m.)	PEL (p.p.m.)	APPROXIMATE %
HYDROGEN CHLORIDE, AQUEOUS	5	5	LESS THAN 10

NOTE: Laboratory tests indicate material to be **BIODEGRADABLE**. Certified to NSF/ANSI 60. NSF Registered for use in beverage, pharmaceutical, bottling, poultry, and other food processing plants. USFDA has no jurisdiction over the product, since it does not come in direct contact with food. Non-reportable under Sara Title 3: Section 311/312/313 Categorization. Not reportable under CERCLA.

PHYSICAL DATA

BOILING POINT:	213° F / 101° C.
FREEZING POINT:	0° F / -18° C
SOLUBILITY IN WATER:	MISCIBLE
SPECIFIC GRAVITY, (WATER=1):	1.045
VAPOR PRESSURE:	30 TORR.
VAPOR DENSITY, (AIR=1):	GREATER THAN 1
PERCENT VOLATILE BY VOLUME:	99.6
APPEARANCE:	DARK LIQUID
ODOR:	ROASTED ALMONDS
pH:	UNREADABLE, GENERALLY <3
EVAPORATION RATE, (WATER=1):	SLOW
PHYSICAL STATE:	LIQUID

FIRE AND EXPLOSION HAZARD DATA

FLASH POINT:	NO FLASH POINT, EXTINQUISHES FLAME
EXTINQUISHING MEDIA:	DOES NOT SUPPORT COMBUSTION
SPECIAL FIRE FIGHTING PROCEDURES:	NONE--WATER WILL CONTROL, OR CO2/DRY CHEMICALS
UNUSUAL FIRE & EXPLOSION HAZARDS:	NON-COMBUSTIBLE OR EXPLOSIVE. BREATHING APPARATUS RECOMMENDED

HMIS

HEALTH:	0
FLAMMABILITY:	0
REACTIVITY:	0
PERSONAL PROTECTION:	B

HEALTH HAZARD DATA

EFFECTS OF OVER EXPOSURE:	SHOULD NOT BE CONSIDERED HAZARDOUS WHEN USED AS DIRECTED.
EMERGENCY & FIRST AID:	IF EYE/SKIN CONTACT, COPIOUS WATER RINSE. CONSULT PHYSICIAN. NOT TO BE TAKEN INTERNALLY. IF INGESTED-DO NOT INDUCE VOMITING-DRINK MILK, EGG WHITES, ETC. AS DIRECTED BY PHYSICIAN.
NOTE:	ADVERSE EFFECTS ON HUMAN HEALTH ARE NOT EXPECTED FROM THE RYDLYME SOLUTION, BASED UPON 60+ YEARS OF USE WITHOUT REPORTED ADVERSE HEALTH INCIDENCE IN DIVERSE POPULATION GROUPS, INCLUDING EXTENSIVE USE IN THE U.S. ARMED FORCES.

REACTIVITY DATA

STABILITY:	STABLE
INCOMPATIBILITIES:	STRONG CAUSTICS
HAZARDOUS DECOMPOSITION PRODUCTS:	NONE
HAZARDOUS POLYMERIZATION:	WILL NOT OCCUR
CONDITIONS TO AVOID:	EXCESSIVE HEATING

SPILL AND DISPOSAL PROCEDURES

ACTION TO TAKE FOR SPILLS:	RINSE WITH COPIOUS AMOUNTS OF WATER TO DILUTE: SODIUM BICARBONATE MAY ALSO BE USED TO SOAK UP AND NEUTRALIZE LIQUID, IF NECESSARY.
DISPOSAL METHOD:	EXPENDED OR USED MATERIAL MAY BE DISPOSED OF DOWN SEWER WITH WATER FLUSH. MATERIAL IS **BIODEGRADABLE**-EVEN IN AS RECEIVED FORM.

SPECIAL HANDLING INFORMATION

VENTILATION:	NORMAL (MECHANICAL)
RESPIRATORY:	NONE
PROTECTIVE GLOVES:	RECOMMENDED, SUCH AS NEOPRENE GLOVES.
EYE PROTECTION:	RECOMMENDED, SUCH AS CHEMICAL GOGGLES.
OTHER PROTECTIVE EQUIPMENT:	AS RECOMMENDED BY PLANT SAFETY DEPARTMENT. TO PREVENT STAINING OF CLOTHES, WEAR AN APRON.

SPECIAL PRECAUTIONS

HANDLING AND STORING:	PRESERVE INTEGRITY OF CONTAINER.
CAN MATERIAL BE STORED OUTSIDE?	YES, MAINTAIN TEMPERATURE BETWEEN 10°-180° F.
OTHER PRECAUTIONS:	Do not circulate material for more than a six hour period without consulting the manufacturer. Most ***RYDLYME*** cleanings can be accomplished within an average of two-four hours. Please use material only as directed. If procedures are not published for your particular application, please call for assistance. Furthermore, ***RYDLYME*** is designed to be used by itself or diluted with water and water only. Do not heat. Use ***RYDLYME*** at an ambient temperature. Vent circulating solution to atmosphere. Some adverse reactions may occur with some alloys of aluminum, magnesium, and/or zinc. Please consult the manufacturer.

CAUTION: *RYDLYME* **is non-corrosive, but the application of** *RYDLYME* **may expose pre-existing under deposit corrosion (pitting, holes or similar damage) that can result in leaks in pipes, equipment or systems.**

FOR ADDITIONAL INFORMATION, PLEASE REVIEW THE RYDLYME SPECIFICATIONS OR CONTACT OUR MANUFACTURING FACILITY AT 800-451-6291.

NSF
Certified to NSF/ANSI 60

SUPER GOLD BOWL CLEANER (B. MILLER PRODUCTS)

B. Miller Products

P.O. Box 544
Hibbing, MN 55746

MSDS S-538

MATERIAL SAFETY DATA SHEET

Revision Date: 6/3/2003

MSDS No.: N-065

Emergency Phones: 218-263-8958

PLEASE NOTE: This MSDS is being provided to your company for the purpose of providing current health and safety information to your management and for your employees who work with this material. Please read the information on these sheets, and then provide this information to those people at your company whose responsibility it is to comply with FEDERAL and STATE RIGHT-TO-KNOW regulations. Also make this information available to any employee who requests it. It is your obligation to comply with these regulations.

SECTION I - PRODUCT IDENTITY

PRODUCT NAME: Super Gold Bowl Cleaner
Formula: Mixture, water, hydrochloric acid, additives
Chemical Type: Mixture, water, hydrochloric acid, additives

HMIS RATINGS

Health = 3 (Serious)	Flammability = 0 (Insignificant)
Reactivity = 0 (Minimal)	Protection = C (Safety Glasses, Gloves, Synthetic Apron)

SECTION II - HAZARDOUS INGREDIENTS

	PERCENT	TLV	CARCINOGEN (OSHA,TP,IARC)
Hydrochloric Acid CAS No. 7647-01-0)	24%	5 ppm	no

SECTION III - CHEMICAL AND PHYSICAL

Appearance: White emulsion
Odor: Acid
pH: <1
Water Solubility: Complete
Viscosity, Cp @ 25°C.: A-5 (Gardner)

Boiling Point: est. 180oF.
Melting Point: N/A
Spec. Gravity (H_2O = 1): 1.1
Vapor Pressure (mm Hg): 39
VOC Content: none (N.A.)

SECTION IV - FIRE AND EXPLOSION HAZARDS

Flash Point (Method): None

Explosion Limits: Upper: N/A
Lower: N/A

Extinguishing Media: N/A (product is non-flammable)
Special Firefighting Procedures and Hazards: : Avoid skin and eye contact, and breathing of acid vapors. Wear head and body protection and HCl respirator if exposure to liquid is likely.

SECTION V - REACTIVITY INFORMATION

Stable: ☒ Unstable: ☐

Precautions:
Incompatibility: Strong alkalis, materials not resistant to strong acids, active metals (zinc, aluminum, magnesium, etc).

Hazardous Decomposition Products: Hydrogen chloride vapors. Contact with active metals can release flammable gas

Hazardous Polymerization: Occurs: ☐ Does Not Occur: ☒

SECTION VI - HEALTH HAZARDS – PROTECTIVE MEASURES - FIRST AID

Inhalation: Breathing of vapor can cause respiratory irritation and inflammation. Breathing of mist or liquid can cause burns. Wear approved HCl vapor/mist respirator if exposure is likely. Remove to fresh air. Give artificial respiration or oxygen if needed. Get prompt medical attention.

Skin: Corrosive. Causes irritation and burns. Wear acid-resistant protective gloves, boots, and clothing. Provide convenient safety showers. Remove contaminated clothing. Flush skin thoroughly with water for 15 minutes. Get medical attention if burns persist.

Eyes: Corrosive. Causes eye damage. Wear splash proof goggles. Provide convenient eyewash stations. Flush immediately with water for 15 minutes. Get prompt medical attention.

Ingestion: Corrosive. Causes irritation and burning in mouth, esophagus, throat and stomach. Avoid swallowing. Drink lots of water or, preferably, milk. Get medical attention if effects persist. Do not induce vomiting.

Most likely routes of entry: Skin, Eyes, Inhalation, Ingestion

Other Important Medical or Precautionary Information: Overexposure to product has the following effects: Inhalation of vapors may cause pulmonary edema, collapse of circulatory system and damage to the upper respiratory system and collapse. Inhalation may cause coughing, throat burning, choking, bronchitis and difficult breathing. Ingestion is harmful and may be fatal. Ingestion may cause burns.

SECTION VII - PRECAUTIONS FOR SAFE HANDLING AND USE

Spills and Leaks: Small spills can be flushed into normal drainage or into ground with copious amounts of water, or taken up with absorbent material. Larger spills should be contained by diking or other methods and held for collection and/or reuse, or for neutralization with alkali before collection & disposal. People should use eye and skin protection & respirator.

Storage and Handling: Check daily for any leaks from containers, vessels, pumps, and piping. Have water hoses and alkali (caustic soda, lime, etc.) convenient. Only use containers and equipment designed for acid service.

Waste Disposal: If neutralized, may be disposable in sewers if local regulations permit. Otherwise, send to licensed treatment and disposal facility. As supplied, this product is a RCRA hazardous waste.

Empty Containers: Rinse well before handling and disposal.

Other Precautions: Areas of use and storage should be ventilated adequately to reduce vapors below odor level.

SECTION VIII - REGULATORY INFORMATION

Reportable for SARA Title III, S:313 (Form R): Hydrochloric Acids

The information herein has been compiled from sources believed to be reliable and is accurate to the best of our knowledge. However, B. Miller Products cannot give any guarantees regarding information from other sources, and expressly does not make any warranties, nor assumes any liability, for its use.

MAGNESIUM CHLORIDE SOLUTION (UNIVAR)

PRODUCT: MAGNESIUM CHLORIDE SOLUTION

ORDER NO: 422792
PROD NO : 769141

DUSTCOATING INC
. ERICKSON TRUAX WHSE
8933 SLATE STREET

MT IRON ,MN 55768

UNIVAR USA INC.
17425 NE UNION HILL RD , REDMOND (425)889-3400 , WA 98052

---------- EMERGENCY ASSISTANCE ----------

FOR EMERGENCY ASSISTANCE INVOLVING CHEMICALS CALL - CHEMTREC
(800)424-9300

PRODUCT NAME:	MAGNESIUM CHLORIDE SOLUTION
MSDS NUMBER:	P16583V
DATE ISSUED:	08/01/2007
SUPERSEDES:	01/26/2006
ISSUED BY:	008645

****
****

MATERIAL SAFETY DATA SHEET

SECTION 1 - CHEMICAL PRODUCT AND COMPANY INFORMATION

UNIVAR
17425 NE UNION HILL ROAD
REDMOND, WA 98052
425-889-3400

SYNONYMS:	NONE KNOWN
CAS #:	7791-18-6 7732-18-5

PRODUCT: MAGNESIUM CHLORIDE SOLUTION

ORDER NO: 422792
PROD NO : 769141

DOT HAZARD CLASS: NOT REGULATED

SECTION 2 - COMPOSITION AND INFORMATION ON INGREDIENTS

MAGNESIUM CHLORIDE HEXAHYDRATE	64% MIN.
WATER	36% MAX.

SECTION 3 - HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW: CLEAR, WATER WHITE SOLUTION, WILL CAUSE LITTLE OR NO HAZARDOUS CONCERNS.

POTENTIAL HEALTH EFFECTS:
EYES & SKIN: MAY CAUSE SLIGHT IRRITATION.
INGESTION: MAY BE HARMFUL IF A LARGE QUANTITY IS SWALLOWED.

CARCINOGENICITY: NOT LISTED UNDER OSHA, IARC, OR NTP.

SECTION 4 - FIRST AID MEASURES

EYES: FLUSH IMMEDIATELY WITH PLENTY OF WATER FOR AT LEAST 10 MINUTES.
SKIN: WASH OFF WITH SOAP AND WATER.
INGESTION: DILUTE WITH SEVERAL GLASSES OF WATER.
WITH ALL OF THE ABOVE: CONSULT A PHYSICIAN IF SYMPTOMS PERSIST.

SECTION 5 - FIRE FIGHTING MEASURES

FLASH POINT: NOT FLAMMABLE

FLAMMABLE LIMITS: NOT APPLICABLE

EXTINGUISHING MEDIA; USE MEDIA THAT IS APPROPRIATE TO TEAT SURROUNDING FIRE.

SPECIAL FIRE FIGHTING PROCEDURES: USE FIRE FIGHTING PROCEDURE THAT IS APPROPRIATE TO TREAT SURROUNDING FIRE.

UNUSUAL FIRE EXPLOSION HAZARD: NONE KNOWN

AUTO IGNITION TEMPERATURE: NOT APPLICABLE

SECTION 6 - ACCIDENTAL RELEASE MEASURES

ISOLATE HAZARD AREA AND DENY ENTRY TO UNNECESSARY OR UNPROTECTED PERSONNEL. CONTAIN SPILL, COLLECT AND PLACE IN A DISPOSAL CONTAINER, AVOID RUNOFF INTO STORM SEWERS AND DITCHES WHICH LEAD TO WATERWAYS.

SECTION 7 - HANDLING AND STORAGE

PRODUCT: MAGNESIUM CHLORIDE SOLUTION

ORDER NO: 422792
PROD NO : 769141

AVOID CONTACT WITH SKIN, EYES AND CLOTHING. USE NORMAL PERSONAL HYGIENE AND HOUSEKEEPING. STORE IN COOL DRY AREA AWAY FROM OTHER INCOMPATIBLE MATERIALS.

SECTION 8 - EXPOSURE CONTROLS, PERSONAL PROTECTION

RESPIRATORY PROTECTION: NOT APPLICABLE

VENTILATION REQUIREMENTS: NOT APPLICABLE

SKIN AND EYE PROTECTION:
USE RUBBER OR NEOPRENE GLOVES, CHEMICAL GOGGLES AND CLOTHING SUFFICIENT TO PROTECT SKIN FROM SPLASHING.

WORK, HYGIENIC PRACTICES:
AS REQUIRED TO PROTECT SKIN AND EYES FROM SPLASH, SAFETY SHOWERS AND/OR EYE WASH SHOULD BE AVAILABLE_ DO NOT LEAVE FOOD OR SMOKE IN WORK AREA. WASH THOROUGHLY AND REMOVE OR CLEAN ANY CONTAMINATED CLOTHING.

EXPOSURE LIMITS: NONE ESTABLISHED

SECTION 9 - PHYSICAL AND CHEMICAL PROPERTIES

BOILING POINT; NOT APPLICABLE

VAPOR PRESSURE (MM HG): NOT APPLICABLE

VAPOR DENSITY (AIR=1): NOT APPLICABLE

SPECIFIC GRAVITY (H2O=1): 1.27

BULK DENSITY: NOT APPLICABLE

PERCENT VOLATILE BY VOLUME (%): NOT APPLICABLE

MELTING POINT: NOT APPLICABLE

EVAPORATION RATE (BUTYL ACETATE-1): NOT APPLICABLE

SOLUBILITY IN WATER: NOT APPLICABLE

PH: APPROXIMATELY 7.0

SECTION 10 - STABILITY AND REACTIVITY

CHEMICAL STABILITY: STABLE UNDER NORMAL TEMPERATURES AND PRESSURES.
HAZARDOUS POLYMERIZATION: WILL NOT OCCUR UNDER NORMAL CONDITIONS.
HAZARDOUS DECOMPOSITION PRODUCTS: HYDROGEN CHLORIDE

PRODUCT: MAGNESIUM CHLORIDE SOLUTION

ORDER NO: 422792
PROD NO : 769141

KEEP AWAY FROM: OXIDIZING AGENTS AND STRONG ACID.

11- TOXICOLOGICAL INFORMATION

LD50 - ORAL-RAT 8100 MG/KG

SECTION 12 - ECOLOGICAL INFORMATION

NOT AVAILABLE

SECTION 13 - DISPOSAL CONSIDERATIONS

DISPOSE OF IN ACCORDANCE WITH ALL FEDERAL, STATE AND LOCAL REGULATIONS.

RCRA WASTE #: NOT LISTED

SECTION 14 - TRANSPORTATION INFORMATION

D.O.T. SHIPPING NAME: MAGNESIUM CHLORIDE SOLUTION - NOT REGULATED

SECTION 15 - REGULATORY INFORMATION

TSCA (TOXIC SUBSTANCE CONTROL ACT):
THIS PRODUCT IS LISTED ON THE TSCA INVENTORY.

CERCLA REPORTABLE REQUIREMENTS: (RQ) NONE

SARA TITLE III INFORMATION:
SECTION 302 EXTREMELY HAZARDOUS SUBSTANCE: UNLISTED
SECTION 313 TOXIC CHEMICALS: UNLISTED
SECTION 311/312 HAZARD CATEGORY: NOT CONSIDERED A HAZARD.

PRODUCT: MAGNESIUM CHLORIDE SOLUTION

ORDER NO: 422792
PROD NO : 769141

FOR ADDITIONAL INFORMATION

CONTACT: MSDS COORDINATOR UNIVAR USA INC.
DURING BUSINESS HOURS, PACIFIC TIME (425)889-3400

04/16/08 07:08 PRODUCT: 769141 CUST NO: 154742 ORDER NO: 422792

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* * * E N D O F M S D S * * *

APPENDIX D – NON-DEGRADATION REVIEW TABLES

Table 1: Allowable Discharge Volume Calculation

2000 Allowable Discharge: 1986 Permit Rules

Area	
Open Water	50,312,000 ft^2
Vegetated and Exposed	152,024,000 ft^2
Run-off	70,567,000 ft^2

Precipitation and Evaporation Factors	
1999 Precipitation	41.07 inches
2000 Precipitation	27.41 inches
Annual Evaporation	23.00 inches
Vegetated and Exposed Run-off Factor	0.81
Run-off Run-off Factor	0.64

Calculated - 1999	
Open Water - Precipitation	172,192,820 ft^3
Vegetated and Exposed - Precipitation	421,444,733 ft^3
Run-off - Precipitation	154,569,957 ft^3
Open Water - Evaporation	-96,431,333 ft^3
1999 Net Non-Process Water Input	651,776,177 ft^3
Carry-Over Factor (B6.6 MN0055948 - 1986)	346,498,560 ft^3
1999 Allowable Carry-Over	**305,277,617 ft^3**

Calculated - 2000	
Open Water - Precipitation	114,920,993 ft^3
Vegetated and Exposed - Precipitation	281,271,004 ft^3
Run-off - Precipitation	103,159,545 ft^3
Open Water - Evaporation	-96,431,333 ft^3
2000 Net Non-Process Water Input	402,920,209 ft^3
1999 Allowable Carry-Over	305,277,617 ft^3
2000 Allowable Discharge	**708,197,826 ft^3**

2000 Allowable Discharge - 1986 Permit	**5,297 MMgal**

1999 Allowable Discharge: Precipitation minus Evaporation

Area	
Open Water	50,312,000 ft^2
Vegetated and Exposed	152,024,000 ft^2
Run-off	70,567,000 ft^2

Precipitation and Evaporation Factors	
1999 Precipitation	41.07 inches
Annual Evaporation	23.00 inches

Calculated	
Total Precipitation	934,010,518 ft^3
Total Evaporation	96,431,333 ft^3
Net P-E	**837,579,184 ft^3**

1999 Allowable Discharge - Net P-E	**6,265 MMgal**

W:\ww\94213\chemistry predictions\1999 P-E Calcs.xls

Table 2. Predicted Sulfate Concentration With Expansion - Annual Average Flow

Year	Inner Tailings Pond Area (acres)	Inner Tailings Pond Volume (gal)	Total System Volume (gal)	Increased Tailings Pond Evap (gal)	Discharge from Sargent Pit into Res 2 (gal)	Res 2 Pumping into Res 6 (gal)	Void Loss (gal)	Res 6 Discharge w/out Sargent (gal)	Pellet Cooling (gal)	Misc to Welcome Creek (gal)	Tailings Basin to Groundwater (gal)	Pellet Indurator Loss (gal)	Total System "Blow-Down" (gal)	Additional Sulfate Equilibrium Conc (ppm)	Estimated System Equilibrium Conc (ppm)	Predicted Actual Conc. (ppm)	Predicted Sulfate Loading (TPY)
2005	600	1.99E+09	3.50E+09	0	0	0	652,486,154	-174,250,474	42,048,000	105,120,000	140,000,000	177,266,187	9.4E+08	141	207	66	0
2006	600	1.99E+09	3.50E+09	0	0	686,900,000	652,486,154	42,510,486	42,048,000	105,120,000	138,000,000	177,266,187	1.8E+09	72	138	96	17
2007	700	2.33E+09	3.83E+09	39479589.6	0	827,700,000	652,486,154	381,878,166	42,048,000	105,120,000	336,000,000	177,266,187	2.5E+09	53	119	107	170
2008	800	2.66E+09	4.16E+09	78959179.2	0		652,486,154	86,854,951	42,048,000	105,120,000	138,000,000	177,266,187	1.2E+09	111	177	124	45
2009	1000	2.93E+09	4.43E+09	157,918,358	0		652,486,154	1,044,033,145*	42,048,000	105,120,000	281,000,000	177,266,187	2.3E+09	58	124	124	540
2010	1300	3.39E+09	4.89E+09	276,357,127	254,000,000	254,000,000	652,486,154	776,319,212	42,048,000	105,120,000	281,000,000	177,266,187	2.3E+09	58	124	124	533
2011	1700	3.88E+09	5.38E+09	434,275,486	254,000,000	254,000,000	652,486,154	618,033,969	42,048,000	105,120,000	281,000,000	177,266,187	2.1E+09	62	128	126	456
2012	2000	3.91E+09	5.41E+09	552,714,254	298,000,000	298,000,000	942,480,000	624,919,406	67,276,800	168,192,000	281,000,000	265,899,281	2.6E+09	25	91	112	432
2013	2000	3.91E+09	5.41E+09	552,714,254	342,000,000	342,000,000	942,480,000	631,804,842	67,276,800	168,192,000	281,000,000	265,899,281	2.7E+09	25	91	104	421
2014	2000	3.91E+09	5.41E+09	552,714,254	386,000,000	386,000,000	942,480,000	638,690,279	67,276,800	168,192,000	281,000,000	265,899,281	2.7E+09	24	90	98	420
2015	2000	3.91E+09	5.41E+09	552,714,254	430,000,000	430,000,000	942,480,000	645,575,715	67,276,800	168,192,000	281,000,000	265,899,281	2.8E+09	24	90	95	425
2016	2000	3.91E+09	5.41E+09	552,714,254	474,000,000	474,000,000	942,480,000	652,461,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	93	435
2017	2000	3.91E+09	5.41E+09	552,714,254	530,200,000	530,200,000	942,480,000	613,661,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	91	435
2018	2000	3.91E+09	5.41E+09	552,714,254	586,400,000	586,400,000	942,480,000	574,861,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	90	437
2019	2000	3.91E+09	5.41E+09	552,714,254	642,600,000	642,600,000	942,480,000	536,061,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	90	441
2020	2000	3.91E+09	5.41E+09	552,714,254	698,800,000	698,800,000	942,480,000	497,261,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	89	445
2021	2000	3.91E+09	5.41E+09	552,714,254	755,000,000	755,000,000	942,480,000	458,461,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	89	450
2022	2000	3.91E+09	5.41E+09	552,714,254	727,000,000	727,000,000	942,480,000	502,661,152	67,276,800	168,192,000	281,000,000	265,899,281	3.0E+09	23	89	89	455
2023	2000	3.91E+09	5.41E+09	552,714,254	699,000,000	699,000,000	942,480,000	546,861,152	67,276,800	168,192,000	281,000,000	265,899,281	3.0E+09	22	88	89	460
2024	2000	3.91E+09	5.41E+09	552,714,254	671,000,000	671,000,000	942,480,000	591,061,152	67,276,800	168,192,000	281,000,000	265,899,281	3.0E+09	22	88	88	465
2025	2000	3.91E+09	5.41E+09	552,714,254	643,000,000	643,000,000	942,480,000	635,261,152	67,276,800	168,192,000	281,000,000	265,899,281	3.0E+09	22	88	88	471
2026	2000	3.91E+09	5.41E+09	552,714,254	615,000,000	615,000,000	942,480,000	679,461,152	67,276,800	168,192,000	281,000,000	265,899,281	3.0E+09	22	88	88	476
2027	2000	3.91E+09	5.41E+09	552,714,254	616,800,000	616,800,000	942,480,000	850,061,152	67,276,800	168,192,000	281,000,000	265,899,281	3.2E+09	21	87	88	536
2028	2000	3.91E+09	5.41E+09	552,714,254	618,600,000	618,600,000	942,480,000	1,020,661,152	67,276,800	168,192,000	281,000,000	265,899,281	3.4E+09	20	86	87	593
2029	2000	3.91E+09	5.41E+09	552,714,254	620,400,000	620,400,000	942,480,000	1,191,261,152	67,276,800	168,192,000	281,000,000	265,899,281	3.5E+09	19	85	86	648
2030	2000	3.91E+09	5.41E+09	552,714,254	622,200,000	622,200,000	942,480,000	1,361,861,152	67,276,800	168,192,000	281,000,000	265,899,281	3.7E+09	18	84	85	702
2031	2000	3.91E+09	5.41E+09	552,714,254	624,000,000	624,000,000	942,480,000	1,532,461,152	67,276,800	168,192,000	281,000,000	265,899,281	3.9E+09	17	83	84	755
2032	2000	3.91E+09	5.41E+09	552,714,254	680,800,000	680,800,000	942,480,000	1,493,861,152	67,276,800	168,192,000	281,000,000	265,899,281	3.9E+09	17	83	84	757
2033	2000	3.91E+09	5.41E+09	552,714,254	737,600,000	737,600,000	942,480,000	1,455,261,152	67,276,800	168,192,000	281,000,000	265,899,281	3.9E+09	17	83	83	761
2034	2000	3.91E+09	5.41E+09	552,714,254	794,400,000	794,400,000	942,480,000	1,416,661,152	67,276,800	168,192,000	281,000,000	265,899,281	3.9E+09	17	83	83	765
2035	2000	3.91E+09	5.41E+09	552,714,254	851,200,000	851,200,000	942,480,000	1,378,061,152	67,276,800	168,192,000	281,000,000	265,899,281	4.0E+09	17	83	83	771
2036	2000	3.91E+09	5.41E+09	552,714,254	908,000,000	908,000,000	942,480,000	1,339,461,152	67,276,800	168,192,000	281,000,000	265,899,281	4.0E+09	17	83	83	776

* Sargent Mine Yield was discharge to Reservoir 6 through the Russell Pit in 2009.

Pre-scrubber sulfate	66 ppm	Average AET in non-clear pool tailings area	11.96 inches
Tailings Pond Avg Depth	10.2 ft	Increased Evap when water covered	26.5 inches
Second Stage Pond Acres	319 acres	Sulfate addition from scrubber	555 tons/yr
Second Stage Pond Avg Depth	9 ft	Current avg annual flow	1502 MMgal/yr
Res 6 Acres	174 acres	Sulfate Treatment	50% (278 tons sulfate removed)
Res 6 Avg Depth	10 ft		

Table 3. Predicted Sulfate Concentration With Expansion - Annual High Flow Phase 1

Year	Inner Tailings Pond Area (acres)	Inner Tailings Pond Volume (gal)	Total System Volume (gal)	Increased Tailings Pond Evap (gal)	Discharge from Sargent Pit into Res 2 (gal)	Res 2 Pumping into Res 6 (gal)	Void Loss (gal)	Res 6 Discharge w/out Sargent (gal)	Pellet Cooling (gal)	Misc to Welcome Creek (gal)	Tailings Basin to Groundwater (gal)	Pellet Indurator Loss (gal)	Total System "Blow-Down" (gal)	Additional Sulfate Equilibrium Conc (ppm)	Estimated System Equilibrium Conc (ppm)	Predicted Actual Conc. (ppm)
2005	600	1.99E+09	3.50E+09	0	0	0	652,486,154	-174,250,474	42,048,000	105,120,000	140,000,000	177,266,187	9.4E+08	141	207	66
2006	600	1.99E+09	3.50E+09	0	0	686,900,000	652,486,154	42,510,486	42,048,000	105,120,000	138,000,000	177,266,187	1.8E+09	72	138	96
2007	700	2.33E+09	3.83E+09	39479589.6	0	827,700,000	652,486,154	381,878,166	42,048,000	105,120,000	336,000,000	177,266,187	2.5E+09	53	119	107
2008	800	2.66E+09	4.16E+09	78959179.2	0		652,486,154	86,854,951	42,048,000	105,120,000	138,000,000	177,266,187	1.2E+09	111	177	124
2009	1000	2.93E+09	4.43E+09	157,918,358	0		652,486,154	1,044,033,145*	42,048,000	105,120,000	281,000,000	177,266,187	2.3E+09	58	124	124
2010	1300	3.39E+09	4.89E+09	276,357,127	254,000,000	254,000,000	652,486,154	776,319,212	42,048,000	105,120,000	281,000,000	177,266,187	2.3E+09	58	124	124
2011	1700	3.88E+09	5.38E+09	434,275,486	254,000,000	254,000,000	652,486,154	618,033,969	42,048,000	105,120,000	281,000,000	177,266,187	2.1E+09	62	128	126
2012	2000	3.91E+09	5.41E+09	552,714,254	298,000,000	298,000,000	942,480,000	624,919,406	67,276,800	168,192,000	281,000,000	265,899,281	2.6E+09	25	91	112
2013	2000	3.91E+09	5.41E+09	552,714,254	342,000,000	342,000,000	942,480,000	631,804,842	67,276,800	168,192,000	281,000,000	265,899,281	2.7E+09	25	91	104
2014	2000	3.91E+09	5.41E+09	552,714,254	386,000,000	386,000,000	942,480,000	638,690,279	67,276,800	168,192,000	281,000,000	265,899,281	2.7E+09	24	90	98
2015	2000	3.91E+09	5.41E+09	552,714,254	430,000,000	430,000,000	942,480,000	645,575,715	67,276,800	168,192,000	281,000,000	265,899,281	2.8E+09	24	90	95
2016	2000	3.91E+09	5.41E+09	552,714,254	523,700,000	523,700,000	942,480,000	2,481,000,000	67,276,800	168,192,000	281,000,000	265,899,281	4.7E+09	14	80	86
2017	2000	3.91E+09	5.41E+09	552,714,254	530,200,000	530,200,000	942,480,000	613,661,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	87
2018	2000	3.91E+09	5.41E+09	552,714,254	586,400,000	586,400,000	942,480,000	574,861,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	88
2019	2000	3.91E+09	5.41E+09	552,714,254	642,600,000	642,600,000	942,480,000	536,061,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	88
2020	2000	3.91E+09	5.41E+09	552,714,254	698,800,000	698,800,000	942,480,000	497,261,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	89
2021	2000	3.91E+09	5.41E+09	552,714,254	755,000,000	755,000,000	942,480,000	458,461,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	89
2022	2000	3.91E+09	5.41E+09	552,714,254	727,000,000	727,000,000	942,480,000	502,661,152	67,276,800	168,192,000	281,000,000	265,899,281	3.0E+09	23	89	89
2023	2000	3.91E+09	5.41E+09	552,714,254	699,000,000	699,000,000	942,480,000	546,861,152	67,276,800	168,192,000	281,000,000	265,899,281	3.0E+09	22	88	88
2024	2000	3.91E+09	5.41E+09	552,714,254	671,000,000	671,000,000	942,480,000	591,061,152	67,276,800	168,192,000	281,000,000	265,899,281	3.0E+09	22	88	88
2025	2000	3.91E+09	5.41E+09	552,714,254	643,000,000	643,000,000	942,480,000	635,261,152	67,276,800	168,192,000	281,000,000	265,899,281	3.0E+09	22	88	88
2026	2000	3.91E+09	5.41E+09	552,714,254	615,000,000	615,000,000	942,480,000	679,461,152	67,276,800	168,192,000	281,000,000	265,899,281	3.0E+09	22	88	88
2027	2000	3.91E+09	5.41E+09	552,714,254	616,800,000	616,800,000	942,480,000	850,061,152	67,276,800	168,192,000	281,000,000	265,899,281	3.2E+09	21	87	88
2028	2000	3.91E+09	5.41E+09	552,714,254	618,600,000	618,600,000	942,480,000	1,020,661,152	67,276,800	168,192,000	281,000,000	265,899,281	3.4E+09	20	86	87
2029	2000	3.91E+09	5.41E+09	552,714,254	620,400,000	620,400,000	942,480,000	1,191,261,152	67,276,800	168,192,000	281,000,000	265,899,281	3.5E+09	19	85	86
2030	2000	3.91E+09	5.41E+09	552,714,254	622,200,000	622,200,000	942,480,000	1,361,861,152	67,276,800	168,192,000	281,000,000	265,899,281	3.7E+09	18	84	85
2031	2000	3.91E+09	5.41E+09	552,714,254	624,000,000	624,000,000	942,480,000	1,532,461,152	67,276,800	168,192,000	281,000,000	265,899,281	3.9E+09	17	83	84
2032	2000	3.91E+09	5.41E+09	552,714,254	680,800,000	680,800,000	942,480,000	1,493,861,152	67,276,800	168,192,000	281,000,000	265,899,281	3.9E+09	17	83	84
2033	2000	3.91E+09	5.41E+09	552,714,254	737,600,000	737,600,000	942,480,000	1,455,261,152	67,276,800	168,192,000	281,000,000	265,899,281	3.9E+09	17	83	83
2034	2000	3.91E+09	5.41E+09	552,714,254	794,400,000	794,400,000	942,480,000	1,416,661,152	67,276,800	168,192,000	281,000,000	265,899,281	3.9E+09	17	83	83
2035	2000	3.91E+09	5.41E+09	552,714,254	851,200,000	851,200,000	942,480,000	1,378,061,152	67,276,800	168,192,000	281,000,000	265,899,281	4.0E+09	17	83	83
2036	2000	3.91E+09	5.41E+09	552,714,254	908,000,000	908,000,000	942,480,000	1,339,461,152	67,276,800	168,192,000	281,000,000	265,899,281	4.0E+09	17	83	83

* Sargent Mine Yield was discharge to Reservoir 6 through the Russell Pit in 2009.

Pre-scrubber sulfate	66 ppm
Tailings Pond Avg Depth	10.2 ft
Second Stage Pond Acres	319 acres
Second Stage Pond Avg Depth	9 ft
Res 6 Acres	174 acres
Res 6 Avg Depth	10 ft

Average AET in non-clear pool tailings area	11.96 inches
Increased Evap when water covered	26.5 inches
Sulfate addition from scrubber	555 tons/yr
Current avg annual flow	1502 MMgal/yr
Sulfate Treatment	50% (278 tons sulfate removed)

Table 4. Predicted Sulfate Concentration With Expansion - Annual High Flow Phase 2

Year	Inner Tailings Pond Area (acres)	Inner Tailings Pond Volume (gal)	Total System Volume (gal)	Increased Tailings Pond Evap (gal)	Discharge from Sargent Pit into Res 2 (gal)	Res 2 Pumping into Res 6 (gal)	Void Loss (gal)	Res 6 Discharge w/out Sargent (gal)	Pellet Cooling (gal)	Misc to Welcome Creek (gal)	Tailings Basin to Groundwater (gal)	Pellet Indurator Loss (gal)	Total System "Blow-Down" (gal)	Additional Sulfate Equilibrium Conc (ppm)	Estimated System Equilibrium Conc (ppm)	Predicted Actual Conc. (ppm)
2005	600	1.99E+09	3.50E+09	0	0	0	652,486,154	-174,250,474	42,048,000	105,120,000	140,000,000	177,266,187	9.4E+08	141	207	66
2006	600	1.99E+09	3.50E+09	0	0	686,900,000	652,486,154	42,510,486	42,048,000	105,120,000	138,000,000	177,266,187	1.8E+09	72	138	96
2007	700	2.33E+09	3.83E+09	39479589.6	0	827,700,000	652,486,154	381,878,166	42,048,000	105,120,000	336,000,000	177,266,187	2.5E+09	53	119	107
2008	800	2.66E+09	4.16E+09	78959179.2	0		652,486,154	86,854,951	42,048,000	105,120,000	138,000,000	177,266,187	1.2E+09	111	177	124
2009	1000	2.93E+09	4.43E+09	157,918,358	0		652,486,154	1,044,033,145*	42,048,000	105,120,000	281,000,000	177,266,187	2.3E+09	58	124	124
2010	1300	3.39E+09	4.89E+09	276,357,127	254,000,000	254,000,000	652,486,154	776,319,212	42,048,000	105,120,000	281,000,000	177,266,187	2.3E+09	58	124	124
2011	1700	3.88E+09	5.38E+09	434,275,486	254,000,000	254,000,000	652,486,154	618,033,969	42,048,000	105,120,000	281,000,000	177,266,187	2.1E+09	62	128	126
2012	2000	3.91E+09	5.41E+09	552,714,254	298,000,000	298,000,000	942,480,000	624,919,406	67,276,800	168,192,000	281,000,000	265,899,281	2.6E+09	25	91	112
2013	2000	3.91E+09	5.41E+09	552,714,254	342,000,000	342,000,000	942,480,000	631,804,842	67,276,800	168,192,000	281,000,000	265,899,281	2.7E+09	25	91	104
2014	2000	3.91E+09	5.41E+09	552,714,254	386,000,000	386,000,000	942,480,000	638,690,279	67,276,800	168,192,000	281,000,000	265,899,281	2.7E+09	24	90	98
2015	2000	3.91E+09	5.41E+09	552,714,254	430,000,000	430,000,000	942,480,000	645,575,715	67,276,800	168,192,000	281,000,000	265,899,281	2.8E+09	24	90	95
2016	2000	3.91E+09	5.41E+09	552,714,254	474,000,000	474,000,000	942,480,000	652,461,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	93
2017	2000	3.91E+09	5.41E+09	552,714,254	530,200,000	530,200,000	942,480,000	613,661,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	91
2018	2000	3.91E+09	5.41E+09	552,714,254	586,400,000	586,400,000	942,480,000	574,861,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	90
2019	2000	3.91E+09	5.41E+09	552,714,254	642,600,000	642,600,000	942,480,000	536,061,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	90
2020	2000	3.91E+09	5.41E+09	552,714,254	698,800,000	698,800,000	942,480,000	497,261,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	89
2021	2000	3.91E+09	5.41E+09	552,714,254	869,200,000	869,200,000	942,480,000	2,211,000,000	67,276,800	168,192,000	281,000,000	265,899,281	4.8E+09	14	80	84
2022	2000	3.91E+09	5.41E+09	552,714,254	727,000,000	727,000,000	942,480,000	502,661,152	67,276,800	168,192,000	281,000,000	265,899,281	3.0E+09	23	89	86
2023	2000	3.91E+09	5.41E+09	552,714,254	699,000,000	699,000,000	942,480,000	546,861,152	67,276,800	168,192,000	281,000,000	265,899,281	3.0E+09	22	88	87
2024	2000	3.91E+09	5.41E+09	552,714,254	671,000,000	671,000,000	942,480,000	591,061,152	67,276,800	168,192,000	281,000,000	265,899,281	3.0E+09	22	88	87
2025	2000	3.91E+09	5.41E+09	552,714,254	643,000,000	643,000,000	942,480,000	635,261,152	67,276,800	168,192,000	281,000,000	265,899,281	3.0E+09	22	88	88
2026	2000	3.91E+09	5.41E+09	552,714,254	615,000,000	615,000,000	942,480,000	679,461,152	67,276,800	168,192,000	281,000,000	265,899,281	3.0E+09	22	88	88
2027	2000	3.91E+09	5.41E+09	552,714,254	616,800,000	616,800,000	942,480,000	850,061,152	67,276,800	168,192,000	281,000,000	265,899,281	3.2E+09	21	87	87
2028	2000	3.91E+09	5.41E+09	552,714,254	618,600,000	618,600,000	942,480,000	1,020,661,152	67,276,800	168,192,000	281,000,000	265,899,281	3.4E+09	20	86	87
2029	2000	3.91E+09	5.41E+09	552,714,254	620,400,000	620,400,000	942,480,000	1,191,261,152	67,276,800	168,192,000	281,000,000	265,899,281	3.5E+09	19	85	86
2030	2000	3.91E+09	5.41E+09	552,714,254	622,200,000	622,200,000	942,480,000	1,361,861,152	67,276,800	168,192,000	281,000,000	265,899,281	3.7E+09	18	84	85
2031	2000	3.91E+09	5.41E+09	552,714,254	624,000,000	624,000,000	942,480,000	1,532,461,152	67,276,800	168,192,000	281,000,000	265,899,281	3.9E+09	17	83	84
2032	2000	3.91E+09	5.41E+09	552,714,254	680,800,000	680,800,000	942,480,000	1,493,861,152	67,276,800	168,192,000	281,000,000	265,899,281	3.9E+09	17	83	83
2033	2000	3.91E+09	5.41E+09	552,714,254	737,600,000	737,600,000	942,480,000	1,455,261,152	67,276,800	168,192,000	281,000,000	265,899,281	3.9E+09	17	83	83
2034	2000	3.91E+09	5.41E+09	552,714,254	794,400,000	794,400,000	942,480,000	1,416,661,152	67,276,800	168,192,000	281,000,000	265,899,281	3.9E+09	17	83	83
2035	2000	3.91E+09	5.41E+09	552,714,254	851,200,000	851,200,000	942,480,000	1,378,061,152	67,276,800	168,192,000	281,000,000	265,899,281	4.0E+09	17	83	83
2036	2000	3.91E+09	5.41E+09	552,714,254	908,000,000	908,000,000	942,480,000	1,339,461,152	67,276,800	168,192,000	281,000,000	265,899,281	4.0E+09	17	83	83

* Sargent Mine Yield was discharge to Reservoir 6 through the Russell Pit in 2009.

Pre-scrubber sulfate	66 ppm
Tailings Pond Avg Depth	10.2 ft
Second Stage Pond Acres	319 acres
Second Stage Pond Avg Depth	9 ft
Res 6 Acres	174 acres
Res 6 Avg Depth	10 ft

Average AET in non-clear pool tailings area	11.96 inches
Increased Evap when water covered	26.5 inches
Sulfate addition from scrubber	555 tons/yr
Current avg annual flow	1502 MMgal/yr
Sulfate Treatment	50% (278 tons sulfate removed)

Table 5. Predicted Sulfate Concentration With Expansion - Annual High Flow Phase 3

Year	Inner Tailings Pond Area (acres)	Inner Tailings Pond Volume (gal)	Total System Volume (gal)	Increased Tailings Pond Evap (gal)	Discharge from Sargent Pit into Res 2 (gal)	Res 2 Pumping into Res 6 (gal)	Void Loss (gal)	Res 6 Discharge w/out Sargent (gal)	Pellet Cooling (gal)	Misc to Welcome Creek (gal)	Tailings Basin to Groundwater (gal)	Pellet Indurator Loss (gal)	Total System "Blow-Down" (gal)	Additional Sulfate Equilibrium Conc (ppm)	Estimated System Equilibrium Conc (ppm)	Predicted Actual Conc. (ppm)
2005	600	1.99E+09	3.50E+09	0	0	0	652,486,154	-174,250,474	42,048,000	105,120,000	140,000,000	177,266,187	9.4E+08	141	207	66
2006	600	1.99E+09	3.50E+09	0	0	686,900,000	652,486,154	42,510,486	42,048,000	105,120,000	138,000,000	177,266,187	1.8E+09	72	138	96
2007	700	2.33E+09	3.83E+09	39479589.6	0	827,700,000	652,486,154	381,878,166	42,048,000	105,120,000	336,000,000	177,266,187	2.5E+09	53	119	107
2008	800	2.66E+09	4.16E+09	78959179.2	0		652,486,154	86,854,951	42,048,000	105,120,000	138,000,000	177,266,187	1.2E+09	111	177	124
2009	1000	2.93E+09	4.43E+09	157,918,358	0		652,486,154	1,044,033,145*	42,048,000	105,120,000	281,000,000	177,266,187	2.3E+09	58	124	124
2010	1300	3.39E+09	4.89E+09	276,357,127	254,000,000	254,000,000	652,486,154	776,319,212	42,048,000	105,120,000	281,000,000	177,266,187	2.3E+09	58	124	124
2011	1700	3.88E+09	5.38E+09	434,275,486	254,000,000	254,000,000	652,486,154	618,033,969	42,048,000	105,120,000	281,000,000	177,266,187	2.1E+09	62	128	126
2012	2000	3.91E+09	5.41E+09	552,714,254	298,000,000	298,000,000	942,480,000	624,919,406	67,276,800	168,192,000	281,000,000	265,899,281	2.6E+09	25	91	112
2013	2000	3.91E+09	5.41E+09	552,714,254	342,000,000	342,000,000	942,480,000	631,804,842	67,276,800	168,192,000	281,000,000	265,899,281	2.7E+09	25	91	104
2014	2000	3.91E+09	5.41E+09	552,714,254	386,000,000	386,000,000	942,480,000	638,690,279	67,276,800	168,192,000	281,000,000	265,899,281	2.7E+09	24	90	98
2015	2000	3.91E+09	5.41E+09	552,714,254	430,000,000	430,000,000	942,480,000	645,575,715	67,276,800	168,192,000	281,000,000	265,899,281	2.8E+09	24	90	95
2016	2000	3.91E+09	5.41E+09	552,714,254	474,000,000	474,000,000	942,480,000	652,461,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	93
2017	2000	3.91E+09	5.41E+09	552,714,254	530,200,000	530,200,000	942,480,000	613,661,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	91
2018	2000	3.91E+09	5.41E+09	552,714,254	586,400,000	586,400,000	942,480,000	574,861,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	90
2019	2000	3.91E+09	5.41E+09	552,714,254	642,600,000	642,600,000	942,480,000	536,061,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	90
2020	2000	3.91E+09	5.41E+09	552,714,254	698,800,000	698,800,000	942,480,000	497,261,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	89
2021	2000	3.91E+09	5.41E+09	552,714,254	755,000,000	755,000,000	942,480,000	458,461,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	89
2022	2000	3.91E+09	5.41E+09	552,714,254	727,000,000	727,000,000	942,480,000	502,661,152	67,276,800	168,192,000	281,000,000	265,899,281	3.0E+09	23	89	89
2023	2000	3.91E+09	5.41E+09	552,714,254	699,000,000	699,000,000	942,480,000	546,861,152	67,276,800	168,192,000	281,000,000	265,899,281	3.0E+09	22	88	89
2024	2000	3.91E+09	5.41E+09	552,714,254	671,000,000	671,000,000	942,480,000	591,061,152	67,276,800	168,192,000	281,000,000	265,899,281	3.0E+09	22	88	88
2025	2000	3.91E+09	5.41E+09	552,714,254	643,000,000	643,000,000	942,480,000	635,261,152	67,276,800	168,192,000	281,000,000	265,899,281	3.0E+09	22	88	88
2026	2000	3.91E+09	5.41E+09	552,714,254	728,700,000	728,700,000	942,480,000	2,460,000,000	67,276,800	168,192,000	281,000,000	265,899,281	4.9E+09	14	80	83
2027	2000	3.91E+09	5.41E+09	552,714,254	616,800,000	616,800,000	942,480,000	850,061,152	67,276,800	168,192,000	281,000,000	265,899,281	3.2E+09	21	87	85
2028	2000	3.91E+09	5.41E+09	552,714,254	618,600,000	618,600,000	942,480,000	1,020,661,152	67,276,800	168,192,000	281,000,000	265,899,281	3.4E+09	20	86	85
2029	2000	3.91E+09	5.41E+09	552,714,254	620,400,000	620,400,000	942,480,000	1,191,261,152	67,276,800	168,192,000	281,000,000	265,899,281	3.5E+09	19	85	85
2030	2000	3.91E+09	5.41E+09	552,714,254	622,200,000	622,200,000	942,480,000	1,361,861,152	67,276,800	168,192,000	281,000,000	265,899,281	3.7E+09	18	84	84
2031	2000	3.91E+09	5.41E+09	552,714,254	624,000,000	624,000,000	942,480,000	1,532,461,152	67,276,800	168,192,000	281,000,000	265,899,281	3.9E+09	17	83	84
2032	2000	3.91E+09	5.41E+09	552,714,254	680,800,000	680,800,000	942,480,000	1,493,861,152	67,276,800	168,192,000	281,000,000	265,899,281	3.9E+09	17	83	83
2033	2000	3.91E+09	5.41E+09	552,714,254	737,600,000	737,600,000	942,480,000	1,455,261,152	67,276,800	168,192,000	281,000,000	265,899,281	3.9E+09	17	83	83
2034	2000	3.91E+09	5.41E+09	552,714,254	794,400,000	794,400,000	942,480,000	1,416,661,152	67,276,800	168,192,000	281,000,000	265,899,281	3.9E+09	17	83	83
2035	2000	3.91E+09	5.41E+09	552,714,254	851,200,000	851,200,000	942,480,000	1,378,061,152	67,276,800	168,192,000	281,000,000	265,899,281	4.0E+09	17	83	83
2036	2000	3.91E+09	5.41E+09	552,714,254	908,000,000	908,000,000	942,480,000	1,339,461,152	67,276,800	168,192,000	281,000,000	265,899,281	4.0E+09	17	83	83

* Sargent Mine Yield was discharge to Reservoir 6 through the Russell Pit in 2009.

Pre-scrubber sulfate	66 ppm
Tailings Pond Avg Depth	10.2 ft
Second Stage Pond Acres	319 acres
Second Stage Pond Avg Depth	9 ft
Res 6 Acres	174 acres
Res 6 Avg Depth	10 ft

Average AET in non-clear pool tailings area	11.96 inches
Increased Evap when water covered	26.5 inches
Sulfate addition from scrubber	555 tons/yr
Current avg annual flow	1502 MMgal/yr
Sulfate Treatment	50% (278 tons sulfate removed)

Table 6. Predicted Sulfate Concentration With Expansion - Annual High Flow Phase 4

Year	Inner Tailings Pond Area (acres)	Inner Tailings Pond Volume (gal)	Total System Volume (gal)	Increased Tailings Pond Evap (gal)	Discharge from Sargent Pit into Res 2 (gal)	Res 2 Pumping into Res 6 (gal)	Void Loss (gal)	Res 6 Discharge w/out Sargent (gal)	Pellet Cooling (gal)	Misc to Welcome Creek (gal)	Tailings Basin to Groundwater (gal)	Pellet Indurator Loss (gal)	Total System "Blow-Down" (gal)	Additional Sulfate Equilibrium Conc (ppm)	Estimated System Equilibrium Conc (ppm)	Predicted Actual Conc. (ppm)
2005	600	1.99E+09	3.50E+09	0	0	0	652,486,154	-174,250,474	42,048,000	105,120,000	140,000,000	177,266,187	9.4E+08	141	207	66
2006	600	1.99E+09	3.50E+09	0	0	686,900,000	652,486,154	42,510,486	42,048,000	105,120,000	138,000,000	177,266,187	1.8E+09	72	138	96
2007	700	2.33E+09	3.83E+09	39479589.6	0	827,700,000	652,486,154	381,878,166	42,048,000	105,120,000	336,000,000	177,266,187	2.5E+09	53	119	107
2008	800	2.66E+09	4.16E+09	78959179.2	0		652,486,154	86,854,951	42,048,000	105,120,000	138,000,000	177,266,187	1.2E+09	111	177	124
2009	1000	2.93E+09	4.43E+09	157,918,358	0		652,486,154	1,044,033,145*	42,048,000	105,120,000	281,000,000	177,266,187	2.3E+09	58	124	124
2010	1300	3.39E+09	4.89E+09	276,357,127	254,000,000	254,000,000	652,486,154	776,319,212	42,048,000	105,120,000	281,000,000	177,266,187	2.3E+09	58	124	124
2011	1700	3.88E+09	5.38E+09	434,275,486	254,000,000	254,000,000	652,486,154	618,033,969	42,048,000	105,120,000	281,000,000	177,266,187	2.1E+09	62	128	126
2012	2000	3.91E+09	5.41E+09	552,714,254	298,000,000	298,000,000	942,480,000	624,919,406	67,276,800	168,192,000	281,000,000	265,899,281	2.6E+09	25	91	112
2013	2000	3.91E+09	5.41E+09	552,714,254	342,000,000	342,000,000	942,480,000	631,804,842	67,276,800	168,192,000	281,000,000	265,899,281	2.7E+09	25	91	104
2014	2000	3.91E+09	5.41E+09	552,714,254	386,000,000	386,000,000	942,480,000	638,690,279	67,276,800	168,192,000	281,000,000	265,899,281	2.7E+09	24	90	98
2015	2000	3.91E+09	5.41E+09	552,714,254	430,000,000	430,000,000	942,480,000	645,575,715	67,276,800	168,192,000	281,000,000	265,899,281	2.8E+09	24	90	95
2016	2000	3.91E+09	5.41E+09	552,714,254	474,000,000	474,000,000	942,480,000	652,461,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	93
2017	2000	3.91E+09	5.41E+09	552,714,254	530,200,000	530,200,000	942,480,000	613,661,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	91
2018	2000	3.91E+09	5.41E+09	552,714,254	586,400,000	586,400,000	942,480,000	574,861,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	90
2019	2000	3.91E+09	5.41E+09	552,714,254	642,600,000	642,600,000	942,480,000	536,061,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	90
2020	2000	3.91E+09	5.41E+09	552,714,254	698,800,000	698,800,000	942,480,000	497,261,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	89
2021	2000	3.91E+09	5.41E+09	552,714,254	755,000,000	755,000,000	942,480,000	458,461,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	89
2022	2000	3.91E+09	5.41E+09	552,714,254	727,000,000	727,000,000	942,480,000	502,661,152	67,276,800	168,192,000	281,000,000	265,899,281	3.0E+09	23	89	89
2023	2000	3.91E+09	5.41E+09	552,714,254	699,000,000	699,000,000	942,480,000	546,861,152	67,276,800	168,192,000	281,000,000	265,899,281	3.0E+09	22	88	89
2024	2000	3.91E+09	5.41E+09	552,714,254	671,000,000	671,000,000	942,480,000	591,061,152	67,276,800	168,192,000	281,000,000	265,899,281	3.0E+09	22	88	88
2025	2000	3.91E+09	5.41E+09	552,714,254	643,000,000	643,000,000	942,480,000	635,261,152	67,276,800	168,192,000	281,000,000	265,899,281	3.0E+09	22	88	88
2026	2000	3.91E+09	5.41E+09	552,714,254	615,000,000	615,000,000	942,480,000	679,461,152	67,276,800	168,192,000	281,000,000	265,899,281	3.0E+09	22	88	88
2027	2000	3.91E+09	5.41E+09	552,714,254	616,800,000	616,800,000	942,480,000	850,061,152	67,276,800	168,192,000	281,000,000	265,899,281	3.2E+09	21	87	88
2028	2000	3.91E+09	5.41E+09	552,714,254	618,600,000	618,600,000	942,480,000	1,020,661,152	67,276,800	168,192,000	281,000,000	265,899,281	3.4E+09	20	86	87
2029	2000	3.91E+09	5.41E+09	552,714,254	620,400,000	620,400,000	942,480,000	1,191,261,152	67,276,800	168,192,000	281,000,000	265,899,281	3.5E+09	19	85	86
2030	2000	3.91E+09	5.41E+09	552,714,254	622,200,000	622,200,000	942,480,000	1,361,861,152	67,276,800	168,192,000	281,000,000	265,899,281	3.7E+09	18	84	85
2031	2000	3.91E+09	5.41E+09	552,714,254	740,600,000	740,600,000	942,480,000	3,327,000,000	67,276,800	168,192,000	281,000,000	265,899,281	5.8E+09	11	77	80
2032	2000	3.91E+09	5.41E+09	552,714,254	680,800,000	680,800,000	942,480,000	1,493,861,152	67,276,800	168,192,000	281,000,000	265,899,281	3.9E+09	17	83	82
2033	2000	3.91E+09	5.41E+09	552,714,254	737,600,000	737,600,000	942,480,000	1,455,261,152	67,276,800	168,192,000	281,000,000	265,899,281	3.9E+09	17	83	82
2034	2000	3.91E+09	5.41E+09	552,714,254	794,400,000	794,400,000	942,480,000	1,416,661,152	67,276,800	168,192,000	281,000,000	265,899,281	3.9E+09	17	83	83
2035	2000	3.91E+09	5.41E+09	552,714,254	851,200,000	851,200,000	942,480,000	1,378,061,152	67,276,800	168,192,000	281,000,000	265,899,281	4.0E+09	17	83	83
2036	2000	3.91E+09	5.41E+09	552,714,254	908,000,000	908,000,000	942,480,000	1,339,461,152	67,276,800	168,192,000	281,000,000	265,899,281	4.0E+09	17	83	83

* Sargent Mine Yield was discharge to Reservoir 6 through the Russell Pit in 2009.

Pre-scrubber sulfate	66 ppm
Tailings Pond Avg Depth	10.2 ft
Second Stage Pond Acres	319 acres
Second Stage Pond Avg Depth	9 ft
Res 6 Acres	174 acres
Res 6 Avg Depth	10 ft

Average AET in non-clear pool tailings area	11.96 inches
Increased Evap when water covered	26.5 inches
Sulfate addition from scrubber	555 tons/yr
Current avg annual flow	1502 MMgal/yr
Sulfate Treatment	50% (278 tons sulfate removed)

Table 7. Predicted Sulfate Concentration With Expansion - Annual High Flow Phase 5

Year	Inner Tailings Pond Area (acres)	Inner Tailings Pond Volume (gal)	Total System Volume (gal)	Increased Tailings Pond Evap (gal)	Discharge from Sargent Pit into Res 2 (gal)	Res 2 Pumping into Res 6 (gal)	Void Loss (gal)	Res 6 Discharge w/out Sargent (gal)	Pellet Cooling (gal)	Misc to Welcome Creek (gal)	Tailings Basin to Groundwater (gal)	Pellet Indurator Loss (gal)	Total System "Blow-Down" (gal)	Additional Sulfate Equilibrium Conc (ppm)	Estimated System Equilibrium Conc (ppm)	Predicted Actual Conc. (ppm)
2005	600	1.99E+09	3.50E+09	0	0	0	652,486,154	-174,250,474	42,048,000	105,120,000	140,000,000	177,266,187	9.4E+08	141	207	66
2006	600	1.99E+09	3.50E+09	0	0	686,900,000	652,486,154	42,510,486	42,048,000	105,120,000	138,000,000	177,266,187	1.8E+09	72	138	96
2007	700	2.33E+09	3.83E+09	39479589.6	0	827,700,000	652,486,154	381,878,166	42,048,000	105,120,000	336,000,000	177,266,187	2.5E+09	53	119	107
2008	800	2.66E+09	4.16E+09	78959179.2	0		652,486,154	86,854,951	42,048,000	105,120,000	138,000,000	177,266,187	1.2E+09	111	177	124
2009	1000	2.93E+09	4.43E+09	157,918,358	0		652,486,154	1,044,033,145*	42,048,000	105,120,000	281,000,000	177,266,187	2.3E+09	58	124	124
2010	1300	3.39E+09	4.89E+09	276,357,127	254,000,000	254,000,000	652,486,154	776,319,212	42,048,000	105,120,000	281,000,000	177,266,187	2.3E+09	58	124	124
2011	1700	3.88E+09	5.38E+09	434,275,486	254,000,000	254,000,000	652,486,154	618,033,969	42,048,000	105,120,000	281,000,000	177,266,187	2.1E+09	62	128	126
2012	2000	3.91E+09	5.41E+09	552,714,254	298,000,000	298,000,000	942,480,000	624,919,406	67,276,800	168,192,000	281,000,000	265,899,281	2.6E+09	25	91	112
2013	2000	3.91E+09	5.41E+09	552,714,254	342,000,000	342,000,000	942,480,000	631,804,842	67,276,800	168,192,000	281,000,000	265,899,281	2.7E+09	25	91	104
2014	2000	3.91E+09	5.41E+09	552,714,254	386,000,000	386,000,000	942,480,000	638,690,279	67,276,800	168,192,000	281,000,000	265,899,281	2.7E+09	24	90	98
2015	2000	3.91E+09	5.41E+09	552,714,254	430,000,000	430,000,000	942,480,000	645,575,715	67,276,800	168,192,000	281,000,000	265,899,281	2.8E+09	24	90	95
2016	2000	3.91E+09	5.41E+09	552,714,254	474,000,000	474,000,000	942,480,000	652,461,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	93
2017	2000	3.91E+09	5.41E+09	552,714,254	530,200,000	530,200,000	942,480,000	613,661,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	91
2018	2000	3.91E+09	5.41E+09	552,714,254	586,400,000	586,400,000	942,480,000	574,861,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	90
2019	2000	3.91E+09	5.41E+09	552,714,254	642,600,000	642,600,000	942,480,000	536,061,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	90
2020	2000	3.91E+09	5.41E+09	552,714,254	698,800,000	698,800,000	942,480,000	497,261,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	89
2021	2000	3.91E+09	5.41E+09	552,714,254	755,000,000	755,000,000	942,480,000	458,461,152	67,276,800	168,192,000	281,000,000	265,899,281	2.9E+09	23	89	89
2022	2000	3.91E+09	5.41E+09	552,714,254	727,000,000	727,000,000	942,480,000	502,661,152	67,276,800	168,192,000	281,000,000	265,899,281	3.0E+09	23	89	89
2023	2000	3.91E+09	5.41E+09	552,714,254	699,000,000	699,000,000	942,480,000	546,861,152	67,276,800	168,192,000	281,000,000	265,899,281	3.0E+09	22	88	89
2024	2000	3.91E+09	5.41E+09	552,714,254	671,000,000	671,000,000	942,480,000	591,061,152	67,276,800	168,192,000	281,000,000	265,899,281	3.0E+09	22	88	88
2025	2000	3.91E+09	5.41E+09	552,714,254	643,000,000	643,000,000	942,480,000	635,261,152	67,276,800	168,192,000	281,000,000	265,899,281	3.0E+09	22	88	88
2026	2000	3.91E+09	5.41E+09	552,714,254	615,000,000	615,000,000	942,480,000	679,461,152	67,276,800	168,192,000	281,000,000	265,899,281	3.0E+09	22	88	88
2027	2000	3.91E+09	5.41E+09	552,714,254	616,800,000	616,800,000	942,480,000	850,061,152	67,276,800	168,192,000	281,000,000	265,899,281	3.2E+09	21	87	88
2028	2000	3.91E+09	5.41E+09	552,714,254	618,600,000	618,600,000	942,480,000	1,020,661,152	67,276,800	168,192,000	281,000,000	265,899,281	3.4E+09	20	86	87
2029	2000	3.91E+09	5.41E+09	552,714,254	620,400,000	620,400,000	942,480,000	1,191,261,152	67,276,800	168,192,000	281,000,000	265,899,281	3.5E+09	19	85	86
2030	2000	3.91E+09	5.41E+09	552,714,254	622,200,000	622,200,000	942,480,000	1,361,861,152	67,276,800	168,192,000	281,000,000	265,899,281	3.7E+09	18	84	85
2031	2000	3.91E+09	5.41E+09	552,714,254	624,000,000	624,000,000	942,480,000	1,532,461,152	67,276,800	168,192,000	281,000,000	265,899,281	3.9E+09	17	83	84
2032	2000	3.91E+09	5.41E+09	552,714,254	680,800,000	680,800,000	942,480,000	1,493,861,152	67,276,800	168,192,000	281,000,000	265,899,281	3.9E+09	17	83	84
2033	2000	3.91E+09	5.41E+09	552,714,254	737,600,000	737,600,000	942,480,000	1,455,261,152	67,276,800	168,192,000	281,000,000	265,899,281	3.9E+09	17	83	83
2034	2000	3.91E+09	5.41E+09	552,714,254	794,400,000	794,400,000	942,480,000	1,416,661,152	67,276,800	168,192,000	281,000,000	265,899,281	3.9E+09	17	83	83
2035	2000	3.91E+09	5.41E+09	552,714,254	851,200,000	851,200,000	942,480,000	1,378,061,152	67,276,800	168,192,000	281,000,000	265,899,281	4.0E+09	17	83	83
2036	2000	3.91E+09	5.41E+09	552,714,254	1,027,000,000	1,027,000,000	942,480,000	3,133,000,000	67,276,800	168,192,000	281,000,000	265,899,281	5.9E+09	11	77	79

* Sargent Mine Yield was discharge to Reservoir 6 through the Russell Pit in 2009.

Pre-scrubber sulfate	66 ppm
Tailings Pond Avg Depth	10.2 ft
Second Stage Pond Acres	319 acres
Second Stage Pond Avg Depth	9 ft
Res 6 Acres	174 acres
Res 6 Avg Depth	10 ft

Average AET in non-clear pool tailings area	11.96 inches
Increased Evap when water covered	26.5 inches
Sulfate addition from scrubber	555 tons/yr
Current avg annual flow	1502 MMgal/yr
Sulfate Treatment	50% (278 tons sulfate removed)

Table 8. Reservoir 6 Discharge Loading - Annual High Flow

Year	Highest Reservoir 6 Discharge (High Precip) (MGY)	Predicted Reservoir 6 Sulfate Concentration (mg/L)	Maximum Reservoir 6 Annual Sulfate Loading (TPY)
1999-2000*	5,297	62.1	1,370
2012-2016	3,005	86	1,080
2017-2021	3,081	84	1,080
2022-2026	3,189	83	1,100
2027-2031	4,068	80	1,360
2032-2036	4,160	79	1,370

Notes:
MGY - Million gallons per year
TPY - Tons per year
* Nondegredation analysis by 1988 permit rules (conservative)

WaterLegacy September 22, 2025 Comments on U.S. Steel Corp NPDES/SDS Permits for Keetac Mining Area (MN0031879) and Keetac Tailings Basin (MN0055948) and on U.S. Steel Corp Application for Variance from Wild Rice Sulfate Standard

EXHIBIT 32

EPA, U.S. Steel's Minntac Tailings Basin Wastewater Discharge,
Functional Equivalent of a Direct Discharge Technical Assistance, July 2023.

U.S. Steel's Minntac Tailings Basin Wastewater Discharge

Functional Equivalent of a Direct Discharge Technical Assistance

Prepared by U.S. Environmental Protection Agency Region 5

July 2023

Ralph Metcalfe Federal Building

77 West Jackson Boulevard

Chicago, IL 60604

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Executive Summary

In response to a request for technical assistance from the Minnesota Pollution Control Agency (MPCA), the National Pollutant Discharge Elimination System (NPDES) permitting authority for the state of Minnesota, EPA evaluated whether seepage of pollutants from the United States Steel Corporation's (U.S. Steel's) Minntac Tailings Basin Area (tailings basin or basin) (NPDES Permit MN0057207) that reaches surface waters is the "functional equivalent" of a direct discharge. The tailings basin is part of U.S. Steel's Minntac mine, which is located in Mountain Iron, St. Louis County, Minnesota and has been in operation since approximately 1967.

The Clean Water Act (CWA), EPA's regulations, and relevant court decisions provide that an NPDES permit is necessary to authorize the discharge of pollutants from point sources to waters of the United States. The Supreme Court decision in *County of Maui v. Hawaii Wildlife Fund*, 140 S. Ct. 1462 (2020) (*Maui*) determined that a discharge of pollutants requires an NPDES permit if the discharge is the "functional equivalent" of a direct discharge.

The Supreme Court decision in *Maui* outlined a non-exhaustive list of seven factors that may be relevant in determining whether a discharge through groundwater is the "functional equivalent" of a direct discharge. The Supreme Court explained that "*time and distance will be the most important factors in most cases, but not necessarily every case*." *Id.*, 140 S. Ct. at 1477. Those factors include: 1) transit time, 2) distance traveled, 3) the nature of the material through which the pollutant travels, 4) the extent to which the pollutant is diluted or chemically changed as it travels, 5) the amount of pollutant entering the navigable waters relative to the amount of the pollutant that leaves the point source, 6) the manner by or area in which the pollutant enters the navigable waters, and 7) the degree to which the pollution (at that point) has maintained its specific identity. *Id.*, 140 S. Ct. at 1476–77. As the Supreme Court noted, the seven factors identified in its opinion were just some of the factors that may prove relevant to determining whether a discharge through groundwater is the functional equivalent of a direct discharge. For this analysis, EPA did not identify any additional factors that are relevant. The Supreme Court also noted that different considerations may be relevant in factually different cases. The Supreme Court identified time and distance as the most important factors in most cases and left flexibility in how to weigh the relevant factors. While this technical assistance evaluates each of the seven factors identified by the Supreme Court in *Maui* in order to be as helpful to the State as possible, it is not necessary to evaluate every factor to find that a discharge is the functional equivalent of a direct discharge. Where one or two factors, such as transit time and distance traveled, present evidence that a discharge is the functional equivalent of a direct discharge, analysis of other factors may not be needed. For this technical analysis, EPA evaluated each of the factors identified in *Maui* and defers the weighing of the factors to the NPDES permitting authority.

In considering the factors outlined in *Maui*, EPA's site-specific technical assistance evaluates seepage from the tailings basin to waters of the United States, and historic, background, and downstream water quality information. Based on the information available, EPA understands that the basin has been continuously discharging pollutants since approximately 1967 and will continue to do so for the foreseeable future.

EPA is providing this site-specific evaluation for consideration by MPCA in response to MPCA's request. This evaluation is based on information from a variety of publicly available documents provided by MPCA, referenced herein, and could change based on new or additional information. Under section 402(b) of the CWA, a State, such as Minnesota, that has an NPDES

program approved by EPA, has exclusive authority to administer the program. EPA can, as in this instance, provide technical assistance by providing information for the State to consider in administering its program and deciding whether in its judgment, as the exclusive permitting authority, an NPDES permit is required in a particular instance. Such technical assistance to MPCA creates no rights of third parties and is not a permitting action or otherwise a regulatory decision by EPA having any legal effect.

1. *Transit Time*

The tailings basin is located adjacent to jurisdictional surface waters. Pollutants discharge from the basin and reach jurisdictional surface waters adjacent to or in a relatively short distance from the outer edge of the perimeter dike. The perimeter dike (approximately 9.1 miles in length) is pervious and was constructed from waste material that extends below the ground surface. As wastewater travels through the material of the perimeter dike via subsurface flow, pollutants continue to leach into the subsurface water and groundwater. Thus, this report presents estimates of transit time and distance traveled from the outer edge of the perimeter dike to waters of the U.S.

EPA reviewed groundwater models, including pathline studies (which simulate pollutant pathways from the tailings basin to surface waters) that were conducted for the Sand River watershed (east) side of the basin. Transit time from the outer edge of the perimeter dike to the adjacent surface waters within the Sand River watershed (i.e., the shortest pathlines presented in the groundwater studies) is estimated to be less than 1-2 years or in some cases immediately. While pathline studies were not performed in the Dark River watershed, similar timeframes are expected because the tailings basin is similarly located adjacent to surface waters in the Dark River watershed. U.S. Steel's model used the inner edge of the tailings basin perimeter dike to calculate transit time and estimated that pollutants reach surface waters within the Sand River watershed in less than 1-2 years. Some pathways emerge immediately at the toe of the dike while other experience greater transit times through the subsurface before emerging at the surface.

2. *Distance Traveled*

The basin is surrounded by headwaters of major river systems, including wetlands. The basin was constructed on top of the headwaters of the river systems, and discharges from the basin have effectively replaced much of the rivers' headwaters sources. The distance pollutants travel from the basin through waters of the U.S. to downstream waters of the U.S., such as the Twin Lakes, has been the subject of studies carried out by U.S. Steel and others. The records show that pollutants are discharged to waters of the U.S. immediately adjacent to the basin.

3. *The Nature of the Material Through Which the Pollutant Travels*

Pollutants reach surface waters via a variety of pathways, including through the pervious perimeter dike, which is composed of coarse and fine tailings, or underneath the perimeter dike through permeable glacial till. Underlying the glacial till is a relatively impervious granitic bedrock layer that restricts vertical movement of wastewater, thus directing wastewater flow horizontally away from the basin and towards surface waters. The area around the basin to the north, east, and west is relatively flat and characterized as mainly wetlands and streams.

4. *The Extent to Which the Pollutant is Diluted or Chemically Changed as It Travels*

Monitoring data from the tailings basin and at certain locations in surface waters outside of the containment structure were compared. These data indicate that little to no dilution or chemical transformation occurs in these short pathways to surface waters. Additionally, the sulfate and chloride pollutant levels observed in all these locations are much higher than background levels.

For longer pathways to surface water, some pollutants may undergo some transformation while traveling to surface waters. Others, such as chloride, are not transformed at all.

5. *The Amount of Pollutant Entering Waters of the United States Relative to the Amount of the Pollutant That Leaves the Point Source*

EPA reviewed tailings basin wastewater quality data and compared them to water quality data collected at downstream surface water monitoring locations. EPA estimated the amount of pollutant leaving the basin using wastewater seepage rates calculated by U.S. Steel and pollutant loadings calculated at in-stream monitoring sites. EPA used information on sulfate and chloride as general indicators of the presence of a broader spectrum of pollutants.

These estimates indicate that a significant amount of sulfate and chloride that leave the basin and travel through the perimeter dike or via groundwater under the perimeter dike reach surface waters. Furthermore, due to the recirculation and reuse of water from the tailings basin in the on-going taconite processing operations, concentrations of pollutants in the tailings basin are increasing.

EPA did not find an independent measure of the amount of pollutant leaving the tailings basin, only estimates that were themselves based on amounts of basin pollutants observed in surface water. Without that independent measurement it is difficult to evaluate this factor.

6. *The Manner by or Area in Which the Pollutant Enters the Navigable Waters*

The tailings basin was constructed on top of the headwaters of the Sand River and Dark River and in an area rich with jurisdictional wetlands. Pollutants are being discharged from the basin by passing under and through the perimeter dike to surface waters. Generally, the pollutants are transported by advection and dispersion through the materials underlaying and surrounding the tailings basin, with the ultimate result being that the pollutants reach surface waters in significant amounts. The size of this point source, proximity of jurisdictional surface waters, and the abundance of those surface waters results in many potential pathways for pollutants to travel from the basin to surface waters, including discharges to surface waters adjacent to the basin. This technical analysis focuses on certain discrete seeps that emerge immediately adjacent to the basin or within a short distance from the basin. Seepage pathways are depicted in **Figure 19**, **Figure 20**, and **Figure 21**.

7. *The Degree to Which the Pollution (At That Point) Has Maintained Its Specific Identity*

Wastewater from the basin can be specifically identified at locations immediately adjacent to the basin and at downstream surface water monitoring locations. Pollutants discharged via these

short pathways maintain their specific identity and pollutants reaching downstream surface water monitoring locations, while diluted when compared to pollutant concentrations in the tailings basin, still maintain their specific identity emanating from the basin. Chloride is a pollutant that does not alter its structure as it moves from the basin to groundwater and, thereafter, to surface waters. Some of the pollutants discharged from the basin to surface waters may be partially transformed into other pollutants as they migrate through groundwater.

Discussion

EPA's technical assistance and site-specific evaluation, presented in detail in this document, indicates that the tailings basin and its components are a point source that discharges pollutants to jurisdictional surface waters in the Sand and Dark River watersheds. EPA evaluated the seven factors identified by the Supreme Court in *Maui* as applied to the tailings basin to understand whether pollutants from the basin reach surface waters via groundwater or subsurface flow in a manner that is the "functional equivalent" of a direct discharge. Our detailed review is discussed below.

1 Background and Introduction

EPA is providing this evaluation of the United States Steel Corporation's (U.S. Steel) Minntac Tailings Basin Area (tailings basin or basin) in response to a request for technical assistance from MPCA,[1] the permitting authority for the NPDES permit program in the state of Minnesota. This evaluation looks at whether discharges from the tailings basin that reach surface waters via groundwater and directly through the basin's perimeter dike are the functional equivalent of direct discharges under the Supreme Court decision in *County of Maui v. Hawaii Wildlife Fund*, 140 S. Ct. 1462 (2020) (*Maui*). MPCA provided EPA public documents including the administrative record for the 2018 permit and other information available to MPCA. EPA reviewed these materials, which numbered in the hundreds, as a part of this technical assistance. While EPA is not required to provide this technical assistance to the State pursuant to the CWA, and while MPCA is not required to rely upon it, MPCA may consider EPA's evaluation to inform its permitting decisions for the tailings basin.

The information available to EPA indicates that the tailings basin and components are point sources that discharge pollutants to waters of the United States via seeps in the basin's perimeter dike and via groundwater that flows under the basin and the perimeter dike.

EPA's evaluation of whether ongoing discharges from the tailings basin to surface waters via groundwater are the functional equivalent of direct discharges would, in EPA's technical judgement, be consistent with the Supreme Court's decision in *Maui*. In *Maui* the Supreme Court stated, "[w]hether pollutants that arrive at navigable waters after traveling through groundwater are 'from' a point source depends upon how similar to (or different from) the particular discharge is to a direct discharge." *Maui*, 140 S. Ct. at 1476. Further, the Supreme Court in *Maui* outlined a non-exhaustive list of seven factors that may be relevant in determining whether a discharge from a point source to a jurisdictional water is the "functional equivalent" of a direct discharge, depending on the circumstances of a particular case. Those factors include: 1) transit time, 2) distance traveled, 3) the nature of the material through which the pollutant travels, 4) the extent to which the pollutant is diluted or chemically changed as it travels, 5) the amount of pollutant entering the navigable waters relative to the amount of the pollutant that leaves the point source, 6) the manner by or area in which the pollutant enters the navigable waters, and 7) the degree to which the pollution (at that point) has maintained its specific identity. *Id.*, 140 S. Ct. at 1476–77.

EPA evaluated whether the discharge of pollutants from the tailings basin through groundwater and the perimeter dike to jurisdictional surface waters would, in EPA's technical judgment, support a finding by MPCA of the "functional equivalent" of a direct discharge. This is a site-specific evaluation focused on the factors identified in *Maui*.

EPA's evaluation of the tailings basin with respect to the Supreme Court's factors from *Maui* is described in **Section 3**.

[1] MPCA's request was formalized in the October 2021 Joint Evaluation Letter as "**Application of the Maui Decision.** EPA and MPCA will coordinate to apply the Supreme Court decision in the Maui matter to pollutant releases from sources, with a priority on releases from mines."

1.1 *Siting*

The tailings basin spans multiple Sections of Township 59 North, Ranges 18 and 19, Mountain Iron, St. Louis County, Minnesota. The tailings basin covers approximately 8,700 acres (13.6 square miles).[2]

Figure 1 and **Figure 2** provide maps of the facility and site location, respectively. The tailings basin was constructed in the 1960's and has been in operation as a tailings disposal site and process water reservoir for the Minntac Mine since approximately 1967. An NPDES permit was first issued for the tailings basin in 1987 for a portion of the seepage that travels directly through the dike; however, most of the seepage leaving the basin, including seepage underneath and through the dike, was never regulated by an NPDES permit. Seepage collection and return systems (SCRSs) were installed on the east and west sides of the basin and became operational June 2011 and June 2020, respectively.

The basin was constructed by depositing coarse and fine tailings onto the ground and into the wetlands and waterways of the headwaters of the Sand and Dark Rivers, with a smaller portion of the basin within the Johnson Creek watershed, which borders the basin to the north (See **Figure 3** for a site plan depicting the Sand River, Dark River, and Johnson Creek watersheds).

The tailings basin and its receiving waters in the Sand and Dark River watersheds are on the north side of the Laurentian Divide (shown in grey in **Figure 4**), a major watershed divide that separates the Great Lakes basin from the Hudson Bay basin. As shown in **Figure 4**, the Sand River connects downstream to the Pike River, Lake Vermillion, the Vermillion River and onward to Voyageurs National Park, the Boundary Waters Canoe Area Wilderness,[3] and Rainy Lake. The Dark River connects downstream to the Sturgeon River, the Little Fork River, Rainy River, and then Rainy Lake on the border with Canada. Both the Sand River and Dark River begin within a short distance of the basin. The area surrounding these rivers and the basin has expansive wetlands covering thousands of acres which abut rivers and streams that are relatively permanent tributaries, and lakes. See **Figure 5** and **Figure 6** for a depiction of these surface waters including the Sand and Dark Rivers, which are perennial, relatively permanent tributaries and the wetlands abutting those waters.

1.2 *Description of Mining Operation*

The tailings basin is part of a larger mining operation that consists of the Minntac Mine mining area, a processing plant, and the tailings basin. MPCA has issued a separate NPDES permit for the mining area (MN0052493). The principal activity at the Minntac Mine is taconite mining and processing. Taconite processing requires process water and creates process wastewater, fine slurry, and coarse refuse, which are deposited into the tailings basin.[4] Operating at full capacity, the Minntac Mine can produce 15 million long tons of taconite pellets per year.[5] The mining area and processing plant are located on the other side of the Laurentian Divide, in the Great Lakes

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[2] MPCA (2018), *Findings of Fact, Conclusions of Law, and Order*, page 1 of pdf, Background Fact #1.

[3] National Park Service (2016), Letter to MPCA regarding the Public Notice for U.S. Steel Minntac tailings basin National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) Permit MN0057207

[4] MPCA (2018), *Findings of Fact, Conclusions of Law, and Order*, pages 2-3 of pdf, Background Fact #2.

[5] MPCA (2018), *NPDES)/SDS Permit Program Fact Sheet: US Steel Corp. – Minntac Tailings Basin Area*, Permit No. MN0057207, page 9 of pdf.

basin, and are not part of this evaluation.

1.3 *Description of Tailings Basin Operation*

Inputs to the tailings basin consist of fine tailings slurry, coarse refuse, process water from various taconite processes, sewage plant discharge, laboratory wastewater, non-process wastewater including wastewater from air pollution control devices, and runoff from adjacent areas.[6] The tailings basin's two main purposes are: 1) serve as a disposal site to contain tailings, and 2) serve as a reservoir to hold process wastewater so that some of it can be recirculated to the taconite processing plant.[7] The tailings basin is unlined and allows the seepage of pollutant-laden water into groundwater. The pollutant-laden water ultimately discharges into surface waters via pathways that run through and under the tailing basin's perimeter dike (See **Section 2.2**). It is not possible to identify and distinguish every pathway pollutants travel prior to reaching surface waters. Some pollutants may travel through groundwater only, some may travel through subsurface material only, and some may travel through both. The tailings basin has been in operation for over five decades. As the basin does continuously hold water, and is constructed from pervious materials, water is being discharged from the basin continuously.

The tailings basin is a waste treatment system, which is excluded from the definition of "waters of the United States" (See **Section 2.4**). The treatment performed within the tailings basin consists of settling to reduce concentrations of total suspended solids.

1.3.1 Inputs to the Tailings Basin

As noted above, the tailings basin receives process wastewater, fine slurry, and coarse refuse from the Minntac Mine's processing plant (See **Figure 7** for a water flow diagram of the tailings basin). The water held in the tailings basin meets the definition of "process waste water" in 40 C.F.R. § 401.11 as "*any water which, during manufacturing or processing, comes into direct contact with or results from the production or use of any raw material, intermediate product, finished product, by-product, or waste product*." Process wastewater within the tailings basin is either pumped back and reused in the processing plant, evaporates, evapotranspires,[8] or seeps from the basin as wastewater to surface waters beyond the perimeter dike (See **Figure 8**, which shows a mass balance model alongside the water flow of the system).

Approximately 60 million gallons per day (MGD) of process wastewater is continually circulated between the tailings basin and the processing plant (See **Figure 7** for a water flow diagram of the tailings basin). The concentration of pollutants in the basin increases with time as process

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[6] MPCA (2018), *NPDES)/SDS Permit Program Fact Sheet: US Steel Corp. – Minntac Tailings Basin Area*, Permit No. MN0057207, pages 9-10 of pdf.

[7] MWH on behalf of MPCA (2004), *Draft Minntac Water Inventory Reduction EIS,* page 68 of pdf. *"[Tailings basin] serves to store fine and coarse tails waste from taconite processing and to provide a method for recycling process water for the taconite plant processing operations."*

[8] GHD on behalf of U.S. Steel, (2021), *Hydrological Investigation Report,* page 52 of pdf. "*Evapotranspiration Rates: As described in Section 4.1.1, evapotranspiration (ET) is a significant output parameter in the Basin hydraulic balance that is difficult to measure directly. On-site ET research was initiated by DNR during the summer of 2021 in an idled Minntac fine tails cell (Cell G) in an attempt to develop a more representative ET rate for the Minntac Basin. The research equipment was removed/weatherized in November 2021 and the research is slated to be resumed in Spring 2022. Results of this research will likely increase the accuracy of the hydraulic balance*."

wastewater is withdrawn from the basin and reused in taconite processing operations.

An average of 21 million long tons of fine tailings and 14 million long tons of coarse tailings (on a dry basis) are deposited each year into the tailings basin.[9] Coarse tailings are hauled by truck and then dumped into the basin. Coarse tailings are used to construct the berms of various basin cells, channels, and launders, which channelize water movement within the basin. Fine tailings are conveyed as a slurry through a series of channels to various cells throughout the basin. This process is described in more detail in **Section 1.3.2.1**.

1.3.2 Tailings Basin Components

The tailings basin consists of inner cells (labeled A through M), an inner cell perimeter wall, outer cells with standing water in some portions (Cell 1 and Cell 2), an outer perimeter dike, and SCRSs located beyond the perimeter dike along portions of the eastern and western edges of the basin. **Figure 9** depicts the operation of the basin on December 7, 2021. **Figure 10** shows an aerial image of the perimeter dike and one of the east-side SCRS catchment basins abutting a wetland.

1.3.2.1 *Inner Cell*s

Fine tailings slurry, a mix of process wastewater and fine tailings, is pumped from the processing plant through a fine tailings discharge pipe and flows by gravity through a system of ditches and launders which leads to a spigot to inner cells.[10,11] The fine tailings slurry is approximately 50 percent solids and 50 percent water. Each inner cell is surrounded by a dike constructed from coarse tailings that provides a structure for the storage of fine tailings slurry within the cell. Fine tailings settle to the bottom of the inner cells and process wastewater is decanted via an outlet culvert to the permanent process wastewater storage areas of Cells 1 and 2. The basin operation is dynamic and operational decisions and design dictate which cells are used to settle solids. The elevation of the inner cells continually rise as fine and coarse tailings are deposited.

1.3.2.2 *Outer Cell*s

Cells 1 and 2 are reservoirs for process wastewater. Process wastewater is continually pumped from Cell 1 to the processing plant for reuse.[12] The volume of process wastewater in Cells 1 and 2 has doubled since 2012 and, as of 2021, the cells contain between 8.5 and 9 billion gallons of wastewater.[13]

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[9] MPCA (2018), *NPDES)/SDS Permit Program Fact Sheet: US Steel Corp. – Minntac Tailings Basin Area*, Permit No. MN0057207, page 10 of pdf.

[10] MPCA (2018), *NPDES)/SDS Permit Program Fact Sheet: US Steel Corp. – Minntac Tailings Basin Area*, Permit No. MN0057207, page 10 of document.

[11] MWH on behalf of MPCA (2004), *Minntac Water Inventory Reduction Draft EIS Tailings Basin Management Technical Memorandum*, page 13 of pdf. *"The fine tails slurry flows from the plant site to the intermediate cells through a gravity system of open ditches and launders (trough or flume)."*

[12] MPCA (2018), *Findings of Fact, Conclusions of Law, and Order*, page 2 of pdf, Background Fact #4.

[13] GHD on behalf of U.S. Steel (2021), *Hydrological Investigation Report*, page 42 of pdf.

1.3.2.3 *Perimeter Dike*

A perimeter dike extends along the northern, western, and eastern sides of the basin for approximately 9.1 miles. The southern side of the basin is bound by bedrock, where the Laurentian Divide exists - which is a major watershed divide separating the Great Lakes Basin from the Hudson Bay watershed (See **Figure 3** for a site plan of the basin). This perimeter dike, built on glacial till,[14] is constructed primarily of coarse and fine tailings that extend approximately 10 feet below the ground surface.[15] **Figure 11** shows a cross-section of the perimeter dike. Wastewater from the basin reaches surface waters beyond the perimeter dike and the SCRSs, where they exist, by flowing underneath or around the SCRSs.[16]

1.3.2.4 *Seepage Collection and Return System*

SCRSs were installed on portions of the east and west sides of the basin in 2010 and 2019, respectively. The 2018 NPDES Permit Fact Sheet provides a description of the east side SCRS:

"*In 2010, the permittee installed a seep collection and return system (SCRS) along roughly 1 ¾ miles of the east side of the basin including SD002. The SCRS system consists of catch basins located in each of the 13 identified seepage locations, hydraulically connected by subsurface high-density polyethylene piping to pump stations. Each of the seepage areas has been shaped and graded to promote seepage flow to the catch basins. Sheet pile cut-off walls were installed downgradient of each catch basin, connecting areas of higher elevation on either side of each discrete seepage location, to a depth of approximately 15 feet below existing ground level to ensure that surrounding wetlands are minimally impacted. The SCRS system consists of two subsystems, one collecting seepage from the northern section and the other from the southern section. Each subsystem terminates in a pump station consisting of a concrete vault containing a duplex pump system capable of returning the collected seepage back to the tailings basin.*"[17]

The west side SCRS is similar in design to the east side SCRS.[18] Both SCRSs were constructed as non-continuous segments (i.e., the system does not cover the entire extent of the perimeter dike). The SCRSs pump wastewater that surfaces immediately beyond the perimeter dike back

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[14] Glacial till is the layer above the granitic bedrock, composed primarily of fine to medium sand with some silt and rock clasts ranging from cobbles to boulders. Glacial till is often referred to as the "overburden" layer in different studies and reports of the facility.

[15] MPCA (2018), *National Pollutant Discharge Elimination System/State Disposal System Permit MN0057207: US Steel Corp. – Minntac Tailings Basin Area*, page 3 of document. "*Peat was removed from the original ground area to be occupied by the perimeter dam, and a ten foot deep key-way was dug in the glacial drift prior to spigotting fine tailings into the core portion of this area*."

[16] CRA for US Steel (2013) Estimate of Time of Travel, page 3. "*Figure 2 shows the simulated particle pathlines and travel times under current conditions (i.e., with the SC & R system sheet-pile walls in place). The simulated particle pathlines are similar to that occurring for the historical conditions, except that particles reaching the sheet-pile wall move downward from the shallow overburden into the deep overburden to pass under the sheet-pile wall, which extends through the shallow overburden only. The particles then move upwards back into the shallow overburden before discharging to the wetland area*."

[17] MPCA (2018), *NPDES)/SDS Permit Program Fact Sheet: US Steel Corp. – Minntac Tailings Basin Area*, Permit No. MN0057207, page 12 of document.

[18] HATCH on behalf of U.S. Steel Corporation (2014), *Minntac Western Seepage Collection System – Phase 2 Report*, page 5 of pdf. "*This proposed seepage collection system is similar in nature to the seepage collection and return system previously installed on the eastern perimeter of the [tailings basin].*"

into the basin; however, the SCRSs do not prevent wastewater from flowing under or around them. The SCRSs also do not treat or remove pollutants from the system, rather the SCRSs recirculate pollutants back to the basin, where they seep out again or are pumped back for reuse in the processing plant and discharged back to the tailings basin.

Topographic Map of Permitted Facility

MN0057207: U.S. Steel Minntac Tailings Basin
T59N, R18W, Sections 3-10, 14-23, and 27-30
Mt. Iron, St. Louis County, Minnesota

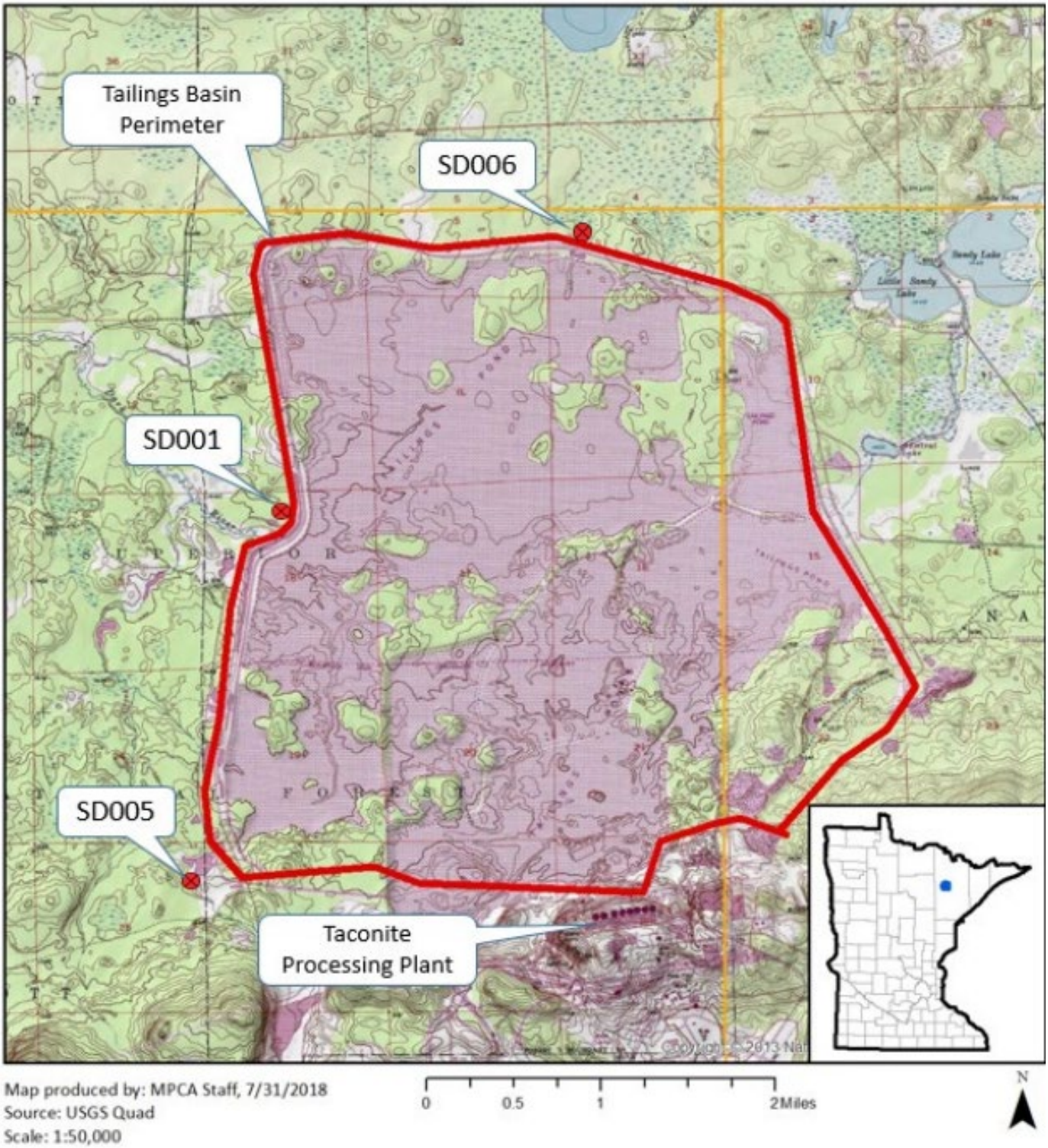


Figure 1. Map of Permitted Facility.
Taken from "NPDES/SDS Permit Program Fact Sheet for Minntac" by MPCA (2018). See page 13 of pdf. Red line represents the tailings basin area. As described by discharge monitoring report data: SD001 is "Seepage outfall 020," SD005 is "Stormwater, Non-specific Runoff," SD006 is "Seep Discharge to north wetlands." Note: SD001 has since been removed as a surface water discharge monitoring point due to the installation of the SCRS on the west side of the basin.

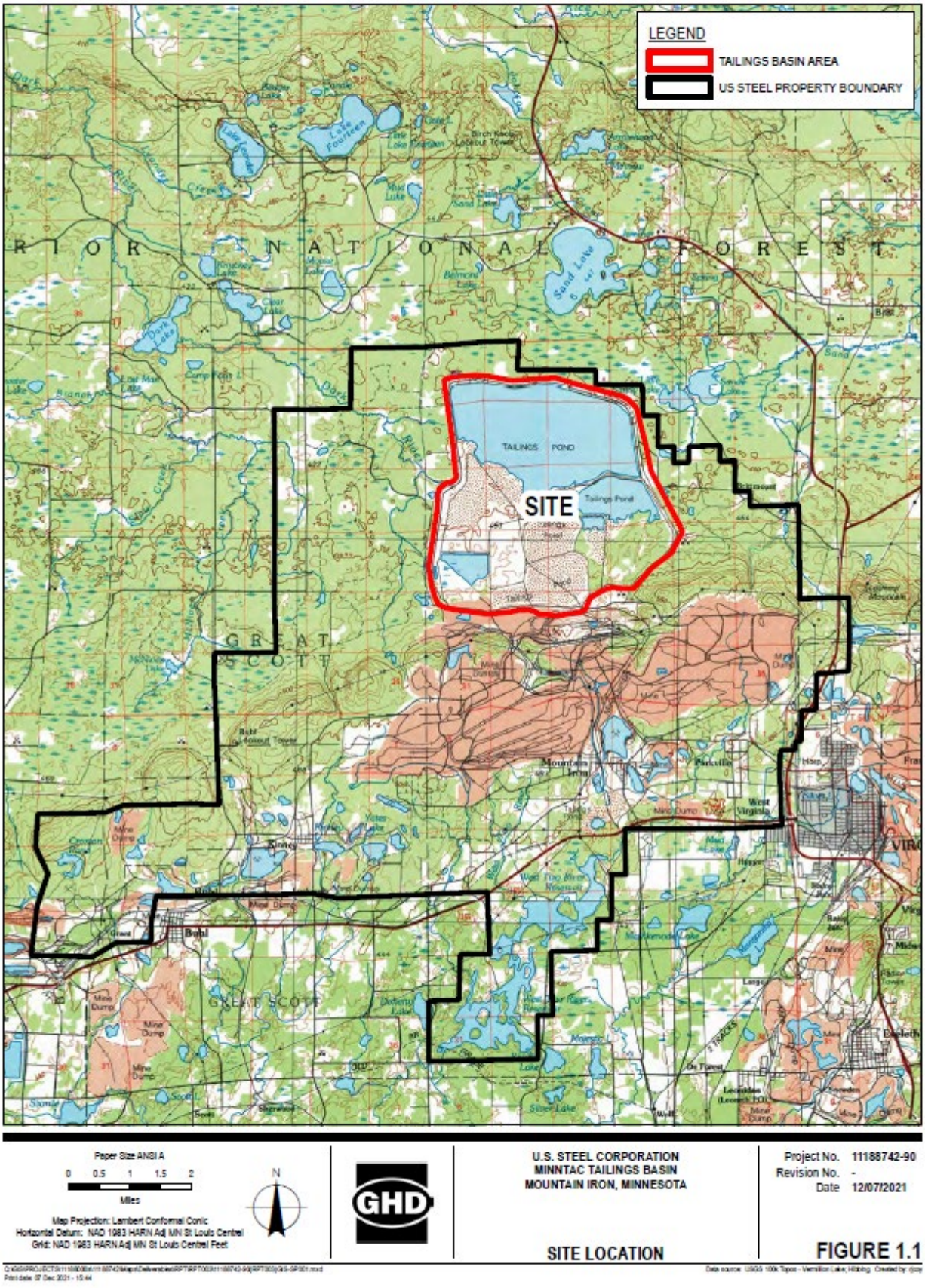


Figure 2. Site Location.
The boundary of the tailings basin area is shown in red and the property boundary in black. Taken from "Hydrological Investigation Report" by GHD on behalf of U.S. Steel (2021). See page 57 of pdf.

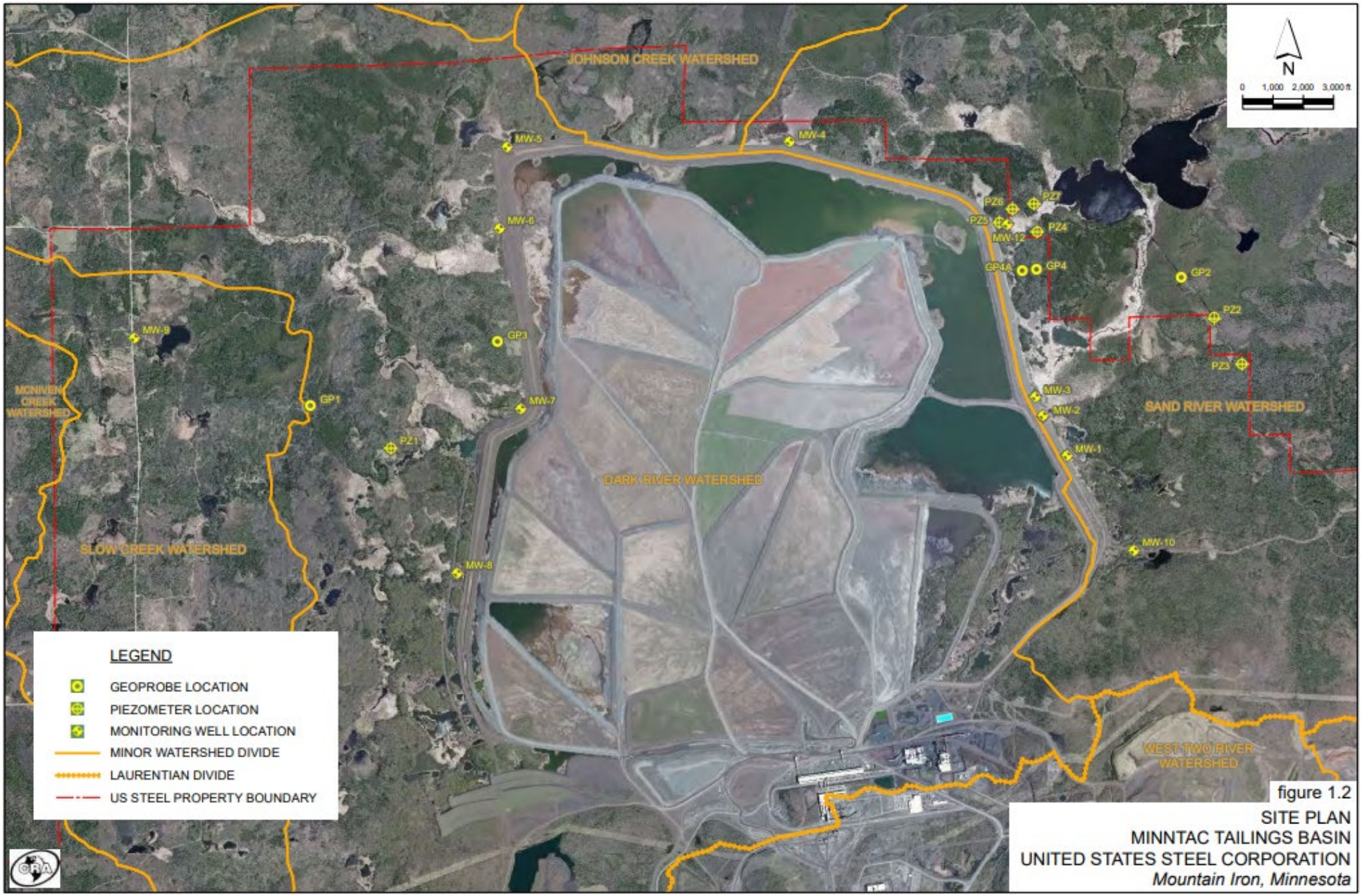


Figure 3. Site Plan.

Taken from "Groundwater Flow and Sulfate Transport Modeling Report" by CRA on behalf of U.S. Steel (2013). See page 56 of pdf.

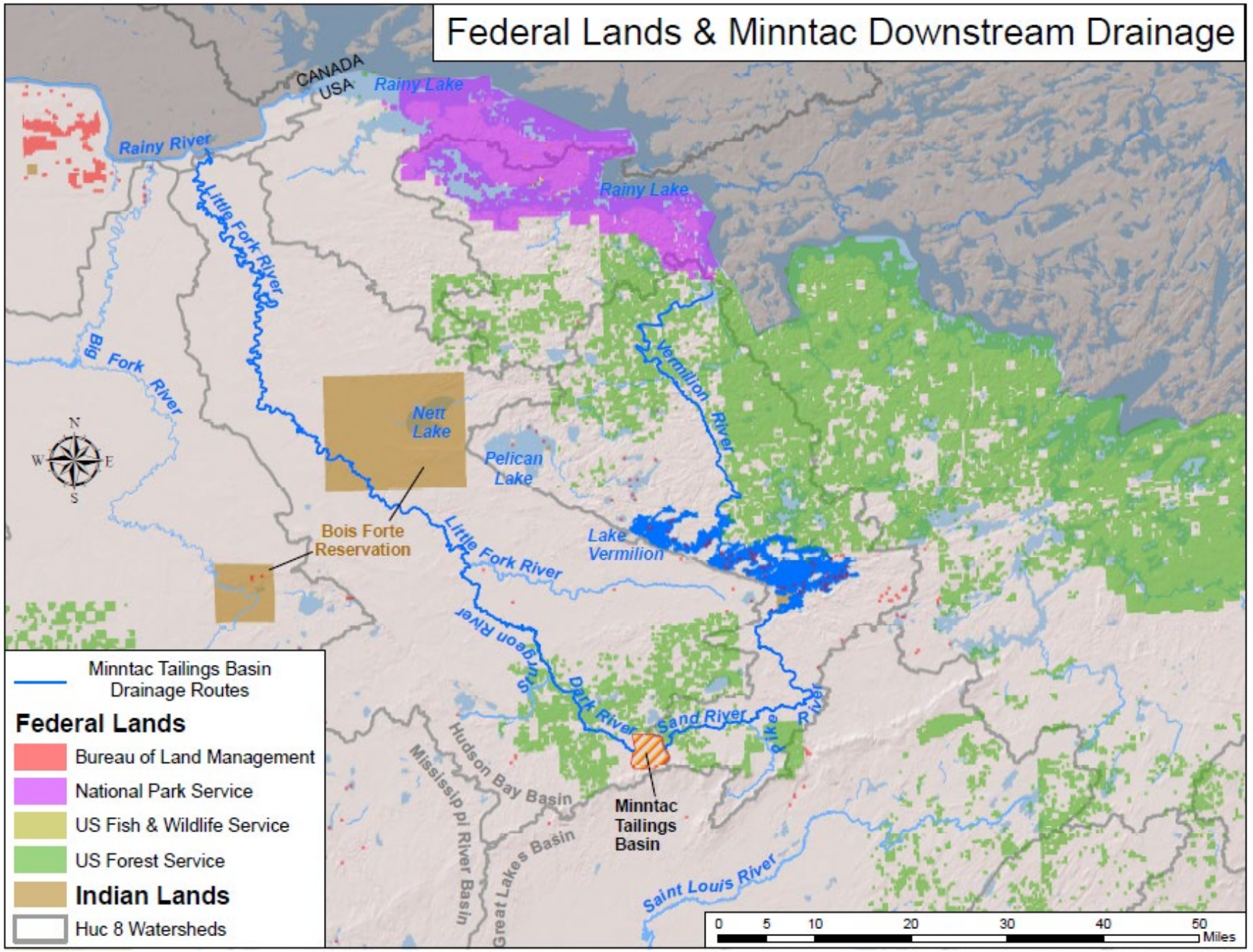


Figure 4. Minntac Tailings Basin and Drainage of Receiving Watersheds to the Border with Canada
(Also Depicting Federal Lands and Tribal Lands). Map created by U.S. EPA in 2016.

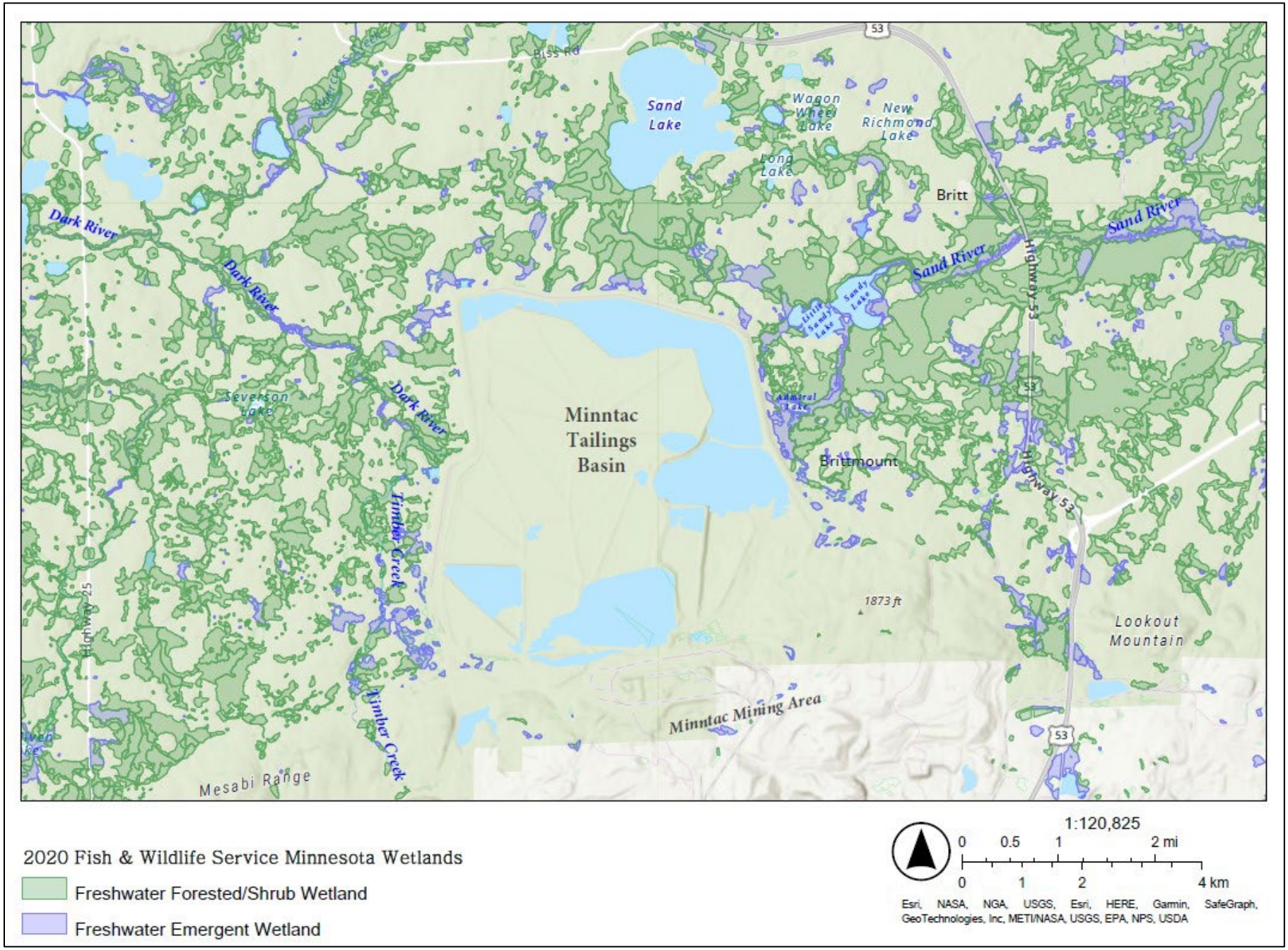


Figure 5. Wetlands Surrounding the Tailings Basin.
Data taken from the U.S. Fish and Wildlife Service National Wetlands Inventory database, last updated May 1, 2020. Map created by EPA.

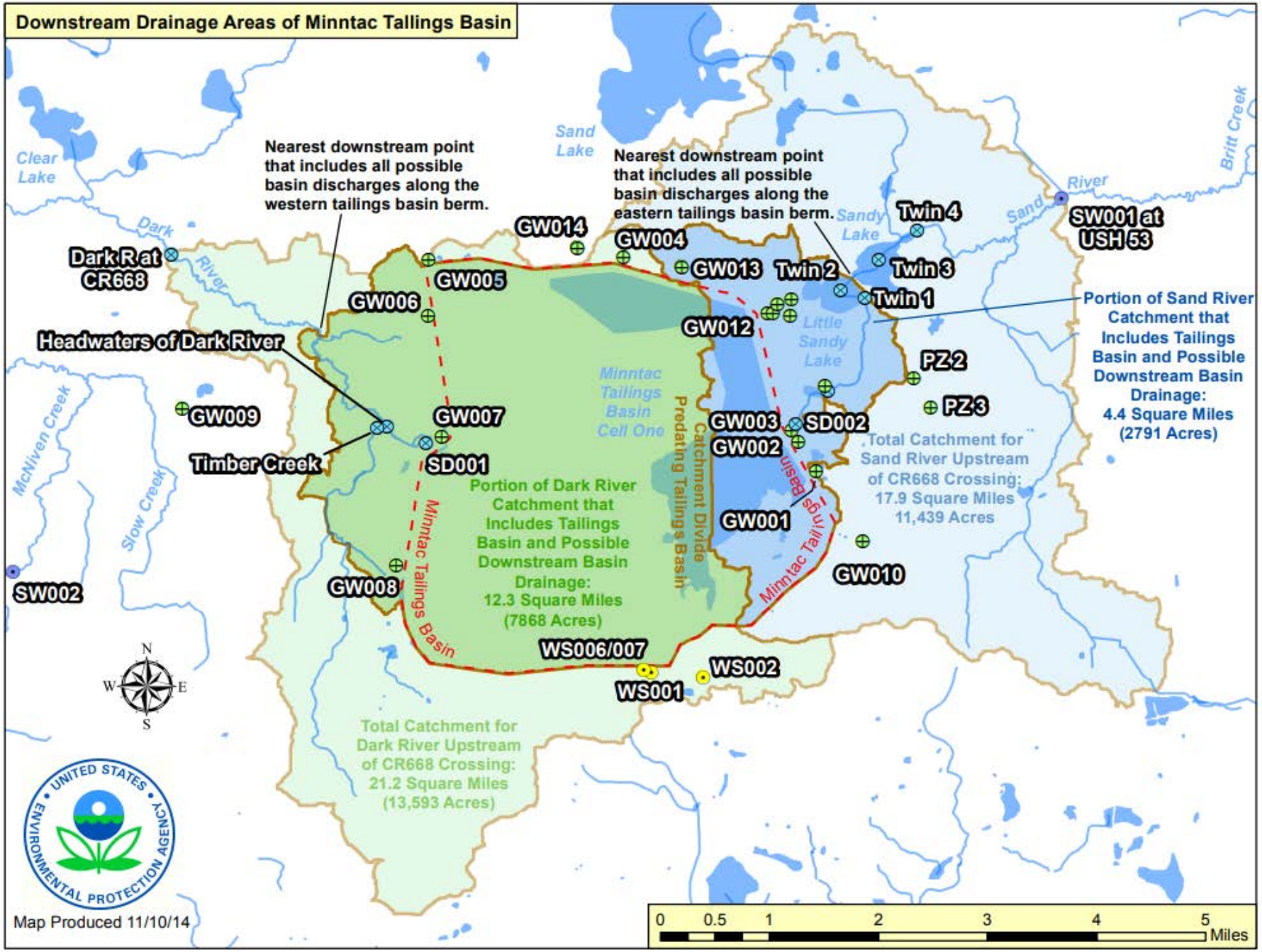


Figure 6. Downstream Drainage Areas of Minntac Tailings Basin.

Map produced by EPA on 11/10/2014. Note: station Dark R at CR668 is also known as SW003 or D-1. Station SW001 at USH 53 is also known as Station 701.

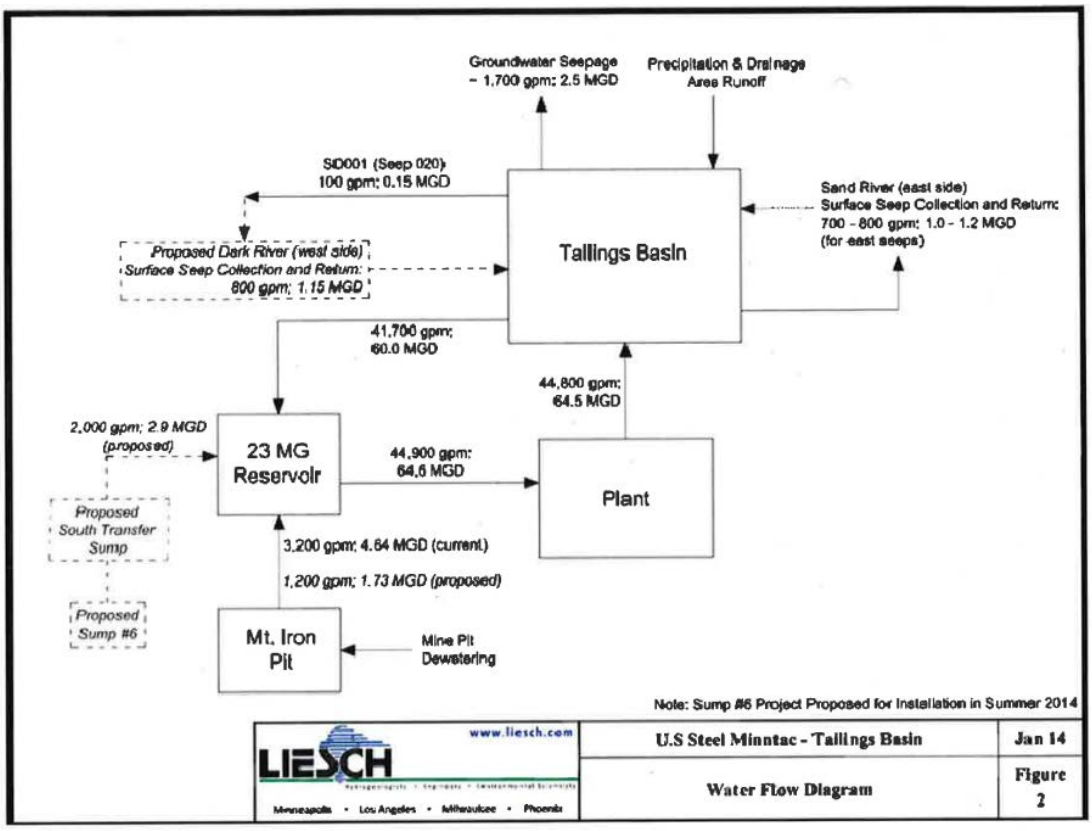


Figure 7. Water Flow Diagram of U.S. Steel Minntac – Tailings Basin.
Taken from "2018 NPDES Permit" by MPCA. See page 8 of pdf. Note: The proposed Dark River (west side) Surface Seep Collection and Return System was installed in 2019 and has been in operation since June 2020.

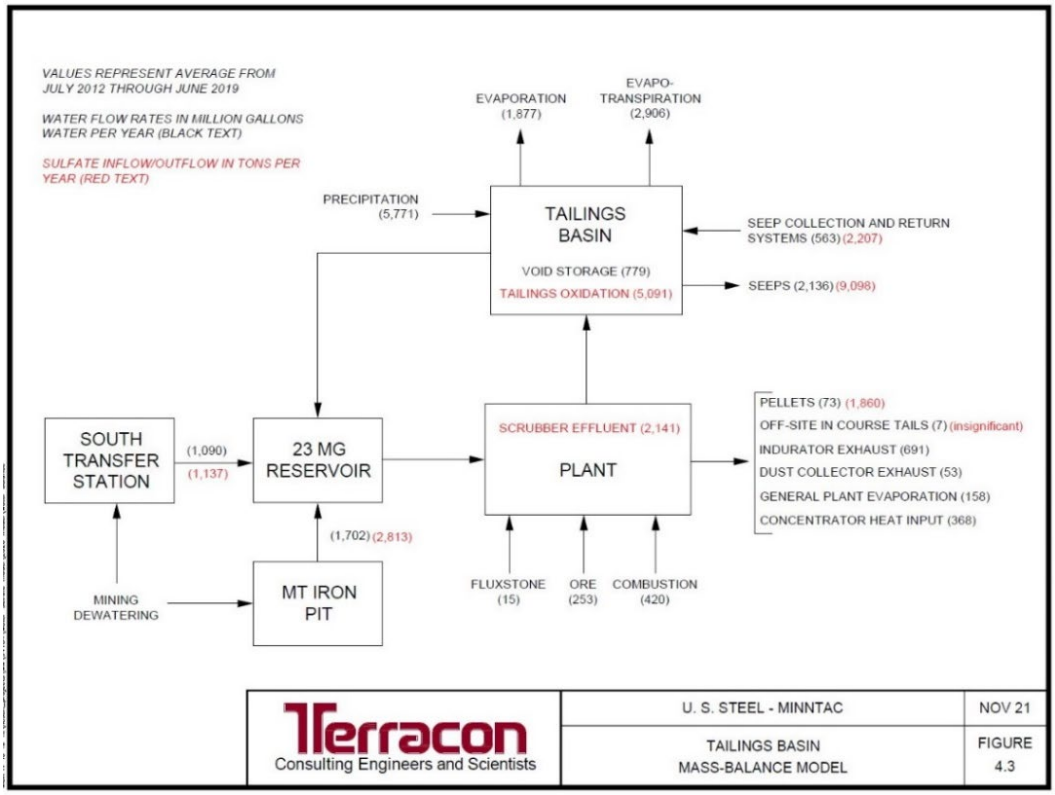


Figure 8. Tailings Basin Mass-Balance Model.
Taken from "Hydrological Investigation Report" by GHD on behalf of U.S. Steel (2021). See page 72 of pdf.

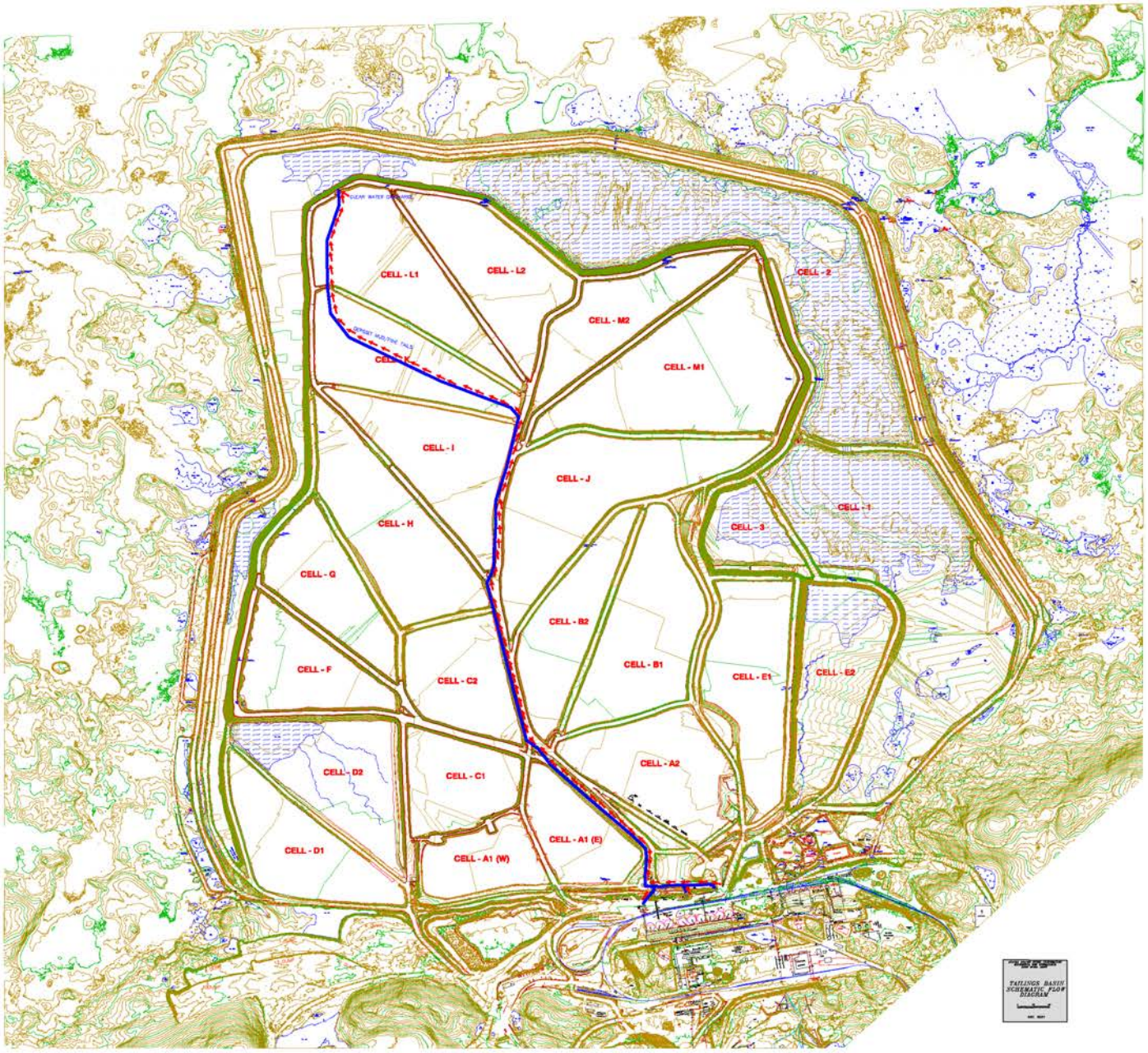
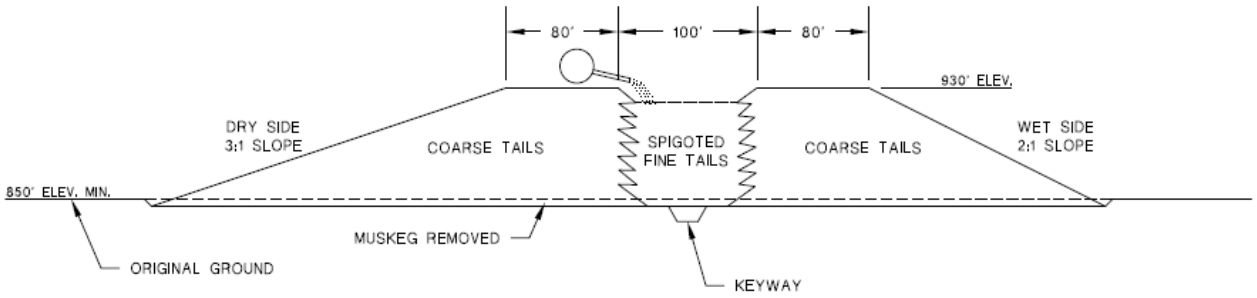


Figure 9. Tailings Basin Schematic.

Note the route of fine tailings flow, settling, and wastewater discharge to the tailings basin. This configuration changes over the course of operations. In summary, wastewater and tailings are conveyed to inner basin cells (labeled with letters and numbers). Process wastewater is drawn off and conveyed to outer cells (Cell 2 and Cell 1). Water from Cell 2 and Cell 1 flows clock-wise to a pumphouse on the southeast corner where water containing pollutants is recirculated to the processing facility. Image provided to U.S. EPA by U.S. Steel via MPCA on December 7, 2021.

Figure 10. Image of Tailings Basin Perimeter Dike.
View of the tailings basin facing south with the Minntac processing plant in the distance. Note: Sheet piling can be seen dividing the wetlands from the east side SCRS collection basin; the tailings basin standing water pool is seen on the right-hand side of this image. Taken from "Thermal imagery 2013 and 2019 for detecting Minntac east-side discharge," Technical Memorandum by Great Lakes Indian Fish & Wildlife Commission (2022). See page 3 of pdf.



TYPICAL CROSS-SECTION OF MINNTAC
BASIN DIKE CONSTRUCTION

N.T.S.

FIGURE 2-14
TYPICAL CROSS-SECTION OF MINNTAC
TAILINGS BASIN DIKE CONSTRUCTION

Figure 11. Typical Cross-Section of Minntac Basin Dike Construction.
Taken from "Draft EIS" by MWH on behalf of MPCA. See page 90 of pdf.

2 The Tailings Basin is a Point Source that Discharges Pollutants to Nearby Surface Waters

The Clean Water Act (CWA), EPA's regulations, and relevant court decisions provide that an NPDES permit is necessary to authorize the discharge of pollutants from a point source to waters of the United States. If the discharge of pollutants is through groundwater, then an NPDES permit is necessary if the discharge is the functional equivalent of a direct discharge. This chapter explains that the tailings basin is a point source and that it discharges pollutants to nearby surface waters. **Section 3** analyzes whether those discharges through groundwater that reach surface water are the functional equivalent of a direct discharge.

2.1 *Description of Point Source*

The tailings basin is a point source. *"The term 'point source' means any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agricultural stormwater discharges and return flows from irrigated agriculture." 33 U.S.C. § 1362(14); 40 C.F.R. § 122.2.*

The tailings basin is a point source because it is a "discernible, confined and discrete conveyance." The tailings basin is surrounded by a dike on the north, east, and west sides and by bedrock on the south side. The dike and bedrock form a perimeter that is intended to contain the tailings and process wastewater for the mining operations. This perimeter is clearly identifiable and the materials inside the perimeter are related to U.S. Steel's mining operations. The tailings basin is located at the headwaters of the nearby streams, making it easy to identify the source of any pollutants in the waters of the United States located directly adjacent to the perimeter dike. The tailings basin is also a circulating system that serves the mining process. The tailings basin contains fine tailings discharge pipes, ditches, launders, spigot lines, culverts, pumps, and other equipment that creates a circulating collection, settling, and drainage system that serves the mining operations (See **Section 1.3.2** for details on components of the tailings basin). When these types of circulating systems result in discharges, the escape of liquid from the system is from a point source. *U.S. v. Earth Sciences, Inc.*, 599 F.2d 368, 374 (10th Cir. 1979) ("We have no problem finding a point source here. The undisputed facts demonstrate the combination of sumps, ditches, hoses and pumps is a circulating or drainage system to serve this mining operation.") The large size of the tailings basin does not preclude it from being a "point source." *Washington Wilderness Coal v. Hecla Mining Co.*, 870 F. Supp. 983, 988 (E.D. Wash. 1994) ("[I]t is clear that the size of the pond is not relevant to determining whether or not it is a point source. As plaintiffs explain, it would be irrational to conclude that the bigger the source of pollution, the less likely it is to be a "source" under the CWA.") Any escape of liquid from the system or cells within constitutes a point source discharge.

Furthermore, the tailings basin is a point source because it is a "container." Like other types of containers, the tailings basin is intended to contain and convey water. U.S. Steel specifically constructed the tailings basin to contain process wastewater, which is evidenced by the fact that U.S. Steel reuses the process wastewater in the tailings basin for ongoing mining and processing operations. *See Cottonwood Env't Law Ctr. v. Edwards*, 2022 WL 952072, *7 (D. Mont. Mar. 30, 2022) (finding that a wastewater holding pond was a point source in part because the holding

pond was "specifically built . . . to contain effluent water"). Similarly, pollutant levels in the tailings basin can be measured directly and the pollutant load that occurs from any leak in the tailings basin may also be approximated with various modeling techniques. These characteristics are unlike non-point source pollution which flows from uncollected runoff water. *See Id*. at *8 (stating that "[c]ourts should not provide a loophole for polluters simply because the amount of pollutant being discharged proves somewhat more difficult to measure"; finding that a wastewater holding pond was a point source in part because the pollutants at issue in the case could be traced to a discrete source). For the same reasons that the tailings basin is a point source, the cells within the basin, which function in a similar manner, are also point sources.

In addition, the tailings basin is a waste treatment system, which is excluded from the definition of "waters of the United States," that discharges to a water of the United States. The area bounded by the outer edge of the perimeter dike of the tailings basin is considered a waste treatment system subject to the waste treatment system exclusion (i.e., not a water of the United States). In 2012, the U.S. Army Corps of Engineers (Corps) determined that wetlands inside the tailings basin were not jurisdictional under the CWA because "*they are part of a treatment system designed to meet the requirements of the Clean Water Act and are excluded from regulation.*"[19] The Corps' memo[20] further explained that the area bounded by the perimeter dike of the tailings basin is considered a treatment system and the waste treatment system exclusion applies to the entire tailings basin. Federal regulations provide that waste treatment systems are not waters of the United States.[21] However, discharges from a waste treatment system to a "water of the United States" require an NPDES permit.

In addition to the tailings basin and the cells within the basin being point sources, the pipes, ditches, or culverts that discharge fine tailings slurry, coarse refuse, process water from various taconite processes, sewage plant discharge, laboratory wastewater, non-process wastewater including wastewater from air pollution control devices, and runoff from adjacent areas[22] into the tailings basin from the mine processing plant areas are also point sources. In *Maui*, the Supreme Court made clear that the term "any point source" refers to such a source that need not be directly nor immediately at the end of the discharge. So long as the pollution travels "from" one such source along its path to the navigable water this requirement is satisfied. *Id*. at 1473-76. As Justice Kavanaugh further explained, the Lahaina Wastewater Reclamation Facility is itself a point source. *Id.* at 1478 (Kavanaugh, concurring). Thus, as "any discernable, confined and discrete conveyance[s]," from the Minntac processing facility to the tailings basin along its path to the navigable waters outside of the basin are also point sources under the CWA.

2.2 *Discharges from the Basin*

The tailings basin discharges pollutants to waters of the United States. As described by Darcy's Law, the discharge rate of a fluid traveling through porous medium is related to the permeability,

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[19] U.S. Army Corps of Engineers (2012), *Approved Jurisdictional Determination Form: 2012-01578-JBB, Minntac Tailings Basin (Wetland E2).*

[20] U.S. Army Corps of Engineers (2012), *Memorandum of File 2012-01578-JCB: Applicability of Waste Treatment Exclusion at the Minntac Tailings Basin*.

[21] 33 CFR 328.3(b)(1)

[22] MPCA (2018), *NPDES)/SDS Permit Program Fact Sheet: US Steel Corp. – Minntac Tailings Basin Area,* Permit No. MN0057207, pages 9-10 of pdf.

hydraulic conductivity, and the difference in pressure or "head."[23] The difference in pressure, or head, is related to the difference in water levels inside the basin and outside of the basin (i.e., transport of pollutants is driven by gravity). Process wastewater discharged from the basin enters waters of the United States adjacent to the basin. Wastewater is discharged from the tailings basin to surface waters by seeping through the perimeter dike via subsurface flow or through groundwater under the perimeter dike.

The SCRSs were designed to allow wastewater and groundwater to flow underneath and around them.[24,25,26] As a result, wastewater continues to flow underneath and around the SCRSs.[27,28] The SCRSs are designed to capture wastewater discharged from the basin and pump it back into the basin; however, the SCRSs only collect a portion of the wastewater that escapes the basin, and the pollutants are returned to the basin – not treated or removed from the process wastewater system. Calculations provided in the 2021 Hydrological Investigation Report suggest that pollutant loadings from the basin that reach downstream surface waters are not significantly affected by the operation of the SCRSs (See **Table A-5**).

The 2021 Hydrological Investigation Report states, "Given the hydraulic conditions of the Basin in relation to the surrounding areas, most of the Basin seepage that migrates past the Seep Collection and Return Systems reports to nearby surface waters within a relatively short distance from the Basin perimeter dike."[29] Rates of wastewater discharge from the tailings basin have been estimated using surface water quality data collected at downstream monitoring stations within the Sand and Dark River watersheds. U.S. Steel's consultant estimated a total seepage rate (i.e., wastewater moving under and through the perimeter dike, including seepage that is pumped back into the basin and seepage that moves downstream beyond the SCRS) at approximately 2,000 gpm (1,052 million gallons per year) to the Dark River and 2,200 gpm (1,157 million

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[23] Fitts, C. R. (2013), *Groundwater Science (2nd Editi*on), page 48.

[24] AECOM (2009), *U.S. Steel Corporation Minnesota Ore Operations – Minntac Tailing Basin Surface Seepage Collection System Design Report*, page 6 of pdf. "*The sheet pile walls will be limited to a driven depth of 15 feet (or less) so that subsurface water flows are not affected. Naturally occuring groundwater flows are present in the area and serve to regenerate the wetland. A deep cutoff wall the eliminates these subsurface flows may have a negative effect on the wetland ecology and would drive additional water to the surface in search of an outlet, requiring additional pumping volumes and energy usage to handle the increased surface seepage.*"

[25] BARR on behalf of U.S. Steel (2014), *Groundwater Sulfate Reduction Plan*, page 8 of pdf. "*Sheet pile was installed as part of the SC&R at each discrete surface seepage location to prevent dewatering of downgradient wetlands and promote additional subsurface seepage capture. The location of the sheet pile in the subject area is shown on Figure 2. Records indicate that the sheet pile was advanced to a depth of 13 – 14 feet bgs. Based upon a review of the pumping tests, groundwater flow below the approximate 400-foot length of installed sheet pile is estimated to be approximately 26 gallons per minute (gpm).*"

[26] AECOM (2009), *U.S. Steel Corporation Minnesota Ore Operations – Minntac Tailing Basin Surface Seepage Collection System Design Report*, page 6 of pdf. *"The sheet pile walls will be limited to a driven depth of 15 feet (or less) so that subsurface water flows are not affected."*

[27] MPCA (2018), *Findings of Fact, Conclusions of Law, and Order*, page 3 of pdf, Background Fact #15.

[28] GHD on behalf of U.S. Steel (2021), *Hydrological Investigation Report*, page 35 of pdf. *"Given the hydraulic conditions of the Basin in relation to the surrounding areas, most of the Basin seepage that migrates past the Seep Collection and Return Systems reports to nearby surface waters within a relatively short distance from the Basin perimeter dike."*

[29] GHD on behalf of U.S. Steel (2021), Hydrological Investigation Report, page 35 of pdf.

gallons per year) to the Sand River[30] (See **Table A-5**). The estimates were based on averaged concentrations of chloride and flow measured at downstream water quality monitoring locations.[31] While the seepage discharge flow rates referenced in the 2018 NPDES Permit Fact Sheet are from different sources and contain slightly different estimates, all reports conclude that there are process wastewater seepages from the basin that move through and under the perimeter dike and discharge to surface waters. The total amounts of sulfate and chloride reaching surface waters in the Sand River and Dark River watersheds were estimated through loading calculations based on downstream surface water monitoring data (years 2018 through 2022) (See **Section 3.5**).

Sulfate, a common component of the taconite ore,[32] is present in the facility's process wastewater. There has been more sampling of sulfate than other pollutant parameters and sulfate has been the focus of several modeling efforts. Additionally, sulfate model inputs and outputs have been estimated for the basin in the most recent 2021 Hydrological Investigation Report, suggesting that approximately 53 percent of the total sulfate entering the basin leaves via seeps (See **Figure 12)**.[33] Further, the 2021 Hydrological Investigation Report estimated that 22,612 kg/day (9,098 tons per year) of sulfate leaves the basin via seeps and is not captured by the SCRSs (See **Figure 8** and **Figure 12**).

Figure 12. Tailings Basin Sulfate Model Inputs and Outputs.
Taken from "Hydrological Investigation Report" (2021) by GHD on behalf of U.S. Steel. See page 37 of pdf. Note: TPY = tons per year.

[30] The 2021 Hydrological Investigation Report provided slightly different flow estimates. One estimate was 2,136 MGY (see Inset 4.1 of the 2021 Hydrological Investigation Report), while another estimate provided 4,200 gpm (which converted is 2,207 MGY). A range of 2,100-2,300 MGY may be more accurate.

[31] GHD on behalf of U.S. Steel (2021), *Hydrological Investigation Report*, pages 35-36 of pdf, Section 4.1.1.2.3 "Seeps."

[32] MPCA (2018), *Findings of Fact, Conclusions of Law, and Order*, page 4 of pdf, Permit History Fact #23. "*U.S. Steel contributes sulfate to the Tailings Basin from a variety of sources, including sulfate that forms as the result of chemical reactions which occur during processing and disposal of the mined ore, sulfate that accumulates in the wastewater stream from the 'wet scrubber' air pollution control equipment that U.S. Steel operates to control air emissions, and sulfate that is present in 'make-up' water used by U.S. Steel in processing the ore*."

[33] Calculations of percentages based on input and output estimates in 2021 HI Report by U.S. Steel Consultants. Sulfate seep (9,098 tons per year [TPY]) divided by total input (17,064 TPY – i.e., adding inputs from scrubbers, 2,141 TPY; Mt. Iron Make-Up, 2,813 TPY; STS Make-up 1,137 TPY; Tailings Oxidation, 5,091 TPY; and SCRS Pump Back, 5,882 TPY). Thus, seepage leaving equals 53% of the input sulfate.

The 2021 Hydrological Investigation Report presents fate and transport conceptual site models that identify the various sources of sulfate and the transformational processes occurring both inside and outside the tailings basin that result from the use of process makeup water, ore processing and waste gas scrubbing, and the deposition of fine and coarse tailings into the tailings basin. **Figure 13** and **Figure 14**, taken from the 2021 Hydrological Investigation Report, are conceptual models of the fate and transport of sulfate from the eastern and western sides of the tailings basin, respectively.

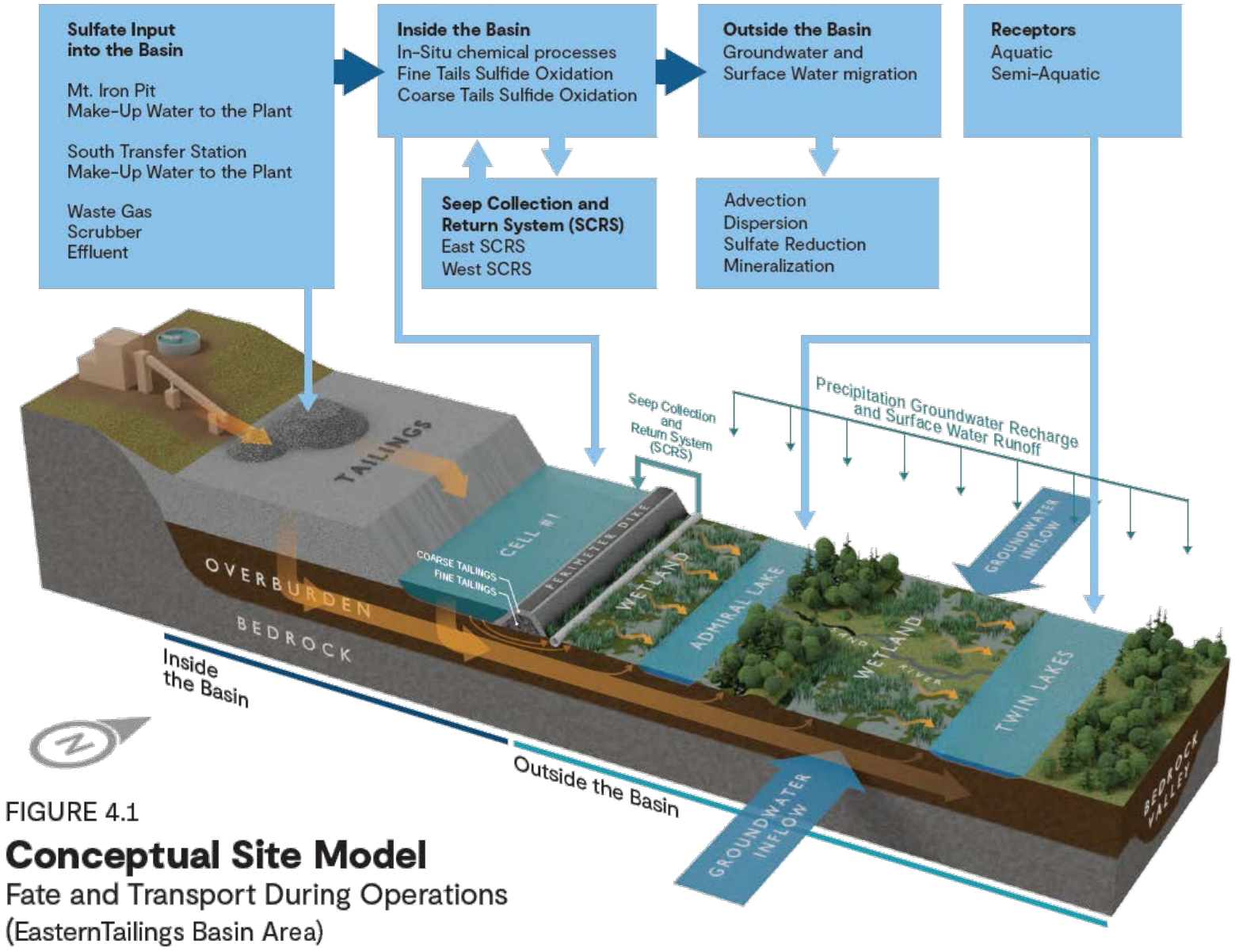

FIGURE 4.1

Conceptual Site Model

Fate and Transport During Operations

(EasternTailings Basin Area)

Figure 13. Eastern Tailings Basin Area Conceptual Site Model – Fate and Transport During Operations.
Taken from "Hydrological Investigation Report" (2021) by GHD on behalf of U.S. Steel. See page 70 of pdf.

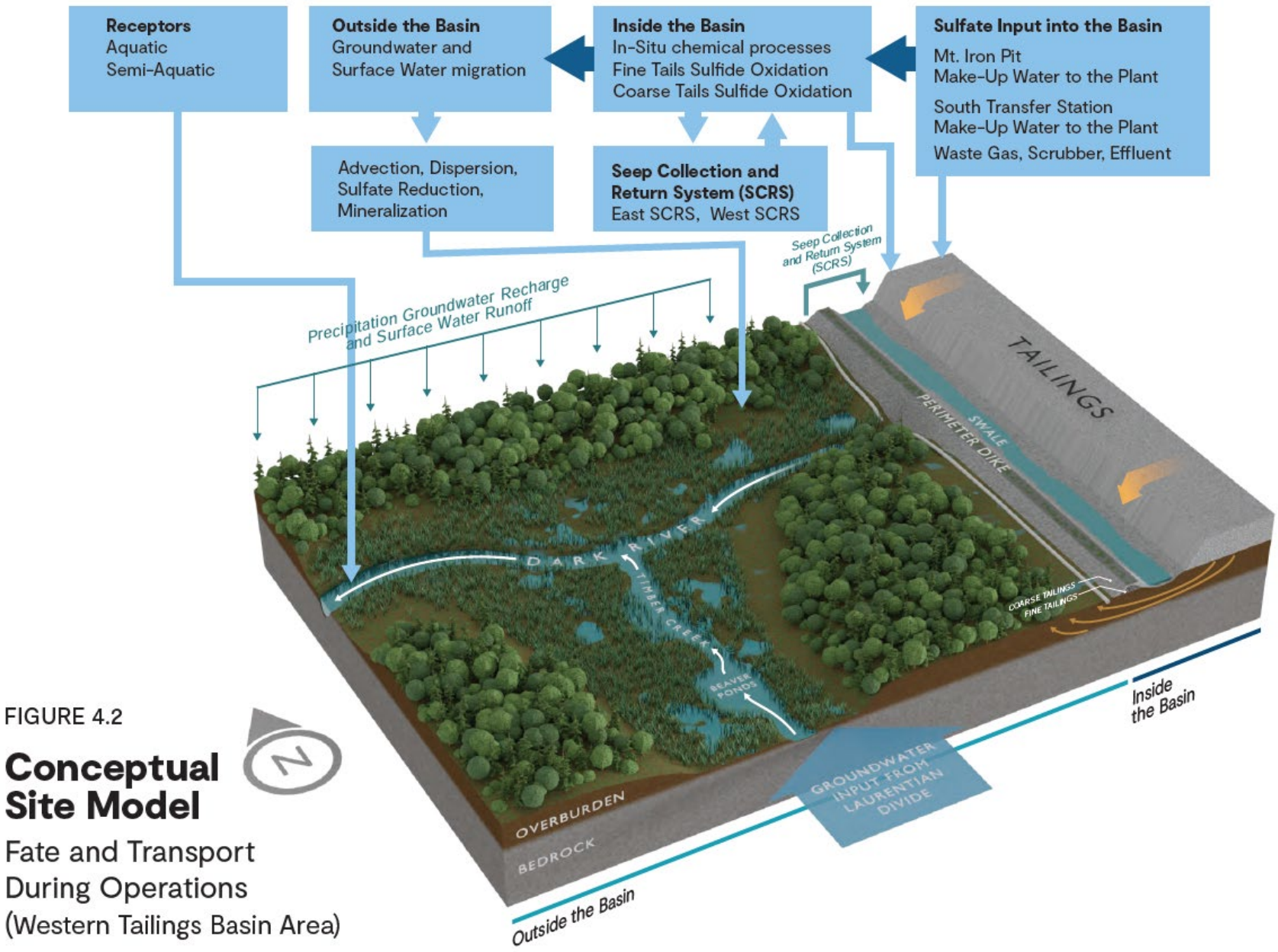

Figure 14. Western Tailings Basin Area Conceptual Site Model – Fate and Transport During Operations.
Taken from "Hydrological Investigation Report" (2021) by GHD on behalf of U.S. Steel. See page 71 of pdf.

2.3 *Discharge of a Pollutant*

2.3.1 Tailings Basin Wastewater Characterization

U.S. Steel identified the following pollutant parameters as present in its discharge in its 2014 NPDES permit application: chemical oxygen demand, total organic carbon, bromide, color, fluoride, nitrate-nitrite, total phosphorus, sulfate, total barium, total cobalt, total ion, total magnesium, total molybdenum, total manganese, total tin, total arsenic, total copper, total mercury, total nickel, total selenium, total thallium, and total zinc.[34] This evaluation focuses on sulfate and chloride because of the robust data which includes sampling, modeling, and studies which also focused on these pollutant parameters. EPA expects that the other pollutants in the wastewater are discharged through the same pathways. EPA would expect these pollutant parameters to be evaluated in an NPDES permitting context which is beyond the scope of this evaluation.

2.3.2 Surface Water Quality

Wastewater discharged from the tailings basin reaches surface waters. U.S. Steel acknowledges that wastewater from the tailings basin seeps under the perimeter dike and travels to surface waters via groundwater pathways.[35,36,37,38] Data collected at the downstream surface water quality monitoring stations show elevated levels of sulfate and chloride compared to pre-facility and background levels (See **Table 1**, **Table 2**, and **Table A-1**).

As shown in **Figure 15** and **Figure 16**, sulfate and chloride concentrations decrease at locations farther away from the basin, which indicates that the basin is a source of pollutants to the receiving water. Furthermore, there are no other sources contributing pollutants to the

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[34] U.S. Steel (2014), *EPA Application Form 1 and 2C, NPDES Permitting Program, Permit No: MN0057207.*

[35] CRA on behalf of U.S. Steel (2013), *Groundwater Flow and Sulfate Transport Model Report*, page 20 of pdf. "*Groundwater primarily discharges to the wetlands and ultimately to the lakes and Sand River*."

[36] CRA on behalf of U.S. Steel (2009), *Groundwater Investigation and Modeling Report,* page 18 of pdf. "*Sulfate-enriched surface seeps flow away from the basin as surface water, which allows for them to travel significant distances within a relatively short time frame. As the surface water moves away from the Minntac Tailings Basin, it also infiltrates into the shallow groundwater system. The effect of this process would be the extension of the sulfate-enriched groundwater plume and may explain the elevated sulfate levels observed at PZ1 and GP4A.*"

[37] GHD on behalf of U.S. Steel (2019), *Hydrological Investigation Work Plan Interim Requirements Status Report NPDES Permit MN005720,* page 6 of pdf. "*GHD reviewed LiDAR contour data, stream flow lines and aerial imagery to divide auto-catchments into areas likely receiving Tailings Basin surface water and groundwater inputs and areas unlikely to receive Tailings Basin surface water and groundwater. Surface water discharge from the Tailings Basin is assumed to be via flow paths from the perimeter of the Tailings Basin through wetlands, seeps, flowages and unnamed tributaries to Timber Creek, Dark River, and Sand River. Groundwater discharge from the Tailings Basin is assumed to extend radially from the perimeter dike to the point where groundwater flows daylight and are intercepted by surface water features such as streams, lakes, ponds or wetlands. Groundwater flow paths were determined from review of hydraulic data, monitoring well and piezometer data, soil borings, and surficial geology*."

[38] GHD on behalf of U.S. Steel (2021), *Hydrological Investigation Report,* page 53 of pdf. "*Surface water sampling and analysis has demonstrated that the surface water bodies that are impacted by discharge from the Basin include Timber Creek (although there is no evidence of impacts to water features on the west side of Timber Creek), the Dark River and wetlands near the Basin perimeter dike that make up the Dark River floodplain, and the Sand River and wetland 'tributaries' to the Sand River adjacent to the perimeter dike.*"

downstream surface water quality monitoring stations discussed in this evaluation.[39,40] Sulfate levels measured in the receiving waters have been increasing throughout the timeframe within which the basin has been operating (See **Figure 17** for graphs of sulfate concentrations within the Sand River and Dark River watersheds, respectively).

[39] MWH on behalf of MPCA, (2004). *Minntac Water Inventory Reduction EIS Surface Water Hydrology and Quality Technical Memorandum*, page 44 of pdf. *"There are at least three other sources of permitted discharge to nearby surface waters [in the Sand River watershed]: [1)] Ispat-Inland Minorca Tailings Basin - NPDES permit MN0055964, [2)] Tower POTW - NPDES permit MN0056618, [3)] Soudan State Park (Department of Natural Resources) - NPDES permit MN0060151. Both the Tower POTW and Soudan State Park, discharge to the East Two Rivers, which in turn discharges to Pike Bay of Lake Vermilion, downstream of monitoring stations discussed here. The Ispat-Inland Minorca Tailings Basin discharges intermittently to Wouri Creek, which in turn discharges to the Sandy River upstream of station S-1."* Wouri Creek connects with the Sand River downstream of Station SW001. Thus, Wouri Creek connects into the Sand River downstream of all monitoring stations discussed here. As such, current data associated with stations SW001, SW005, SW007 are not impacted by the Ispat-Inland Minorca Tailings Basin. Additionally, since the East Two Rivers discharges to Lake Vermilion, current data at stations SW001, SW005, SW007 are not impacted by the Tower POTW or Soudan State Park.

[40] MWH on behalf of MPCA, (2004). *Minntac Water Inventory Reduction EIS Surface Water Hydrology and Quality Technical Memorandum*, page 41 of pdf. *"There is at least one other source of permitted discharge to nearby surface waters in the Dark River watershed and that is the Hibbing Taconite Tailings Basin. This permittee (NPDES permit MN0049760) discharges to the Shannon River (west of the Minntac Tailings Basin), which in turn discharges to the Sturgeon River."* While Hibbing discharge exists, its discharge does not contribute pollutants to any of the monitoring stations discussed in this report.

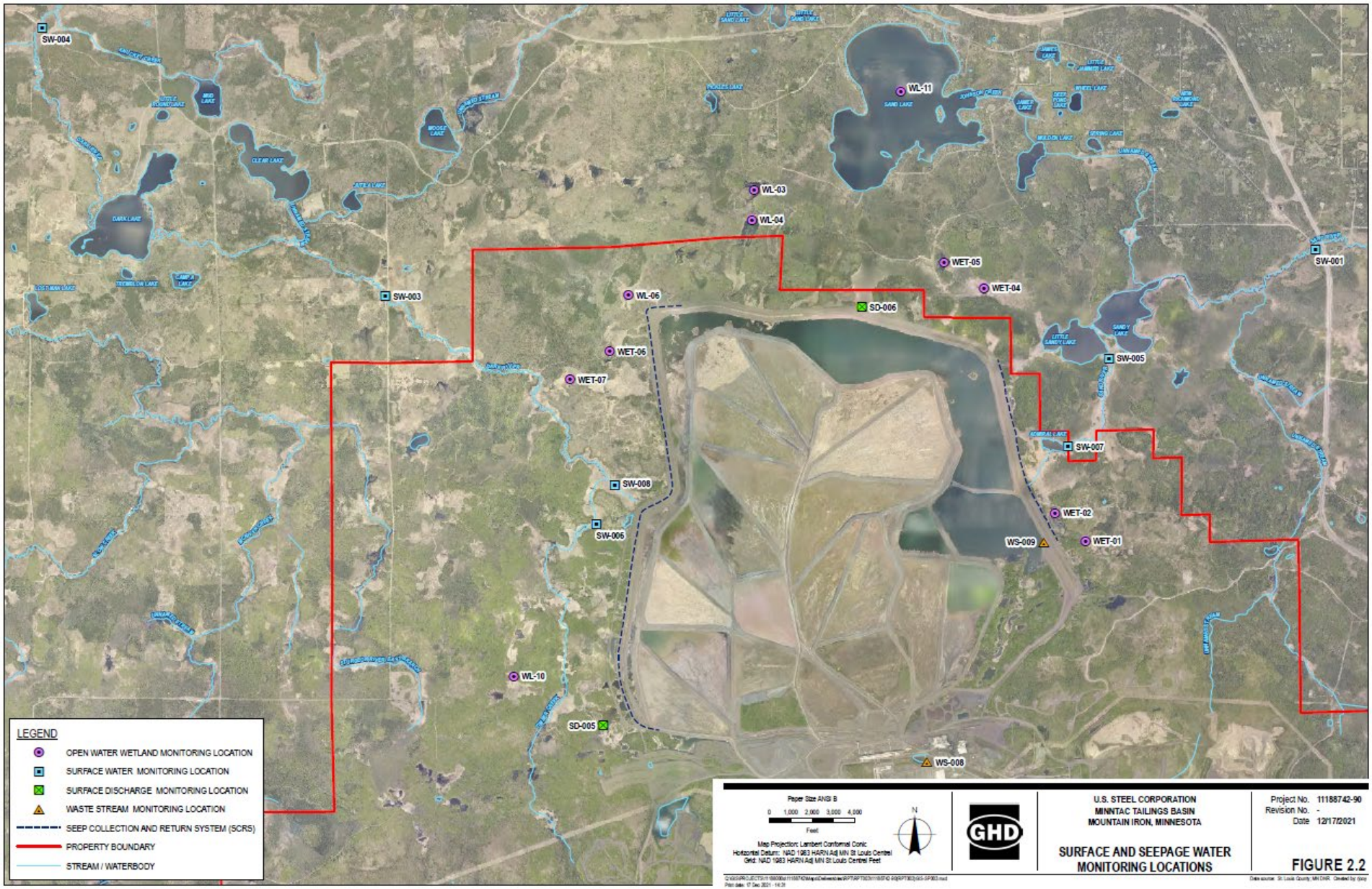

Figure 15. Surface and Seepage Water Monitoring Locations.
Taken from "Hydrological Investigation Report" (2021) by GHD on behalf of U.S. Steel. See page 55 of pdf.

Table 1. Sand River Surface Water Quality Data

Pollutant Parameters	**Current Conditions** (Data from December 2018 to April 2022, U.S. Steel Minntac DMR)				**Available Background**[3] (Data from May 2003 to November 2003, MPCA)		**Historic Conditions** (Data from 1958-1962, USGS)
	SD006 (Adjacent to perimeter dike of basin.) Number of samples = 139 Min – Max (Mean)	SW007 (Approximately 400 meters to perimeter dike of basin.) Number of samples = 39 Min – Max (Mean)	SW005 (Approximately 2,500 meters to perimeter dike of basin.) Number of samples = 41 Min – Max (Mean)	SW001 (i.e., Station 701) (Approximately 5 miles/8 kilometers downstream of basin) Number of samples = 41 Min – Max (Mean)	Britt Creek Number of samples = 7 Min-Max	Unnamed Creek at HW 170 Number of samples = 7 Min-Max	SW001 (i.e., Station 701) (Approximately 5 miles/8 kilometers downstream of basin's current location) Number of samples = 21 Min – Max (Mean)
Sulfate, Total (as SO4) (mg/L)	787-998[2] (891)	167-873 (650)	100-894 (525)	9.3-537 (200)	1-1.8	2.6-5.4	1.8-26 (8.5)
Chloride, Total (mg/L)	91.1-122 (105)	26.7-139 (101)	14.2-141 (83)	16.1-90.2 (45.6)	2.2-3.4	1.4-5.6	0.1-1 (0.25)
Hardness, Calcium & Magnesium, Calculated (as CaCO3) (mg/L)	1,390-1,710 (1,518)	283-1,290 (956)	161-1,260 (785)	161-779 (366)	12.8-50	14.8-72	13-54 (29.6)
Total Dissolved Solids (TDS) (mg/L)	1670-2,080 (1,938)	362-1,830 (1359)	241-1,970 (1,124)	102-1,110 (558)	---	---	---
Specific Conductance (umhos/cm)	867-2,817 (2,369)	765-2,535 (1908)	367-2,534 (1,551)	393-1,625 (781)	---	---	37-119 (63.6)

Notes:

1. This technical assistance focuses on the two pollutant parameters of sulfate and chloride as general indicators of the presence of process wastewater pollutants.
2. Discharge Monitoring Report (DMR) data from December 2018 to April 2022 was provided by MPCA to U.S. EPA on July 8, 2022. Above are summaries of instantaneous measurements. The dataset for Sulfate, Chloride, Hardness, TDS, and Specific Conductance can be found in **Table A-1**. The facility also regularly monitored for pH, bicarbonates (HCO3), and temperature; however, those pollutant parameters are not shown in this assessment.
3. For SD 006, ten samples taken from December 2018 to September 2019 reported units of "degrees C" for sulfate. EPA is considering this as a data entry error and included those values in the statistical summary calculations for sulfate in units of mg/L.
4. Britt Creek and the unnamed creek at Highway 170 had 7 samples taken from May 2003 to November 2003 which were considered background conditions for the 2004 EIS. Background data for stream surface water quality was collected as part of the Surface Water Hydrology and Quality Technical Memorandum for the 2004 Water Inventory Reduction EIS. MPCA confirmed in a May 11, 2022 email that they do not have any more recent data for those streams considered representative of background conditions. MPCA also confirmed in a May 12, 2022 email that they have had difficulty identifying a stream that is appropriately representative of background conditions for the Dark or Sand Rivers. Locations for Britt Creek and unnamed creek at Highway 170 can be found in the 2004 Water Inventory Reduction EIS, Surface Water Hydrology, and Quality Technical Memorandum.

Table 2. Dark River Surface Water Quality Data

Pollutant Parameters	Current Conditions (Data from December 2018-April 2022, U.S. Steel Minntac DMR)					Background Conditions (Data from May 2003 to November 2003)		Historic Conditions (Data from 1955-1961, pre-facility)
	SD001[2] (Adjacent to basin) Number of samples = 59 Min–Max (Mean)	SW006 (Approximately 600 meters to basin) Number of samples = 42 Min–Max (Mean)	SW008[3] (Approximately 1,200 meters to basin) Number of samples = 27 Min–Max (Mean)	SW003 (D-1) (Approximately 8 kilometers to basin) Number of samples = 42 Min–Max (Mean)	SW004 (Approximately 11 kilometers to basin.) Number of samples = 42 Min–Max (Mean)	Knuckey Creek[4] Number of samples = 7 Min-Max	Leander Creek[4] Number of samples = 7 Min-Max	Station D-2 (Approximately 15 miles/24 kilometers downstream of basin's current location) Number of samples = 8 Min-Max (Mean)
Sulfate (mg/L)	954-1150 (1028.4)	80.3-646 (363.4)	264-713 (498.9)	150-853 (516)	76-420 (218.1)	<1-2.2	<1-1.2	6.5-12 (8.2)
Chloride (mg/L)	119-146 (130.5)	4-36.3 (21.1)	26.8-90 (54.6)	16.2-90.6 (54.8)	9.7-43.1 (24.9)	1.7-2	4-7.7	0.3-0.7 (0.44)
Hardness, Calcium & Magnesium, Calculated (as CaCO3) (mg/L)	1450-1,880 (1615)	178-1,300 (758)	446-1,160 (890)	272-1,500 (919)	196-758 (409)	36.2-50	32-54	22-37 (31)
Total Dissolved Solids (TDS) (mg/L)	1940-2,450 (2218)	226-1,530 (897)	652-1,660 (1168)	372-1,990 (1187)	255-940 (511)	---	---	60-104 (79)
Specific Conductance (umhos/cm)	2,498-2,958 (2693)	363-2,150 (1282)	938-2,049 (1571)	568-2,488 (1609)	364-1,429 (218)	---	79-96	55-78 (68)

Notes:

1. This technical assistance focuses on the two pollutant parameters of sulfate and chloride as general indicators of the presence of process wastewater pollutants.
2. Discharge Monitoring Report (DMR) data from December 2018 to April 2022 was provided by MPCA to U.S. EPA on July 8, 2022. Above are summaries of instantaneous measurements. The dataset for Sulfate, Chloride, Hardness, TDS, and Specific Conductance can be found in **Table A-1**. The facility also regularly monitored for pH, bicarbonates (HCO3) and temperature; however, those pollutant parameters are not shown in this assessment.
3. SD001 was monitored until March 2020.
4. SW008 monitored monthly from April-November due to monitoring site access. Four samples between December 2018 and March 2019 were reported as "detect" with concentration values of zero for all the pollutant parameters; EPA is making the assumption that no samples were taken during December 2018-March 2019 and, thus, removed those zero values from the summarized data calculations.
5. Knuckey and Leander Creek had 7 samples taken from May 2003 to November 2003 which were considered background conditions for the 2004 EIS. Background data for stream surface water quality was collected as part of the Surface Water Hydrology and Quality Technical Memorandum for the 2004 Water Inventory Reduction EIS. MPCA confirmed in a May 11, 2022 email that they do not have any more recent data for those streams considered representative of background conditions. MPCA also confirmed in a May 12, 2022 email, that they have had difficulty identifying a stream that is appropriately representative of background conditions for the Dark or Sand Rivers. Locations for Knuckey Creek and Leander Creek can be found in the 2004 Water Inventory Reduction EIS, Surface Water Hydrology and Quality Technical Memorandum.

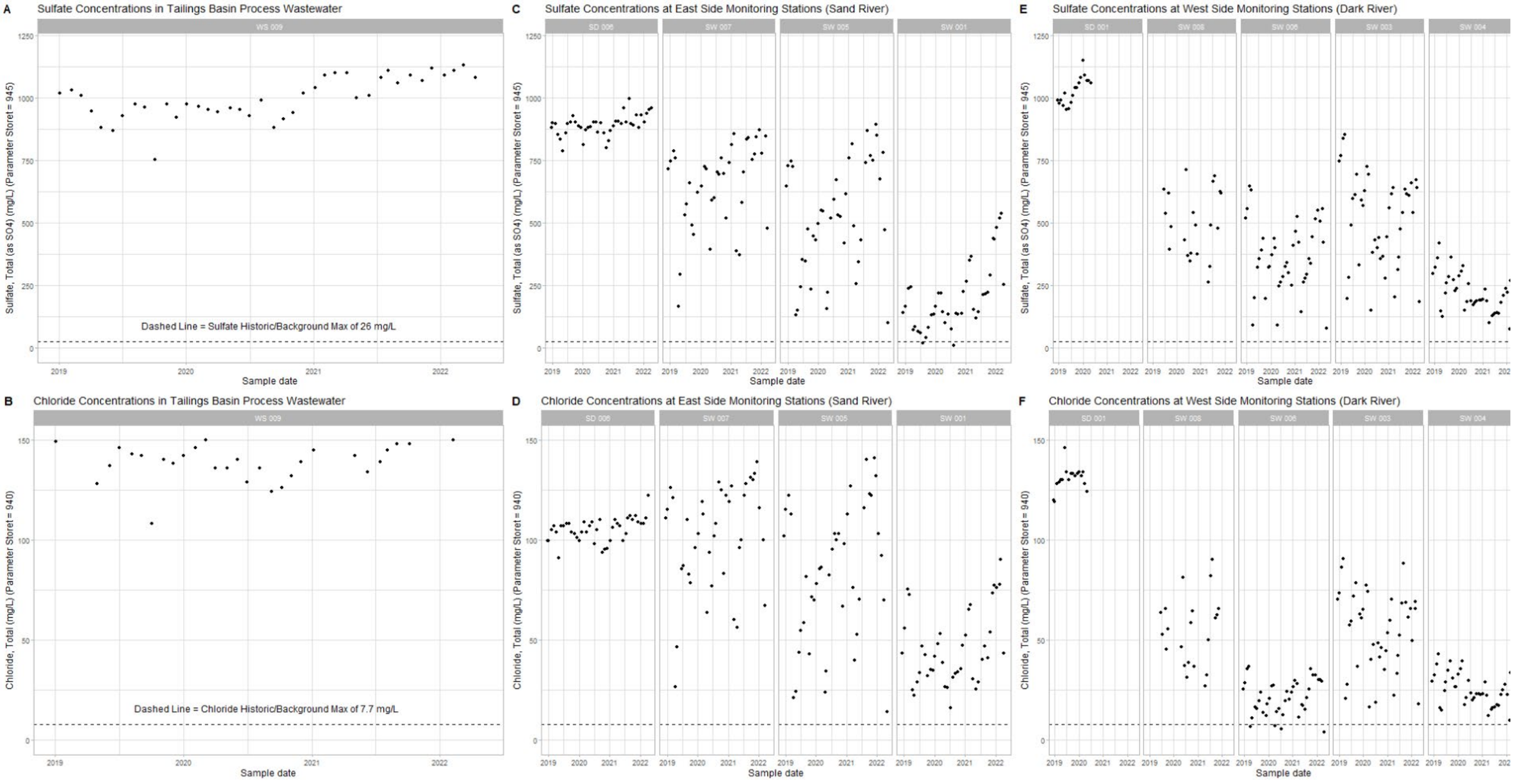

Figure 16. Sulfate and Chloride Concentrations Between December 2018 and April 2022.

Charts A-B show sulfate and chloride concentrations at the tailings basin. Charts C and D (Sand River) and E and F (Dark River) show monitoring stations within each watershed by order of distance from the tailings basin (left =closest and right is furthest from basin). Additional notes on data are included in Table 1 and Table 2. The full data set is included in Table A-1. EPA created charts from DMR Data using R-Project and RStudio.

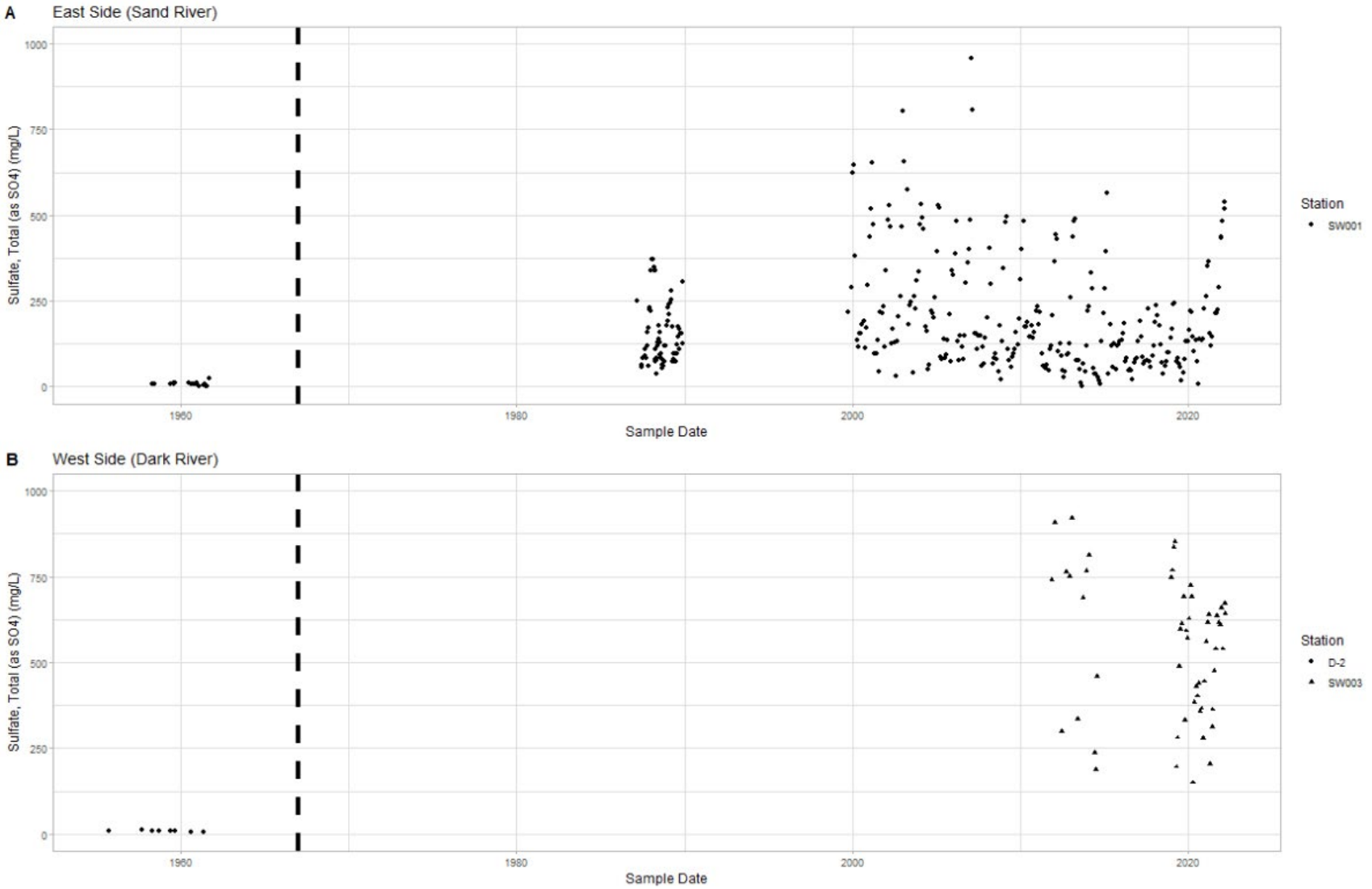

Figure 17. Sulfate Concentrations Over Time.

Chart A shows the east side of the basin (Sand River watershed). SW001 is approximately 5 miles downstream from the basin. Chart B shows the west side of the basin (Dark River watershed) at SW003 and D-2. SW003 and D-2 are within the Dark River watershed. SW003 is approximately 4.5 miles downstream of the basin and D-2 is approximately 15 miles downstream of the basin. Vertical dash lines indicate approximate initiation of tailings basin operation. EPA created charts using R-Project and RStudio from DMR Data and other sources provided by the State. Historic data are located in the Appendix.

2.4 *Waters of the United States*

EPA reviewed documents in the record including CWA section 404 permit applications from U.S. Steel,[41,42] United States Army Corps of Engineers' (Corps) permits,[43,44] and the administrative record for those decisions[45,46] to identify waters of the U.S. Those records identify the rivers, lakes, and wetlands surrounding the basin as waters of the U.S. As part of the 2021 Hydrological Investigation study, U.S. Steel submitted an interim status report,[47] which includes a summary of surface waters inclusive of waters of the U.S. and waters of the State[48] within a two-mile radius of the basin impacted or potentially impacted by the discharge from the basin (See **Figure 6**, which depicts the downstream drainage areas of the basin and **Figure 18**, which identifies surface waters surrounding the basin).[49] While the definition of waters of the State is broader than that for waters of the U.S., the waters identified as waters of the State by U.S. Steel (**Figure 18**) include the waters that were identified and permitted for impacts under CWA section 404 by the Corps.

The Sand River on the east side of the basin is a relatively permanent tributary that flows into the Pike River, a traditionally navigable water. On this side of the basin, the waters of the U.S. which receive discharges from the basin include: 1) the Sand River beginning near the toe of the dike and flowing to Admiral Lake; 2) Admiral Lake which is a relatively permanent water that connects downstream to the Pike River; 3) the Sand River flowing from Admiral Lake to the Twin Lakes (Little Sandy Lake and Sandy Lake); 4) Little Sandy Lake and Sandy Lake which

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[41] Permit Application for Water/Wetland Projects. United States Steel Corporation, Minnesota Ore Operations – Minntac Western Tailings Basin Seepage Collection System.

[42] Wetland Replacement Plan, Minntac Tailings Basin Surface Seepage Collection Project, with CWA section 404 permit application for 2009-02600-TWP attached. U.S. Steel. December 2009

[43] Permit and Letter. USACE, Regulatory File No. 2014-01247-TJH. April 26, 2019

[44] Permit and Letter. USACE Regulatory File No. 2009-02600-TWP June 9, 2009

[45] Memorandum to File 2012-01578-JCB

[46] Memorandum for Record. Department of the Army Environmental Assessment and Statement of Findings for Permit Application MVP-2014-01247-TJH

[47] GHD on behalf of U.S. Steel (2019), *Hydrological Investigation Work Plan Interim Requirements Status Report NPDES Permit MN005720.*

[48] In 1974, Minnesota received authority to administer the NPDES program from the Environmental Protection Agency. In the administration of the NPDES program, the Minnesota Statute Chapter 115 Water Pollution Control Sanitary Districts applies the following definition with respect to pollution of waters of the state: *"Waters of the state" means all streams, lakes, ponds, marshes, watercourses, waterways, wells, springs, reservoirs, aquifers, irrigation systems, drainage systems and all other bodies or accumulations of water, surface or underground, natural or artificial, public or private, which are contained within, flow through, or border upon the state or any portion thereof (Minn. Stat. Ann. § 115.01(22)).*

[49] GHD on behalf of U.S. Steel (2021), *Hydrological Investigation Report*, page 8 of pdf. *"The Interim Status Report noted that the Basin area is located on two major watersheds north of the Laurentian Continental Divide. Within these two major watersheds there are 131 minor sub-catchments watersheds that include 128 wetlands, 3 lakes (Admiral, Little Sandy, and Sandy) and 3 streams (Timber Creek, Dark River, and Sand River), encompassing 3,804 acres. Because the Basin acts as a groundwater recharge source, some surface water or wetland locations near the perimeter dike can receive groundwater due to strong upward vertical hydraulic gradients created by the elevated hydraulic head present inside the Basin."*

are relatively permanent waters that connect downstream to the Pike River; and 5) relatively permanent open water and adjacent wetlands with continuous surface connections to the Sand River and its unnamed tributaries.[50]

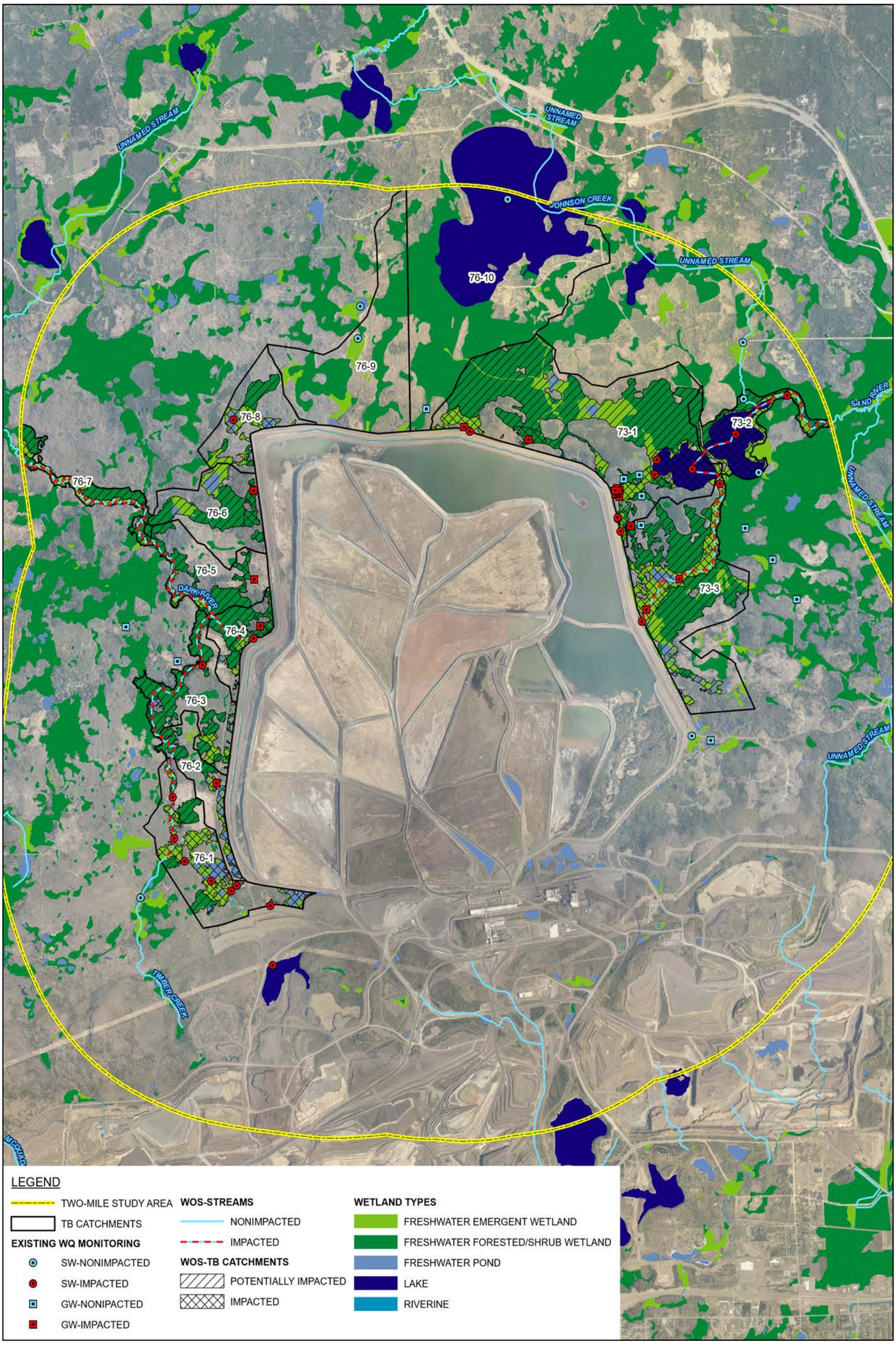
The Dark River is a relatively permanent tributary of the Sturgeon River which flows into the Little Fork River which is navigable-in-fact throughout. Along the Dark River (west) side of the basin, waters of the U.S. which receive discharges from the basin include: 1) the Dark River emerging near the toe of the perimeter dike; 2) Timber Creek, a relatively permanent tributary to the Dark River, which runs north along and parallel to the west side of the tailings basin; and 3) relatively permanent ponds and adjacent wetlands with continuous surface connections to the Dark River and to relatively permanent tributaries thereof. These wetlands span the length of the west side of the perimeter dike and are located immediately next to the perimeter dike and/or outside of the SCRS.

The Johnson Creek watershed to the northwest includes the following surface water features: 1) freshwater ponds, freshwater emergent wetlands, and freshwater forested/shrub wetlands, and 2) Sand Lake. It is unclear at this time whether surface water features within the Johnson Creek watershed are receiving discharges from the basin.

So, while EPA did not evaluate the extent and precise location of all of the waters of the U.S., the review of the permit records as noted above for the East Side SCRS (Permit No. 2009-02600-TWP) and the West Side SCRS (Permit No. MVP-2014-01247-TJH)[51] from the Corps and other documents indicate that the basin discharges to waters of the U.S. Further, as described in **Section 2.3**, pollutants from the tailings basin have been detected at water monitoring locations in waters of the U.S.

[50] U.S. Army Corps of Engineers permit files - Permits No. 2009-02600-TWP and MVP-2014-01247-TJH

[51] U.S. Army Corps of Engineers (2019), *Standard Permit with attachments*, see page 18 of document.



Source: St. Louis County; USFWS National Wetlands Inventory; MN DNR

Figure 18. Identified Waters of the State Classifications.
Taken from "Hydrological Investigation Work Plan Interim Requirements Status Report" by GHD on behalf of U.S. Steel (2019). Page 15 of pdf.

3 Technical Analysis of certain factors that may be relevant to a functional equivalent determination

While transit time and distance traveled will be the most important factors in most cases, and in many cases the only factors that need be considered, multiple other factors may also provide evidence to support the functional equivalent determination where time and distance are not dispositive. For this technical analysis, EPA analyzed each of the factors laid out by the Court and did not identify any additional factors that are relevant. The Supreme Court identified time and distance as the most important factors in most cases and left flexibility in how to weigh the relevant factors. While this technical assistance evaluates each of the seven factors identified by the Supreme Court in *Maui* in order to be as helpful to the State as possible, it is not necessary to evaluate every factor to find that a discharge is the functional equivalent of a direct discharge. Where one or two factors, such as transit time and distance traveled, present evidence that a discharge is the functional equivalent of a direct discharge, analysis of other factors may not be needed. For this technical analysis, EPA defers the weighing of the factors to the NPDES permitting authority. The following is EPA's evaluation of the publicly-available documents relevant to the Minntac tailings basin for each of the Supreme Court factors: (1) transit time, (2) distance traveled, (3) the nature of the material through which the pollutant travels, (4) the extent to which the pollutant is diluted or chemically changed as it travels, (5) the amount of pollutant entering the navigable waters relative to the amount of the pollutant that leaves the point source, (6) the manner by or area in which the pollutant enters the navigable waters, and (7) the degree to which the pollution (at that point) has maintained its specific identity. *Maui*, 140 S. Ct. at 1476–77.

Pollutant discharge pathways described in this section are limited to what has been modeled by various stakeholders. These pathways have not been confirmed with tracer studies.

3.1 *Transit Time*

The time a pollutant takes to reach surface waters depends on the path traveled by the pollutant. Some seepage from the tailings basin reaches surface waters adjacent to the outer edge of the perimeter dike.[52] An example of this is the seepage along the northern perimeter near SD006. In this instance, EPA considers time and distance traveled to be as short as from the outer edge of the basin to the wetlands immediately adjacent to the basin having the shortest amount of time for discharge to occur which is immediately. In instances where pollutants are traveling longer distances in the subsurface, the timeframes are longer, with many pathways taking less than 1-2 years. The specific pathways taken by molecules of wastewater to reach surface waters has been modeled for the Sand River watershed.[53,54]

U.S. Steel's model utilized the inner edge of the tailings basin perimeter dike as the start of the pathline, and transit time estimates for discharges reaching surface waters within the Sand River watershed predicted a minimum transit time of 1 year. As described below, the Great Lakes

[52] MPCA (2018), *Minntac NPDES Permit Fact Sheet*, page 11 of pdf. "*Emergent groundwater seepage at the toe of the basin dam flows into the Dark River and Sand River*"

[53] CRA on behalf of U.S. Steel (2013), *Estimate of Time of Travel between the Tailings Basin and the Twin Lakes.*

[54] Great Lakes Indian Fish and Wildlife Commission (2017), *Water Flow Pathlines from Minntac Basin East and Northeast Berm.*

Indian Fish and Wildlife Commission (GLIFWC), which also considered the start of pollutant pathlines to be at the inner edge of the perimeter dike, showed that some of the transit times to surface waters are relatively short, with many being "1 to 5 years in duration." GLIFWC estimated transit times from the inside of the tailings basin to surface waters at a minimum of 1 year, with most of the pathways emerging into surface waters in less than 25 years.

Retardation, the apparent slowing of contaminants because of adsorption onto the aquifer solids, does not affect sulfate[55] and chloride.[56] Thus, sulfate and chloride would be expected to have the same transit time as groundwater. Other pollutants were not evaluated.

3.1.1 Sand River Watershed

In response to a requirement from MPCA to estimate the transit time between the tailings basin and the Twin Lakes, U.S. Steel's consultant, CRA, simulated transit time for a specific portion of the Sand River Watershed under current (2013) conditions (i.e., with the SCRS sheet pile walls in place). CRA describes the model,[57] as shown in **Figure 19**, as follows:

"[Figure 19] *shows the simulated particle pathlines and travel times under current conditions (i.e., with the SC & R system sheet-pile walls in place). The simulated particle pathlines are similar to that occurring for the historical conditions, except that particles reaching the sheet-pile wall move downward from the shallow overburden [glacial till] into the deep overburden to pass under the sheet-pile wall, which extends through the shallow overburden [glacial till] only. The particles then move upwards back into the shallow overburden [glacial till] before discharging to the wetland area. Particles reach the location of the SC & R system in approximately 8 to 14 years, as occurs under historical conditions. Particles reaching the wetland area do so in approximately 10 to 25 years, and these particles reach piezometer nest PZ-12S/I/D in approximately 9 to 24 years. The sheet-pile wall moderately increases the travel time to piezometer nest PZ-12S/I/D and the wetland area compared to that occurring under historical conditions."*

The GLIFWC presented findings in a 2017 particle tracking assessment that utilized the same MODFLOW model as the 2013 CRA study but expanded the scope to include the entire eastern side of the basin.[58] **Figure 20** and **Figure 21** detail the pathline simulations presented in the GLIFWC report. GLIWFC estimated transit times for the same pathways as CRA's study (as

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[55] CRA on behalf of U.S. Steel (2013), *Groundwater Flow and Sulfate Transport Model Report*, page 47 of pdf. "In the subsurface, sulfate is not subject to sorption to soil particles and therefore travels at the same speed as groundwater. Thus, sorption is not represented for sulfate and a retardation factor of 1.0 is applied."

[56] Fitts, C. R. (2013), *Groundwater Science (2nd Edition).* Elsevier, page 539.

[57] CRA on behalf of U.S. Steel (2013), *Estimate of Time of Travel between the Tailings Basin and the Twin Lakes*

[58] Great Lakes Indian Fish and Wildlife Commission (2017), *Water Flow Pathlines from Minntac Basin East and Northeast Berm. "…we conducted additional particle tracking using the CRA MODFLOW model (T65Fut) that was supplied to the MPCA on a CD as Appendix C to the 2013a report. Using CRA's model output files, we began by duplicating the particle tracking presented in their [Figure 2] of the 2013b report. We then increased the number of particles released to include the entire north and eastern berm that was modeled by CRA in their 2013a MODFLOW model report. Our pathline analysis uses CRA's MODFLOW model output files and MODPATH. The only difference from CRA's work is that our analysis uses more released particles and, therefore, shows a more complete picture of the path that water takes from the basin to the toe of the berm and surrounding surface water features (our [Figure 18])."*

shown circled in **Figure 20**). Estimated flow paths include pathways directly through the dike and via groundwater under the dike. The GLIWFC study also modeled flows via groundwater reaching the SCRS system in approximately 10 years and the monitoring station PZ12 (located roughly 1,000 feet from the interior of the dike) in approximately 20 years. Additionally, in GLIFWC's expanded model, GLIFWC showed that some of the transit times to surface waters are relatively short, with many being "1 to 5 years in duration." Paths to surface water features (wetlands, pools, and channels) emerge at the toe of the basin berm and at locations close to the berm. Most of these flow paths are found within what is characterized as the shallow glacial till zone.[59] Also, the study suggests that most of the pathlines emerge into surface waters in less than 25 years. The study also identifies flow paths at the northern edge of the perimeter dike with less than 5 years of transit time before emerging into the wetlands near the toe of the basin.

3.1.2 Dark River Watershed

Analyses of transit time from the basin to surface waters within the Dark River watershed are not readily available. However, the nature of materials through which wastewater moves, including the berm and glacial till, are similar on both sides of the tailings basin. Therefore, due to similar subsurface conditions between the Sand River and Dark River watersheds (See **Section 3.3**), a similar range of transit times can be expected for discharges that pass under and through the perimeter dike and reach surface waters within the Dark River watershed.

[59] Glacial till zone is the layer above the granitic bedrock, often referred to as the "overburden" layer in the 2013 CRA report on behalf of U.S. Steel. In this report, the term "shallow" appears to refer to the areas where the glacial till ranges from approximately 0-50 ft. deep. The term "deep" appears to refer to the areas where the glacial till is more than 50 ft. deep.

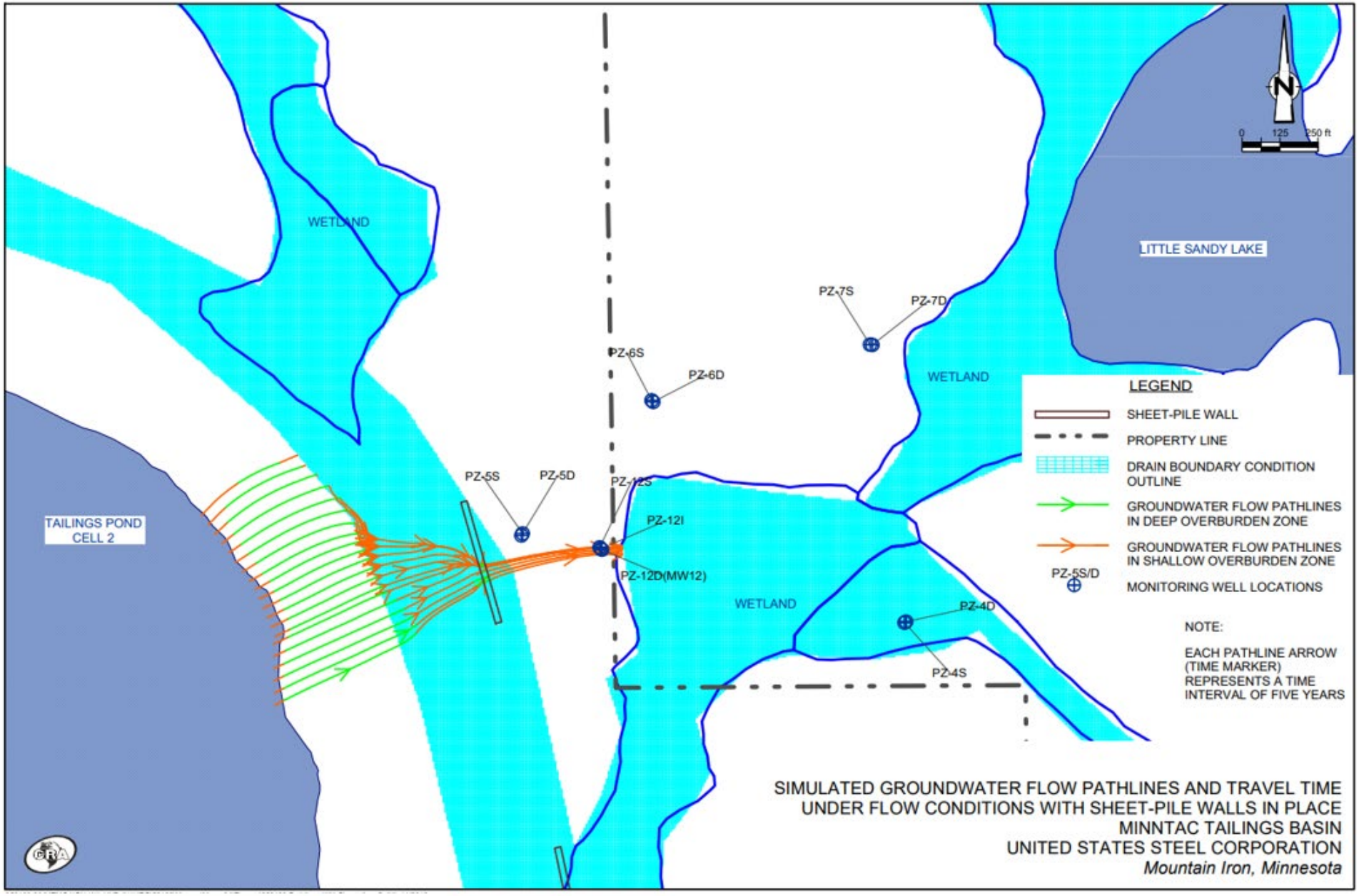

Figure 19. Simulated Groundwater Flow Pathlines and Travel Time Under Flow Conditions With Sheet Pile Walls in Place.
Taken from "Estimate of Time of Travel between the Tailings Basin and the Twin Lakes." by CRA on behalf of U.S. Steel (2013). See Page 5 of pdf. Modified by EPA to remove figure label.

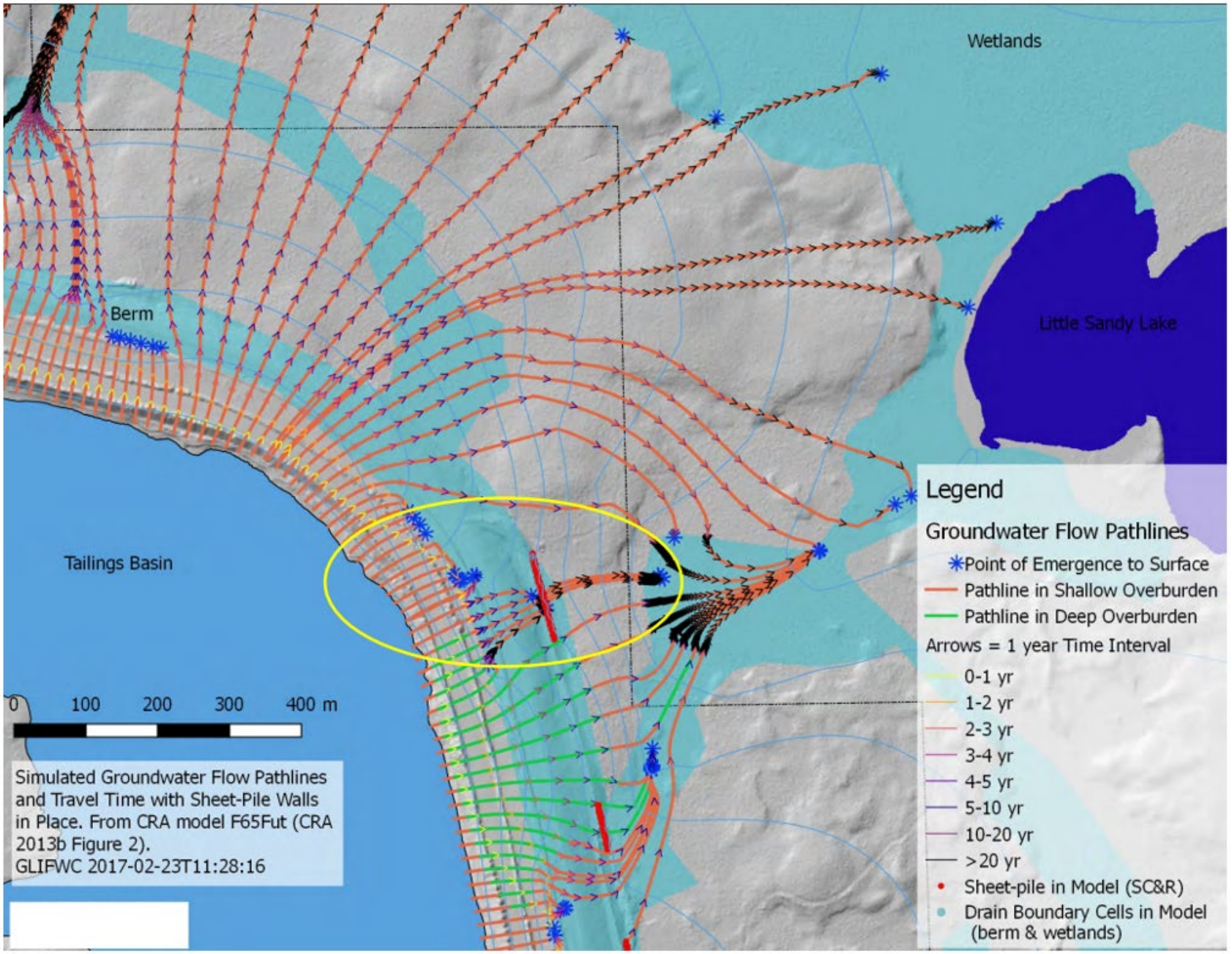

Figure 20. Simulated Groundwater Flow Pathlines and Travel Time With Sheet Pile Walls in Place.
From CRA model F65Fut. Taken from "Water Flow Pathlines from Minntac Basin East and Northeast Berm" by Great Lakes Indian Fish and Wildlife Commission (2017). See page 6 of pdf. Modified by EPA to remove figure label.

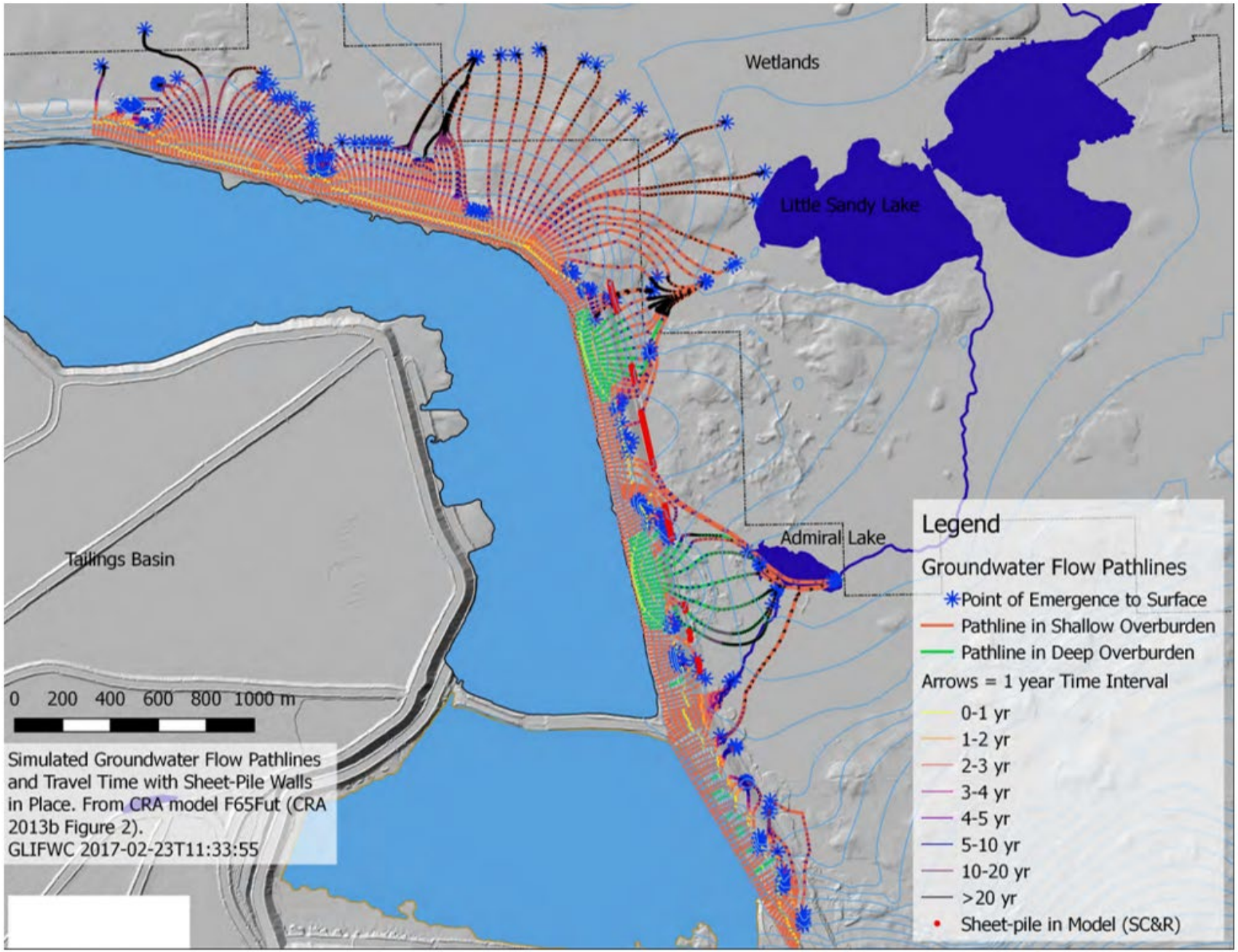

Figure 21. Simulated Groundwater Flow Pathlines and Travel Time With Sheet Pile Walls in Place (full extent).
From CRA model F65Fut. Taken from "Water Flow Pathlines from Minntac Basin East and Northeast Berm" by Great Lakes Fish and Wildlife Commission (2017). See page 7 of pdf. Modified by EPA to remove figure label.

3.2 *Distance Traveled*

Similar to what was discussed in Section 3.1, the distance traveled depends on the pathway traveled by the pollutant. EPA considers the outside of the perimeter dike to be a starting point for pollutant pathways, and as there are wetlands immediately adjacent to the basin in some areas, the shortest distance that can be traveled by pollutants to surface waters is zero feet, or an immediate release.

Other pathways are described in the 2021 Hydrological Investigation Report by U.S. Steel's contractor, GHD. In this report GHD characterized the distance traveled to surface waters: "*[g]iven the hydraulic conditions of the Basin in relation to the surrounding areas, most of the Basin seepage that migrates past the Seep Collection and Return System reports to nearby surface waters within a relatively short distance from the Basin perimeter dike*."[60] Other studies discussed below provide numeric estimates of 100 feet to 3,300 feet of distance traveled, depending on the surface water of interest in each study.

Also, thermal studies (discussed below) suggest that seepage enters surface waters within 100 meters (330 feet) of the perimeter dike. Additionally, a 2017 EPA inspection report (also discussed below) indicates elevated sulfate and chloride levels within and immediately outside of the SCRS, where they are located. Some wastewater emerges in surface waters at the toe of the dike (adjacent to the basin).[61] See **Figure 11** for a cross section of the dike. Other pathways exist that represent longer distances traveled to surface waters.

3.2.1 *Sand River Watershed*

The approximate distance traveled by pollutants that move through the subsurface to surface waters is as little as zero feet where seeps emerge immediately along the outer edge of the perimeter dike into wetlands at the toe of the perimeter dike. Other discharges occur in the large wetland complex that covers over 2,000 acres that abut unnamed tributaries, lakes and the Sand River. See **Section 2.4** and for a description of siting and waters of the U.S.

3.2.1.1 Estimating Distance Traveled Utilizing Pathline Studies

The CRA and GLIFWC studies estimated both transit time and distance travelled for the eastern side of the tailings basin. The 2013 CRA study showed that discharges through groundwater along the study path from inside the perimeter dike emerge to the wetland boundary condition within 1,000 feet (305 meters) of the perimeter dike (See **Figure 19**, which depicts pathline and travel time simulations from the east and northeast berms of the basin).

The 2017 GLIFWC report, which utilized the model from the 2013 CRA study, expanded the scope to include the length of the east side of the basin under conditions with sheet pile walls in place (from the SCRS system). The model estimated multiple pathways resulting in a range of distances traveled for pollutants from the basin to reach surface waters. To the south and north of the SCRS system, pollutants pass through and under the perimeter dike to surface waters via pathways that include subsurface flows emerging into wetlands, which are adjacent to or within

[60] GHD on behalf of U.S. Steel (2021), *Hydrological Investigation Report*, page 35 of pdf.

[61] MPCA (2018), *Minntac NPDES Permit Fact Sheet.* pages 11 of pdf. "*Emergent groundwater seepage at the toe of the basin dam flows into the Dark River and Sand River*"

approximately 330 feet (100 meters) of the perimeter dike and through the "shallow" glacial till zone that travel up to a modeled 3,300 feet (1,000 meters) from the perimeter dike.[62] (See **Figure 20** and **Figure 21**, which show the general location of discharge pathways). The 2017 GLIFWC model estimated that 51 percent of flow paths emerge within 330 feet (100 meters) of the toe of the berm and 87 percent of the flow paths emerge within 1,650 feet (500 meters) from the toe of the tailings basin berm. The pathline studies suggest the vast majority of flow paths in the Sand River watershed reach surface waters within 3,300 feet (1,000 meters).

3.2.1.2 Thermal Studies

In 2022, GLIFWC compared a 2013 thermal and visible light imagery study by Fond du Lac Band and 2019 imagery provided by U.S. Steel in their 2021 Hydrological Investigation Report.[63] Referencing the 2013 study, GLIFWC mentions identifying "*14 areas of open water with thermal anomalies within 100 [meters] of the basin berm toe and outside the SCRS,*" as shown in **Figure 22**. **Figure 10** provides an aerial image of the east side of the basin for visual reference of the proximity of wetlands to the SCRS.

As required under Section 5.29.32(a) of the 2018 NPDES Permit,[64] the 2021 Hydrological Investigation Report included an analysis of thermal imaging around the perimeter dike to identify significant surface and subsurface flow paths coming from the basin.[65] The results are presented in **Figure 23** and in Appendix E of the 2021 Hydrological Investigation Report. In addition to seepage emerging along the length of the east side SCRS, the thermal study is consistent with the 2017 GLIFWC model, which shows seepage emerging in the wetlands to the north and south of the east side SCRS. Disagreements exist as to whether thermal anomalies from the 2019 thermal study appear immediately outside of the east side SCRS (and outside of the associated sheet piling).[66,67]

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[62] The term "shallow glacial till zone" is referred to as the "shallow overburden" in the 2013 CRA report on behalf of U.S. Steel. The term "shallow" glacial till zone appears to refer to the areas where the glacial till ranges from 0-50 ft deep. "Deep" glacial till zone appears to refer to the areas where the glacial till is more than 50 ft deep.

[63] Great Lakes Indian Fish & Wildlife Commission (2022), *Technical Memorandum – Thermal imagery 2013 and 2019 for detecting Minntac east-side discharge.* "*In 2013 the Fond du Lac Band contracted with A.W. Research Laboratories to do an overflight of the entire Minntac tailings basin berm. During the flight on March 26 multi-band imagery was captured. This included visible light imagery and infrared (IR) imagery. The IR imagery was used to identify locations of higher temperature near the toe of the tailings basin berm. Because most water was ice-covered and the ground snow-covered, the visible light imagery could be used to identify areas of open water*."

[64] MPCA *(2018*), *National Pollutant Discharge Elimination System/State Disposal System Permit MN0057207: US Steel Corp. – Minntac Tailings Basin Area,* page 22 of document.

[65] GHD on behalf of U.S. Steel (2021), *Hydrological Investigation Report*, page 14 of pdf.

[66] GHD on behalf of U.S. Steel (2021), *Hydrological Investigation Report*, page 23 of pdf. "*Although a few thermal anomalies were noted on the eastern portion of the perimeter dike, all of the anomalies were within the confines of the east-side SCRS, indicating the existing east-side SCRS is effectively controlling the discharge of surface and shallow subsurface seepage along the eastern perimeter dike*."

[67] Great Lakes Indian Fish & Wildlife Commission (2022), *Technical Memorandum – Thermal imagery 2013 and 2019 for detecting Minntac east-side discharge*, page 2 of pdf. "*USS's consultant identified 4 thermal anomalies as seeps in this same area (USS 2021 Figure 3.4), all of which the consultant crudely mapped as outside of the SCRS. USS provided imagery for 3 of these anomalies. All three of these anomalies were also seen in the 2013 FdL imagery. Of the three, when we accurately aligned them with the location of the SCRS in qGIS, two (9E & 9F) were*

3.2.2 Dark River Watershed

On the west side, some wastewater emerges near the perimeter dike and SCRS. In 2016, U.S. Steel's consultant, Barr Engineering Company, prepared a wetland monitoring plan for wetlands that may be impacted by the west side SCRS.[68] The report, which includes satellite images of the west side of the basin overlaid by seep locations and wetland delineations (delineations were also presented in US Steel's CWA section 404 permit application to construct the SCRS[69]), indicates seepage and wetlands at the toe of the dike and within a short distance from the berm. For instance, **Figure 24** shows an aerial image of the central portion of the west side perimeter dike abutting wetlands. Specific flow paths have not been studied post-SCRS installation in 2019. However, it is reasonable to assume that water continues to flow beyond the SCRS system and emerge in surface water features due to 1) the SCRS design allowing subsurface flows, 2) the west side SCRS being similar in design to the east side SCRS (i.e., allowing subsurface flows), and 3) estimates of seepage that reach surface water locations downstream (post-SCRS) not showing a decreasing trend at this time (See **Table A-5**).

outside (to the east) of the SCRS (Figure 2). Discharge 9E and 9F are near the location of the historical channel of the Sand River, which is visible in 1940's imagery. In addition to georeferencing the USS imagery, we noted that in the USS imagery the consultant used red arrows to indicate the locations of thermal anomalies. Thermal images for anomalies 9E and 9F had arrows identifying anomalies outside the SCRS. The thermal and visible imagery collected in 2013, which shows 14 areas of open water and elevated water temperature outside the east-side SCRS in March, confirms and supplements the thermal imagery in the 2021 USS report identifying basin discharges outside the SCRS."

[68] BARR Engineering Company on behalf of U.S. Steel (2016), *Wetland Monitoring plan – U.S. Steel Minntac West Tailings Basin Seepage Collection Project.*

[69] Permit Application for Water/Wetland Projects – United States Steel Corporation, Minnesota Ore Operations – Minntac. Western Tailings Basin Seepage Collection System. April 4, 2014

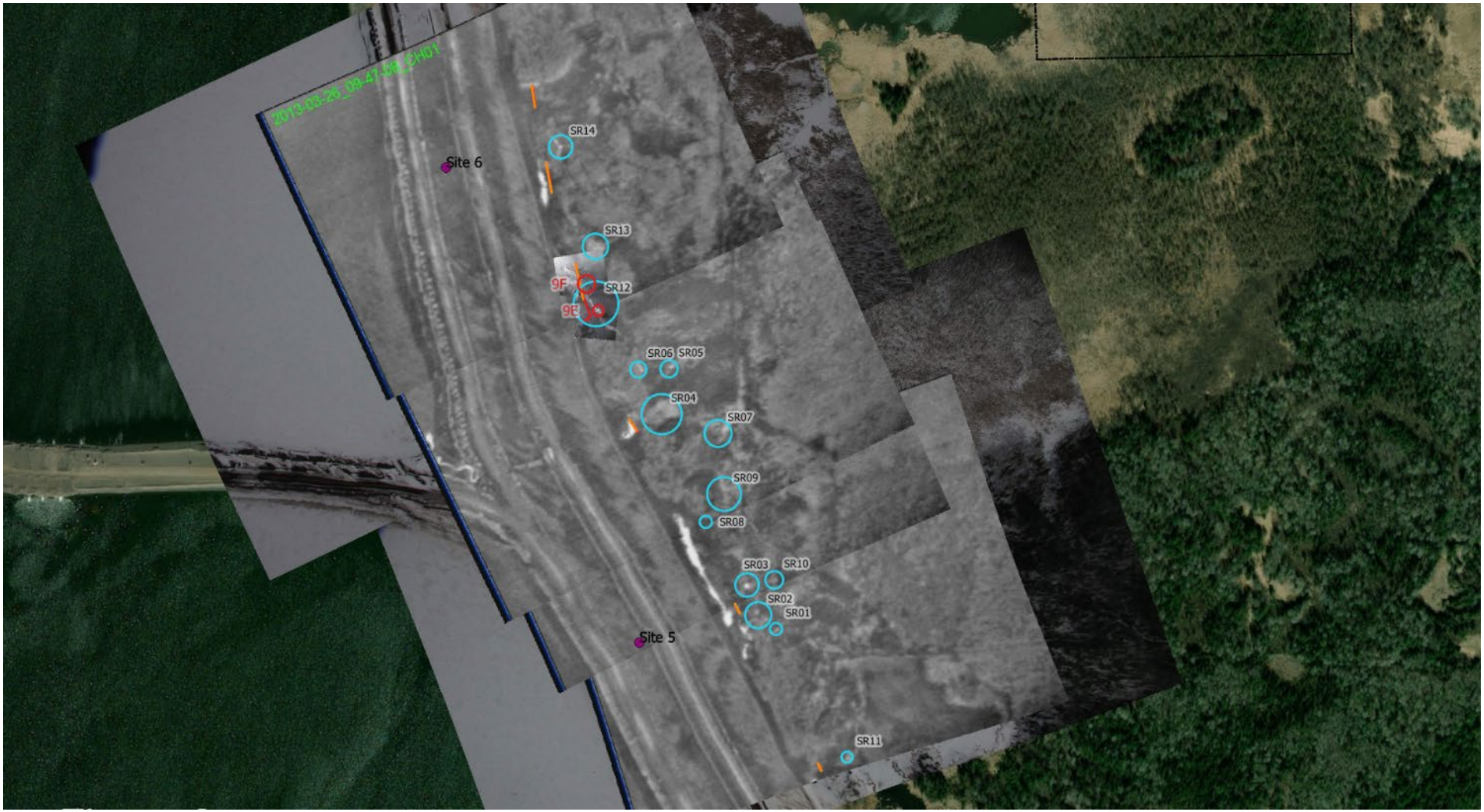

Figure 22. Image of East Side of Tailings Basin With Overlapping Infrared Images.
From "Thermal imagery 2013 and 2019 for detecting Minntac east-side discharge", Technical Memorandum by Great Lakes Indian Fish & Wildlife Commission (2022). See page 3 of pdf.

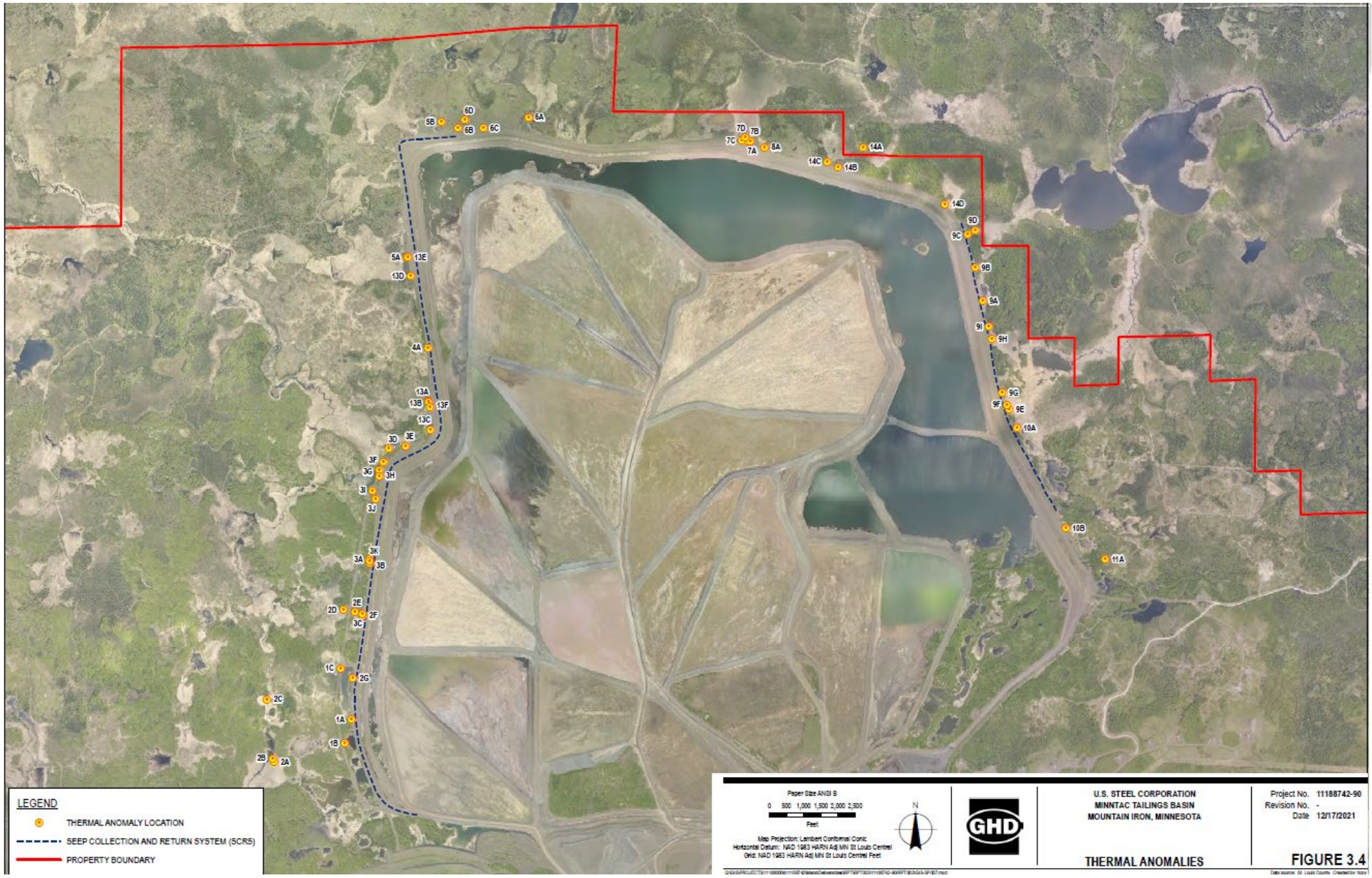

Figure 23. Thermal Anomalies.

Taken from "Hydrological Investigation Report" performed by GHD on behalf of U.S. Steel (2021). Page 58 of pdf. Note: SCRS was not installed on the West Side at time of study.

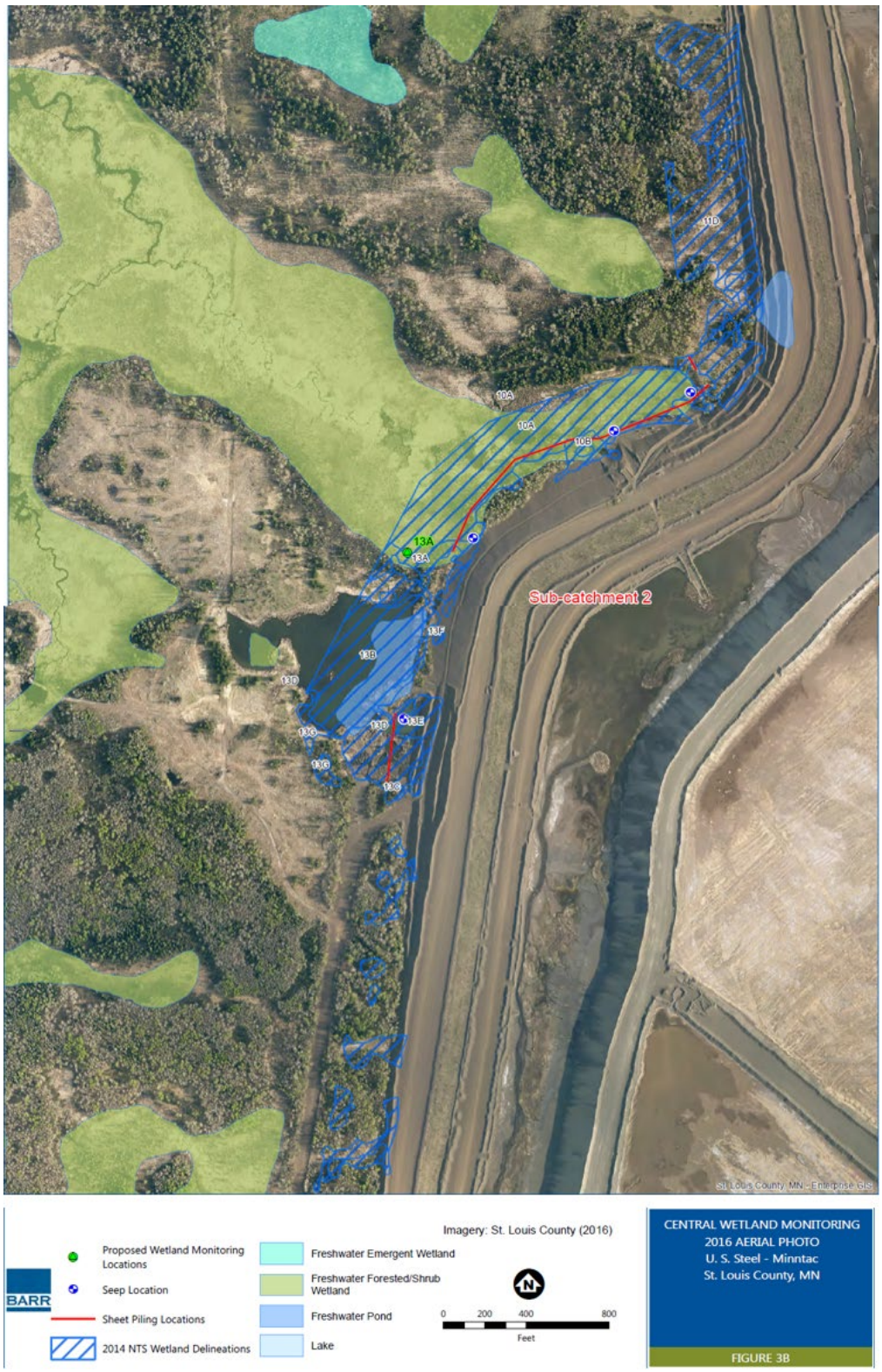

Figure 24. Central Wetland Monitoring 2016 Aerial Photo.

Taken from "Wetland Monitoring Plan – U.S. Steel Minntac West Tailings Basin Seepage Collection Project" - BARR Engineering on behalf of U.S. Steel (2016). [70]. Page 18 of pdf. The wetlands delineation shown here is taken from the 2014 CWA section 404 permit application for construction of the SCRS (see the legend referring to "2014 NTS Wetland Delineations"). Note the presence of wetlands located between the SCRS and the basin perimeter dike.

[70] Permit Application for Water/Wetland Projects – United States Steel Corporation, Minnesota Ore Operations – Minntac. Western Tailings Basin Seepage Collection System. April 4, 2014

3.3 *The Nature of the Material Through Which the Pollutant Travels*

The tailings basin is underlain by unconsolidated glacial till consisting primarily of fine to medium sand with some silt and rock clasts ranging from cobbles to boulders. Pollutants travel through a variety of pathways to reach surface waters such as the basin perimeter dike, composed of coarse and fine tailings, or through the permeable glacial till. Furthermore, while there are pollutants that may be impacted as the discharge moves with groundwater through the subsurface material, there are pollutants (e.g., chloride) that will not be affected.

In localized sites, areas consisting of peat are found underneath the basin and above the glacial till layer. Underneath the glacial till is the bedrock made up of the igneous rock granite, which can be considered a hydraulic barrier due to its low permeability. This granitic bedrock contains overlaying weathered zones within which fractures exist; however, the thickness of these weathered zones remains unknown.[71] The nature of materials along the pollutant transport path can be examined by reviewing subsurface geologic cross-sections and soil borings. A geologic cross section from east to west for a portion along the north side of the basin, as interpreted by NTS (2015), is shown in **Figure 25**, **Figure 26**, and **Figure 27**. The cross-section suggests the presence of sand, silt and occasional gravel underlying the tailings basin. Geologic cross-sections are not available for the entire perimeter of the basin.

Soil borings are located around the perimeter of the basin in the Sand and Dark River watersheds. In the Sand River, subsurface monitoring sites include monitoring wells (MW-1, MW-2, MW-3, MW-4, MW-10, MW-12, MW-17D), soil borings (SB-01-19, SB-02-19, SB-03-19, SB-04-19, SB-05-19), geoprobes (GP-2, GP-3, GP-4, GP-4A), and piezometers (PZ-2, PZ-3, PZ-4, PZ-5, PZ-6, PZ-7). In the Dark River watershed, subsurface monitoring sites include monitoring wells (MW-5, MW-6, MW-7, MW-8), geoprobes (GP-1, GP-3), and piezometers (PZ-1) (See **Figure 28** for a map of monitoring well and soil boring locations). The boring log information concurs with the predominant presence of sands, silt, clay, gravel, and localized areas where a peat layer overlays the glacial till, as interpreted by GHD on behalf of U.S. Steel.[72]

A 2013 study by CRA on behalf of U.S. Steel provided a three-dimensional groundwater flow model of the east side of the basin based on the interpretation of the observed geological and hydrogeological conditions available at the basin and in the surrounding area. The study indicates a bedrock depression beginning at the basin and continuing underneath the Sand River. The study provided model layers that indicate the projected spatial hydraulic conductivities. **Figure 29**, **Figure 30**, and **Figure 31** describe the spatial hydraulic conductivities in the model layers representative of the glacial till.[73] **Table A-6** describes hydraulic conductivity values and soil descriptions at individual monitoring sites (notably higher conductivity values were found at stations PZ-4D, PZ-6D and PZ-7D). The higher hydraulic conductivity values generally indicate

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[71] CRA on behalf of U.S. Steel (2013), *Groundwater Flow and Sulfate Transport Modeling Report*, page 8 and 10..

[72] GHD on behalf of U.S. Steel (2021), *Hydrological Investigation Report*, page 18 of pdf.

[73] CRA on behalf of U.S. Steel (2013), *Groundwater Flow and Transport Modeling Report*, page 24 of pdf. "*The top elevation for Model Layer 2 (or the bottom elevation of Model Layer 1) was assigned equal to the ground surface elevation beyond the Tailings Basin pools and perimeter dike area. Beneath the perimeter dike and Tailings Basin pools, the top elevation of Model Layer 2 was assigned to the ground surface elevation estimated to have existed prior to the presence of the Tailings Basin pools and perimeter dike. The top of bedrock was used for the bottom elevation of the Model Layer 3. The model layer elevation for the bottom of Model Layer 2 was approximately the middle of the saturated overburden thickness*."

dominant flow paths.

From the bottom of the basin, the contaminated wastewater mixes with groundwater in the uppermost, unconfined glacial till aquifer and travels towards the Sand and Dark River watersheds. Glacial till is porous in nature and allows groundwater to flow through it.

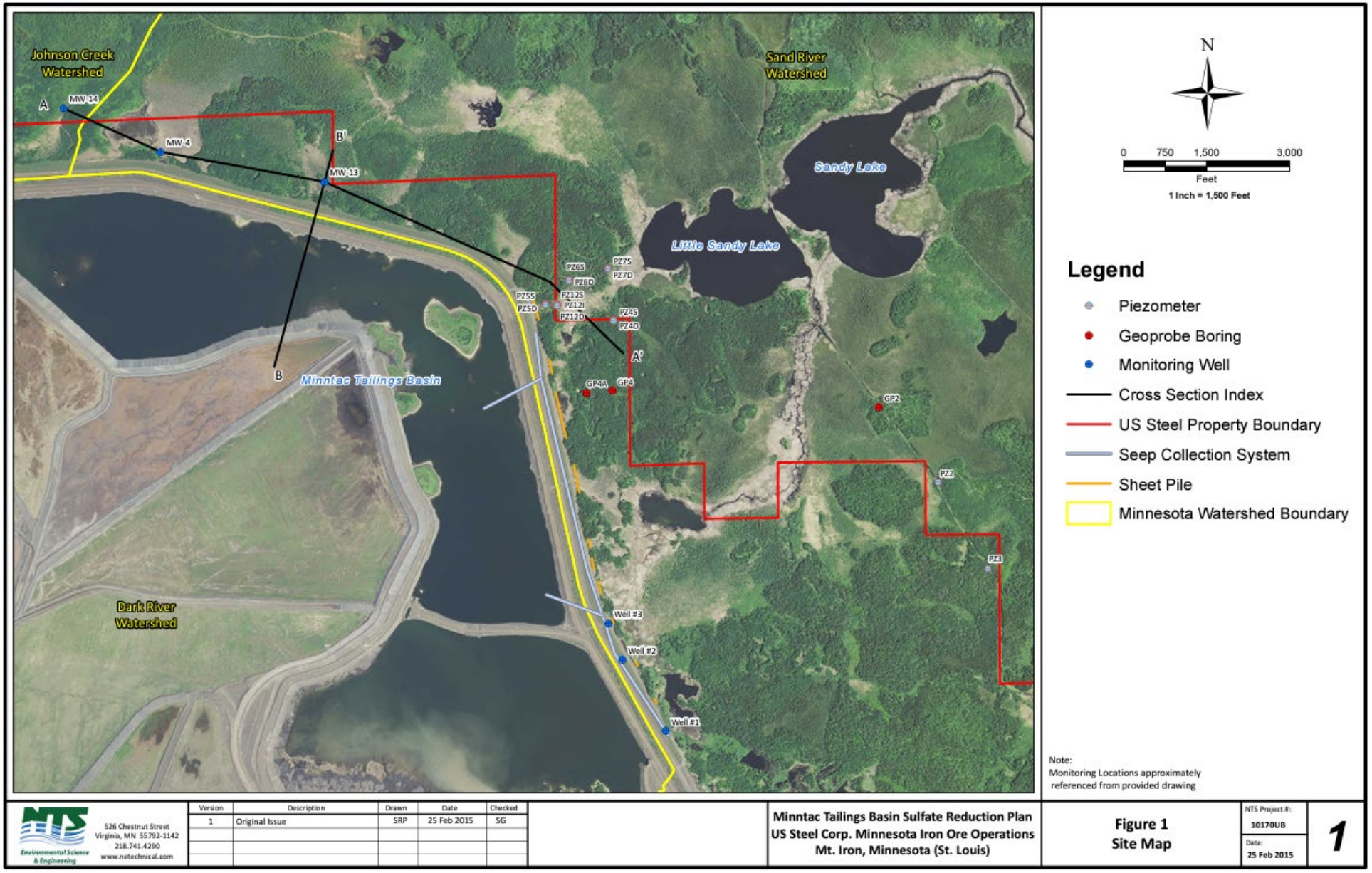

Figure 25. Site Map.
Taken from "Groundwater Sulfate Reduction Plan – Addendum #1, Minntac Tailings Basin – North Side" Northeast Technical Services, Inc. on behalf of U.S. Steel (2015).

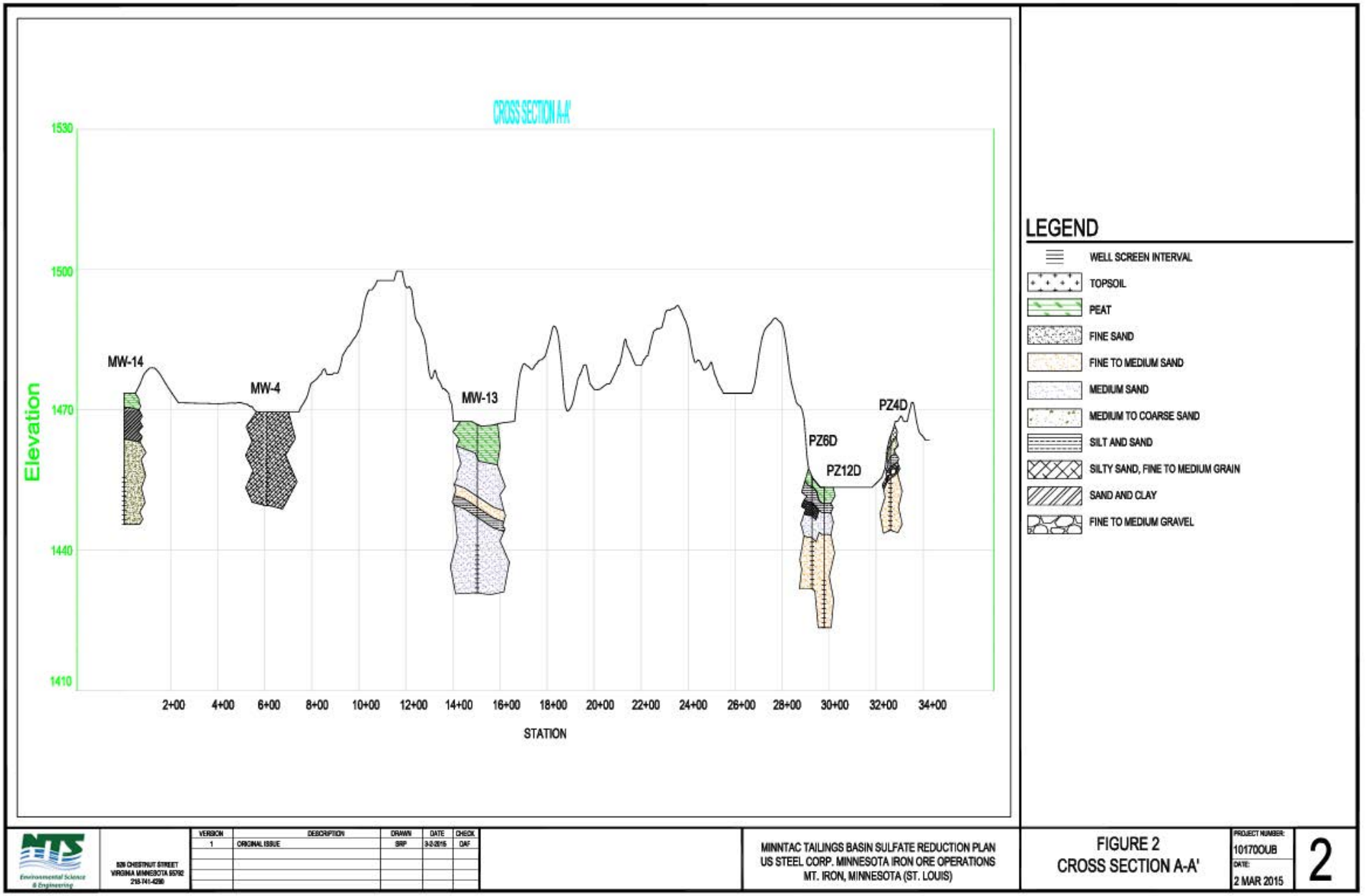

Figure 26. Cross Section A-A'.
Taken from "Groundwater Sulfate Reduction Plan – Addendum #1, Minntac Tailings Basin – North Side" Northeast Technical Services, Inc. on behalf of U.S. Steel (2015).

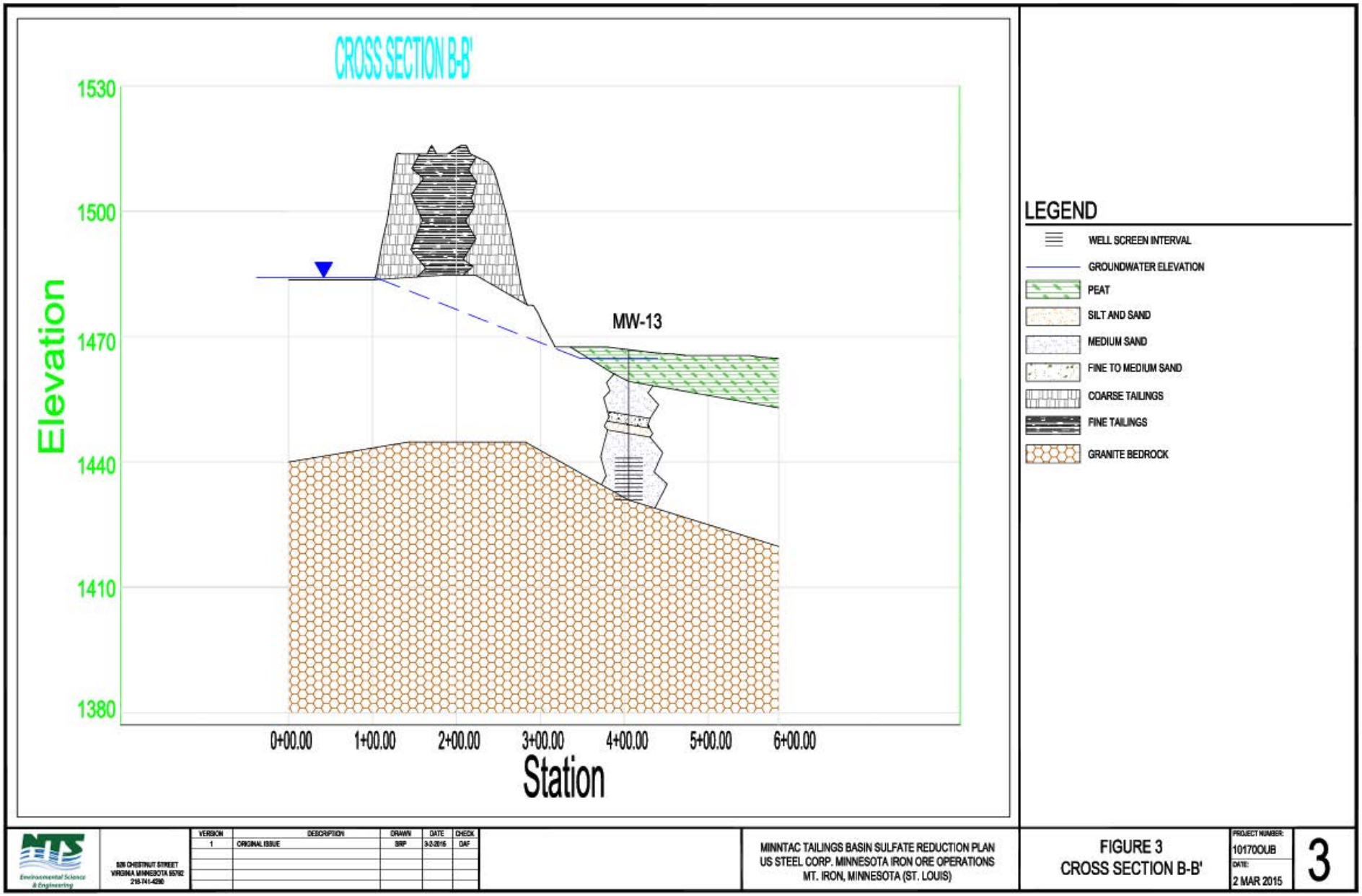

Figure 27. Cross Section B-B'.

Taken from "Groundwater Sulfate Reduction Plan – Addendum #1, Minntac Tailings Basin – North Side" Northeast Technical Services, Inc. on behalf of U.S. Steel (2015).

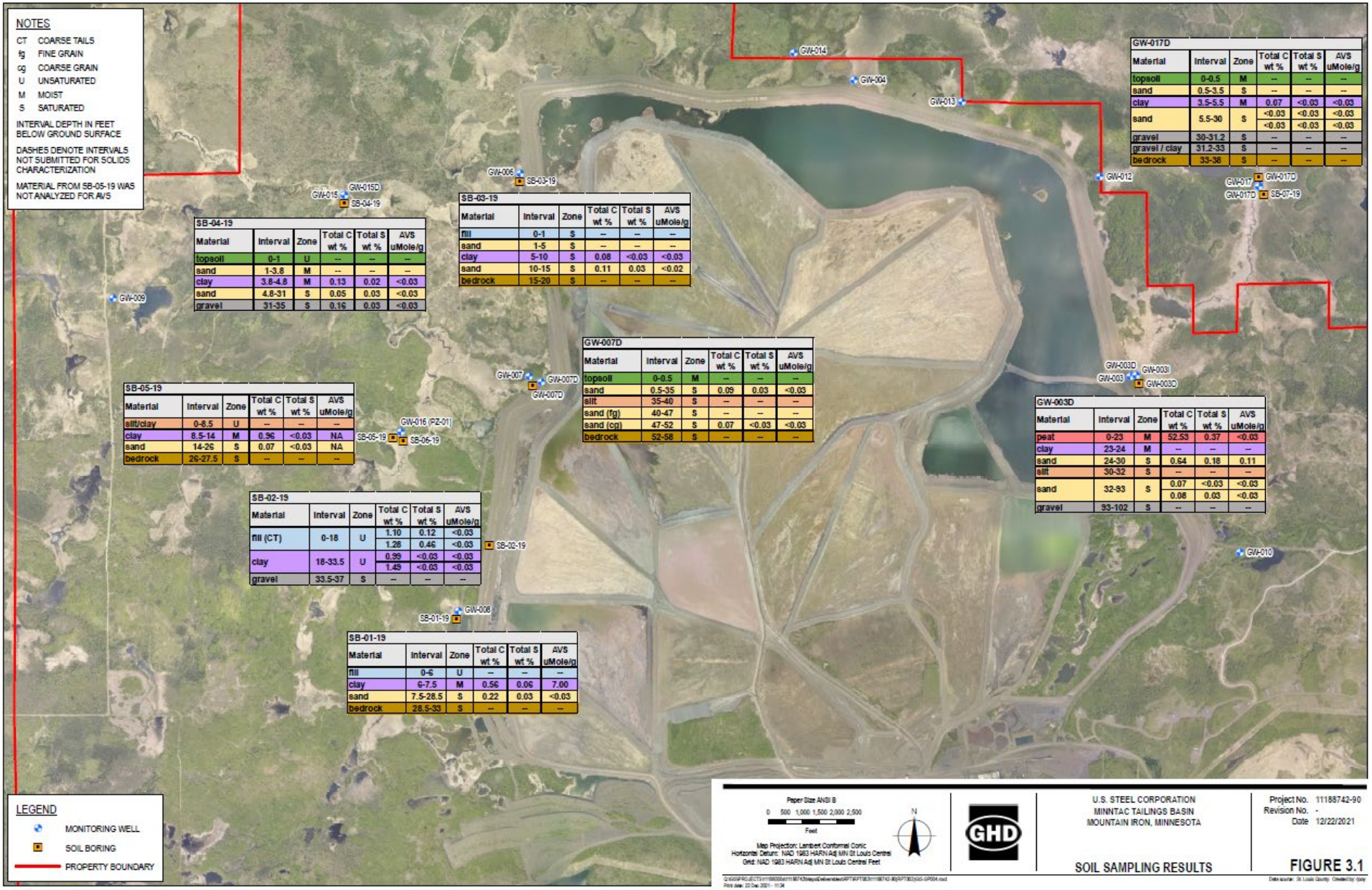

Figure 28. Soil Sampling Results.
Taken from "Hydrological Investigation Report" performed by GHD on behalf of U.S. Steel (2021).

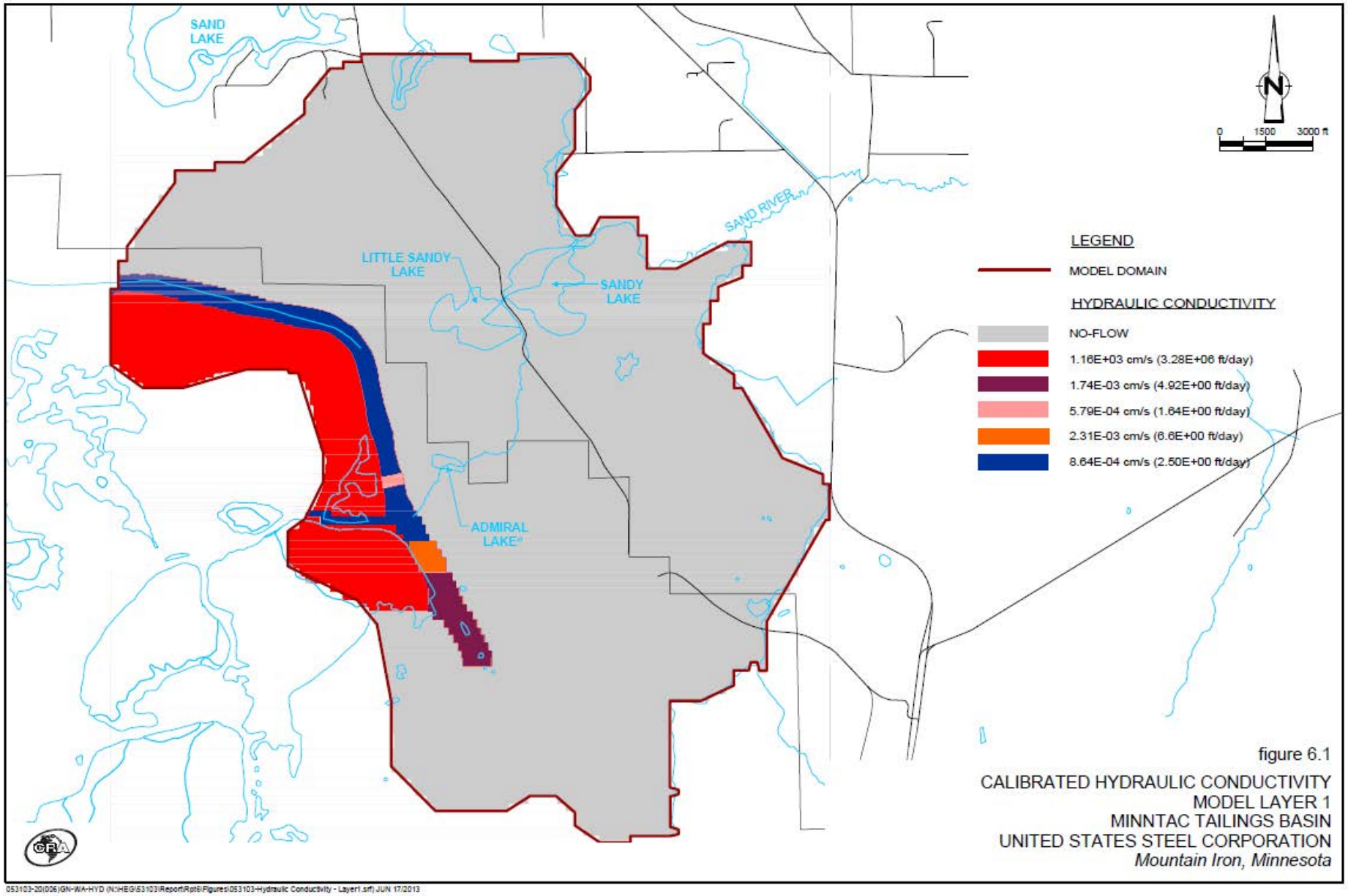

Figure 29. Calibrated Hydraulic Conductivity – Model Layer 1.

Taken from "Groundwater Flow and Sulfate Transport Modeling Report" by CRA on behalf of U.S. Steel. See page 70 of pdf. "Ground surface elevations throughout the model domain were generated using a combination of USGS Digital Elevation Model (DEM) data and survey data associated with the Site boreholes. The current ground surface elevations along the perimeter dike were used to represent the presence of the dike. Over the Tailings Basin pools and perimeter dike area, the top elevation of Model Layer 1 was assigned equal to the groundwater surface elevation. Beyond this area, the top elevation of Model Layer 1 was assigned to a uniform 1-ft distance above ground surface."

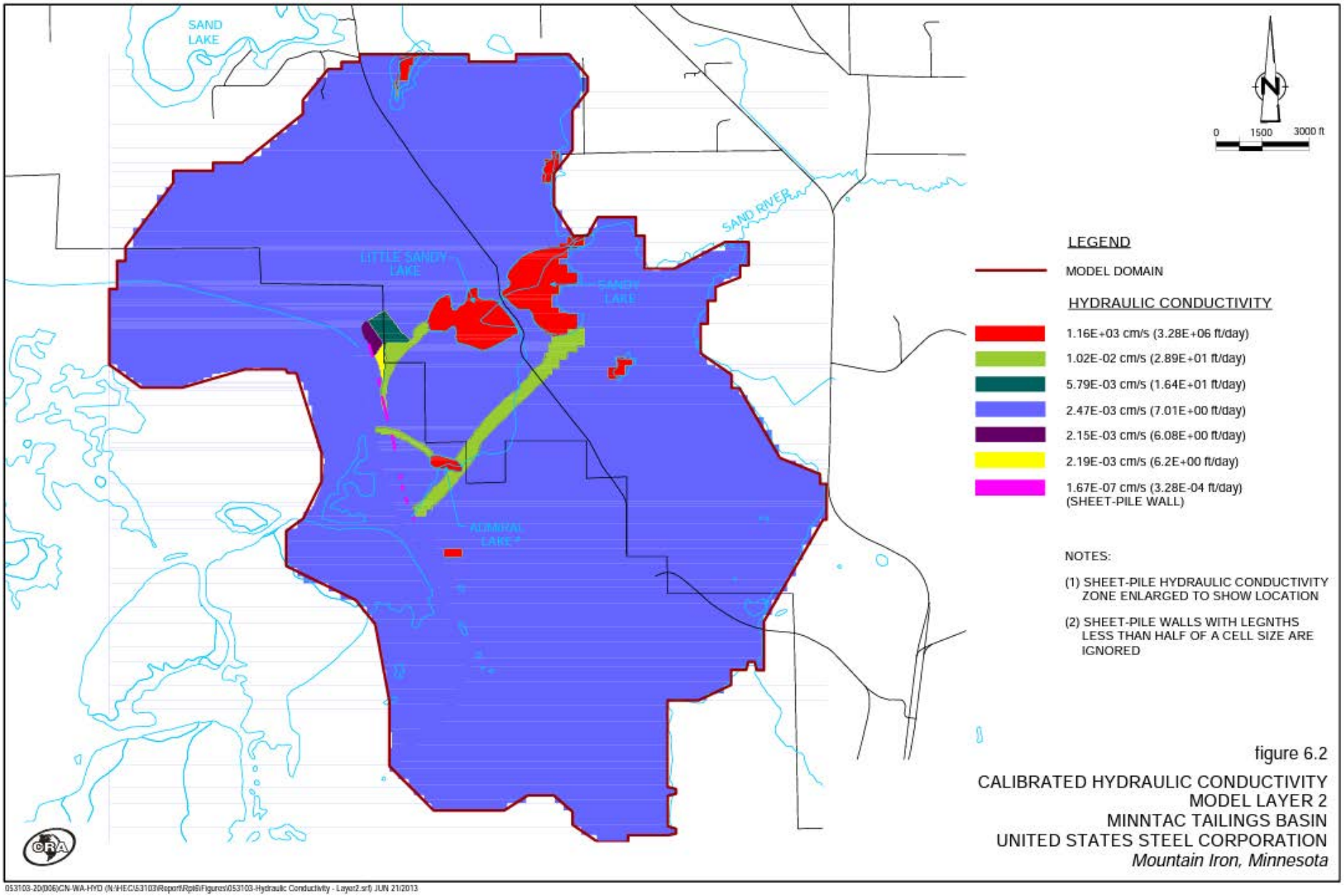

Figure 30. Calibrated Hydraulic Conductivity – Model Layer 2.

Taken from "Groundwater Flow and Sulfate Transport Modeling Report" by CRA on behalf of U.S. Steel. See page 70 of pdf. "The top elevation for Model Layer 2 (or the bottom elevation of Model Layer 1) was assigned equal to the ground surface elevation beyond the Tailings Basin pools and perimeter dike area. Beneath the perimeter dike and Tailings Basin pools, the top elevation of Model Layer 2 was assigned to the ground surface elevation estimated to have existed prior to the presence of the Tailings Basin pools and perimeter dike. The top of bedrock was used for the bottom elevation of the Model Layer 3. The model layer elevation for the bottom of Model Layer 2 was approximately the middle of the saturated overburden thickness."

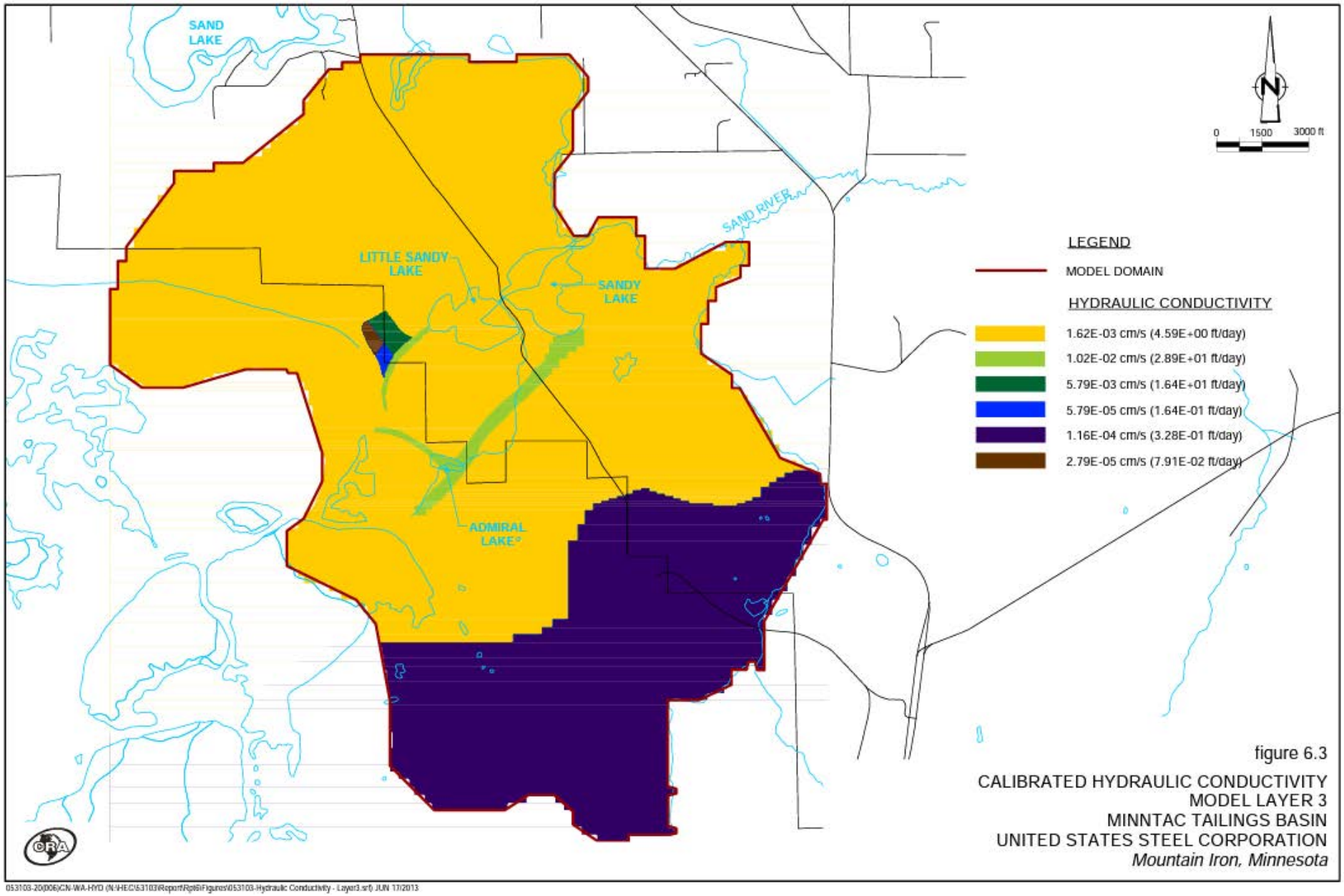

Figure 31. Calibrated Hydraulic Conductivity – Model Layer 3.

Taken from "Groundwater Flow and Sulfate Transport Modeling Report" by CRA on behalf of U.S. Steel. See page 71 of pdf. "The top elevation for Model Layer 2 (or the bottom elevation of Model Layer 1) was assigned equal to the ground surface elevation beyond the Tailings Basin pools and perimeter dike area. Beneath the perimeter dike and Tailings Basin pools, the top elevation of Model Layer 2 was assigned to the ground surface elevation estimated to have existed prior to the presence of the Tailings Basin pools and perimeter dike. The top of bedrock was used for the bottom elevation of the Model Layer 3. The model layer elevation for the bottom of Model Layer 2 was approximately the middle of the saturated overburden thickness."

3.4 *The Extent to Which the Pollutant is Diluted or Chemically Changed as It Travels*

Recent process water monitoring data collected from the tailings basin is presented in **Table A-1**, and data for sulfate and chloride are summarized below (See **Table 3**). U.S. Steel is required to monitor Station WS009 per its NPDES/SDS permit issued by the MPCA. The permit requires that "Samples for Station WS009 shall be taken at: a location in Basin Cell 1 that is representative of the overall composition of the process wastewater that is stored in the basin and recirculated through the taconite processing plant." Therefore, data collected and reported under WS009 are representative of tailings basin water quality. The data generated at two surface discharge points monitored between 2018-2022 (SD001 in the Dark River and SD006 in the Sand River) provide recent direct discharge quality information (See **Table 1** and **Table 2** for water quality data for the surface water discharge points).

Monitoring data from the tailings basin were compared to monitoring data from wetlands just inside and outside of the SCRS. Basin wastewater monitoring data were compared to data from downstream surface water stations to understand the extent to which the pollutants are diluted or chemically changed as they travel. As the distance from the basin to where surface water monitoring is occuring increases, there are greater observed effects of dilution due to: 1) dilution with precipitation; 2) dilution with ambient groundwater and surface water; 3) addition of pollutants to the basin water while it moves through and is in contact with tailings; and 4) processes that occur when wastewater contacts organic matter in glacial till and peat.[74] Only dilution provided by groundwater is considered as part of the functional equivalent evaluation, but it can be difficult to isolate the source of dilution when looking farther downstream. Notably, the farther downstream the monitoring stations are from the basin, the more influence there is by surface water dilution on the downstream surface water sampling monitoring stations.

These data indicated that there is relatively little dilution or chemical transformation happening between the basin and these surface water sampling points located just outside the basin.

The following section explains results from an EPA inspection report that provided data on water quality within the east side SCRS and in the adjacent wetlands (outside of the east side SCRS).

3.4.1 Inspection Report

In 2017, U.S. EPA conducted an NPDES compliance inspection at the Minntac tailings basin.[75] Samples were collected during the inspection, and the results are presented in the inspection report. EPA collected water quality data on both sides of the east side SCRS, including sampling inside the sheet pile (i.e., inside the "catch basin") and outside the sheet pile (i.e., in the wetlands that are immediately adjacent). Sampling results for sulfate and chloride are provided **Table 5** (see **Table A-4** for full results) and sampling locations are depicted in **Figure 32**, **Figure 33**, and **Figure 34**.

Results from the monitoring located at the east side SCRS indicate that the sulfate level in the

[74] Kelly et al (2016), *Geochemical Tracer Based (GTB) Sulfate Balance Models for Active Tailing Basins on Minnesota's Iron Range (III) Well waters, seeps, and downstream surface waters.*

[75] U.S. EPA (2018), *U.S. Steel Corporation – Minntac Tailings Basin Facility NPDES Compliance Sampling Inspection Report.*

wetlands outside of the sheet pile (S09) was within 5 percent of the level inside of the SCRS (S10), and that the wetlands outside of the sheet pile (S09) had higher chloride levels (See **Figure 33** for sampling locations). Additionally, results from samples taken on the east side SCRS in wetlands outside of the sheet pile locations (S11 and S13) were within 1 percent of sulfate level and within 2 percent of the chloride level inside the SCRS (S12) (See **Figure 34** for sampling locations). Specifically, sulfate measured outside of the SCRS was 71-79% of the concentration measured inside the tailings basin, and chloride measured outside of the SCRS was 78-86% of the concentration measured inside the tailings basin.

Data were also collected from a background location (S08) for the same pollutant parameters. The results show impacted areas had more than 190 times greater sulfate levels and had more than 70 times greater chloride levels than background conditions (See **Table 5**).

When compared, the data from the tailings basin, surface discharge sampling points SD001 and SD006, and the data presented in the inspection report show that sulfate and chloride levels sampled in surface waters just outside of the SCRS are similar to levels inside the SCRS, indicating that there is little to no dilution or chemical transformation occurring in these short pathways to surface waters. Additionally, the sulfate and chloride pollutant levels observed in all these locations are much higher than background levels.

These monitoring results indicate that sulfate and chloride, which are parameters representative of other pollutants in the wastewater being discharged from the basin, are not chemically changed or significantly diluted between the tailings basin and where they emerge inside the SCRS and just outside of the SCRS.

Table 3. Tailings Basin Process Wastewater Data (December 2018-April 2022)

Pollutant Parameters (units of measurement)	Tailings Basin Process Wastewater Pollutant Characterization (WS009) Min-Max (Average)
Total Sulfate (as SO_4) (mg/L)	752-1,120 (994)
Total Chloride (mg/L)	108-158 (142)
Bicarbonates (mg/L)	345-435 (385)
Hardness (mg/L)	1,250-1,560 (1,356)
pH (S.U.)	7.2-8.6 (8.2)
Total Dissolved Solids (mg/L)	1,490-2,210 (1,976)
Specific Conductance (umhos/cm)	2,060-2,755 (2,510)

Notes:

1. This technical assistance focuses on the two pollutant parameters of sulfate and chloride as general indicators of the presence of process wastewater pollutants.
2. Monitoring Data was provided by MPCA to U.S. EPA on July 8, 2022. The dataset for total chloride, hardness, TDS, specific conductance, and total sulfate can be found in **Table A-1**.

Table 4. Tailings Basin Process Wastewater Sulfate and Chloride Pollutant Concentrations Compared to Surface Water Sampling Points Adjacent to the Basin (December 2018-April 2022)

Pollutant Parameters (units of measurement)	Tailings Basin Process Wastewater Pollutant Characterization (WS009) Min-Max (Average)	SD006 (Adjacent to perimeter dike of basin.) Number of samples = 139 Min – Max (Mean)	SD001 (Adjacent to the basin) Number of samples = 59 Min–Max (Mean)
Total Sulfate (as SO_4) (mg/L)	752-1,120 (994)	787-998[2] (891)	954-1150 (1028.4)
Total Chloride (mg/L)	108-158 (142)	91.1-122 (105)	119-146 (130.5)

Table 5. Sulfate and Chloride Monitoring Results in Wetlands and SCRS Catch Basins. September 12-13, 2017 EPA Inspection.

Pollutant Parameters (units)	S08 **Background Conditions**[2] (Sampled wetland at foot of berm)	S09 **Wetland** (Sampled wetland immediately outside of sheet pile at SCRS Catch Basin-12)	S10 **Catch Basin** (Sampled seepage collected in SCRS Catch Basin-12)	S11 **Wetland** (Sampled wetland immediately outside of sheet pile at SCRS Catch Basin-5)	S12 **Catch Basin** (Sampled seepage collected in SCRS Catch Basin-5, near inlet)	S13 **Wetland** (Sampled wetland immediately outside of north end of sheet pile at SCRS Catch Basin-5)
Sulfate as SO4 (mg/L)	3.61	702	720	773	780	781
Chloride (mg/L)	1.28	122	91.2	114	114	110

Notes:
1. See **Figure 33**, **Figure 34** for sampling locations.
2. U.S. Steel confirmed the S08 location as "background area" (See page 9 of Inspection Report)

3.4.2 Geochemical Transformation

For other longer pathways (and/or as the discharge flows from inside the tailings basin to the outer edge of the basin), a portion of the sulfate discharged may be involved in geochemical transformations as it travels through groundwater from the basin to surface waters. The 2021 Hydrological Investigation Report explains that, generally, a chemical process known as sulfate reduction occurs as the pollutant travels underground in the presence of naturally occuring organic carbon and sulfate reducing bacteria, which can transform some of the sulfate into sulfide. In the presence of dissolved iron, the iron bonds with the sulfide to produce iron sulfide, which then precipitates out as a mineral, thus removing sulfide.[76]

The chemical reduction of sulfate is dependent on organic carbon reactivity and groundwater velocities.[63] According to Kelly et al. (2016), when sulfate encounters naturally occurring organic carbon in the glacial till below the perimeter dike, it can be reduced to sulfide and precipitate in the presence of dissolved iron as iron sulfide minerals are formed.

The 2016 study by the University of Minnesota (which implemented reactive transport models for six cross sections across the perimeter dike of the tailings basin) confirmed sulfate reduction

[76] GHD on behalf of U.S. Steel (2021), *Hydrological Investigation Report.*

and established that the extent to which sulfate chemically changes is dependent on certain factors, stating "*[h]ow much sulfate reduction occurs depends on organic carbon degradation rates and on groundwater velocities. However, in nearly all cross sections, the majority of sulfate leaves via out-flux at the down-gradient end rather than is reduced*." The study also suggested that groundwater velocity may have a significant control on sulfate reduction as increased transit times (i.e., slower velocity) through the subsurface provides more time for chemical processes and sulfate reduction.[63]

Given the size of the basin and multiple pathways pollutants travel in groundwater and beyond the basin, the exact amount of sulfate reduction that occurs as the pollutant travels is unknown; however, sulfate reduction appears to primarily occur when the pollutant travels through peat materials. This pattern was observed in a series of studies by the Minnesota Department of Natural Resources in 2016, which used geochemical tracer-based methods to quantify the impact of dilution, sulfide oxidation, and microbial sulfate reduction on surrounding surface waters and groundwaters. Also, according to the 2021 Hydrological Investigation Report, the extent to which sulfate is reduced within the subsurface appears to be closely associated with the peat units surrounding the basin. These areas where sulfate reduction is likely to occur are identified based on 1) confirmation of the presence of acid volatile sulfide (AVS)[77] in solids, 2) demonstration of equilibria between water chemistry and iron sulfide phases, and 3) documented subsurface geologic types that are known to be amenable to sulfate reduction (i.e., are commonly anoxic with a source of organic carbon).[78] The 2021 Hydrological Investigation Report further describes the fate and transport of sulfate inside and outside the basin.[79, 80]

Chloride is not involved in geochemical transformations and is considered to be conserved as it is discharged out of the basin and travels to surface waters unchanged.[81] There are other pollutants present in the discharge (See **Section 2.3**), but EPA did not evaluate the extent to which other pollutants may chemically change.

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[77] GHD on behalf of U.S. Steel, Hydrological Investigation Report (2021), page 13 of pdf. AVS is defined as follows: "*AVS is an operationally defined constituent that includes some quantity of several iron sulfide phases likely to precipitate in anoxic sediments*," .

[78] A site-specific rate for sulfate attenuation model was developed in the *2021 Hydrological Investigation Report*.

[79] GHD on behalf of U.S. Steel (2021), *Hydrological Investigation Report*, page 41 of pdf.

[80] MPCA (2018), *Findings of Fact, Conclusions of Law, and Order*, pages 4-5 of pdf, Permit History Fact #24. "*U.S. Steel recirculates water that accumulates in the Tailings Basin for use in processing the ore, which causes sulfate, hardness, bicarbonate, and chloride concentrations to build up in the water. In addition, the deposited tailings themselves generate pollutants, including sulfate, when exposed to precipitation*."

[81] Ng et al. (2016), *Development of a Reactive Sulfate Transport Model for a Minnesota Taconite Tailings Basin (Minntac).* Department of Earth Sciences, University of Minnesota, page 6 of pdf.

Figure 32. Sampling Locations in Township 59N, Range 18W, Section 23.
Taken from "NPDES Compliance Sampling Inspection Report" by U.S. EPA. See page 29 of pdf. Image modified by EPA to remove prior figure label and description.

Figure 33. Sampling Locations in Township 59N, Range 18W, Section 10.
Taken from "NPDES Compliance Sampling Inspection Report" by U.S. EPA. See page 27 of pdf. Image modified by EPA to remove figure label and description.

Figure 34. Sampling Locations in Township 59N, Range 18W, Section 15.
Taken from "NPDES Compliance Sampling Inspection Report" by U.S. EPA. See page 28 of pdf. Sample results for S11, S12, and S13 are located in Image modified by EPA to remove prior figure label and description.

3.5 *The Amount of Pollutant Entering the Navigable Waters Relative to the Amount of the Pollutant That Leaves the Point Source*

U.S. Steel's contractor, GHD, in the 2021 Hydrological Investigation Report, estimated that 22,612 kg/day (9,098 tons per year) of sulfate leaves the basin via seeps (See **Figure 8** and **Figure 12**). This estimate was derived using a mass balance approach modeling sulfate inputs and outputs to the tailings basin as well as downstream surface water data.

As explained in **Section 3.2**, most of the wastewater traveling through groundwater is believed to enter surface water within 1,000 meters of the basin. Further, the 2021 Hydrological Investigation Report states, "[g]iven the hydraulic conditions of the Basin in relation to the surrounding areas, most of the Basin seepage that migrates past the SCRSs reports to nearby surface waters within a relatively short distance from the Basin perimeter dike."

The total amounts of sulfate and chloride reaching surface waters in the Sand River and Dark River watersheds were estimated through loading calculations based on downstream surface water monitoring data (years 2018 through 2022). The sulfate and chloride loading rates at stations (SW001 or "Station 701" on the Sand River and SW003 or "D-1" on the Dark River) were calculated using measured values of flow and concentration. These stations are located downstream of where most of the surficial discharge from the tailings basin flows, as seen in **Figure 6**. Evidence suggests pollutants are stored within wetlands during low flow conditions and released downstream in medium and high flow events.[82] Thus, daily load fluctuations are observed in the data and may be due to precipitation/run-off events. Averaged values may be more representative of the discharge as it reaches receiving waters.[83] The average sulfate and chloride loading rates calculated were 4,221 kg/day sulfate and 1,058 kg/day chloride in the Sand River watershed at SW001; and 9,550 kg/day sulfate and 993 kg/day chloride in the Dark River watershed at SW003 (See **Table 6** for loading calculations in the Sand River and **Table 7** for the Dark River).

Background loading values averaged 264 kg/day sulfate and 4.4 kg/day chloride in the Sand River (SW001) and 904 kg/day sulfate and 20.4 kg/day chloride in the Dark River at Station D-2 (See **Table 6** for loading calculations for the Sand River and **Table 7** for the Dark River).

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[82] BARR Engineering Co. on behalf of U.S. Steel Minnesota Ore Operations - Minntac (2010), *Memorandum: Tailings Basin Seepage Estimation Method*, page 2 of pdf. "*A general phenomenon observed at the 701 and the D-1 monitoring locations was that high stream flows led to increased delivery of sulfate mass when compared to lower flow conditions (the concentration of sulfate in the streams at these points would not go down during high flows). If tailings basin seep waters were delivered at a constant rate, sulfate levels should have declined at 701 and D-1 at high stream flow rates and increased during lower flows. To explain this observation, it was hypothesized that seepage from the tailings basin (other than seepage from 020 and 030) is stored during low flow conditions and released during medium and high flow events. Wetlands or subsurface soils were hypothesized to be the storage media.*"

[83] GHD on behalf of U.S. Steel (2021), *Hydrological Investigation Report*, pages 30-31 of pdf. "*The field measurements and chloride concentrations used in the seep estimate are included in Table 4.1. It should be noted that seepage flow rates do not fluctuate per the line-by-line Table 4.1 calculations. These line-by-line measurements fluctuate significantly due to local precipitation/run-off events but the average is expected to represent seepage rates from the Basin. Basin seepage flowrates are much more stable/steady than the individual calculations suggest. It is expected that seepage flow rates gradually increase and decrease modestly in response to Basin clear pool elevation changes. The model incorporates an adjustment based on clear pool elevation to account for this change in head pressure on seeps.*"

Due to recirculation and reuse of water from the tailings basin in ongoing taconite processing, concentrations and loadings of pollutants, including sulfate, have increased over time within the tailings basin pond. MPCA acknowledged the continual increase in pollutant concentrations due to recirculation of process wastewater.[84] In 2015, U.S. Steel began importing water with lower sulfate concentrations to potentially mitigate the increased concentrations of sulfate in the tailings basin.[85] The 2018 NPDES Minntac Tailings Basin Permit[86] authorizes U.S. Steel to look for other sources of intake water for the purpose of dilution and to allow new water sources to be used without modification to the permit under certain conditions. The volume of process wastewater within the tailings basin outer cells has increased from 2012 to 2021.[87] The 2018 Fact Sheet summarizes annual mass calculations where net sulfate increases ranged from 81,094 lbs/year to 402,639 lbs/year from 2011 to 2017.[88]

The total amounts of sulfate and chloride reaching receiving waters within the Sand River and Dark River watersheds as a result of wastewater leaking from the tailings basin at rates discussed in this section are significant. However, EPA did not find an independent measure of the amount of pollutant leaving the tailings basin, only estimates that were themselves based on amounts of basin pollutants observed in surface water. Without that independent measurement it is difficult to quantify the amount of pollutant reaching surface waters compared to the amount that is discharged from the tailings basin. However, we are able to find that a significant portion of the discharge does reach surface waters.

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[84] MPCA (2018), *Findings of Fact, Conclusions of Law, and Order*, pages 4-5 of pdf, Permit History Fact #24. "*U.S. Steel recirculates water that accumulates in the Tailings Basin for use in processing the ore, which causes sulfate, hardness, bicarbonate, and chloride concentrations to build up in the water. In addition, the deposited tailings themselves generate pollutants, including sulfate, when exposed to precipitation.*"

[85] MPCA (2018), *Findings of Fact, Conclusions of Law, and Order*, page 19 of pdf. "*The operation currently imports approximately 4.64 MGD of water from the Mt. Iron pit at the mining area to make up for losses that occur during taconite processing and recirculation of the water through the tailings basin ponds. Under Part 7.ppp of the June 9, 2011, SOC, the MPCA identified the use of alternate make up water with a lower sulfate concentration than Mt. Iron pit water as a means to mitigate the increased loading of sulfate to the basin water and required a study to evaluate alternative water sources. To fulfill this requirement, the permittee identified Sump 6 at the mining area as a suitable source, a pipeline was constructed, and the permittee began to utilize a minimum of 2000 gpm (monthly average) of Sump 6 water on January 26, 2015.*"

[86] MPCA (2018), *National Pollutant Discharge Elimination System/State Disposal System Permit MN0057207 – Minntac Tailings Basin Area.*

[87] GHD on behalf of U.S. Steel (2021), *Hydrological Investigation Report*, page 42 of pdf.

[88] MPCA (2018), *NPDES)/SDS Permit Program Fact Sheet: US Steel Corp. – Minntac Tailings Basin Area*, Permit No. MN0057207, page 23-24 of pdf.

Table 6. Calculated Pollutant Load in the Sand River Watershed.

Pollutant Parameter	Loading calculations using 2018-2022 DMR data from downstream Station SW001 (i.e., Station 701) (Approximately 5 miles/8 kilometers downstream of basin)		Pre-basin data from SW001 (i.e., Station 701) (Approximately 5 miles/8 kilometers downstream of basin's current location)	
	Concentration (mg/L) Min-Max (Average)	Calculated Load (kg/day)[1] Min-Max (Average)	Concentration (mg/L) Min-Max (Average)	Calculated Load (kg/day)[1] Min-Max (Average)
Sulfate	9.3-537 (200)	20.9[5]-20,363 (4221)	1.8-26 (8.5)	2.6-1507.4 (263.6)
Chloride	16.1-90.2 (45.6)	36.6[5]-5,407 (1058)	0-1 (0.125)	0-25.9 (4.4)

Notes:

1. See **Table A-1** for 2018-2022 DMR data.
2. Loads based on field measurements were calculated by using reported concentration and corresponding flow values collected during the same monitoring events by using the following equation:

$$Reported\ Concentration\ in\ \frac{mg}{L} * reported\ flow\ in\ \frac{cubic\ feet}{sec} * \left(\frac{60\ sec}{min}\right) * \left(\frac{60 min}{hr}\right) * \left(\frac{24 hr}{day}\right) * \left(\frac{28.3168\ liters}{cubic\ feet}\right) * \left(\frac{1\ kg}{10^6 mg}\right) = Pollutant\ Load\ in\ kg/day$$

3. SW001 is the only surface water monitoring station in the Sand River watershed where flow is monitored. Thus, SW001 was assessed for loading values.

Table 7. Calculated Pollutant Load in the Dark River Watershed

Pollutant Parameters	Loading calculations using 2018-2022 DMR data from downstream Station SW003 (Approximately 5 miles/8 kilometers downstream of tailings basin)		Pre-basin Data from Station D-2[3] (Approximately 15 miles/24 kilometers downstream of basin's current location)	
	Concentration (mg/L) Min-Max (Average)	Calculated Load(kg/d)[1] Min-Max (Average)	Concentration (mg/L) Min-Max (Average)	Calculated Load (kg/d)[1] Min-Max (Average)
Sulfate	150-853 (515.7)	1,321-27,333 (9550)	6.5-12 (8.2)	513.7-2,017 (904.1)
Chloride	16.2-90.6 (45.6)	167-2,901 (993)	0-0.7 (0.3)	0-42.8 (20.6)

Notes:

1. See **Table A-1** for 2018-2022 DMR data.
2. Loads based on field measurements were calculated by using reported concentration and corresponding flow values collected during the same monitoring events by using the following equation:

$$Reported\ Concentration\ in\ \frac{mg}{L} * reported\ flow\ in\ \frac{cubic\ feet}{sec} * \left(\frac{60\ sec}{min}\right) * \left(\frac{60 min}{hr}\right) * \left(\frac{24 hr}{day}\right) * \left(\frac{28.3168\ liters}{cubic\ feet}\right) * \left(\frac{1\ kg}{10^6 mg}\right) = Pollutant\ Load\ in\ kg/day$$

3. SW003 is the only surface water monitoring station in the Dark River watershed where flow is consistently monitored. Thus, SW003 was assessed for loading values.
4. Pre-facility monitoring in the Dark River watershed was done at Station D-2.

3.6 *The Manner by or Area in Which the Pollutant Enters the Navigable Waters*

As explained in **Section 1.1**, the 8,700-acre tailings basin was constructed on top of the headwaters of the Sand River and Dark River and in an area rich with jurisdictional wetlands. Wastewater from the tailings basin seeps through and under the perimeter dike. The predominant direction of groundwater flow and pollutant (e.g., sulfate and chloride) transport is from the tailings basin east to the Sand River watershed and from the tailings basin west to the Dark River watershed (See **Figure 35** for a map of groundwater elevation contours).

Wastewater takes different pathways to reach surface water features. As explained in **Section 3.3**, there have been several studies of groundwater discharge pathways over the years, which depict and model a variety of pollutant pathways from the tailings basin. The general locations of these pathways are modeled for the Sand River watershed in **Figure 19**, **Figure 20**, and **Figure 21**. As depicted in the simulated groundwater flow pathlines in these figures, the pollutants emerge in surface waters via distinct plumes. **Section 3.3** details the nature of the materials through which a pollutant travels, including spatial hydraulic conductivity values as documented by U.S. Steel contractor, CRA.[89] **Figure 29**, **Figure 30**, and **Figure 31** describe the spatial hydraulic conductivities in the model layers representative of the glacial till.[73] The higher hydraulic conductivity values generally indicate dominant flow paths.

Pollutants enter surface waters in the Sand and Dark River watersheds via a contaminate plume after traveling with groundwater through the soil or rock medium (glacial till). This process is primarily through advection (the transport of a substance or quantity by bulk motion of a fluid[90]) and dispersion (the spreading of the contaminant plume from highly concentrated areas to less concentrated areas[91]). Pollutants reach surface waters from the tailings basin via advection and dispersion, with the ultimate result being that the pollutants reach surface waters in significant amounts. The size of this point source, proximity of jurisdictional surface waters, and the abundance of those surface waters results in many potential pathways for pollutants to travel from the basin to surface waters.

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[89] CRA on behalf of U.S. Steel (2013), *Groundwater Flow and Transport Modeling Report.*

[90] Fitts, C. R. (2013), *Groundwater Science (2nd Edition).* Elsevier, page 527.

[91] CRA on behalf of U.S. Steel (2012), *Revised Conceptual Groundwater Model Report*, page 18 of pdf. "*Dispersion results from two basic processes, molecular diffusion and mechanical mixing. Molecular diffusion is a process where solutes move from zones of higher concentration to zones of lower concentration. The driving force of this movement is kinetic activity at the molecular level. Mechanical dispersion is derived from the variability (heterogeneity) of the microscopic velocities in groundwater which act to spread or mix a solute in an aquifer. The primary aquifer characteristics that cause this mixing are variable frictional forces in pore channels, variations in pore channel geometry, and pore channel branching. Dispersion/spreading of solutes during groundwater flow results in dilution of solute pulses and attenuation of concentration peaks*."

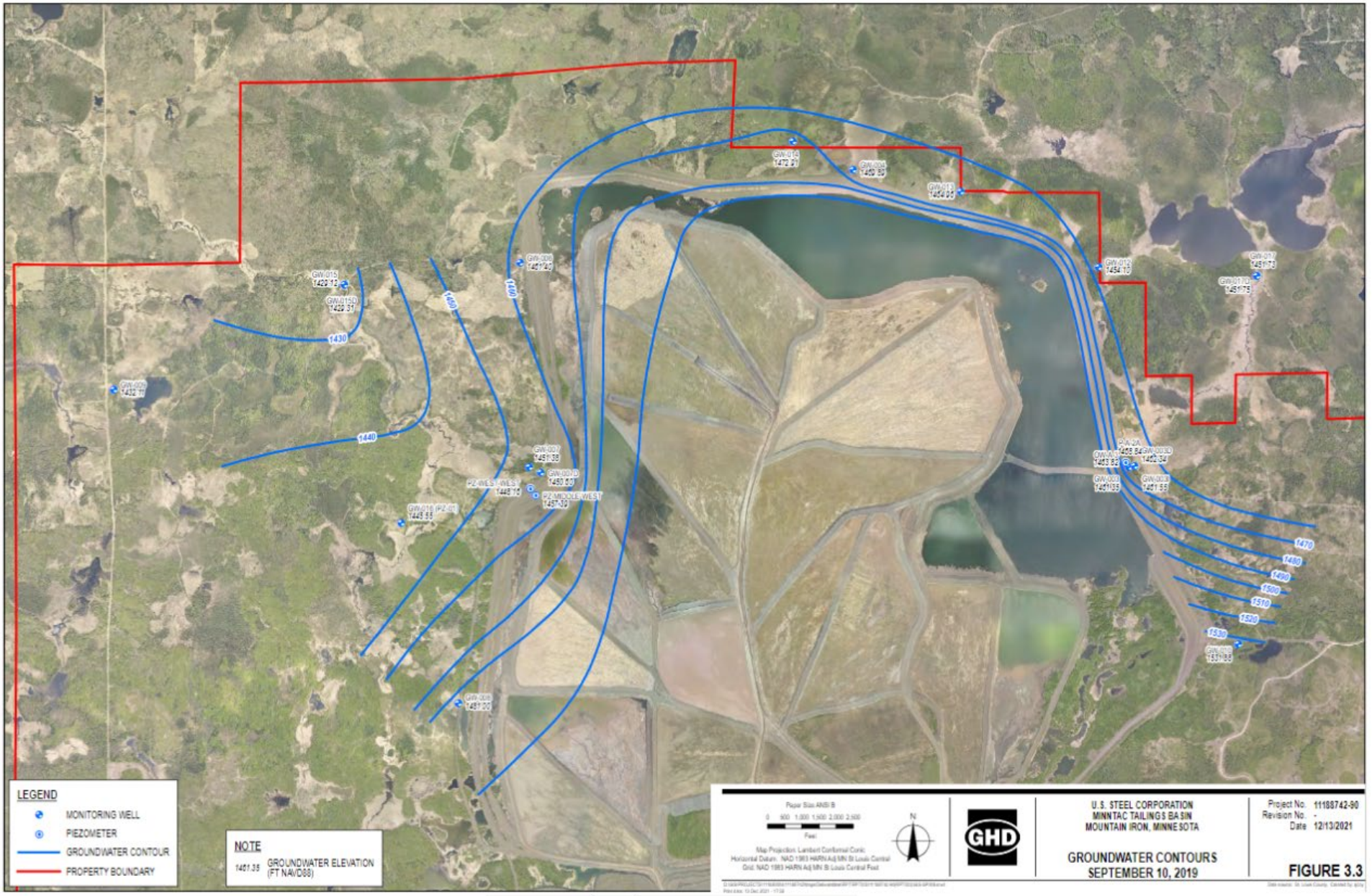

Figure 35. Groundwater Contours on September 10, 2019.
Taken from "Hydrological Investigation Report" performed by GHD on behalf of U.S. Steel (2021).

3.7 The Degree to Which the Pollution (At that point) Has Maintained Its Specific Identity

Sulfate and chloride from the basin are observed at downstream surface water monitoring locations in the Sand and Dark River watersheds (See **Table 1** and **Table 2**). Other pollutants have been identified in the discharge and receiving waters (See **Section 2.3**), but their fate and transport are not evaluated here. Further, a 2017 EPA inspection report described sulfate and chloride levels outside of the east side SCRS (i.e., in the adjacent wetlands) as being similar to levels inside the east side SCRS (See **Section 3.4**). These findings suggest that discharges from the basin have maintained their identity inside and outside of the basin and the SCRSs, and that pollutant concentrations in the discharge are much higher than background levels.

As wastewater seeps from the tailings basin, its geochemical signature may be affected by factors including 1) dilution by groundwater, 2) oxidation and rinsing of sulfide minerals present in the materials used to construct the basin (i.e., coarse and fine tailings), and 3) processes that occur when wastewater contacts buried organic matter in glacial till and peat.[92] While sulfate may undergo chemical transformation as it travels through groundwater beyond the basin, as explained in **Section 3.4.2**, there is still a significant amount of sulfate that leaves the basin and enters surface waters as discussed in **Section 3.5**. Like sulfate, a significant amount of chloride leaves the basin and enters surface waters; however, chloride is a conservative pollutant and does not chemically change as it travels through groundwater.

[92] Kelly et al. (2016), *Geochemical Tracer Based (GTB) Sulfate Balance Models for Active Tailing Basins on Minnesota's Iron Range (III) Well waters, seeps, and downstream surface waters.*

4 Discussion

While transit time and distance traveled will be the most important factors in most cases, and in many cases the only factors that need be considered, multiple other factors may also provide evidence to support the functional equivalent determination where time and distance are not dispositive. In this case, EPA considered the Supreme Court's seven factors as they relate to the Minntac tailings basin and information from a variety of publicly available documents which are referenced herein. The outcome of EPA's evaluation could change based on new or additional information. As noted above, EPA is providing this technical assistance to MPCA at their request and as part of EPA's longstanding practice of offering technical assistance to authorized states. EPA's technical assistance is not required by the CWA and creates no rights of third parties, nor does it constitute a permitting action or decision.

The observations and available data suggest that the tailings basin is discharging pollutants, including (but not limited to) sulfate and chloride, through groundwater and through the perimeter dike to surface waters. EPA did not identify any other significant sources of pollutants to the receiving water monitoring station data reviewed here. The effect on surface waters due to the discharge from the Minntac tailings basin via groundwater and subsurface flow under and through the perimeter dike is similar to the effect that would be expected if the discharges were direct to surface waters.

Transit time – Pollutants reach surface waters after a range of timeframes dependent on the location from which they leave the basin and the surface water body they are discharged into. Various studies have been conducted over the operational period of the tailings basin, resulting in a variety of estimates. The shortest estimate of transit time involves the consideration of wastewater traveling through the perimeter dike where it continues to accumulate pollutants and then is discharged into surface waters directly adjacent to the basin resulting in an immediate discharge when measuring from the outer edge of the tailings basin.

Distance traveled – Pollutants discharged from the tailings reach surface waters via a variety of pathways and corresponding distances. The shortest distance would be the distance from the outer edge of the tailings basin to adjacent surface waters, which would be immediately adjacent to the basin. Some studies reviewed in this evaluation concluded that longer distances are traveled by pollutants, for example those pollutants that travel from inside the dike, under the dike and into more distant downstream surface waters. Those estimates are as low as 3,300 feet (1,000 meters) traveled for pollutants discharged from the tailings basin to reach nearby surface waters.

The nature of the material through which the pollutants travel – Pollutants travel through porous media consisting of glacial till consisting of sands, silt, clay, and gravel. There are also localized areas where a peat layer overlays the glacial till. Pollutants flow with groundwater through this glacial till and to surface waters. The porous media through which the pollutants travel is not a hydraulic barrier to the transport of pollutants via groundwater from the point source to surface waters. **Section 3.3** considers the available data specific to the nature of the material through which the pollutant travels. Evaluation of the nature of the material through which the pollutant travels informs the evaluation of the other factors.

The extent to which the pollutant is diluted or chemically changed as it travels - Sulfate and chloride levels outside of the perimeter dike or SCRS are similar to levels inside the SCRS, are comparable to levels in the basin, and are much higher than background levels. This suggests that these pollutants are not diluted or changed as they travel these short pathways. Sulfate may be chemically changed as it travels in other longer pathways to reach surface waters.

The amount of pollutant entering the navigable waters relative to the amount of the pollutant that leaves the point source – EPA reviewed a robust record documenting pollutant discharge via groundwater to surface waters based on information collected over many years. EPA did not find an independent measure of the amount of pollutant leaving the tailings basin, only estimates that were themselves based on amounts of basin pollutants observed in surface water. Without that independent measurement it is difficult to evaluate this factor. However, EPA does observe that basin pollutants are present in basin receiving waters at levels significantly higher than is observed in background locations and in data collected in the same receiving water locations before the basin was constructed. Due to the nature of the materials under the basin, porous media overlain on relatively impermeable bedrock, and the abundance of surface waters that are connected to groundwater, it is reasonable to find that most of the pollutant leaving the basin would enter surface waters within a short distance of the basin.

The manner by or area in which the pollutant enters navigable waters – The 8,700-acre tailings basin was constructed on top of the headwaters of the Sand and Dark Rivers and in an area rich with jurisdictional wetlands. Pollutants are being discharged from the basin by passing under and through the perimeter dike via groundwater to surface waters. Pollutants from the tailings basin are found throughout downstream waters on the east and west side of the basin. Generally, the pollutants are transported with groundwater by advection and dispersion through the materials underlaying and surrounding the tailings basin and emerge in the nearby surface waters. The size of this point source, its close proximity to jurisdictional surface waters, and the abundance of those surface waters result in many potential pathways for pollutants to travel from the basin to surface waters.

The degree to which the pollution (at that point) has maintained its specific identity Information considered in this evaluation shows that several pollutants present in the basin are also present in surface waters surrounding the basin, and that those pollutants are clearly traceable to the basin. EPA did not evaluate every pollutant parameter being discharged from the basin. Most studies of the basin focus on a short list of pollutants. Some pollutants are known to be conserved as they are transported with groundwater to surface water while others may undergo some transformation. In general, the pollutant parameters that have been observed in the basin have been found in surrounding surface waters where monitoring was conducted. Pollutants found in receiving waters are clearly traceable to the basin, and some, including chloride and sulfate generally retain their specific identity while traveling through groundwater.

In *Maui*, the Supreme Court stated that of the factors listed, "[t]ime and distance will be the most important factors in most cases, but not necessarily every case." *Id*., 140 S. Ct. at 1477. Although the Supreme Court declined to define the exact outer parameters for time and distance, it expressed doubt that a point source pollutant discharge ending 50 miles from a navigable water and with a groundwater transit time of "many" years that first mixes with "much other

material[s]" would qualify as a functional equivalent discharge under the Clean Water Act. *Id*., 140 S. Ct. at 1477. As to those "many years" and distance, the Court concluded that Congress did not intend to extend the "point source-permitting requirement" to a 100-year migration of pollutants through 250 miles of groundwater to a river. *Id*., 140 S. Ct. at 1471.

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Appendix A

Table A-1. Discharge Monitoring Reporting Data from 2018-2022.
Table created by EPA using data submitted by U.S. Steel to MPCA.

Subject Item Designation	Subject Item Desc	Watershed	Source	Sample date	Sulfate, Total (as SO4) (mg/L)	Chloride, Total (mg/L)	Hardness, Calcium & Magnesium, Calculated (as CaCO3) (mg/L)	Solids, Total Dissolved (TDS) (mg/L)	Specific Conductance (umhos/cm)	Flow, Stream, Instantaneous (cfs)
SD 001	Seepage outfall 020	Dark River	Minntac DMR	12/19/2018	990	120	1530	1940	2667	
SD 001	Seepage outfall 020	Dark River	Minntac DMR	1/2/2019	978	119	1520	1960	2618	
SD 001	Seepage outfall 020	Dark River	Minntac DMR	2/6/2019	991	128	1580	2060	2584	
SD 001	Seepage outfall 020	Dark River	Minntac DMR	3/6/2019	970	129	1520	2180	2500	
SD 001	Seepage outfall 020	Dark River	Minntac DMR	4/3/2019	1020	130	1510	2150	2661	
SD 001	Seepage outfall 020	Dark River	Minntac DMR	5/1/2019	954	130	1450	2060	2579	
SD 001	Seepage outfall 020	Dark River	Minntac DMR	6/5/2019	957	146	1510	2130	2615	
SD 001	Seepage outfall 020	Dark River	Minntac DMR	7/3/2019	982	134	1530	2200	2548	
SD 001	Seepage outfall 020	Dark River	Minntac DMR	8/7/2019	1010	130	1530	2150	2704	
SD 001	Seepage outfall 020	Dark River	Minntac DMR	9/4/2019	1040	133	1520	2240	2634	
SD 001	Seepage outfall 020	Dark River	Minntac DMR	10/3/2019	1040	133	1650	2230	2633	
SD 001	Seepage outfall 020	Dark River	Minntac DMR	11/6/2019	1060	132	1660	2350	2498	
SD 001	Seepage outfall 020	Dark River	Minntac DMR	12/6/2019	1080	133	1690	2360	2945	
SD 001	Seepage outfall 020	Dark River	Minntac DMR	1/3/2020	1150	134	1800	2450	2946	
SD 001	Seepage outfall 020	Dark River	Minntac DMR	2/5/2020	1090	132	1880	2420	2704	
SD 001	Seepage outfall 020	Dark River	Minntac DMR	3/4/2020	1070	134	1770	2390	2871	
SD 001	Seepage outfall 020	Dark River	Minntac DMR	4/1/2020	1070	128	1710	2360	2815	
SD 001	Seepage outfall 020	Dark River	Minntac DMR	5/6/2020	1060	124	1710	2290	2958	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	12/19/2018	882	99.7	1650	1960	2454	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	1/2/2019	899	99.7	1620	1870	1364	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	2/6/2019	897	105	1710	1980	867	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	3/6/2019	854	107	1540	1920	1815	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	4/3/2019	835	104	1500	1960	1448	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	5/1/2019	787	91.1	1510	2010	2528	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	6/5/2019	861	107	1640	1930	2413	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	7/3/2019	898	107	1660	2050	2316	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	8/7/2019	905	108	1590	1970	1954	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	9/4/2019	928	108	1510	2020	2611	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	10/3/2019	902	104	1610	1940	2161	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	11/6/2019	887	103	1500	1870	2546	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	12/6/2019	882	101	1470	1910	2539	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	1/3/2020	814	99.4	1590	1990	1678	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	2/5/2020	873	104	1630	1990	2425	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	3/4/2020	881	109	1510	1970	2534	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	4/1/2020	885	104	1410	1940	2425	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	5/6/2020	905	107	1460	1950	2587	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	6/3/2020	903	109	1530	2000	2511	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	7/1/2020	862	98.1	1540	2010	2575	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	8/5/2020	899	105	1610	1980	2597	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	9/9/2020	861	110	1530	1940	2583	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	10/7/2020	799	93.5	1510	1910	2817	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	11/4/2020	829	95.1	1520	1950	2531	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	12/2/2020	870	95.7	1520	1930	2542	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	1/6/2021	887	99.5	1410	1960	2540	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	2/3/2021	906	106	1390	1900	2529	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	3/3/2021	907	110	1450	2000		
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	4/7/2021	896	108	1400	2060	2618	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	5/5/2021	961	107	1530	2080	2504	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	6/9/2021	905	99.6	1500	2070	2553	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	7/15/2021	998	103	1530	2000	2576	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	8/4/2021	898	111	1450	1930	2552	

Subject Item Designation	Subject Item Desc	Watershed	Source	Sample date	Sulfate, Total (as SO4) (mg/L)	Chloride, Total (mg/L)	Hardness, Calcium & Magnesium, Calculated (as CaCO3) (mg/L)	Solids, Total Dissolved (TDS) (mg/L)	Specific Conductance (umhos/cm)	Flow, Stream, Instantaneous (cfs)
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	9/1/2021	892	112	1510	1870	2567	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	10/6/2021	931	110	1430	1670	2545	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	11/10/2021	883	112	1430	1730	2530	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	12/8/2021	932	109	1520	1800	2421	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	1/12/2022	904	108	1430	1870	2515	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	2/9/2022	937	108	1400	2030	2658	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	3/9/2022	952	111	1450	1830	2491	
SD 006	Seep Discharge to north wetlands	Sand River	Minntac DMR	4/11/2022	961	122	1530	1700	2563	
SW 001	Sandy River Station 701	Sand River	Minntac DMR	12/7/2018	141	43.3	304	364	636	13.2
SW 001	Sandy River Station 701	Sand River	Minntac DMR	1/4/2019	167	55.7	366	416	778	9.18
SW 001	Sandy River Station 701	Sand River	Minntac DMR	2/11/2019	239	75.5	501	670	1102	7
SW 001	Sandy River Station 701	Sand River	Minntac DMR	3/8/2019	245	72.6	576	712	1193	9.5
SW 001	Sandy River Station 701	Sand River	Minntac DMR	4/8/2019	72.1	25.1	161	234	413	49.6
SW 001	Sandy River Station 701	Sand River	Minntac DMR	5/1/2019	83.8	22.4	163	256	393	43.6
SW 001	Sandy River Station 701	Sand River	Minntac DMR	6/7/2019	66.4	28.8	185	250	411	16.9
SW 001	Sandy River Station 701	Sand River	Minntac DMR	7/1/2019	58.9	33.6	201	236	457	10.106
SW 001	Sandy River Station 701	Sand River	Minntac DMR	8/5/2019	18.8	46.7	228	324	522	3.329
SW 001	Sandy River Station 701	Sand River	Minntac DMR	9/6/2019	41.6	42.4	195	278	450	2.372
SW 001	Sandy River Station 701	Sand River	Minntac DMR	10/8/2019	81.3	32	201	276	446.8	39.164
SW 001	Sandy River Station 701	Sand River	Minntac DMR	11/12/2019	133	35.2	283	380	616.5	10.602
SW 001	Sandy River Station 701	Sand River	Minntac DMR	12/13/2019	134	34.9	288	412	663	9.752
SW 001	Sandy River Station 701	Sand River	Minntac DMR	1/3/2020	166	41.9	338	458	636	12.684
SW 001	Sandy River Station 701	Sand River	Minntac DMR	2/10/2020	220	47.9	401	322	828	5.288
SW 001	Sandy River Station 701	Sand River	Minntac DMR	3/6/2020	219	53.1	446	608	906.5	7.372
SW 001	Sandy River Station 701	Sand River	Minntac DMR	4/3/2020	145	38.5	265	102	417	57.391
SW 001	Sandy River Station 701	Sand River	Minntac DMR	5/1/2020	102	26.7	175	644	432	21.4835
SW 001	Sandy River Station 701	Sand River	Minntac DMR	6/5/2020	135	26.3	250	334	545	10.019
SW 001	Sandy River Station 701	Sand River	Minntac DMR	7/10/2020	74.6	16.1	203	290	598	0.925
SW 001	Sandy River Station 701	Sand River	Minntac DMR	8/7/2020	9.3	31.3	190	256	425	0.9185
SW 001	Sandy River Station 701	Sand River	Minntac DMR	9/4/2020	138	33.1	287	384	630.2	6.0185
SW 001	Sandy River Station 701	Sand River	Minntac DMR	10/2/2020	136	34	297	402	634	2.4405
SW 001	Sandy River Station 701	Sand River	Minntac DMR	11/10/2020	138	35.5	266	394	574	17.696
SW 001	Sandy River Station 701	Sand River	Minntac DMR	12/4/2020	226	47.3	414	569	882	4.363
SW 001	Sandy River Station 701	Sand River	Minntac DMR	1/8/2021	265	52.3	514	673	882.5	3.146
SW 001	Sandy River Station 701	Sand River	Minntac DMR	2/16/2021	352	65.1	632	875	1276	1.69711
SW 001	Sandy River Station 701	Sand River	Minntac DMR	3/5/2021	365	67.4	598	855	1257	2.98
SW 001	Sandy River Station 701	Sand River	Minntac DMR	4/6/2021	155	30.6	273	413	585	24.57175
SW 001	Sandy River Station 701	Sand River	Minntac DMR	5/7/2021	121	25.2	203	311	472	9.4795
SW 001	Sandy River Station 701	Sand River	Minntac DMR	6/4/2021	145	29	271	402	517	8.277
SW 001	Sandy River Station 701	Sand River	Minntac DMR	7/29/2021	214	40.1	338	600	796	2.523
SW 001	Sandy River Station 701	Sand River	Minntac DMR	8/25/2021	215	46.9	381	588	862	1.1585
SW 001	Sandy River Station 701	Sand River	Minntac DMR	9/29/2021	224	40.8	334	535	770	3.93625
SW 001	Sandy River Station 701	Sand River	Minntac DMR	10/26/2021	291	53.7	474	624	978	0.381
SW 001	Sandy River Station 701	Sand River	Minntac DMR	11/30/2021	437	73.4	597	884	1297	4.44
SW 001	Sandy River Station 701	Sand River	Minntac DMR	12/14/2021	434	77.2	624	944	1336	2.702
SW 001	Sandy River Station 701	Sand River	Minntac DMR	1/10/2022	482	76.1	693	1000	1417	6.67
SW 001	Sandy River Station 701	Sand River	Minntac DMR	2/21/2022	520	77.7	736	1100	1539	3.603
SW 001	Sandy River Station 701	Sand River	Minntac DMR	3/4/2022	537	90.2	779	1110	1625	3.481
SW 001	Sandy River Station 701	Sand River	Minntac DMR	4/11/2022	253	43.3	385	538	817.5	23.879
SW 003	Dark River at CR668	Dark River	Minntac DMR	12/7/2018	747	70.1	1300	1560	2106	10.8
SW 003	Dark River at CR668	Dark River	Minntac DMR	1/4/2019	769	73.2	1410	1610	2283	7.52

Subject Item Designation	Subject Item Desc	Watershed	Source	Sample date	Sulfate, Total (as SO4) (mg/L)	Chloride, Total (mg/L)	Hardness, Calcium & Magnesium, Calculated (as CaCO3) (mg/L)	Solids, Total Dissolved (TDS) (mg/L)	Specific Conductance (umhos/cm)	Flow, Stream, Instantaneous (cfs)
SW 003	Dark River at CR668	Dark River	Minntac DMR	2/11/2019	837	86.1	1450	1990	2483	9.8
SW 003	Dark River at CR668	Dark River	Minntac DMR	3/8/2019	853	90.6	1500	1880	2488	9.8
SW 003	Dark River at CR668	Dark River	Minntac DMR	4/8/2019	196	20.8	372	506	771	57
SW 003	Dark River at CR668	Dark River	Minntac DMR	5/1/2019	281	27.8	492	678	978	25.8
SW 003	Dark River at CR668	Dark River	Minntac DMR	6/7/2019	490	57.3	935	1180	1605	10
SW 003	Dark River at CR668	Dark River	Minntac DMR	7/1/2019	597	59.3	1010	1240	1769	15.879
SW 003	Dark River at CR668	Dark River	Minntac DMR	8/5/2019	613	72	1150	1490	1987	4.97325
SW 003	Dark River at CR668	Dark River	Minntac DMR	9/6/2019	693	78.5	1180	1540	1992	2.763
SW 003	Dark River at CR668	Dark River	Minntac DMR	10/8/2019	332	36.8	618	758	1107	4.51975
SW 003	Dark River at CR668	Dark River	Minntac DMR	11/12/2019	592	62.8	1050	1300	1851	7.891
SW 003	Dark River at CR668	Dark River	Minntac DMR	12/2/2019	570	60.8	982	1250	1741	10.246
SW 003	Dark River at CR668	Dark River	Minntac DMR	1/3/2020	628	65.2	1080	1350	1756	10.433
SW 003	Dark River at CR668	Dark River	Minntac DMR	2/10/2020	725	77.4	1200	1600	2025	6.562
SW 003	Dark River at CR668	Dark River	Minntac DMR	3/6/2020	693	74	1230	1590	2028	8.66
SW 003	Dark River at CR668	Dark River	Minntac DMR	4/3/2020	150	16.2	272	372	568	51.02925
SW 003	Dark River at CR668	Dark River	Minntac DMR	5/1/2020	383	40.2	622	792	1183	12.40475
SW 003	Dark River at CR668	Dark River	Minntac DMR	6/5/2020	431	47.7	851	1070	1470	2.3765
SW 003	Dark River at CR668	Dark River	Minntac DMR	7/10/2020	402	18.6	796	1030	1417	9.857
SW 003	Dark River at CR668	Dark River	Minntac DMR	8/7/2020	441	48.4	864	1110	1557	1.427
SW 003	Dark River at CR668	Dark River	Minntac DMR	9/4/2020	358	41.5	745	922	1348	6.984
SW 003	Dark River at CR668	Dark River	Minntac DMR	10/2/2020	366	46	786	984	1366	4.42075
SW 003	Dark River at CR668	Dark River	Minntac DMR	11/10/2020	280	35.1	573	718	1041	19.3485
SW 003	Dark River at CR668	Dark River	Minntac DMR	12/4/2020	445	44.4	842	1060	1481	4.64
SW 003	Dark River at CR668	Dark River	Minntac DMR	1/8/2021	561	53.4	1090	1320	1833	3.702
SW 003	Dark River at CR668	Dark River	Minntac DMR	2/12/2021	616	59.9	1170	1460	1971	2.292
SW 003	Dark River at CR668	Dark River	Minntac DMR	3/5/2021	640	70.3	1100	1520	2031	3.519
SW 003	Dark River at CR668	Dark River	Minntac DMR	4/6/2021	205	22.2	388	496	729	12.02975
SW 003	Dark River at CR668	Dark River	Minntac DMR	5/26/2021	312	33.1	578	790	1093	6.101
SW 003	Dark River at CR668	Dark River	Minntac DMR	6/4/2021	363	42	644	896	1087	4.5025
SW 003	Dark River at CR668	Dark River	Minntac DMR	7/2/2021	476	52.4	796		1571	1.6585
SW 003	Dark River at CR668	Dark River	Minntac DMR	7/16/2021				1240		
SW 003	Dark River at CR668	Dark River	Minntac DMR	8/6/2021	540	68.3	918	1280	1582	0.996
SW 003	Dark River at CR668	Dark River	Minntac DMR	9/3/2021	635	88.4	1160	1490	1897	0.9105
SW 003	Dark River at CR668	Dark River	Minntac DMR	10/8/2021	616	68.8	989	1280	1753	6.1425
SW 003	Dark River at CR668	Dark River	Minntac DMR	11/9/2021	610	61.3	913	1260	1690	2.5685
SW 003	Dark River at CR668	Dark River	Minntac DMR	12/14/2021	659	65.4	1100	1450	1916	3.554
SW 003	Dark River at CR668	Dark River	Minntac DMR	1/10/2022	540	49.6	931	1230	1708	3.121
SW 003	Dark River at CR668	Dark River	Minntac DMR	2/21/2022	672	65.4	1150	1430	2049	3.733
SW 003	Dark River at CR668	Dark River	Minntac DMR	3/4/2022	642	69.1	1120	1490	2011	3.925
SW 003	Dark River at CR668	Dark River	Minntac DMR	4/11/2022	185	17.8	319	450	658.6	26.3915
SW 004	Dark River at CH65	Dark River	Minntac DMR	12/7/2018	298	29.3	508	638	943	
SW 004	Dark River at CH65	Dark River	Minntac DMR	1/4/2019	324	32.4	573	568	1076	
SW 004	Dark River at CH65	Dark River	Minntac DMR	2/11/2019	361	38	659	876	1278	
SW 004	Dark River at CH65	Dark River	Minntac DMR	3/8/2019	420	43.1	758	940	1429	
SW 004	Dark River at CH65	Dark River	Minntac DMR	4/8/2019	148	15.8	284	358	603	
SW 004	Dark River at CH65	Dark River	Minntac DMR	5/1/2019	127	14.9	234	362	509	
SW 004	Dark River at CH65	Dark River	Minntac DMR	6/14/2019	219	24.5	411	524	808	
SW 004	Dark River at CH65	Dark River	Minntac DMR	7/1/2019	261	29	465	550	905.8	
SW 004	Dark River at CH65	Dark River	Minntac DMR	8/5/2019	286	34.6	556	702	1070	
SW 004	Dark River at CH65	Dark River	Minntac DMR	9/6/2019	363	39.5	648	860	1190	
SW 004	Dark River at CH65	Dark River	Minntac DMR	10/8/2019	272	31	492	624	925	

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SW 004	Dark River at CH65	Dark River	Minntac DMR	11/12/2019	228	26.4	423	526	364.4	
SW 004	Dark River at CH65	Dark River	Minntac DMR	12/2/2019	237	26.6	444	534	837	
SW 004	Dark River at CH65	Dark River	Minntac DMR	1/3/2020	288	32.8	510	668	899	
SW 004	Dark River at CH65	Dark River	Minntac DMR	2/10/2020	307	35.4	537	366	977	
SW 004	Dark River at CH65	Dark River	Minntac DMR	3/6/2020	328	39.3	629	790	1119	
SW 004	Dark River at CH65	Dark River	Minntac DMR	4/3/2020	152	17.6	268	384	573	
SW 004	Dark River at CH65	Dark River	Minntac DMR	5/1/2020	184	21.1	311	406	648.7	
SW 004	Dark River at CH65	Dark River	Minntac DMR	6/5/2020	258	29.7	483	594	915	
SW 004	Dark River at CH65	Dark River	Minntac DMR	7/10/2020	187	23.3	366	502	754	
SW 004	Dark River at CH65	Dark River	Minntac DMR	8/7/2020	173	19.9	341	424	678	
SW 004	Dark River at CH65	Dark River	Minntac DMR	9/4/2020	183	21.1	351	442	714	
SW 004	Dark River at CH65	Dark River	Minntac DMR	10/2/2020	189	22.9	396	500	757	
SW 004	Dark River at CH65	Dark River	Minntac DMR	11/10/2020	190	23.1	378	448	702	
SW 004	Dark River at CH65	Dark River	Minntac DMR	12/4/2020	192	22.7	391	492	750	
SW 004	Dark River at CH65	Dark River	Minntac DMR	1/8/2021	195	23.1	392	472	765.3	
SW 004	Dark River at CH65	Dark River	Minntac DMR	2/12/2021	234	28.9	498	579	788	
SW 004	Dark River at CH65	Dark River	Minntac DMR	3/5/2021	189	22.4	341	445	793.4	
SW 004	Dark River at CH65	Dark River	Minntac DMR	4/6/2021	102	12.2	217	280	418	
SW 004	Dark River at CH65	Dark River	Minntac DMR	5/26/2021	128	15.1	255	346	510	
SW 004	Dark River at CH65	Dark River	Minntac DMR	6/4/2021	132	15.8	269	358	480.6	
SW 004	Dark River at CH65	Dark River	Minntac DMR	7/2/2021	139	16.4	291		512	
SW 004	Dark River at CH65	Dark River	Minntac DMR	7/16/2021				314		
SW 004	Dark River at CH65	Dark River	Minntac DMR	8/6/2021	141	17.4	272	370	600	
SW 004	Dark River at CH65	Dark River	Minntac DMR	9/3/2021	139	17.1	278	350	557.7	
SW 004	Dark River at CH65	Dark River	Minntac DMR	10/8/2021	182	22.7	333	480	736	
SW 004	Dark River at CH65	Dark River	Minntac DMR	11/9/2021	210	25.1	368	478	761	
SW 004	Dark River at CH65	Dark River	Minntac DMR	12/14/2021	237	27.7	422	572	853.3	
SW 004	Dark River at CH65	Dark River	Minntac DMR	1/10/2022	221	22.6	371	522	773	
SW 004	Dark River at CH65	Dark River	Minntac DMR	2/21/2022	75.5	9.7	196	255	843	
SW 004	Dark River at CH65	Dark River	Minntac DMR	3/4/2022	270	33.7	507	658	862	
SW 004	Dark River at CH65	Dark River	Minntac DMR	4/11/2022	172	19	323	414	632.5	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	12/13/2018	648	102	991	1330	1863	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	1/4/2019	728	115	1080	1450	2005	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	2/11/2019	747	122	1170	1610	2200	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	3/8/2019	725	113	1120	1600	2153	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	4/8/2019	131	20.9	213	316	524	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	5/1/2019	152	24.3	238	374	549	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	6/7/2019	243	43.6	425	588	872	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	7/1/2019	353	54.8	538	736	1115	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	8/5/2019	347	58.5	615	874	1240	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	9/6/2019	475	81.4	779	968	1506	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	10/8/2019	235	43.1	401	538	834	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	11/12/2019	446	71.3	691	978	1440	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	12/11/2019	431	69.9	679	956	1363	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	1/3/2020	498	78.1	760	1050	1415	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	2/10/2020	552	85.3	791	1150	1622	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	3/6/2020	547	86.1	909	1240	1703	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	4/15/2020	157	23.9	233	344	545	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	5/1/2020	222	34.5	319	458	726	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	6/5/2020	520	82.5	788	1090	1535	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	7/10/2020	593	95.1	882	1330	1777	

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SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	8/7/2020	672	103	996	1390	1909	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	9/4/2020	533	100	872	1230	1740	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	10/2/2020	527	103	911	1310	1722	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	11/17/2020	420	66.9	630	896	1261	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	12/4/2020	617	97.9	932	1330	1792	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	1/8/2021	759	113	1100	1690	2010	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	2/16/2021	815	127	1260	1730	2130	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	3/15/2021	489	76.3	744	1100	1498	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	4/6/2021	256	39.7	404	543	819	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	5/7/2021	344	52.7	493	733	1054	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	6/4/2021	432	70.4	630	1010	1215	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	7/29/2021	741	116	1060	1560	2063	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	8/25/2021	870	140	1160	1970	2359	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	9/29/2021	769	123	1040	1570	2000	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	10/26/2021	750	122	1080	1200	2018	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	11/30/2021	894	141	1150	1770	2349	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	12/14/2021	851	132	1200	1700	2306	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	1/17/2022	674	103	963	1470	2039	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	2/25/2022	781	92	1060	1700	2534	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	3/21/2022	471	69.7	722	972	1434	
SW 005	Little Sandy Lake Inlet	Sand River	Minntac DMR	4/27/2022	99.9	14.2	161	241	366.7	
SW 006	Timber Creek	Dark River	Minntac DMR	12/13/2018	520	25.5	1090	1220	1769	
SW 006	Timber Creek	Dark River	Minntac DMR	1/4/2019	557	28.5	1160	1240	1847	
SW 006	Timber Creek	Dark River	Minntac DMR	2/11/2019	646	35.4	1300	1530	2150	
SW 006	Timber Creek	Dark River	Minntac DMR	3/8/2019	633	36.6	1280	1480	2125	
SW 006	Timber Creek	Dark River	Minntac DMR	4/8/2019	92.6	6.5	226	278	463	
SW 006	Timber Creek	Dark River	Minntac DMR	5/1/2019	200	11.1	416	550	779	
SW 006	Timber Creek	Dark River	Minntac DMR	6/14/2019	322	16.3	716	810	1239	
SW 006	Timber Creek	Dark River	Minntac DMR	7/5/2019	356	15.7	755	866	1283	
SW 006	Timber Creek	Dark River	Minntac DMR	8/16/2019	390	19.4	853	852	1442	
SW 006	Timber Creek	Dark River	Minntac DMR	9/9/2019	439	23.7	894	1060	788	
SW 006	Timber Creek	Dark River	Minntac DMR	10/15/2019	197	13.7	445	532	739	
SW 006	Timber Creek	Dark River	Minntac DMR	11/25/2019	322	11.9	706	806	1278	
SW 006	Timber Creek	Dark River	Minntac DMR	12/13/2019	327	18.1	711	890	1317	
SW 006	Timber Creek	Dark River	Minntac DMR	1/14/2020	372	20.6	833	1010	1441	
SW 006	Timber Creek	Dark River	Minntac DMR	2/24/2020	437	27	935	1120	1573	
SW 006	Timber Creek	Dark River	Minntac DMR	3/10/2020	402	27.3	841	1050	1473	
SW 006	Timber Creek	Dark River	Minntac DMR	4/6/2020	92.7	7	196	250	390	
SW 006	Timber Creek	Dark River	Minntac DMR	5/4/2020	247	14.1	494	596	904	
SW 006	Timber Creek	Dark River	Minntac DMR	6/5/2020	264	15.7	654	708	1075	
SW 006	Timber Creek	Dark River	Minntac DMR	7/10/2020	284	5.4	685	836	1204	
SW 006	Timber Creek	Dark River	Minntac DMR	8/7/2020	326	12.6	779	898	1330	
SW 006	Timber Creek	Dark River	Minntac DMR	9/8/2020	342	19.6	748	874	1297	
SW 006	Timber Creek	Dark River	Minntac DMR	10/2/2020	301	24	726	836	1207	
SW 006	Timber Creek	Dark River	Minntac DMR	11/10/2020	250	20.1	523	602	883	
SW 006	Timber Creek	Dark River	Minntac DMR	12/11/2020	409	23.9	789	1020	1291	
SW 006	Timber Creek	Dark River	Minntac DMR	1/14/2021	465	26.6	946	1170	1620	
SW 006	Timber Creek	Dark River	Minntac DMR	2/8/2021	526	29.6	1090	978	1809	
SW 006	Timber Creek	Dark River	Minntac DMR	3/9/2021	422	28.1	835	1090	1446	
SW 006	Timber Creek	Dark River	Minntac DMR	4/6/2021	143	11.4	306	363	571	
SW 006	Timber Creek	Dark River	Minntac DMR	5/21/2021	264	17.4	529	708	1007	

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SW 006	Timber Creek	Dark River	Minntac DMR	6/7/2021	279	17.2	609	740	1134	
SW 006	Timber Creek	Dark River	Minntac DMR	7/2/2021	294	15.2	724		1180	
SW 006	Timber Creek	Dark River	Minntac DMR	7/16/2021				896		
SW 006	Timber Creek	Dark River	Minntac DMR	8/6/2021	358	21	742	964	1314	
SW 006	Timber Creek	Dark River	Minntac DMR	9/3/2021	339	25.5	793	932	1370	
SW 006	Timber Creek	Dark River	Minntac DMR	10/1/2021	444	35.6	857	1070	1446	
SW 006	Timber Creek	Dark River	Minntac DMR	11/9/2021	517	32.5	797	1070	1445	
SW 006	Timber Creek	Dark River	Minntac DMR	12/14/2021	550	32.5	983	1200	1665	
SW 006	Timber Creek	Dark River	Minntac DMR	1/28/2022	507	30	1000	1190	1717	
SW 006	Timber Creek	Dark River	Minntac DMR	2/25/2022	558	30	1110	1310	1760	
SW 006	Timber Creek	Dark River	Minntac DMR	3/18/2022	423	29.4	823	968	1417	
SW 006	Timber Creek	Dark River	Minntac DMR	4/27/2022	80.3	4	178	226	362.9	
SW 007	Admiral Lake	Sand River	Minntac DMR	12/13/2018	717	111	1100	1470	2019	
SW 007	Admiral Lake	Sand River	Minntac DMR	1/4/2019	746	115	1150	1490	2342	
SW 007	Admiral Lake	Sand River	Minntac DMR	2/11/2019	788	126	1210	1670	2231	
SW 007	Admiral Lake	Sand River	Minntac DMR	3/8/2019	760	121	1200	1630	2246	
SW 007	Admiral Lake	Sand River	Minntac DMR	4/8/2019	167	26.7	283	362	765	
SW 007	Admiral Lake	Sand River	Minntac DMR	5/1/2019	295	46.3	454	690	1179	
SW 007	Admiral Lake	Sand River	Minntac DMR	6/25/2019	533	85.6	815	1130	1581	
SW 007	Admiral Lake	Sand River	Minntac DMR	7/17/2019	575	87.1	876	1160	1706	
SW 007	Admiral Lake	Sand River	Minntac DMR	8/28/2019	660	110	1010	1470	1946	
SW 007	Admiral Lake	Sand River	Minntac DMR	9/18/2019	492	82.8	808	1090	1578	
SW 007	Admiral Lake	Sand River	Minntac DMR	10/9/2019	455	78.6	776	1000	1490	
SW 007	Admiral Lake	Sand River	Minntac DMR	12/2/2019	621	95.9	895	1300	1765	
SW 007	Admiral Lake	Sand River	Minntac DMR	1/14/2020	648	103	1020	1520	1989	
SW 007	Admiral Lake	Sand River	Minntac DMR	2/24/2020	724	119	1120	1590	2175	
SW 007	Admiral Lake	Sand River	Minntac DMR	3/10/2020	716	113	1000	1390	1982	
SW 007	Admiral Lake	Sand River	Minntac DMR	4/28/2020	394	63.7	583	876	1193	
SW 007	Admiral Lake	Sand River	Minntac DMR	5/22/2020	590	93.6	785	1230	1596	
SW 007	Admiral Lake	Sand River	Minntac DMR	6/15/2020	601	76.9	851	1270	1697	
SW 007	Admiral Lake	Sand River	Minntac DMR	7/22/2020	703	102	1020	1440	1932	
SW 007	Admiral Lake	Sand River	Minntac DMR	8/10/2020	695	108	1090	1580	2025	
SW 007	Admiral Lake	Sand River	Minntac DMR	9/14/2020	759	129	1170	1680	2142	
SW 007	Admiral Lake	Sand River	Minntac DMR	10/12/2020	696	125	1050	1510	2001	
SW 007	Admiral Lake	Sand River	Minntac DMR	11/6/2020	518	83	803	1180	1765	
SW 007	Admiral Lake	Sand River	Minntac DMR	12/11/2020	740	122	1080	1630	2147	
SW 007	Admiral Lake	Sand River	Minntac DMR	1/14/2021	812	119	1140	1670	2197	
SW 007	Admiral Lake	Sand River	Minntac DMR	2/8/2021	856	127	1190	1750	2340	
SW 007	Admiral Lake	Sand River	Minntac DMR	3/9/2021	387	60.3	588	880	1835	
SW 007	Admiral Lake	Sand River	Minntac DMR	4/23/2021	373	56.1	566	840	1194	
SW 007	Admiral Lake	Sand River	Minntac DMR	5/21/2021	581	96.1	842	1320	1714	
SW 007	Admiral Lake	Sand River	Minntac DMR	6/7/2021	705	100	941	1420	1897	
SW 007	Admiral Lake	Sand River	Minntac DMR	7/13/2021	834	122	1170	1740	2173	
SW 007	Admiral Lake	Sand River	Minntac DMR	8/6/2021	842	128	1140	1830	2295	
SW 007	Admiral Lake	Sand River	Minntac DMR	9/24/2021	752	131	912	1680	2140	
SW 007	Admiral Lake	Sand River	Minntac DMR	10/22/2021	774	130	1140	1200	2128	
SW 007	Admiral Lake	Sand River	Minntac DMR	11/10/2021	843	133	1290	1330	2201	
SW 007	Admiral Lake	Sand River	Minntac DMR	12/14/2021	873	139	1250	1700	2366	
SW 007	Admiral Lake	Sand River	Minntac DMR	1/11/2022	779	116	1120	1630	2170	
SW 007	Admiral Lake	Sand River	Minntac DMR	2/25/2022	848	100	1130	1700	2535	
SW 007	Admiral Lake	Sand River	Minntac DMR	3/21/2022	479	67.1	697	956	1742	

Subject Item Designation	Subject Item Desc	Watershed	Source	Sample date	Sulfate, Total (as SO4) (mg/L)	Chloride, Total (mg/L)	Hardness, Calcium & Magnesium, Calculated (as CaCO3) (mg/L)	Solids, Total Dissolved (TDS) (mg/L)	Specific Conductance (umhos/cm)	Flow, Stream, Instantaneous (cfs)
SW 008	Dark River near Basin	Dark River	Minntac DMR	6/25/2019	636	63.7	1140	1460	1898	
SW 008	Dark River near Basin	Dark River	Minntac DMR	7/17/2019	538	52.6	921	1170	1648	
SW 008	Dark River near Basin	Dark River	Minntac DMR	8/28/2019	619	65.7	1050	1400	1865	
SW 008	Dark River near Basin	Dark River	Minntac DMR	9/18/2019	393	45.1	721	900	1342	
SW 008	Dark River near Basin	Dark River	Minntac DMR	10/9/2019	486	55.6	866	1100	1576	
SW 008	Dark River near Basin	Dark River	Minntac DMR	4/28/2020	432	46.6	768	1000	1368	
SW 008	Dark River near Basin	Dark River	Minntac DMR	5/22/2020	713	81.2	1140	1590	2002	
SW 008	Dark River near Basin	Dark River	Minntac DMR	6/15/2020	368	37.2	652	856	1218	
SW 008	Dark River near Basin	Dark River	Minntac DMR	7/22/2020	349	31.1	682	906	1246	
SW 008	Dark River near Basin	Dark River	Minntac DMR	8/10/2020	378	38.6	779	978	1327	
SW 008	Dark River near Basin	Dark River	Minntac DMR	9/14/2020	540	58.5	1000	1290	1711	
SW 008	Dark River near Basin	Dark River	Minntac DMR	10/12/2020	490	64.4	881	1180	1620	
SW 008	Dark River near Basin	Dark River	Minntac DMR	11/6/2020	376	36.6	756	982	1383	
SW 008	Dark River near Basin	Dark River	Minntac DMR	4/23/2021	264	26.8	446	652	938	
SW 008	Dark River near Basin	Dark River	Minntac DMR	5/21/2021	326	32.2	611	816	1176	
SW 008	Dark River near Basin	Dark River	Minntac DMR	6/7/2021	490	50	818	1120	1430	
SW 008	Dark River near Basin	Dark River	Minntac DMR	7/13/2021	667	82	1120	1560	2005	
SW 008	Dark River near Basin	Dark River	Minntac DMR	8/6/2021	687	90	1120	1660	2049	
SW 008	Dark River near Basin	Dark River	Minntac DMR	9/24/2021	478	60.8	1090	1220	1600	
SW 008	Dark River near Basin	Dark River	Minntac DMR	10/22/2021	626	62.3	967	1320	1773	
SW 008	Dark River near Basin	Dark River	Minntac DMR	11/10/2021	620	65.7	1160	1370	1809	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	1/2/2019	1020	149	1370	1980	2487	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	2/6/2019	1030	154	1560	1980	2495	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	3/6/2019	1010	152	1380	2080	2597	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	4/3/2019	947	155	1400	2040	2449	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	5/1/2019	881	128	1330	1770	2261	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	6/5/2019	870	137	1360	1850	2344	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	7/3/2019	930	146	1340	2020	2457	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	8/7/2019	975	143	1310	1960	2456	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	9/4/2019	962	142	1324	1980	2420	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	10/3/2019	752	108	1350	1490	2386	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	11/6/2019	975	140	1300	1910	2462	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	12/4/2019	923	138	1290	1860	2452	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	1/2/2020	975	142	1320	1930	2442	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	2/5/2020	965	146	1250	2010	2495	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	3/4/2020	954	150	1270	1980	2566	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	4/1/2020	944	136	1250	2000	2412	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	5/6/2020	961	136	1320	1950	2060	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	6/3/2020	954	140	1330	1980	2375	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	7/1/2020	927	129	1370	1970	2432	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	8/5/2020	990	136	1390	1970	2375	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	9/9/2020	881	124	1330	1960	2755	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	10/7/2020	917	126	1350	1970	2755	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	11/4/2020	940	132	1360	2010	2485	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	12/2/2020	1020	139	1330	2030	2532	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	1/6/2021	1040	145	1250	2050	2645	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	2/3/2021	1090	153	1440	2080	2581	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	3/3/2021	1100	155	1480	2210	2576	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	4/7/2021	1100	158	1400	2170	2609	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	5/5/2021	1000	142	1330	2130	2472	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	6/9/2021	1010	134	1320	2070	2500	

Subject Item Designation	Subject Item Desc	Watershed	Source	Sample date	Sulfate, Total (as SO4) (mg/L)	Chloride, Total (mg/L)	Hardness, Calcium & Magnesium, Calculated (as CaCO3) (mg/L)	Solids, Total Dissolved (TDS) (mg/L)	Specific Conductance (umhos/cm)	Flow, Stream, Instantaneous (cfs)
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	7/15/2021	1080	139	1360	2000		
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	8/4/2021	1110	145	1440	2100	2571	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	9/1/2021	1060	148	1390	1900	2593	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	10/6/2021	1090	148	1260	1770	2614	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	11/10/2021	1070	155	1310	1930	2647	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	12/8/2021	1120	158	1530	1930	2672	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	1/6/2022					2673	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	1/12/2022	1090	152	1410	1900		
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	2/9/2022	1110	150	1440	2170	2733	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	3/9/2022	1130	157	1410	1900	2694	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	4/6/2022			1410		2655	
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	4/11/2022	1080	159		2000		
WS 009	Basin Water	Tailings Basin Water	Minntac DMR	4/30/2022						

Background/Pre-Facility	Data Source	Date Range	Sulfate, Total (as SO4) (mg/L)	Chloride, Total (mg/L)	Hardness, Calcium & Magnesium, Calculated (as CaCO3) (mg/L)	Solids, Total Dissolved (TDS) (mg/L)	Specific Conductance (umhos/cm)
Background Max	2004 EIS	May 2003- Nov 2003	5.4	7.7	72		96
Pre-Facility Historic Max	USGS	1955-1962	26	1	54	104	119

Note:
123 Shaded cells indicate values that exceed the highest background or historic value.

Table A-2. Historic Water Quality Data – 1955-1979.

MWH on behalf of MPCA, from "Minntac Water Inventory Reduction EIS – Surface Water Hydrology and Quality Technical Memorandum" (2004), pages 163-165 of pdf.

			General Inorganics																													Metals/Mettaloids						
Station	Watershed	Date Sampled	Acid Neutral Potential (mg/L as CaCO3)	Bicarbonate, total (mg/L)	Calcium, dissolved (mg/L)	Carbonate, total (mg/L	Chloride, dissolved (mg/L)	CO2, total (mg/L)	Conductivity (usiemens/cm)	Discharge (CFS)	Fluoride, dissolved (mg/L)	Hardness, total (mg/L as CaCO3)	Iron, dissolved (ug/L)	Iron, total (ug/L)	Nitrate as N, dissolved (mg/L)	Nitrate, dissolved (ug/L)	Nitrate, total (mg/L)	Nitrite + nitrate, dissolved (mg/L)	Non-Carbonate Hardness (mg/L as CaCO3)	pH	Phosphorous, total (mg/L)	Potassium, dissolved (mg/L)	Silica, dissolved (mg/L)	Sodium (% of major cations)	Sodium + Potassium, dissolved (mg/l as Na	Sodium adsorption ratio	Sodium, dissolved (mg/L)	Sulfate, dissolved (mg/L)	Temp (C)	Total Dissolved Solids (mg/L)	Total Suspended Solids (mg/L)	Boron, dissolved (ug/L)	Boron, total rec (ug/L)	Magnesium, dissolved (mg/L)	Manganese, dissolved (ug/L)	Manganese, total (ug/L)	Manganese, total rec (ug/L)
701	Sandy/Pike River	04/26/58	13	16	3.6	0	0.5	10	43	12	0.2	17			0.8	3.5	0.8		4	6.4		0.8	3.5	15		0.2	1.5	7.5				50		1.9			
701	Sandy/Pike River	05/21/58	14	17	5.1	0	1	6.8	47	11	0.1	19			0.3	1.3	0.3		5	6.6		0.6	2.2	16		0.2	1.7	7.8						1.5			
701	Sandy/Pike River	06/25/58	11	14	5	0	0.2	11	38	22	0.1	19			0.5	2.2	0.5		8	6.3		0.2	3	14		0.1	1.4	9.5						1.6			
701	Sandy/Pike River	08/04/59	11	13	3.7	0	0.1	26	37		0.2	17	780	1	4.4	1		6	5.9		0.1	1.6	15		0.1	1.4	8.3						1.9		0	
701	Sandy/Pike River	08/04/59	20	24	6	0	0.1		51	3.1	0.2	26		1.6	7.1	1.6		6			0.2	7.6	11		0.1	1.5	9.5						2.7			
701	Sandy/Pike River	08/26/59	16	20	6.4	0	0.1	13	57	18	0.3	26		0.8	3.5	0.8		10	6.4		0.4	11	10		0.1	1.4	10						2.4			
701	Sandy/Pike River	09/04/59	11	14	5.5	0	0	22	41	313	0.2	22	1400	3.8	17	3.8		11	6		0.4	9.4	14		0.2	1.7	12						2		0	
701	Sandy/Pike River	07/06/60		16	4.9	0	0.1		43	8.6	0	20	520		2			7	6.1		0.6	5.4			0.2	1.9	11						1.9			
701	Sandy/Pike River	07/28/60							41	27																											
701	Sandy/Pike River	08/10/60		18	5.2	0	0.1		44		0.1	23	1100		1.9			8	6.5		0.6	10			0.1	1.4	9.3						2.4		0	
701	Sandy/Pike River	09/30/60		35	11	0	0		70		0.1	32	1900		1.5			3	6.5		1	12			0.2	2	7.8				10		1.1			
701	Sandy/Pike River	10/29/60	21	25	6.3	0	0	10	67	4.4	0.1	26	1500	1.5	6.6	1.5		5	6.6		1	11	14		0.2	2	9.3				30	30	2.5			
701	Sandy/Pike River	11/16/60	20	24	7.3	0	0	9.6	59	8.9	0.1	24	1700	1.3	5.8	1.3		4	6.6		1.4	11	14		0.2	2	7.3				50	50	1.4			
701	Sandy/Pike River	12/22/60	49	60	18	0	0.2	7.6	119	0.85	0.1	54	1900	0.9	4	0.9		5	7.1		1.2	24	11		0.2	3.2	10				120	120	2.2			
701	Sandy/Pike River	01/23/61	55	67	16	0	0	17	118	0.37	0.1	54	1500	1.2	5.3	1.2		0	6.8		1.8	22	10		0.2	2.8	5.5				20	20	3.4			
701	Sandy/Pike River	02/11/61											1300																								
701	Sandy/Pike River	02/21/61	52	64	15	0	0	13	114	0.54	0.1	50		0.9	4	0.9		0	6.9		2.3	21	11		0.2	3.1	2				10	10	3.1			
701	Sandy/Pike River	05/11/61	7	8	3.2	0	0.1	8.1	37	43	0.1	13	370	1.1	4.9	1.1		6	6.2		1.5	3.6	16		0.2	1.3	6				70	70	1.2		50	
701	Sandy/Pike River	05/23/61							39	61																											
701	Sandy/Pike River	06/21/61	25	30	7.9	0	0	9.6	62	5	0.2	28	2200	1.1	4.9	1.1		3	6.7		0.8	5.6	16		0.2	2.6	7.3				70	70	2			
701	Sandy/Pike River	07/17/61	43	52	11	0	0	6.6	93	1.3	0.3	41	1700	0.6	2.7	0.6		0	7.1		1.1	11	12		0.2	2.7	1.8				20	20	3.3			
701	Sandy/Pike River	08/14/61	48	58	13	0	0	4.7	103	0.38	0.2	45	590	0.6	2.7	0.6		0	7.3		1.2	8.5	14		0.2	3.4	2.8				20	20	3.1			
701	Sandy/Pike River	09/13/61	11	13	9.2	0	0	4.2	76	23	0.4	35	1300	1.8	8	1.8		24	6.7		1	11	14		0.2	2.7	26				20	20	2.9			
S-2	Sandy/Pike River	09/25/57											1500																								
S-2	Sandy/Pike River	04/18/58		20	7		0.8		56		0.1	24	690			1.5		8	6.6		0.9	7.1	15		0.2	2	11						1.6			
S-2	Sandy/Pike River	10/01/58		26	7.4		0.8		65		0.2	31	960			0.5		10	6.1		0	8	11		0.1	1.7	11						3.1			
S-2	Sandy/Pike River	06/03/59		18	5.4		0.5		47		0.2	22	730			0.8		7	6.1		0.2	3.1	14		0.1	1.6	10						2.1			
S-2	Sandy/Pike River	09/03/59		17	6.3		0.1		57		0.4	28	1300			0.8		14	6.1		0.4	9.9	11		0.1	1.6	16						3			
S-2	Sandy/Pike River	08/09/60		26	7.8	0	0		60		0.2	30				1.3		9	6.6		0.5	11			0.1	1.8	11						2.6			
S-2	Sandy/Pike River	05/11/61		15	7.2	0	0		53		0.1	21	370			1.2		9	6.4		0.8	4.6			0.2	1.6	13					80	0.7		20	
S-2	Sandy/Pike River	05/23/62		14	5.7	0	0.7		51		0.2	22	580			0.6		11	6.3		0.5	2.8			0.1	1.6	11					50	1.9			0
S-2	Sandy/Pike River	09/26/62		38	9.2	0	1		84		0.2	41	1500			2.3		10	6.8		1.6	10			0.2	2.3	11					60	4.4			10
S-2	Sandy/Pike River	04/17/63											520																						0		
ST-1	Dark/Sturgeon River	09/28/55	43	52	12	0	0.2	6.6	96	77		45		1.2	5.3			2	7.1			12	15	3.7	0.2		8.8				10		3.6			
ST-1	Dark/Sturgeon River	09/27/57	41	50	14	0	0.4	16	101	82	0.2	48	1100	2.1	9.3	2.1		7	6.7		1.3	11	9		0.1	2.3	14				60		3.2			
ST-1	Dark/Sturgeon River	04/18/58	35	43	12	0	1	5.5	84	75	0.1	40	610	1.1	4.9	1.1		5	7.1		1.1	6.9	11		0.2	2.4	7.3				50		2.4		120	
ST-1	Dark/Sturgeon River	07/20/58	34	42	12	0	0.6	13	85	60	0.2	44		2.1	9.3	2.1		10	6.7		0.7	7.1	9		0.1	2	14						3.4			
ST-1	Dark/Sturgeon River	08/17/58	42	51	14	0	0.2	13	94	27	0.2	46		0.9	4	0.9		4	6.8		0.8	6.2	12		0.2	3	11						2.7			
ST-1	Dark/Sturgeon River	09/26/58	35	43	11	0	0.4	8.7	85	28	0.2	41		0.6	2.7			6	6.9		1.2	10	12		0.2	2.6	7.3						3.3			

Station	Watershed	Date Sampled	General Inorganics																												Metals/Mettaloids					
			Acid Neutral Potential (mg/L as CaCO3)	Bicarbonate, total (mg/L)	Calcium, dissolved (mg/L)	Carbonate, total (mg/L	Chloride, dissolved (mg/L)	CO2, total (mg/L)	Conductivity (usiemens/cm)	Discharge (CFS)	Fluoride, dissolved (mg/L)	Hardness, total (mg/L as CaCO3)	Iron, dissolved (ug/L)	Iron, total (ug/L)	Nitrate as N, dissolved (mg/L)	Nitrate, dissolved (ug/L)	Nitrate, total (mg/L)	Nitrite + nitrate, dissolved (mg/L)	Non-Carbonate Hardness (mg/L as CaCO3)	pH	Phosphorous, total (mg/L)	Potassium, dissolved (mg/L)	Silica, dissolved (mg/L)	Sodium (% of major cations)	Sodium + Potassium, dissolved (mg/l as Na	Sodium adsorption ratio	Sodium, dissolved (mg/L)	Sulfate, dissolved (mg/L)	Temp (C)	Total Dissolved Solids (mg/L)	Total Suspended Solids (mg/L)	Boron, dissolved (ug/L)	Boron, total rec (ug/L)	Magnesium, dissolved (mg/L)	Manganese, dissolved (ug/L)	Manganese, total (ug/L)	Manganese, total rec (ug/L)
ST-1	Dark/Sturgeon River	10/02/58	37	45	13	0	0.2	23	89	62	0.2	45		790	1.9	8.4	1.9		8	6.5		1.2	9.3	10		0.1	2.3	14						3.1		0	
ST-1	Dark/Sturgeon River	10/24/58							89	47																											
ST-1	Dark/Sturgeon River	11/22/58	30	36	10	0	0.1	11	84	179	0.2	38			1.5	6.6	1.5		8	6.7		1.2	11	11		0.2	2.3	9.5						3.2			
ST-1	Dark/Sturgeon River	12/19/58	39	48	13	0	0.1	2.4	108	26	0.2	49			7.3	32	7.3		10	7.5		1.5	12	12		0.2	3.1	9.8						4			
ST-1	Dark/Sturgeon River	01/22/59	57	69	16	0	0.3	8.8	122	18	0.1	58			0.5	2.2	0.5		1	7.1		1.5	13	10		0.2	3.1	7						4.4			
ST-1	Dark/Sturgeon River	02/22/59	68	83	18	0	0.4	42	154	11	0.1	72			0.8	3.5			4	6.5		1.7	17	10		0.2	3.7	20						6.6			
ST-1	Dark/Sturgeon River	02/25/59		83	18		0.4		154		0.1	72					0.8		4	6.5		1.7	17	10		0.2	3.7	20						6.6			
ST-1	Dark/Sturgeon River	03/26/59	69	84	19	0	1.7	5.4	150	19	0.1	68			0.8	3.5	0.8		0	7.4		1.6	16	11		0.2	4	3						5			
ST-1	Dark/Sturgeon River	04/29/59	32	39	9.2	0	0	7.9	78	93	0.1	35			0.9	4	0.9		3	6.9		1	6.9	10		0.1	1.9	8						2.9			
ST-1	Dark/Sturgeon River	05/27/59	25	31	8	0	0	12	65	313	0.2	31			1.8	8	1.8		6	6.6		0.8	5.3	10		0.1	1.6	9.5						2.7			
ST-1	Dark/Sturgeon River	06/04/59	29	35	9	0	0.1	11	77	186	0.2	34		520	1.2	5.3	1.2		5	6.7		0.7	6.9	11		0.1	1.9	8.3						2.8		0	
ST-1	Dark/Sturgeon River	08/02/59	41	50	13	0	0.1	8	88	43	0.3	46			1	4.4	1		5	7		0.6	7.8	9		0.1	2.1	7.3						3.3			
ST-1	Dark/Sturgeon River	08/27/59	39	48	12	0	0.1	31	96	93	0.2	44			2.6	12	2.6		5	6.4		1	10	11		0.2	2.5	5.8						3.4			
ST-1	Dark/Sturgeon River	09/05/59	30	37	11	0	0	9.4	72	274	0.3	38		740	2.3	10	2.3		8	6.8		0.6	9	9		0.1	1.7	9.5						2.6		0	
ST-1	Dark/Sturgeon River	07/06/60		41	10	0	0.7		77	61	0.1	37				0.3	0.3		3	6.7		1	5			0.1	2.1	11						2.9			
ST-1	Dark/Sturgeon River	07/27/60							71	113																											
ST-1	Dark/Sturgeon River	08/10/60		37	10	0	0		70	83	0.2	37		460		0.9	0.9		7	6.8		1	8.8			0.1	1.8	8.8						2.9		0	
ST-1	Dark/Sturgeon River	09/20/60		60	14	0	0		104	22	0.2	48		780		0.5	0.5		0	7		1.2	9.1			0.2	2.7	6.5						3.2		0	
ST-1	Dark/Sturgeon River	10/19/60		70	16	0	0		126	20	0.1	56		690		0.3	0.3		0	7.4		1.6	10			0.2	3.1	5.3				30	30	3.9			
ST-1	Dark/Sturgeon River	11/16/60		59	14	0	0		106	39	0.1	49		800		0.6	0.6		1	7.5		1.2	12			0.2	2.6	7.3				60	60	3.4			
ST-1	Dark/Sturgeon River	02/28/61		82	18	0	0.2		142	14	0.1	66		890		0.8	0.8		0	7.4		1.1	15			0.2	3.3	4				30	30	5.1			
ST-1	Dark/Sturgeon River	04/12/61		47	10	0	0.5		91	47	0.1	39		670		0.8	0.8		0	7.1		2	7.3			0.2	2.2	3.5				20	20	3.4		70	
ST-1	Dark/Sturgeon River	05/11/61		28	7.7	0	0.5		63	243	0.2	28		360		1.5	1.5		5	6.6		1.2	5.4			0.1	1.8	5.8				60	60	2.1		50	
ST-1	Dark/Sturgeon River	05/17/61		20		0	0		54	940		22							6	6.7					0.8	0.1	0.8	7									
ST-1	Dark/Sturgeon River	06/12/61		45	12	0	0		86	86	0.2	42		360		1.4	1.4		5	6.6		0.9	4.8			0.1	1.9	4.8				50	50	2.9			
ST-1	Dark/Sturgeon River	07/12/61		76	20	0	0		134	14	0.2	64		340		0.8	0.8		2	7.8		1.2	5.3			0.1	2.5	5				30	30	3.4			
ST-1	Dark/Sturgeon River	08/10/61		63	14	0	0		114	14	0.2	51		220		0.3	0.3		0	7.3		1.2	6.1			0.2	3.1	6				40	40	3.9			
ST-1	Dark/Sturgeon River	09/16/61		46	14	0	0.3		97	104	0.2	45		510		0.8	0.8		7	6.9		1.4	8.8			0.2	2.5	14				20	20	2.4			
ST-1	Dark/Sturgeon River	10/03/61		41		0	0.2		86	54		38		570					4	6.9					1.1	0.1	1.1	6.3									
ST-1	Dark/Sturgeon River	10/31/61		43	14	0	0		91	74	0.2	41		570		0.9	0.9		6	7.2		0.8	8.6			0.2	2.3	12				60	60	1.5		0	
ST-1	Dark/Sturgeon River	11/28/61		55	14	0	0		110	36	0.2	50		790		0.9	0.9		5	6.9		1.6	10			0.2	2.7	12				50	50	3.7			
ST-1	Dark/Sturgeon River	01/03/62		67	15	0	0.2		129	19		57							2	6.8					4	0.2	4	10						4.8			
ST-1	Dark/Sturgeon River	02/07/62		72		0	0.2		126	17		58							0	7.1					3.6	0.2	3.6	6.3									
ST-1	Dark/Sturgeon River	03/14/62		78		0	0		137	14		64							0	7.2					2.7	0.1	2.7	5.8									
ST-1	Dark/Sturgeon River	04/16/62		41	9.9	0	0.5		96	89	0.1	40		560		1.7	1.7		6	6.7		2.1	9.6			0.2	2.2	9.5				40	40	3.7			
ST-1	Dark/Sturgeon River	05/12/62							66	393																											
ST-1	Dark/Sturgeon River	05/24/62		24	7	0	1.1		58	770	0.1	27		410		0.4	0.4		7	6.4		0.6	5.2			0.2	1.8	9.3				40	40	2.3		0	
ST-1	Dark/Sturgeon River	06/11/62		33		0	0		69	317		33							6	7					1.2	0.1	1.2	8.3									
ST-1	Dark/Sturgeon River	07/10/62		34		0	0.1		65	243		34							6	6.9					0.3	0	0.3	6.5									

Station	Watershed	Date Sampled	General Inorganics																													Metals/Mettaloids					
			Acid Neutral Potential (mg/L as CaCO3)	Bicarbonate, total (mg/L)	Calcium, dissolved (mg/L)	Carbonate, total (mg/L	Chloride, dissolved (mg/L)	CO2, total (mg/L)	Conductivity (usiemens/cm)	Discharge (CFS)	Fluoride, dissolved (mg/L)	Hardness, total (mg/L as CaCO3)	Iron, dissolved (ug/L)	Iron, total (ug/L)	Nitrate as N, dissolved (mg/L)	Nitrate, dissolved (ug/L)	Nitrate, total (mg/L)	Nitrite + nitrate, dissolved (mg/L)	Non-Carbonate Hardness (mg/L as CaCO3)	pH	Phosphorous, total (mg/L)	Potassium, dissolved (mg/L)	Silica, dissolved (mg/L)	Sodium (% of major cations)	Sodium + Potassium, dissolved (mg/l as Na	Sodium adsorption ratio	Sodium, dissolved (mg/L)	Sulfate, dissolved (mg/L)	Temp (C)	Total Dissolved Solids (mg/L)	Total Suspended Solids (mg/L)	Boron, dissolved (ug/L)	Boron, total rec (ug/L)	Magnesium, dissolved (mg/L)	Manganese, dissolved (ug/L)	Manganese, total (ug/L)	Manganese, total rec (ug/L)
ST-1	Dark/Sturgeon River	09/27/82		42		0	0.2		78	72		40							6	6.8					0.6	0	0.6	6.3									
ST-1	Dark/Sturgeon River	10/10/82		45	11	0	0		83	55	0.2	40		860		0.8			3	6.9		1.3	9			0.1	2	6.8				40		3.1			
ST-1	Dark/Sturgeon River	12/04/82		53	13	0	0		97	61	0.1	44		1100		1.2			1	7.3		1	11			0.2	2.4	5.8				30		2.8			
ST-1	Dark/Sturgeon River	02/11/83		78	19	0	0.8		136	9.1	0.2	66		930		1			2	7.3		1.4	18			0.2	3.1	7.2				20		4.5			
ST-1	Dark/Sturgeon River	04/18/83		28	7.6	0	0.1		65	348	0.2	28		390		1			5	6.6		1.3	6.4			0.1	1.7	9				70		2.3		20	
ST-1	Dark/Sturgeon River	05/15/83		33		0	1.2		70	193		32							5	7					2.4	0.2		8.2									
ST-1	Dark/Sturgeon River	07/16/83		52	13	0	1.4		92	68	0.2	45		1100		0.6			2	7		0.9	8.2			0.2	2.4	6.8				30		3.1			
ST-1	Dark/Sturgeon River	10/18/72	36	44	10	0	1.9	2.8	81	117	0.3	39	1200					0.07	3	7.4	0.05	1.1	11	9		0.1	1.9	6.9	2			110		3.4	40		
ST-1	Dark/Sturgeon River	04/21/79																											2.5		44						
D-2	Dark/Sturgeon River	09/27/55		38	7.4	0	0.4		74	28		36	810				1.5		5	6.9			11			0.2	2.1	7.5		76		20		4.3			
D-2	Dark/Sturgeon River	09/26/57		38	9.3	0	0.3		77.4	25	0.2	36	1500				1.8		5	6.5		1.1	11			0.2	2.1	12		86		70		3.1			
D-2	Dark/Sturgeon River	04/18/58		41	10	0	0.7		78	24	0.1	37	980				1.1		3	7.2		1.3	10	11		0.2	2.2	9.3		77		60		2.9	21		
D-2	Dark/Sturgeon River	10/02/58		34	8.6	0	0.5		70	28	0.2	34	950				1.5		6	6.2		0.4	8.9	12		0.2	2.1	7.3		83				3.1	0		
D-2	Dark/Sturgeon River	06/04/59		27	6.6	0	0.3		57	53	0.2	26	510				0.9		4	6.5		0.6	5.1	13		0.2	1.8	7.8		72				2.3	0		
D-2	Dark/Sturgeon River	09/05/59		26	6.9	0	0		55	95	0.2	28	830				2.4		7	6.7		0.6	8.3	11		0.1	1.6	8.5		104				2.6	0		
D-2	Dark/Sturgeon River	08/10/60		30	7.6	0	0		61	39	0.2	29	670			0.4	0.4		4	6.6		0.6	6			0.2	1.9	6.5		76				2.4	0		0
D-2	Dark/Sturgeon River	05/11/61		23	4.6	0	0		68	76	0.1	22	370				0.9		3	6.7		1.3	5.6			0.1	1.5	6.5		60		50	50	2.6	0		0
D-2	Dark/Sturgeon River	10/18/72		56	13	0	3.7	2.8	128	22	0.3	57	930					0.12	11	7.5	0.05	1.8	13	12		0.2	3.7	14	2			100		6	50		

Notes:
1. USGS Swater Quality Data downloaded from the following website: http://nwis.waterdata.usgs.gov/mn/nwis/sw

Table A-3. Historic Sulfate Data.

MWH on behalf of MPCA, taken from "Minntac Water Inventory Reduction EIS – Surface Water Hydrology and Quality Technical Memorandum" (2004), pages 168-170 of pdf.

Dark River Watershed				Sandy/Pike Rivers Watershed			
020		D2		030		701	
Date	Sulfate[1]	Date	Sulfate[1]	Date	Sulfate[1]	Date	Sulfate[1]
10/22/84	400	08/18/87	57	10/22/84	290	03/04/87	250
05/21/85	490	09/22/87	68	05/21/85	410	06/05/87	63
08/27/85	490	10/06/87	110	08/27/85	420	06/18/87	57
11/08/85	370	11/12/87	100	11/08/85	280	07/16/87	84
08/19/87	430	12/02/87	121	08/19/87	605	08/18/87	110
11/04/87	330	01/07/88	140	11/04/87	280	08/19/87	90
11/18/87	430	02/03/88	130	11/18/87	470	09/22/87	83
12/02/87	370	03/02/88	92	12/02/87	370	10/06/87	160
01/14/88	325	04/07/88	86	01/14/88	355	10/22/87	120
02/17/88	370	05/05/88	95	02/17/88	390	11/12/87	173
03/23/88	350	06/02/88	98	03/23/88	360	11/18/87	60
04/06/88	360	07/04/88	12	04/06/88	370	12/02/87	225
04/20/88	290	08/10/88	110	04/20/88	380	12/10/87	230
05/03/88	405	09/07/88	54	05/03/88	390	12/17/87	220
05/18/88	425	10/05/88	45	05/18/88	410	12/22/87	340
06/02/88	365	11/02/88	60	06/02/88	385	01/15/88	370
06/15/88	360	12/02/88	80	06/15/88	380	01/21/88	370
07/14/88	390	01/11/89	65	07/14/88	360	02/17/88	370
08/11/88	410	02/10/89	76	08/11/88	335	03/02/88	350
08/24/88	430	04/20/99	92.1	08/24/88	400	03/10/88	340
09/07/88	460	05/19/99	139	09/07/88	430	03/16/88	340
09/21/88	455	06/17/99	113	09/21/88	410	03/30/88	340
10/05/88	370	07/22/99	79	10/05/88	500	04/07/88	110
10/19/88	590	08/24/99	112	10/19/88	430	04/14/88	75
11/02/88	610	09/20/99	130	11/02/88	370	04/15/88	80
11/17/88	370	10/21/99	128	11/17/88	370	04/22/88	84
12/02/88	675	12/27/99	161	12/02/88	370	05/05/88	76
12/13/88	705	02/18/00	221	12/13/88	400	05/12/88	37
01/11/89	720	05/08/03	136	01/11/89	365	05/26/88	120
01/25/89	580	06/05/03	187	01/25/89	360	06/02/88	130
02/15/89	620	07/09/03	136	02/15/89	330	06/09/88	140
02/22/89	480	08/07/03	131	02/22/89	350	06/15/88	140
03/10/89	520	09/04/03	143	03/10/89	380	06/23/88	180
03/22/89	540	10/02/03	159	03/22/89	380	06/29/88	140
04/05/89	590	11/05/03	169	04/05/89	380	07/04/88	130
04/19/89	660	--	--	04/19/89	480	07/07/88	160
05/03/89	680	--	--	05/03/89	440	07/21/88	94
05/17/89	740	--	--	05/17/89	500	07/27/88	85
05/31/89	760	--	--	05/31/89	480	08/11/88	98
06/15/89	765	--	--	06/15/89	475	08/24/88	65
07/12/89	760	--	--	07/12/89	470	08/30/88	63
07/26/89	750	--	--	07/26/89	410	09/07/88	55
08/09/89	780	--	--	08/09/89	440	09/21/88	60
08/23/89	830	--	--	08/23/89	480	10/05/88	77
10/04/89	825	--	--	10/04/89	450	10/19/88	73
10/18/89	820	--	--	10/18/89	440	11/02/88	120
11/14/89	860	--	--	11/14/89	435	11/17/88	120
11/29/89	875	--	--	11/29/89	425	12/14/88	180
01/31/90	790	--	--	01/31/90	418	12/27/88	--
02/28/90	793	--	--	02/28/90	395	12/28/88	190
03/31/90	781	--	--	03/31/90	475	01/12/89	230
04/30/90	738	--	--	04/30/90	420	01/25/89	210
05/31/90	719	--	--	05/31/90	420	02/10/89	240
06/30/90	763	--	--	06/30/90	520	02/22/89	245
07/31/90	780	--	--	07/31/90	480	03/08/89	280

Dark River Watershed				Sandy/Pike Rivers Watershed			
020		D2		030		701	
Date	Sulfate[1]	Date	Sulfate[1]	Date	Sulfate[1]	Date	Sulfate[1]
08/31/90	811	--	--	08/31/90	468	03/22/89	255
09/30/90	880	--	--	09/30/90	435	04/06/89	175
10/31/90	884	--	--	10/31/90	--	04/19/89	74
12/31/90	735	--	--	12/31/90	415	05/03/89	75
01/31/91	784	--	--	01/31/91	407	05/17/89	95
02/28/91	801	--	--	02/28/91	415	05/31/89	79
03/31/91	788	--	--	03/31/91	410	06/15/89	75
04/30/91	681	--	--	04/30/91	417.5	06/28/89	95
05/31/91	729	--	--	05/31/91	444	07/12/89	98
06/30/91	808	--	--	06/30/91	435	07/26/89	123
07/31/91	775	--	--	07/31/91	435	08/09/89	145
08/31/91	895	--	--	08/31/91	465	08/23/89	175
09/30/91	925	--	--	09/30/91	485	09/06/89	110
10/31/91	725	--	--	10/31/91	460	09/20/89	168
12/31/91	775	--	--	12/31/91	450	10/04/89	155
01/31/92	550	--	--	01/31/92	465	10/18/89	155
02/29/92	812	--	--	02/29/92	450	11/14/89	127
03/31/92	950	--	--	03/31/92	440	11/29/89	305
04/30/92	725	--	--	04/30/92	450	04/19/99	113
05/31/92	730	--	--	05/31/92	450	05/19/99	129
06/30/92	725	--	--	06/30/92	460	06/17/99	187
07/31/92	725	--	--	07/31/92	420	07/22/99	58.6
08/31/92	--	--	--	08/31/92	712	08/24/99	78
09/30/92	712	--	--	09/30/92	440	09/20/99	122
10/31/92	662	--	--	10/31/92	410	10/21/99	163
11/30/92	662	--	--	11/30/92	640	12/27/99	550
12/31/92	550	--	--	12/31/92	440	02/18/00	713
01/31/93	650	--	--	01/31/93	440	05/08/03	172
02/28/93	650	--	--	02/28/93	430	06/05/03	227
03/31/93	600	--	--	03/31/93	420	07/09/03	247
04/30/93	660	--	--	04/30/93	150	08/07/03	31.9
05/31/93	650	--	--	05/31/93	440	09/04/03	259
06/30/93	675	--	--	06/30/93	455	10/02/03	210
07/31/93	590	--	--	07/31/93	420	11/05/03	304
08/31/93	670	--	--	08/31/93	490	--	--
09/30/93	825	--	--	09/30/93	540	--	--
10/31/93	750	--	--	10/31/93	535	--	--
11/30/93	800	--	--	11/30/93	520	--	--
12/31/93	685	--	--	12/31/93	470	--	--
03/31/94	640	--	--	03/31/94	530	--	--
04/30/94	650	--	--	04/30/94	505	--	--
05/31/94	650	--	--	05/31/94	530	--	--
06/30/94	760	--	--	06/30/94	512	--	--
07/31/94	580	--	--	07/31/94	552	--	--
08/31/94	633	--	--	08/31/94	546	--	--
09/30/94	780	--	--	09/30/94	580	--	--
10/31/94	697	--	--	10/31/94	593	--	--
11/30/94	676	--	--	11/30/94	523	--	--
12/31/94	820	--	--	12/31/94	578	--	--
01/31/95	700	--	--	01/31/95	562	--	--
02/28/95	785	--	--	02/28/95	570	--	--
03/31/95	725	--	--	03/31/95	590	--	--
04/30/95	725	--	--	04/30/95	545	--	--
08/31/95	749	--	--	08/31/95	542	--	--
09/30/95	772	--	--	09/30/95	545	--	--

Dark River Watershed				Sandy/Pike Rivers Watershed			
020		D2		030		701	
Date	Sulfate[1]	Date	Sulfate[1]	Date	Sulfate[1]	Date	Sulfate[1]
11/30/95	835	--	--	11/30/95	364	--	--
12/31/95	850	--	--	12/31/95	675	--	--
01/31/96	825	--	--	01/31/96	562	--	--
02/29/96	765	--	--	02/29/96	590	--	--
04/30/96	790	--	--	04/30/96	600	--	--
05/31/96	860	--	--	05/31/96	740	--	--
06/30/96	830	--	--	06/30/96	555	--	--
07/31/96	887	--	--	07/31/96	645	--	--
08/31/96	816	--	--	08/31/96	641	--	--
09/30/96	845	--	--	09/30/96	611	--	--
10/31/96	832	--	--	10/31/96	611	--	--
11/30/96	750	--	--	11/30/96	580	--	--
12/31/96	802	--	--	12/31/96	580	--	--
01/31/97	765	--	--	01/31/97	580	--	--
02/28/97	810	--	--	02/28/97	585	--	--
03/31/97	775	--	--	03/31/97	600	--	--
04/30/97	711	--	--	04/30/97	550	--	--
05/31/97	858	--	--	05/31/97	667	--	--
06/30/97	845	--	--	06/30/97	619	--	--
07/31/97	765	--	--	07/31/97	583	--	--
08/31/97	682	--	--	08/31/97	583	--	--
09/30/97	712	--	--	09/30/97	712	--	--
10/31/97	667	--	--	10/31/97	530	--	--
11/30/97	710	--	--	11/30/97	560	--	--
12/31/97	672	--	--	12/31/97	516	--	--
01/31/98	765	--	--	01/31/98	573	--	--
04/20/99	824	--	--	04/20/99	728	--	--
04/28/99	--	--	--	04/28/99	697	--	--
05/20/99	842	--	--	05/20/99	633	--	--
06/18/99	860	--	--	06/18/99	704	--	--
07/22/99	987	--	--	07/22/99	806	--	--
08/24/99	948	--	--	08/24/99	742	--	--
09/21/99	812	--	--	09/21/99	709	--	--
10/21/99	834	--	--	10/21/99	712	--	--
01/24/00	822	--	--	01/24/00	716	--	--
02/16/00	703	--	--	02/16/00	637	--	--
05/08/03	898	--	--	05/08/03	761	--	--
06/05/03	1050	--	--	06/05/03	885	--	--
07/09/03	999	--	--	07/09/03	877	--	--
08/07/03	983	--	--	08/07/03	876	--	--
09/04/03	900	--	--	09/04/03	824	--	--
10/02/03	898	--	--	10/02/03	772	--	--
11/05/03	995	--	--	11/05/03	796	--	--

Notes:

1. Total sulfate in mg/L

-- = not analyzed

Data duplicated from Table C.1

Table A-4. Water Quality and Field Measurement Results in Wetlands and SCRS Catch Basins from September 12-13, 2017 EPA Inspection.

Pollutant Parameters (units)	S08 (Sampled wetland at foot of berm) -Background Conditions[2]	S09 (Sampled wetland immediately outside of sheet pile at SCRS Catch Basin-12)	S10 (Sampled seepage collected in SCRS Catch Basin-12)	S11 (Sampled wetland immediately outside of sheet pile at SCRS Catch Basin-5)	S12 (Sampled seepage collected in SCRS Catch Basin-5, near inlet)	S13 (Sampled wetland immediately outside of north end of sheet pile at SCRS Catch Basin-5)	CB11 out (Field measurement at wetland location immediately outside of sheet pile at SCRS Catch Basin-11)	CB11 in (Field measurements of seepage collected in SCRS Catch Basin-11, immediately inside of sheet pile)	CB 12 in (Field measurements of seepage collected in SCRS Catch Basin-12, 20 feet southeast of inlet)
Specific Conductance (uS/cm)	134	2,163	2,509	2,399	2,316	2,348	877	2,518	2,387
pH (S.U.)	7.19	7.24	7.08	7.83	7.13	7.51	7.71	8.16	7.23
Dissolved Oxygen (mg/L)	7.11	No reading	3.64	12.53	1.47	6.62	9.64	7.79	7.54
Temperature (deg. C)	19.11	17.47	19.17	17.91	11.19	17.54	20.1	26.06	21.8
Hardness (mg/L)	60	1,210	1,330	1,290	1,260	1,250	---	---	---
Chloride (mg/L)	1.28	122	91.2	114	114	110	---	---	---
Sulfate as SO4 (mg/L)	3.61	702	720	773	780	781	---	---	---
TDS (mg/L)	104 J[1]	1,780 J[1]	1,970 J[1]	1,930	1,890	1,900	---	---	---

Notes:

1. See **Figure 32**, **Figure 33**, **Figure 34** for sampling locations
2. J – The identification of the analyte is acceptable; the reported value is an estimate.
3. U.S. Steel confirmed the S08 location as “background area” (See page 9 of Inspection Report)
4. Stations CB 11 and CB 12 monitored only for specific conductance, pH, dissolved oxygen, temperature.

Table A-5. Minntac Tailings Basin Seepage Estimates.
Taken from "Hydrological Investigation Report" performed by GHD on behalf of U.S. Steel (2021). Pages 97-100.

DARK RIVER - Station D-1

Sampling Date	D-1 Flow (gpm)	D-1 Chloride (mg/L)	West Side Seep Chloride (020) (ppm)	Seeps Pumped Back (gpm)	Calculated Basin Seep Flow - West (gpm)
01/24/14	1,827	81.3	115	0	1,271
05/23/14	9,923	21.4	134	0	1,292
06/20/14	10,794	17.4	141	0	1,012
07/18/14	4,107	44.4	134	0	1,261
08/18/14	5,000	43.8	132	0	1,542
09/11/14	1,867	58.3	127	0	818
10/17/14	4,811	55.5	113	0	2,265
11/17/14	1,921	80.1	113	0	1,338
12/08/14	2,096	91.0	118	0	1,595
01/12/15	1,530	98.9	116	0	1,290
02/06/15	2,789	98	119	0	2,272
03/09/15	707	96.7	118	0	576
04/03/15	6,329	53.9	127	0	2,545
05/08/15	4,755	72.8	145	0	2,319
06/05/15	7,098	46.6	138	0	2,236
07/10/15	2,321	72	140	0	1,158
08/07/15	2,430	98.4	133	0	1,771
09/04/15	6,646	83.3	135	0	4,024
10/07/15	3,504	85.4	127	0	2,306
11/06/15	7,363	63	126	0	3,532
02/05/16	4,245	79.2	120	0	2,733
03/04/16	3,633	70.7	117	0	2,131
04/08/16	9,884	5.2	115	0	56
05/05/16	7,458	31.4	114	0	1,826
06/03/16	5,684	37.4	106	0	1,838
07/01/16	6,136	27.5	106	0	1,386
08/01/16	2,765	41.7	103	0	1,040
09/09/16	8,135	37.6	118	0	2,372
10/07/16	4,904	46.7	112	0	1,932
11/04/16	3,403	52.8	116	0	1,476
12/02/16	13,670	28.1	114	0	2,937
01/06/17	5,710	57.2	113	0	2,760
02/10/17	5,015	63.2	116	0	2,648
03/03/17	7,380	38.8	114	0	2,304
04/07/17	10,561	16.5	113	0	1,167
05/05/17	14,854	16.9	111	0	1,723
06/02/17	5,980	31.4	99	0	1,695
07/07/17	3,733	28.7	103	0	915
08/04/17	2,459	59.8	103	0	1,379
09/01/17	4,862	34	103	0	1,453
10/06/17	11,245	23.7	104	0	2,153
11/03/17	5,589	44.3	104	0	2,223
12/08/17	5,023	53.3	110	0	2,326
01/19/18	3,010	65.9	105	0	1,835
02/13/18	2,790	75.3	105	0	1,962
03/09/18	3,817	72.9	126	0	2,150
04/06/18	4,438	66	113	0	2,513
05/04/18	11,155	22.1	110	0	1,861
06/01/18	9,412	34.7	103	0	2,895
07/06/18	13,447	21.6	95	0	2,528
08/08/18	2,087	58.1	104	0	1,120
09/07/18	2,932	70.8	104	0	1,947

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10/05/18	6,858	59.2	109	0	3,574
11/02/18	5,096	45.6	109	0	1,998
12/07/18	4,840	70.1	123	0	2,680
01/04/19	3,377	73.2	120	0	2,013
02/11/19	4,378	86.1	123	0	3,009
03/08/19	4,391	90.6	129	0	3,033
04/08/19	25,559	20.8	133	0	3,227
5/3/2019	11,579	27.8	134	0	2,073
6/7/2019	4,492	57.3	143	0	1,712
7/1/2019	7,126	59.3	143	0	2,819
8/5/2019	2,232	72	143	0	1,088
9/6/2019	1,240	78.5	126	0	755
11/12/2019	3,541	62.8	132	0	1,615
12/2/2019	4,598	60.8	132	0	2,025
01/03/20	4,667	65.2	130	0	2,265
02/10/20	2,944	77.4	129	0	1,718
03/06/20	3,889	74	134	0	2,087
04/03/20	22,917	16.2	138	0	2,003
05/01/20	5,565	40.2	138	0	1,491
06/05/20	1,067	47.7	122	1,500	1,892
06/19/20	2,297	31.5	122	1,500	2,027
07/10/20	4,424	18.6	122	1,500	2,028
07/27/20	2,885	9.6	122	1,500	1,624
08/07/20	640	48.4	122	1,500	1,739
08/21/20	2,174	25.7	122	1,500	1,891
09/04/20	3,134	41.5	122	1,500	2,486
09/18/20	1,356	51.3	122	1,500	2,040
10/02/20	1,984	46	122	1,500	2,200
11/10/20	8,684	35.1	122	1,500	3,757
12/04/20	2,082	44.4	122	1,500	2,206
01/08/21	1,661	53.4	122	1,500	2,191
02/12/21	1,029	59.9	122	1,500	1,985
02/16/21	730	67.5	122	1,500	1,891
02/19/21	736	69.3	122	1,500	1,906
03/05/21	1,579	70.3	122	1,500	2,384
04/06/21	5,399	22.2	122	1,500	2,310
05/26/21	2,738	33.1	122	1,500	2,165
06/04/21	2,021	42	122	1,500	2,144
07/02/21	744	52.4	122	1,500	1,803
08/06/21	447	68.3	122	1,500	1,743
				average estimated flow to west =	1,992

Outfall 020 (aka SD001) has been eliminated after westside SCRS operations began. Therefore, an average of Outfall 020 chloride concentrations from 2012-2020 is used after 5/28/2020.

SAND RIVER - Station 701

Sampling Date	701 Flow (gpm)	701 Chloride (mg/L)	Basin Return Water Chloride (ppm)	Seeps Pumped Back (gpm)	Calculated Basin Seep Flow - East (gpm)
08/06/14	3,451	19.3	176	769	916
09/03/14	247	26.9	176	764	786
11/05/14	4,694	30	176	766	1,272
04/01/15	1,364	42.2	176	657	905
05/06/15	4,605	41.6	144	693	1,720
06/03/15	9,748	31	145	723	2,100
07/01/15	9,084	25.3	148	710	1,580
08/05/15	1,979	26.8	148	698	909
09/09/15	6,710	31.4	141	745	1,741
10/02/15	6,219	35.6	141	742	1,868
11/06/15	8,976	44.1	140	714	2,955
12/04/15	9,318	39.9	139	723	2,749
01/08/16	6,779	42.9	135	572	2,270
03/04/16	4,138	62.2	144	484	2,054
04/08/16	18,087	24.4	144	388	2,053
05/04/16	12,091	20.4	125	640	1,512
06/03/16	9,039	23.1	139	737	1,510
07/01/16	12,706	25.5	123	752	2,268
08/01/16	8,025	19.1	123	588	1,080
09/09/16	12,068	19.9	128	479	1,271
10/07/16	10,596	32.5	125	837	2,745
11/04/16	6,265	35.9	125	971	2,279
12/02/16	15,331	39.2	131	907	4,391
01/06/17	5,619	44.5	135	575	2,055
02/10/17	4,084	57.2	136	468	1,949
03/03/17	11,117	40.3	136	533	3,048
04/07/17	26,560	20.4	136	524	2,263
05/05/17	25,142	22.2	120	530	2,840
06/02/17	8,945	19.4	124	1,167	1,736
07/07/17	6,391	24	126	1,162	1,822
08/04/17	1,750	65.8	122	1,214	2,068
09/01/17	7,652	29	128	1,278	2,380
10/06/17	30,272	29.5	128	1,301	5,791
11/03/17	9,541	30.6	139	1,302	2,679
12/08/17	6,123	42.1	138	1,279	2,735
01/19/18	2,851	58.2	138	1,272	2,310
02/13/18	2,327	68.8	138	1,253	2,296
03/09/18	3,694	73.1	171	1,246	2,659
04/06/18	7,818	71.8	155	1,257	4,529
05/04/18	27,346	25.1	154	1,242	3,722
06/01/18	13,401	29.9	154	1,224	2,895
07/06/18	24,765	26	136	1,224	3,963
08/03/18	4,035	24.5	136	1,215	1,613
09/07/18	1,696	28.8	141	1,225	1,442
10/05/18	6,912	32.9	145	1,253	2,331
11/02/18	8,693	32.2	143	1,245	2,568
12/07/18	5,957	43.3	144	1,122	2,526
01/04/19	4,118	55.7	146	1,120	2,454
02/11/19	3,151	75.5	150	1,086	2,535
03/08/19	4,253	72.6	165	1,042	2,722
04/08/19	22,279	25.1	155	1,063	3,063
05/03/19	19,577	22.4	120	1,062	2,898
06/07/19	7,598	28.8	131	964	2,017

07/01/19	4,536	33.6	131	999	1,810
08/05/19	1,494	46.7	134	1,134	1,558
09/06/19	1,065	42.4	144	1,134	1,377
10/08/19	17,577	32	142	1,134	3,811
11/12/19	4,758	35.2	141	1,134	1,978
12/11/19	4,377	34.9	142	1,134	1,896
1/3/2020	5,693	41.9	143	1,134	2,423
2/10/2020	2,373	47.9	143	1,134	1,781
3/6/2020	3,309	53.1	151	1,134	2,109
4/3/2020	25,757	38.5	149	1,134	6,081
5/1/2020	9,642	26.7	149	1,134	2,152
6/5/2020	4,497	26.3	136	1,134	1,644
7/10/2020	415	16.1	138	1,134	1,147
8/7/2020	412	31.3	142	1,134	1,195
9/4/2020	2,701	33.1	142	1,134	1,568
10/2/2020	1,095	34	141	1,134	1,319
11/17/2020	7,942	35.5	148	1,134	2,488
12/4/2020	1,958	47.3	154	1,134	1,617
1/8/2021	1,391	52.3	148	1,134	1,545
2/16/2021	1,179	65.1	149	1,134	1,589
2/19/2021	966	71.5	149	1,134	1,552
3/5/2021	1,337	67.4	153	1,134	1,660
4/6/2021	11,028	30.6	153	1,134	2,573
5/7/2021	4,254	25.2	142	1,134	1,556
6/4/2021	3,715	29	135	1,134	1,639
7/29/2021	1,132	40.1	133	1,134	1,394
8/25/2021	520	46.9	140	1,134	1,275
				average estimated flow to east =	2,195

Dark River background chloride removed from downstream concentration (mg/L) =	4.6
Sand River background chloride removed from downstream concentration (mg/L) =	12.3
Total estimated tailings basin seep flow reporting downstream (gpm) =	4,187
Estimated seep flow not reporting at D-1/701 (gpm) =	0
Total Estimated Tailings Basin Seep Flow Rate (gpm) =	**4,187**

Table A-6. Summary of Estimated Hydraulic Conductivity Values and Soil Descriptions of Slug and Pumping Tests in the Minntac Tailings Basin.
Taken from "Groundwater Flow and Sulfate Transport Modeling Report" by CRA on behalf of U.S. Steel. See page 80 of pdf.

Well ID	Hydraulic Conductivity [1]			Soil Descriptions
	(ft/min)	(ft/day)	(cm/s)	
Slug Tests (by CRA)				
PZ-4S	1.02E-02	14.67	5.17E-03	Medium to coarse grained sand (SP/SM)
PZ-4D	1.13E-02	16.34	5.76E-03	Fine to coarse grained sand (SP/SM)
PZ-5S	3.28E-03	4.72	1.66E-03	Fine to coarse grained sand (SP)
PZ-5D	7.52E-04	1.08	3.82E-04	Fine to coarse grained sand (SP) with some silt
PZ-6S	1.84E-04	0.27	9.37E-05	Fine to coarse grained sand (SP/SM)
PZ-6D	1.68E-02	24.17	8.53E-03	Medium grained sand (SP) with silt and gravel
PZ-7S	1.15E-03	1.66	5.85E-04	Fine grained sand (SM)
PZ-7D	3.16E-02	45.48	1.60E-02	Medium to coarse grained sand (SW)
MW-12S	1.28E-03	1.85	2.14E-03	Interbedded peat and fine sand
MW-12I	1.09E-03	1.58	1.82E-03	Medium grained sand (SP) with trace fine gravel/clay
MW-12D	1.78E-03	2.56	2.97E-03	Medium grained sand (SP) with trace fine gravel/clay
Slug Tests (by STS)				
B-B-2/P-B-2	1.68E-04	0.24	8.53E-05	Granite Bedrock
OW-A-1	3.12E-04	0.45	1.58E-04	Coarse Tails (SP)
OW-A-2	7.80E-05	0.11	3.96E-05	Fine Tails (ML to CL)
P-A-2A	4.86E-05	0.07	2.47E-05	Till - Fine to medium sand (SP)
OW-A-3	2.04E-03	2.94	1.04E-03	Coarse Tails (SP)
OW-A-4	8.40E-04	1.21	4.27E-04	Coarse Tails (SP)
OW-B-1	3.48E-03	5.01	1.77E-03	Coarse Tails (SP)
OW-B-2	7.20E-05	0.10	3.66E-05	Fine Tails (ML to CL)
P-B-2A	9.00E-04	1.30	4.57E-04	Till- Silty fine to coarse sand, trace clay, some gravel
OW-B-3	1.68E-03	2.42	8.53E-04	Coarse Tails (SP)
OW-C-2	8.40E-04	1.21	4.27E-04	Coarse Tails (SP)
MW-1	2.94E-03	4.23	1.49E-03	Till-Fine to coarse sand (SP)
MW-2	3.90E-03	5.62	1.98E-03	Till-Fine to medium sand (SP)
MW-3	2.76E-03	3.97	1.40E-03	Till-fibrous peat and fine to medium sand (Pt and SP)
Pumping Tests (by CRA)				
MW-12S	2.53E-03	3.65	1.29E-03	Interbedded peat and fine sand
MW-12I	6.70E-04	0.96	3.40E-04	Medium grained sand (SP) with trace fine gravel/clay
MW-12D	1.36E-03	1.96	6.92E-04	Medium grained sand (SP) with trace fine gravel/clay
PZ-6S	2.20E-02	31.68	1.12E-02	Fine to coarse grained sand (SP/SM)
PZ-6D	1.62E-02	23.35	8.24E-03	Medium grained sand (SP) with silt and gravel

Note:

(1) The hydraulic conductivity values presented are the geometric means of the values estimated for individual wells.

WaterLegacy September 22, 2025 Comments on U.S. Steel Corp NPDES/SDS Permits for Keetac Mining Area (MN0031879) and Keetac Tailings Basin (MN0055948) and on U.S. Steel Corp Application for Variance from Wild Rice Sulfate Standard

EXHIBIT 33

Discharge Monitoring Reports, Bulk Exports for Keetac Permit MN0031879,
Mercury in scrubber blowdown after treatment, 2018-2024.

MPCA Online Discharge Monitoring Reports (Bulk Export of Data from 2018-2024)

U.S. Steel Corp - Keetac Permit MN0031879

Mercury in Waste Stream

Facility	Preferred Id	Permit Action	Station	Station Description	Avg Wet Weather Flow Rate	Year of Mon End Date	Month of Mon End Date	Mon End Date	Parameter	Limit	Rpt Value	Units	Limit Type	No Discharge Flag
United State	MN0031879	IND2012000	WS 012	Scrubber blowdown after treatment		2018	March	03/31/2018	Mercury, Total (as Hg)		1910	ng/L	SingleVal	N
United State	MN0031879	IND2012000	WS 012	Scrubber blowdown after treatment		2018	June	06/30/2018	Mercury, Total (as Hg)		4190	ng/L	SingleVal	N
United State	MN0031879	IND2012000	WS 012	Scrubber blowdown after treatment		2018	September	09/30/2018	Mercury, Total (as Hg)		393	ng/L	SingleVal	N
United State	MN0031879	IND2012000	WS 012	Scrubber blowdown after treatment		2018	December	12/31/2018	Mercury, Total (as Hg)		1480	ng/L	SingleVal	N
United State	MN0031879	IND2012000	WS 012	Scrubber blowdown after treatment		2019	March	03/31/2019	Mercury, Total (as Hg)		241	ng/L	SingleVal	N
United State	MN0031879	IND2012000	WS 012	Scrubber blowdown after treatment		2019	June	06/30/2019	Mercury, Total (as Hg)		411	ng/L	SingleVal	N
United State	MN0031879	IND2012000	WS 012	Scrubber blowdown after treatment		2019	September	09/30/2019	Mercury, Total (as Hg)		580	ng/L	SingleVal	N
United State	MN0031879	IND2012000	WS 012	Scrubber blowdown after treatment		2019	December	12/31/2019	Mercury, Total (as Hg)		408	ng/L	SingleVal	N
United State	MN0031879	IND2012000	WS 012	Scrubber blowdown after treatment		2020	March	03/31/2020	Mercury, Total (as Hg)		347	ng/L	SingleVal	N
United State	MN0031879	IND2012000	WS 012	Scrubber blowdown after treatment		2020	June	06/30/2020	Mercury, Total (as Hg)			ng/L	SingleVal	Y
United State	MN0031879	IND2012000	WS 012	Scrubber blowdown after treatment		2020	September	09/30/2020	Mercury, Total (as Hg)			ng/L	SingleVal	Y
United State	MN0031879	IND2012000	WS 012	Scrubber blowdown after treatment		2020	December	12/31/2020	Mercury, Total (as Hg)		583	ng/L	SingleVal	N
United State	MN0031879	IND2012000	WS 012	Scrubber blowdown after treatment		2021	March	03/31/2021	Mercury, Total (as Hg)		634	ng/L	SingleVal	N
United State	MN0031879	IND2012000	WS 012	Scrubber blowdown after treatment		2021	June	06/30/2021	Mercury, Total (as Hg)		4980	ng/L	SingleVal	N
United State	MN0031879	IND2012000	WS 012	Scrubber blowdown after treatment		2021	September	09/30/2021	Mercury, Total (as Hg)		343	ng/L	SingleVal	N
United State	MN0031879	IND2012000	WS 012	Scrubber blowdown after treatment		2021	December	12/31/2021	Mercury, Total (as Hg)		400	ng/L	SingleVal	N
United State	MN0031879	IND2012000	WS 012	Scrubber blowdown after treatment		2022	March	03/31/2022	Mercury, Total (as Hg)		558	ng/L	SingleVal	N
United State	MN0031879	IND2012000	WS 012	Scrubber blowdown after treatment		2022	June	06/30/2022	Mercury, Total (as Hg)		739	ng/L	SingleVal	N
United State	MN0031879	IND2012000	WS 012	Scrubber blowdown after treatment		2022	September	09/30/2022	Mercury, Total (as Hg)		290	ng/L	SingleVal	N
United State	MN0031879	IND2012000	WS 012	Scrubber blowdown after treatment		2022	December	12/31/2022	Mercury, Total (as Hg)		144	ng/L	SingleVal	N
United State	MN0031879	IND2012000	WS 012	Scrubber blowdown after treatment		2023	March	03/31/2023	Mercury, Total (as Hg)		38.5	ng/L	SingleVal	N
United State	MN0031879	IND2012000	WS 012	Scrubber blowdown after treatment		2023	June	06/30/2023	Mercury, Total (as Hg)		66	ng/L	SingleVal	N
United State	MN0031879	IND2012000	WS 012	Scrubber blowdown after treatment		2023	September	09/30/2023	Mercury, Total (as Hg)		138	ng/L	SingleVal	N
United State	MN0031879	IND2012000	WS 012	Scrubber blowdown after treatment		2023	December	12/31/2023	Mercury, Total (as Hg)		118	ng/L	SingleVal	N
United State	MN0031879	IND2012000	WS 012	Scrubber blowdown after treatment		2024	March	03/31/2024	Mercury, Total (as Hg)		76	ng/L	SingleVal	N
United State	MN0031879	IND2012000	WS 012	Scrubber blowdown after treatment		2024	June	06/30/2024	Mercury, Total (as Hg)		199	ng/L	SingleVal	N
United State	MN0031879	IND2012000	WS 012	Scrubber blowdown after treatment		2024	September	09/30/2024	Mercury, Total (as Hg)		996	ng/L	SingleVal	N
											810.5	AVERAGE		

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EXHIBIT 34

Myrbo A, Swain EB, Johnson NW, Engstrom DR, Pastor J, Dewey B, Monson P, Brenner J, Dykhuizen Shore M, Peters EB (2017) Increase in nutrients, mercury, and methylmercury as a consequence of elevated sulfate reduction to sulfide in experimental wetland mesocosms. *J. Geophysical Research: Biogeosciences* 10.1002: 2769-85.

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Journal of Geophysical Research: Biogeosciences

RESEARCH ARTICLE
10.1002/2017JG003788

This article is a companion to Myrbo et al. (2017), https://doi.org/10.10022017JG003787 and Pollman et al. (2017), https://doi.org/10.10022017JG003785.

Key Points:
- Sulfate addition increased organic matter mineralization in wetland sediment, releasing C, N, P, and Hg to the water column
- Sulfate reduction caused not only higher methylmercury concentrations but higher total mercury concentrations in the surface water
- Increased sulfate loading to freshwaters can cause deleterious effects separate from direct sulfide toxicity to organisms

Supporting Information:
- Supporting Information S1
- Figure S1
- Data Set S1

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Increase in Nutrients, Mercury, and Methylmercury as a Consequence of Elevated Sulfate Reduction to Sulfide in Experimental Wetland Mesocosms

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Abstract Microbial sulfate reduction (MSR) in both freshwater and marine ecosystems is a pathway for the decomposition of sedimentary organic matter (OM) after oxygen has been consumed. In experimental freshwater wetland mesocosms, sulfate additions allowed MSR to mineralize OM that would not otherwise have been decomposed. The mineralization of OM by MSR increased surface water concentrations of ecologically important constituents of OM: dissolved inorganic carbon, dissolved organic carbon, phosphorus, nitrogen, total mercury, and methylmercury. Increases in surface water concentrations, except for methylmercury, were in proportion to cumulative sulfate reduction, which was estimated by sulfate loss from the surface water into the sediments. Stoichiometric analysis shows that the increases were less than would be predicted from ratios with carbon in sediment, indicating that there are processes that limit P, N, and Hg mobilization to, or retention in, surface water. The highest sulfate treatment produced high levels of sulfide that retarded the methylation of mercury but simultaneously mobilized sedimentary inorganic mercury into surface water. As a result, the proportion of mercury in the surface water as methylmercury peaked at intermediate pore water sulfide concentrations. The mesocosms have a relatively high ratio of wall and sediment surfaces to the volume of overlying water, perhaps enhancing the removal of nutrients and mercury to periphyton. The presence of wild rice decreased sediment sulfide concentrations by 30%, which was most likely a result of oxygen release from the wild rice roots. An additional consequence of the enhanced MSR was that sulfate additions produced phytotoxic levels of sulfide in sediment pore water.

Plain Language Summary In the water-saturated soils of wetlands, which are usually anoxic, decomposition of dead plants and other organic matter is greatly retarded by the absence of oxygen. However, the addition of sulfate can allow bacteria that respire sulfate, instead of oxygen, to decompose organic matter that would not otherwise decay. The accelerated decay has multiple consequences that are concerning. The bacteria that respire sulfate "breathe out" hydrogen sulfide (also called sulfide), analogous to the conversion or respiration of oxygen to CO_2. Sulfide is very reactive with metals, which makes it toxic at higher concentrations. In addition to the release of sulfide, the sulfate-accelerated decomposition of plants releases phosphorus and nitrogen, fertilizing the waterbody. Decomposition also mobilizes mercury (which is everywhere, thanks to atmospheric transport) into the surface water. The microbes that convert sulfate to sulfide also methylate mercury, producing methylmercury, the only form of mercury that contaminates fish. This study demonstrates that adding sulfate to a wetland can not only produce toxic levels of sulfide but also increase the surface water concentrations of nitrogen, phosphorus, mercury, and methylmercury.

1. Introduction

Organic matter (OM) accumulates in the sediments of aquatic systems when sediment concentrations of terminal electron acceptors (TEAs) are too low for microbes to completely decompose OM, especially when the supply of the most energy-efficient TEA, oxygen, is low. In water-saturated, organic-rich sediment, microbial sulfate reduction (MSR) can be a dominant pathway for the respiration of OM because oxygen is depleted in the uppermost sediment (Boye et al., 2017). Dissolved sulfate (SO_4) concentrations in continental surface

waters are often low (less than 50 mgL^{-1} or 0.5 mmol L^{-1}) (e.g., Gorham et al., 1983) compared to ocean concentrations (2,800 mg L^{-1} or 29 mmol L^{-1}). Because of lower SO_4 concentrations, and because MSR rates can be limited by SO_4 concentrations (Holmer & Storkholm, 2001), the biogeochemical significance of MSR is often considered minimal in freshwater and low-salinity systems (e.g., Capone & Kiene, 1988; Nielsen et al., 2003; Stagg et al., 2017). However, absolute rates of MSR are not clearly lower in freshwater systems than in marine systems (Pallud & Van Cappellen, 2006), and in some cases, rapid cycling between oxidized and reduced forms of S can occur (Hansel et al., 2015).

In this study, we investigated the cascade of biogeochemical effects associated with increased MSR that result from increased surface water SO_4. We simultaneously quantified three different categories of biogeochemical responses related to MSR: (1) mineralization of organic matter and associated release of dissolved C, N, P, and Hg; (2) methylation of Hg; and (3) production of sulfide.

The stoichiometric release of the constituents of OM during MSR, notably C, N, and P, is a phenomenon long recognized by marine scientists. For instance, Boudreau and Westrich (1984) constructed a model of the MSR-mediated decomposition of marine sediment. They showed that SO_4 is reduced to sulfide (H_2S) in stoichiometric proportion to the mineralization of C, N, and P according to the reaction

$$2(CH_2O)_x(NH_3)_y(H_3PO_4)_z + xSO_4^{2-} \rightarrow 2xHCO_3^- + xH_2S + 2yNH_3 + 2zH_3PO_4 \quad (1)$$

C is released as both dissolved inorganic carbon (DIC, from complete oxidation, produced as bicarbonate alkalinity in stoichiometric proportion to sulfide (reaction (1); Boudreau & Westrich, 1984)) and dissolved organic carbon (DOC, from partial oxidation). The nutrients N and P are released in forms that are readily taken up by plants; N is released as ammonia, and P as phosphate. The mineralization of sediment organic matter associated with MSR releases sulfide (S^{2-}) into sediment pore water, which speciates, depending on the pH, into hydrogen sulfide (H_2S) and bisulfide (HS^-), henceforth collectively termed sulfide. If reduced S compounds accumulate in the sediment, there may be additional consequences to an aquatic system, such as toxic concentrations of sulfide in pore water (Lamers et al., 2013; Pastor et al., 2017; Myrbo et al., 2017) or conversion of sediment Fe(III) to FeS compounds, which enhances the mobilization of P (Curtis, 1989; Maynard et al., 2011).

The multiple biogeochemical consequences of MSR in freshwater systems have been investigated and documented in more than two dozen publications (Table S1 in the supporting information), which typically address a single issue, such as the production of alkalinity that neutralizes atmospherically deposited H_2SO_4 (Baker et al., 1986; Cook et al., 1986; and others) or the methylation of Hg (Gilmour et al., 1992; Branfireun et al., 1999, 2001; and others). Experimental studies addressing SO_4 reduction, sulfide production, associated OM mineralization, and release of nutrients have been broader (Lamers et al., 2001, 2002; Weston et al., 2006, 2011; and others), but aside from the results reported in this paper, only the experiments of Gilmour, Krabbenhoft, et al. (2007) and Gilmour, Orem, et al. (2007) have investigated all three categories of biogeochemical consequences of SO_4 reduction: OM mineralization, Hg methylation, and sulfide accumulation (Table S1). We also investigated the potential for Hg to be released by mineralization, a phenomenon proposed by Regnell and Hammar (2004).

Sulfate-driven enhanced mineralization of sediment OM and release of dissolved sulfide, N, P, DOC, DIC, and associated increases in alkalinity and pH have the potential to change the nature of an aquatic ecosystem. The immediate release is to the sediment pore water, but these dissolved materials can diffuse into the surface water. Increased internal loading of N and P can drive a system toward eutrophy, which can increase carbon fixation and amplify the cascade of biogeochemical effects associated with increased MSR. Increases in DOC also have the potential to fundamentally change the nature of a waterbody. DOC influences many processes in freshwater ecosystems, including light availability for macrophyte growth, thermal stratification, and bioavailability of metals, P, and C. In addition, DOC interferes with drinking water purification (Williamson et al., 1999). Increases in DIC, alkalinity, and pH can also change the nature of a system. Aquatic macrophyte and algal species often have different optimal alkalinity concentrations (e.g., Moyle, 1945; Vestergaard & Sand-Jensen, 2000), so increases in alkalinity may change aquatic community composition. Because pH is a master variable in aquatic systems (Stumm & Morgan, 2012), increases in pH can cause changes in both aquatic chemistry and the biota that dominate a system, as best documented by changes in diatom assemblages (Patrick et al., 1968).

The release of sulfide into sediment pore water has multiple biological and geochemical consequences, several of which are related to the reactivity of sulfide with metals. If dissolved sulfide accumulates in pore water, it can negatively affect multicellular organisms inhabiting the sediment because sulfide can denature a range of metal-containing biomolecules, including cytochrome C oxidase, which is essential for respiration by both animals and plants (Bagarinao, 1992). Because aquatic sediment is a primary site of sulfide production, plants that root in sediment are vulnerable to toxic sulfide concentrations (Lamers et al., 2013; Pastor et al., 2017). However, if the watershed supplies sufficiently high loading of reactive Fe or other metals to the sediment, pore water sulfide concentrations may stay below toxic levels even while MSR proceeds as an important mineralization process (Pollman et al., 2017). The formation of FeS compounds effectively detoxifies sulfide (e.g., Marbà et al., 2007; Van der Welle et al., 2007). When Fe availability exceeds the production of sulfide, the accumulation of FeS is a measure of cumulative SO_4 reduction, which can be quantified as acid-volatile sulfide (AVS) (Heijs & van Gemerden, 2000). In addition, phosphorus is mobilized when oxidized Fe compounds with significant capacity to bind phosphate are converted to FeS compounds, which are incapable of binding phosphate (Lamers et al., 1998; Maynard et al., 2011). Thus, MSR mobilizes P both by mineralization of P-containing OM and by changing the form of Fe in sediment.

In addition to releasing C, N, and P, producing potentially toxic concentrations of sulfide, and reducing the solubility of metals, MSR is a primary process leading to the formation of MeHg, the bioaccumulative form of Hg (Gilmour et al., 1992; Hsu-Kim et al., 2013), although other microbial groups can also methylate Hg (Podar et al., 2015). In some cases, MSR can lead to toxic levels of MeHg higher in the food chain. The relationship between SO_4 concentrations and MeHg production is complex, however, and both field and laboratory studies in freshwater and saline ecosystems suggest that there is a dual effect of S on Hg methylation. At low SO_4 concentrations, the addition of SO_4 can stimulate MSR and Hg methylation (Jeremiason et al., 2006). At higher SO_4 concentrations, a greater abundance of inorganic sulfide appears to decrease the availability of inorganic Hg for Hg methylation (Hsu-Kim et al., 2013; Johnson et al., 2016). Because it has been observed that low SO_4 additions often increase Hg methylation and higher SO_4 concentrations decrease methylation, it has been proposed that there is a range of SO_4 and sulfide concentrations are optimal for Hg methylation, above which methylation is inhibited (Hsu-Kim et al., 2013). There is some debate regarding the underlying mechanism, but there is substantial evidence suggesting that dissolved inorganic sulfide above concentrations of 300–3,000 $\mu g\ L^{-1}$ has an inhibitory effect on Hg methylation (Bailey et al., 2017).

This study presents results from 30 wetland mesocosms in which the surface waters were treated to maintain a wide range of SO_4 concentrations over the course of 5 years (2011–2015) to assess the impact on wild rice, *Zizania palustris* (Pastor et al., 2017). We took advantage of this experiment to analyze the geochemical conditions in surface and pore water in the mesocosms during late summer 2013, 3 years into the experiment. Pastor et al. (2017) specifically examined the effect of increased SO_4 loading on wild rice, whereas this paper examines the broader biogeochemical impact of augmenting SO_4 to a low-SO_4 system.

2. Materials and Methods

2.1. Experimental Design

The experimental setup (Figure S1 in the supporting information), described in detail by Pastor et al. (2017), consisted of thirty 375 L polyethylene stock tanks containing sediment from a wild rice lake (Rice Portage Lake; +46.6987°, −92.6886°) in which wild rice was grown in self-perpetuating populations at five SO_4 treatment levels (control, 50, 100, 150, and 300 $mg\ L^{-1}$). SO_4 concentrations in six replicate mesocosms were routinely monitored, and amendments of SO_4 were added as Na_2SO_4 during the growing season as SO_4 was removed by MSR (Figure 1). Due to MSR, the mesocosm surface waters actually had time-weighted average concentrations of 7, 27, 59, 93, and 207 $mg\ L^{-1}$, respectively. Local well water containing an average of 10.6 $mg\ L^{-1}$ SO_4 was added as needed to compensate for evapotranspiration. Precipitation in the region contains an average of 2.1 $mg\ L^{-1}$ SO_4, and Rice Portage Lake has an average SO_4 concentration of 2.2 $mg\ L^{-1}$ (Fond du Lac Band, 2016), so the control was slightly elevated above the ambient SO_4 concentration of the sediment source for the experiment. During the ice-free period (generally May through October), the surface water temperature (T) measured in the morning was correlated with the previous day's mean air temperature (mesocosm T = 0.72 air T + 4.4 °C; R^2 = 0.65). Peak air temperature is reached in July, when the average

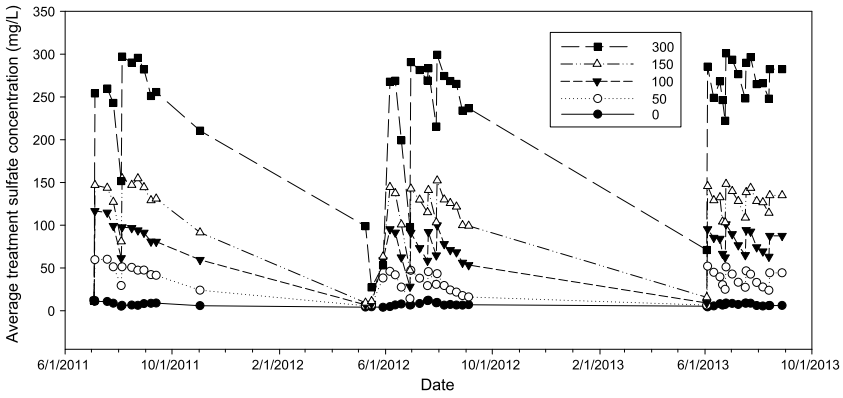

Figure 1. SO_4 concentrations in surface waters of each treatment, showing repetitive depletion and periodic amendment with Na_2SO_4 (average of six mesocosms per treatment on each sampling date).

temperature is 18.8°C (based on 1981–2010 air temperatures measured at the Duluth, Minnesota, airport, 10 km from the experimental site).

The experiments had been in progress for three growing seasons at the time of the sampling for this study, 27 and 28 August 2013, and for five growing seasons at the time of the second, less intensive, sampling (August 2015). The sediment of each mesocosm was divided into two parts for the 2013 growing season by a clear acrylic plate and all wild rice plants removed from one side in order to evaluate the effects of plant root presence on the geochemistry of the sediments. The plate was situated near one end of each mesocosm, such that about 10% of the surface area of 0.6 m^2 was plant-free (Figure S1). The plate was positioned to segregate the sediment without impeding the circulation of the surface water above all of the sediment. Sediment chemistry results presented here are from the side with wild rice plants present, except when analyzing the difference in AVS between the two sides.

2.2. Methods

2.2.1. Sample Collection

Rhizon™ samplers with a 10 cm long, 2.5 mm diameter, cylindrical porous tip (hydrophilic membrane pore size 0.12–0.18 μm (Rhizosphere.com, Netherlands; Shotbolt, 2010)), were connected by Teflon-taped Luer-Lok connectors and silicone tubing to a syringe needle. The sampler was inserted into the sediment, and the needle was then inserted through the 20 mm thick butyl rubber septum of an evacuated serum bottle (Bellco Glass) to initiate pore water draw through the tubing and displace air. After water was observed entering the serum bottle, the needle was removed from the first sacrificial bottle and inserted through the septum of a second evacuated serum bottle to collect the sample. One Rhizon and bottle were used to collect a sample for dissolved iron, preserved with 20% nitric acid. A second Rhizon and evacuated, N_2 gas-flushed sealed bottle, preloaded with 0.2 mL 2 N zinc acetate, 0.5 mL 15 M NaOH, and a stir bar, was used to collect a sample for dissolved sulfide analysis. Each Rhizon was positioned to sample pore water from the top 10 cm of sediment and to avoid collecting water from above the sediment surface. However, it is conceivable that some surface water was able to follow the path of the Rhizon into the sediment and dilute or partially oxidize the pore water sample.

Surface water in each mesocosm was collected for analysis of nitrate + nitrite, TP, TN, DOC, pH, temperature, and alkalinity from 5 cm below the surface of the water. Surface water samples for analysis of total Hg (THg) and MeHg were collected using clean hands/dirty hands protocols in September 2013, filtered through 0.45 μm glass fiber filters, and immediately acidified with 0.5% (by volume) trace metal hydrochloric acid. Samples were stored on ice during transport and at 4°C until analysis.

Pore water P availability was measured with three mixed bed ion exchange bags (Fisher Rexyn 300 resin) placed in the sediment of each tank in spring and harvested at the end of the growing season in 2013. A 3.8 cm diameter piston corer was used to obtain 10 cm long sediment samples for various analyses. Sediment samples for the analysis of AVS were taken monthly from June to October 2013 from replicate mesocosms of four SO_4 treatments (control, 50 150, and 300 mg L^{-1}; no mesocosm was sampled more

than once). Sediment samples were also taken on 8 October 2013 for the analysis of THg in bulk sediment and on 6 October 2015 for the analysis of total organic carbon (TOC).

2.2.2. Laboratory Analyses

Surface water and pore water analyses were conducted by the Minnesota Department of Health Environmental Laboratory (MDHEL). Total P was measured by in-line ultraviolet/persulfate digestion and flow injection (APHA, 2005, 4500 P-I), DOC by persulfate-ultraviolet oxidation and IR CO_2 detection (APHA, 2005, 5310-C), and alkalinity by automated titration (APHA, 2005, 2320-B). Pore water sulfide samples were prepared for inline distillation and flow injection colorimetric analysis using procedures that avoided exposure to oxygen. The sulfide serum bottle was weighed to determine the amount of sample collected and to adjust for the slight dilution factor of an alkaline antioxidant that was added by injection through the stoppers. The sealed samples were then placed on a stir plate for at least 1 h and subsamples withdrawn for analysis through a needle. Reanalysis of sealed, processed samples 12 months later shows no significant difference in sulfide concentrations, indicating that the sulfide samples were stable prior to analysis (data not shown). SO_4 concentration was measured using a Lachat QuikChem 8000 Autoanalyzer (Lachat Method 10-116-10-1-A). The resin was eluted using a KCl solution and analyzed for PO_4 using a Lachat Autoanalyzer, following the methods of Walker et al. (2006).

An aliquot of the nitrate + nitrite/TP/TN/DOC serum bottle was filtered in the lab within 10 days of sampling using a 0.45 μm filter, preserved to a pH $<$ 2 with 10% sulfuric acid, and transferred to a 250 mL polyethylene bottle for DOC analysis. The remaining sample was preserved to a pH $<$ 2, with 10% sulfuric acid and transferred to 250 mL polyethylene bottle for nitrate + nitrite/TP/TN analysis. The contents of the metal serum bottle were transferred to a 250 mL polyethylene bottle and preserved to a pH $<$ 2 with 10% nitric acid. Analyses were conducted within 30 days of sampling.

THg in surface water and bulk sediment were analyzed with EPA method 1631 by MDHEL, and surface water MeHg was analyzed with EPA method 1630 by Frontier Global Sciences (Bothell, Washington). Inorganic Hg (iHg) was calculated as the difference between THg and MeHg. Sediment AVS was analyzed colorimetrically, as above for pore water sulfide, following acid distillation and in-line alkaline trapping (APHA, 2005; SM 4500-S2). Sediment TOC was analyzed following SM5310C (APHA, 2005), using an OI Analytical Aurora 1030 at Pace Analytical Services, Virginia, Minnesota.

3. Data Analysis

3.1. Sulfate Depletion as the Independent Variable

Because SO_4 is relatively unreactive under oxidized conditions, its loss is attributable to diffusion or transpiration-driven advection (Bachand et al., 2014) into sediment and conversion to sulfide by bacteria. Surface water SO_4 concentrations decreased partly due to dilution by precipitation but largely from loss after movement into the sediment and reduction to sulfide. Sulfide would largely be retained in the sediment as FeS compounds, although some could be lost to the atmosphere as H_2S gas (Bagarinao, 1992) or as volatile organic sulfur compounds (Lomans et al., 2002). The cumulative SO_4 lost from surface water was calculated from a mass balance for each mesocosm from the inception of the experiment in spring 2011 through fall 2013; this quantity, termed here SO_4 depletion, $(SO_4)_{Depl}$, is used as a proxy for net MSR, following Weston et al. (2006). The surface water remained frozen from approximately 1 December to 1 April each winter, and the mesocosms were covered with plastic from November to late April each year and not amended with SO_4. SO_4 reduction was the major biogeochemical process altered by the experimental treatments, and therefore, $(SO_4)_{Depl}$ is the independent variable used in subsequent data analyses. It was only possible to perform a complete mass balance for SO_4, the only parameter consistently quantified in source water, precipitation, and overflow water.

3.2. Calculation of DIC From Measured Alkalinity

Dissolved inorganic carbon (DIC ≡ $[CO_3^{2-}]$ + $[HCO_3^-]$ + $[CO_2^*]$, where $[CO_2^*] = [CO_{2(g)}] + [H_2CO_3]$) was calculated from measured alkalinity and speciated using pH, temperature, and specific conductance of the surface water. At the pH range of the mesocosms (7.60–8.84), 95–98% of DIC is in the form of HCO_3^-, so DIC concentration on a molar basis is nearly the same as alkalinity (ALK) on an equivalent basis (DIC = 0.988 ALK + 0.077, R^2 = 0.995). In studies of freshwater, most inorganic carbon data are presented in terms of alkalinity because

alkalinity is a familiar metric; however, in comparisons with DOC, inorganic carbon data are presented as DIC so that the units are directly comparable. PHREEQC version 3 geochemical modeling software (Parkhurst & Appelo, 2013) was used to calculate saturation indices for carbonate minerals.

3.3. Statistical Analysis

Statistical analysis was conducted with R version 3.2.3 and STATA (StataCorp, 2015). The effect of increased sulfate availability was assessed through both categorical analysis of the sulfate treatments (Kruskal-Wallis ANOVA test, followed by Dunn's test for multiple comparisons with Holm-Sidak corrections) and through linear regression and nonparametric Spearman rank correlations. We rely primarily on regressions against SO_4 depletion to detect the effects of enhanced sulfate-reduction driven mineralization, rather than categorical analysis of the sulfate treatment results, because (a) biogeochemical changes are not driven directly by SO_4 concentration, but rather by MSR, quantified as SO_4 depletion; (b) although SO_4 depletion may be highly correlated to SO_4 concentration, deviations between experimental mesocosms develop over time, so cumulative SO_4 depletion values eventually no longer align exactly with treatment categories, but rather become continuous variables; and (c) regression provides more statistical power than ANOVA and builds models that allowed us to describe the relationships between SO_4 depletion and response variables (Cottingham et al., 2005). However, when the relationship is not linear, ANOVA and comparison of treatments through Dunn's analysis can help describe the nature of a relationship.

4. Results and Discussion

4.1. The Impact of SO_4 Reduction on Mineralization of Sediment Organic Matter

Increased concentrations of surface water SO_4 resulted in increased sulfate reduction, which necessarily increased the mineralization of organic carbon, as described by reaction (1). Concentrations of surface water DOC and DIC increased in proportion to sulfate reduction, as measured by $(SO_4)_{Depl}$ (Table 1 and Figure 2). The marine literature generally assumes complete mineralization of particulate organic carbon (POC) to DIC in the water column (e.g., Boudreau & Westrich, 1984) (reaction 1), but in freshwater systems and especially wetlands, not all carbon is completely oxidized during decomposition, and a portion of POC may be mobilized as DOC (Howes et al., 1985; Selvendiran et al., 2008). In principle, the constituents of organic matter, such as the nutrients N and P, are mobilized in proportion to the mass of carbon mineralized as a result of MSR-driven decomposition. Surface water DOC and DIC, and the sum DOC + DIC, are therefore used as indicators of OM mineralization in interpreting the mobilization of N, P, and Hg to surface waters (Figure 2 and Tables 2 and 3).

In contrast to many marine systems, it is likely that SO_4 reduction in these sediments was limited more by SO_4 than by organic carbon, given that $(SO_4)_{Depl}$ was linearly proportional to the average SO_4 concentration (Figure S2a; R^2 = 0.87), without any obvious curvature to the relationship that would indicate saturation of MSR.

Regressions of surface water DOC and DIC against SO_4 depletion demonstrate that, on a net basis, about 60% more DIC than DOC was mobilized to the surface water as a result of MSR-driven mineralization (slope of 0.235 mM C per unit SO_4 depletion compared to 0.148; Table 2). The significantly positive slope of the DIC:DOC ratio against SO_4 depletion (Table 2) indicates that increasingly more DIC than DOC was observed in the surface water as sulfate depletion increased. Some mineralization of DOC to DIC likely occurs in the surface water as a result of exposure to oxygen, aerobic bacteria, and sunlight, processes that could have a larger effect as DOC increases.

Not only did surface water DIC and DOC increase in concert with sulfate reduction, but parallel increases occurred in surface water concentrations of constituents of organic matter: N, P, and Hg (Table 1 and Figure 2). DIC, DOC, total P, total N, ammonia, and total Hg in surface water all had increases from the control to the highest SO_4 addition of about twofold, (2.3, 1.7, 1.9, 1.8, 1.7, and 2.6-fold, respectively, Table 1). However, available phosphate in the sediment, an estimate of P availability in pore water, had a larger increase (7.5-fold). MSR consumes acidity as the DIC-based alkalinity is produced (Baker et al., 1986), which increased the average pH from 7.57 to 7.81, a 44% decrease in hydrogen ion concentration (Table 1). If the sulfide subsequently oxidizes (which could happen in a natural system during drought (Laudon et al., 2004) or intentional dewatering), a proportional quantity of alkalinity is consumed as acid is produced

Table 1
Summary of Effects of Experimentally Increased SO_4 Concentrations on SO_4 Reduction (Quantified as SO_4 Depletion), Organic Matter Mineralization, and Mercury Methylation

		Average of each sulfate treatment (n = 6 for each treatment)						Correlation with SO_4 depletion (Spearman)	
Variable	Matrix	Control	50	100	150	300	Max/Min	Rho	p value
Variables mainly associated with SO_4 reduction									
SO_4 (T-W mean mg SO_4 L^{-1})	sw	6.7^{a}	26.9^{ab}	58.5^{abc}	93.2^{BC}	206.5^{c}	31.0	0.93	<0.0001
SO_4 depletion (mg S cm^{-2})	sw	0.14^{a}	2.52^{ab}	3.63^{abc}	4.28^{BC}	6.90^{c}	48.5	1	
Pore water sulfide (μg S L^{-1})	pw	69^{a}	184^{a}	224^{a}	393^{b}	728^{b}	10.5	0.81	<0.0001
Pore water iron (μg L^{-1})	pw	$12{,}883^{a}$	$11{,}122^{ab}$	$6{,}808^{abc}$	$4{,}483^{BC}$	$3{,}032^{c}$	4.25	−0.82	<0.0001
AVS (mg S kg^{-1})	sed	102^{a}	483^{ab}	NA	826^{ab}	$1{,}413^{b}$	13.8	0.77	<0.0001
pH	pw	7.57^{a}	7.52^{a}	7.55^{a}	7.75^{a}	7.81^{a}	1.03	0.39	=0.03
H^+ ion (μmol L^{-1})	pw	0.027	0.030	0.028	0.018	0.015	1.72	0.39	=0.03
Variables mainly associated with mineralization of organic matter									
TOC (% dry mass)	sed	9.26^{a}	7.90^{a}	8.18^{a}	7.17^{a}	8.22^{a}	1.29	−0.34	=0.065
DIC (mg C L^{-1})	sw	28.9^{a}	47.2^{ab}	56.3^{BC}	56.7^{BC}	66.3^{c}	2.30	0.94	<0.0001
DOC (mg C L^{-1})	sw	16.3^{a}	21.4^{a}	26.8^{BC}	24.0^{abc}	28.3^{bc}	1.74	0.79	<0.0001
Total N (mg N L^{-1})	sw	1.42^{a}	1.75^{a}	2.35^{BC}	2.03^{abc}	2.57^{BC}	1.81	0.77	<0.0001
Ammonia (mg N L^{-1})	sw	0.09^{a}	0.09^{a}	0.10^{a}	0.10^{a}	0.16^{a}	1.70	0.38	=0.04
Total P (μg P L^{-1})	sw	13^{a}	16^{ab}	22^{ab}	21^{ab}	25^{b}	1.92	0.73	<0.0001
Available P (μg P g^{-1} resin)	Resin in sed	0.34^{a}	0.40^{a}	0.59^{ab}	0.92^{ab}	2.56^{b}	7.45	0.86	<0.0001
Total Hg (ng L^{-1})	sw	1.83^{a}	2.09^{a}	3.61^{ab}	3.25^{ab}	4.80^{b}	2.63	0.82	<0.0001
Variables mainly associated with Hg methylation									
Methylmercury (ng Hg L^{-1})	sw	0.20^{a}	0.49^{ab}	1.21^{b}	1.08^{b}	1.18^{b}	5.91	0.66	<0.0001
Inorganic Hg (ng L^{-1})	sw	1.63^{a}	1.60^{ab}	2.40^{abc}	2.17^{BC}	3.62^{c}	2.22	0.80	<0.0001
Percent methylmercury	sw	$11\%^{a}$	$23\%^{ab}$	$30\%^{b}$	$32\%^{b}$	$23\%^{ab}$	2.90	0.45	=0.02

Note. Matrix abbreviations: sw = surface water, pw = pore water, sed = bulk sediment. Averages with superscript letters in common are not significantly different at the 0.05 level.

(Hall et al., 2006). However, the sulfide reoxidation does not reverse the mobilization of the constituents of organic matter (C, N, P, and Hg) or the production of methylmercury (MeHg; see below). Rather, any production of SO_4 from sulfide oxidation creates the potential for additional MSR-driven OM mineralization and Hg methylation (Coleman Wasik et al., 2015; Hansel et al., 2015).

The slope of linear regressions of the C, N, and P in surface water against $(SO_4)_{Depl}$ is an estimate of the increase of that variable in mesocosm surface waters per unit SO_4 reduction (Table 2). The regression slopes provide a basis for estimates of stoichiometric ratios of the constituents mobilized from the sediment solid phase, similar to the calculation that Weston et al. (2006) performed for pore water. The calculation of stoichiometric ratios from the slopes of regressions with $(SO_4)_{Depl}$ is more accurate than calculating ratios from surface water concentrations alone, as the use of slopes accounts for the concentrations of the control (the intercept of the linear regression).

The regression slopes of surface water C versus surface water N, P, and Hg in mesocosms are estimates of the net release of each element relative to that of C (Table 3). These estimates can then be compared to the ratio of these constituents in the primary source material—the sediment—to determine the efficiency of mobilization of sediment N, P, and Hg to surface water, compared to C (Table 3). Although we present efficiency relative to only DOC and only DIC, calculating efficiency relative to the sum of mineralized OM (DOC + DIC) represents the overall net efficiency of mineralization, which ranges from 8% to 38% for the three constituents (Table 3). Although the increases in surface water N, P, and Hg are consistent with the hypothesis that those elements were released to the surface water through sulfate-enhanced mineralization of sediment OM, their lower mobilization efficiencies relative to carbon suggest that other processes were operating to either increase carbon, decrease N, P, and Hg mobilization relative to carbon, and/or increase N, P, and Hg losses. It is likely that some carbon was introduced to the surface waters from sources other than the sediment (e.g., photosynthetic fixation of atmospheric carbon) and that there were losses for N, P, and Hg from the surface water (though adsorption, settling, biological uptake, or atmospheric evasion of N and Hg).

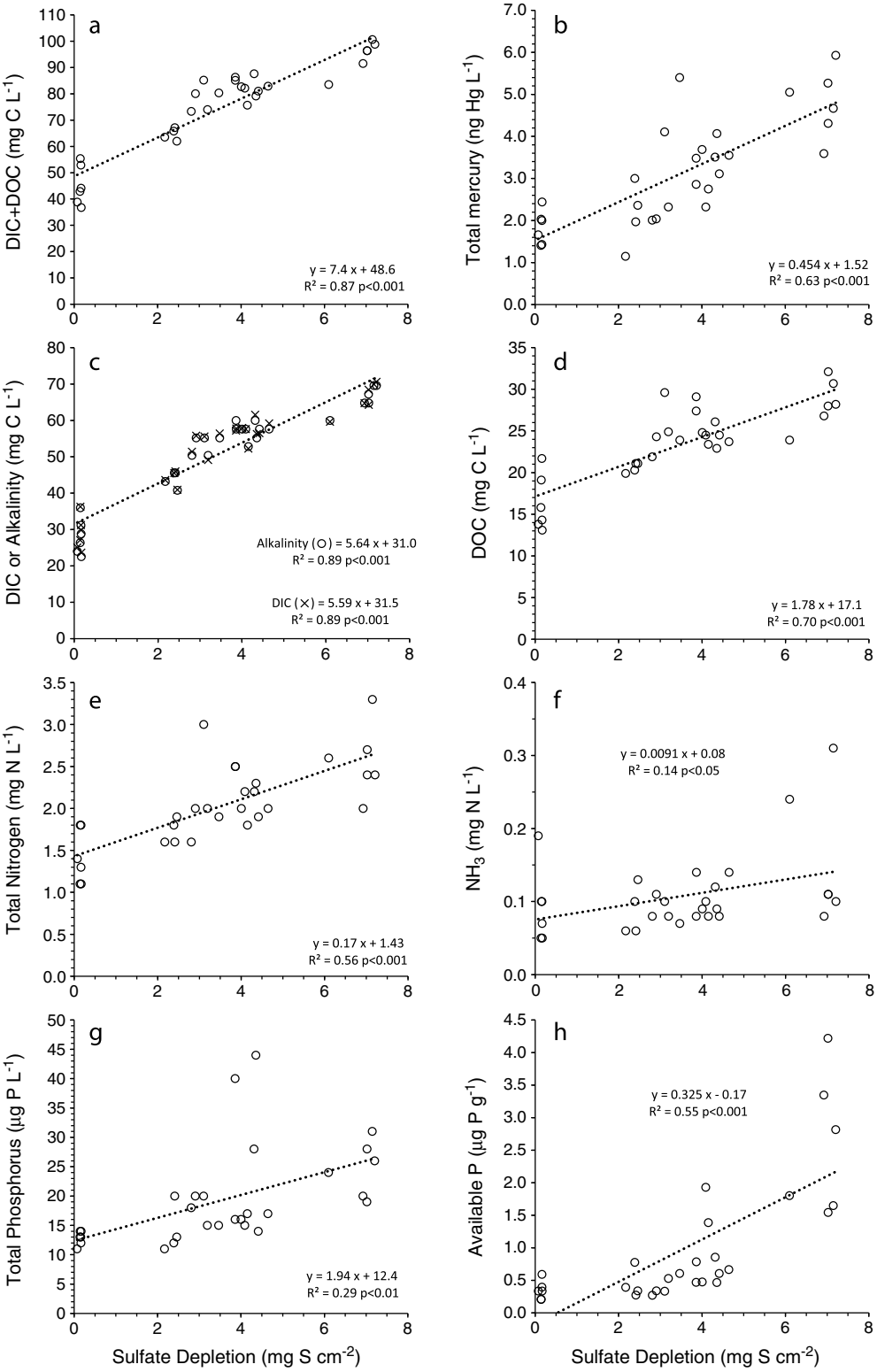

Figure 2. The release of constituents of sedimentary organic matter as a function of SO_4 depletion, showing linear regressions (dotted lines). (a) Sum of surface water DIC and DOC; (b) surface water total mercury; (c) surface water alkalinity and DIC (symbols ○ and ×, respectively; the two regressions are superimposed); (d) surface water DOC; (e) surface water total nitrogen; (f) surface water ammonia; (g) surface water total phosphorus; (h) available phosphate in the sediment, as quantified on ion-exchange resin.

Table 2
Slopes of Regressions of Surface Water Parameters (mM) Against SO_4 Depletion (mg S cm^{-2})

Surface water variable (molar basis)	Regression against $(SO_4)_{Depl}$ (mg S cm^{-2})		
	Slope	R^2	p
DIC	0.235	0.89	<0.0001
DOC	0.148	0.70	<0.0001
DIC + DOC	0.383	0.84	<0.0001
DIC: DOC	0.044	0.56	<0.0001
TN	0.0121	0.56	<0.0001
TN: DIC	−0.0028	0.25	<0.01
TN: DOC	0.0004	0.01	NS
TN: DIC + DOC	−0.0006	0.08	NS
TP	6.26E−05	0.29	<0.002
TP: DIC	−7.00E−06	0.03	NS
TP: DOC	7.00E−06	0.02	NS
TP: DIC + DOC	−1.00E−07	0.00	NS
THg	2.26E−09	0.63	<0.0001
THg: DIC	9.00E−06	0.46	<0.0001
THg: DOC	6.00E−06	0.23	<0.01
THg: DIC + DOC	2.00E−05	0.42	<0.0001

Note. When a sediment constituent's ratio to DIC or DOC has a significant slope against sulfate depletion, it indicates that the constituent was mobilized to the surface water at a significantly different rate than the DIC or DOC.

In addition to increases of TP in the surface water, the sediment pore water in the highest SO_4 treatment contained 7.5-fold greater available phosphate than the controls, as quantified with ion-exchange resin (Table 1 and Figure 2h). In comparison, the increase in surface water TP was only 1.9-fold (Table 1 and Figure 2g). The difference between phosphorus response in the resin and the surface water may be partly due to (a) loss of TP from the surface water after mobilization or (b) irreversible trapping of mobilized P on the resin. If phosphorus is released from sediment en masse in response to an S-induced shift from iron oxides to iron sulfides, the sediment pore water would experience this release first, while release to surface waters would take longer due to diffusion-limited transport and potentially an iron-oxide barrier at the sediment-water (anoxic-oxic) interface.

DIC in surface water is not conservative, being subject to exchange across the air-water interface, carbonate mineral precipitation, and photosynthetic uptake. Surface water pCO_2 in all mesocosms was above saturation with respect to atmospheric equilibrium by a factor of 1.4–15.5 (based on the DIC speciation calculations discussed earlier; data not shown), so the mesocosms were losing, not gaining, C through gas exchange with the atmosphere. The pCO_2 values in the mesocosms are similar to those reported from epilimnia of small, organic-rich, temperate lakes of low to moderate salinity (Cole et al., 1994; Myrbo & Shapley, 2006). With respect to mineral precipitation, based on geochemical equilibrium calculations, surface waters were undersaturated with respect to all carbonate minerals. Thus, although DIC in surface water is subject to several transport and transformation processes, the sustained presence of CO_2 at quantities significantly above saturation with respect to the atmosphere and the observation of increasing DIC and DOC with increasing $(SO_4)_{Depl}$ (Table 1) provide strong evidence of sulfate-induced increases in net carbon mineralization in the mesocosms.

In addition to the carbon originally present in the sediment, organic carbon was also photosynthetically fixed by wild rice and algae in the mesocosms and subsequently subjected to respiration and some decomposition, adding to the DIC and DOC in surface waters. DOC may also have been released into sediment pore water as an exudate from the wild rice roots (Rothenberg et al., 2014; Windham-Myers et al., 2009). Exudate DOC, however, does not account for the observed increase in DOC, since a negative relationship between the number of wild rice plants and DOC was observed (Spearman's rho = −0.63, $p < 0.001$, Table S2).

4.2. Effects of SO_4 Reduction on Mercury and Methylmercury in Surface Water

We interpret Hg mobilization to the surface water in an analogous manner to C, N, and P, as Hg tends to associate strongly with organic matter in sediment (Feyte et al., 2010). In the mesocosm surface waters,

Table 3
Elemental Ratios in Sediment and Surface Water Across the Range of SO_4 Depletion

Molar ratio in sediment[a]		Molar ratio in surface water[b]			Efficiency of mobilization of sediment N, P, or Hg to surface water, relative to carbon		
		DIC	DOC	DOC + DIC	DIC	DOC	DOC + DIC
C: N	12[a]	19	12	32	63%	100%	38%
C: P	463[a]	3,752	2,366	6,118	12%	20%	8%
C: Hg	1.90E + 07	1.04E + 08	6.5E + 07	1.69E + 08	18%	29%	11%

Note. Together, the ratios are used to calculate the efficiency of mobilization of the constituents of particulate organic matter into the surface water.
[a]Sediment data from Hildebrandt, Pastor, and Dewey (2012), a mesocosm study that obtained sediment from the same natural wild rice stand. [b]Regression slopes of C versus N, P, and Hg in mesocosm surface waters; calculations are made based on surface water DIC alone, surface water DOC alone, and the sum of surface water DOC + DIC.

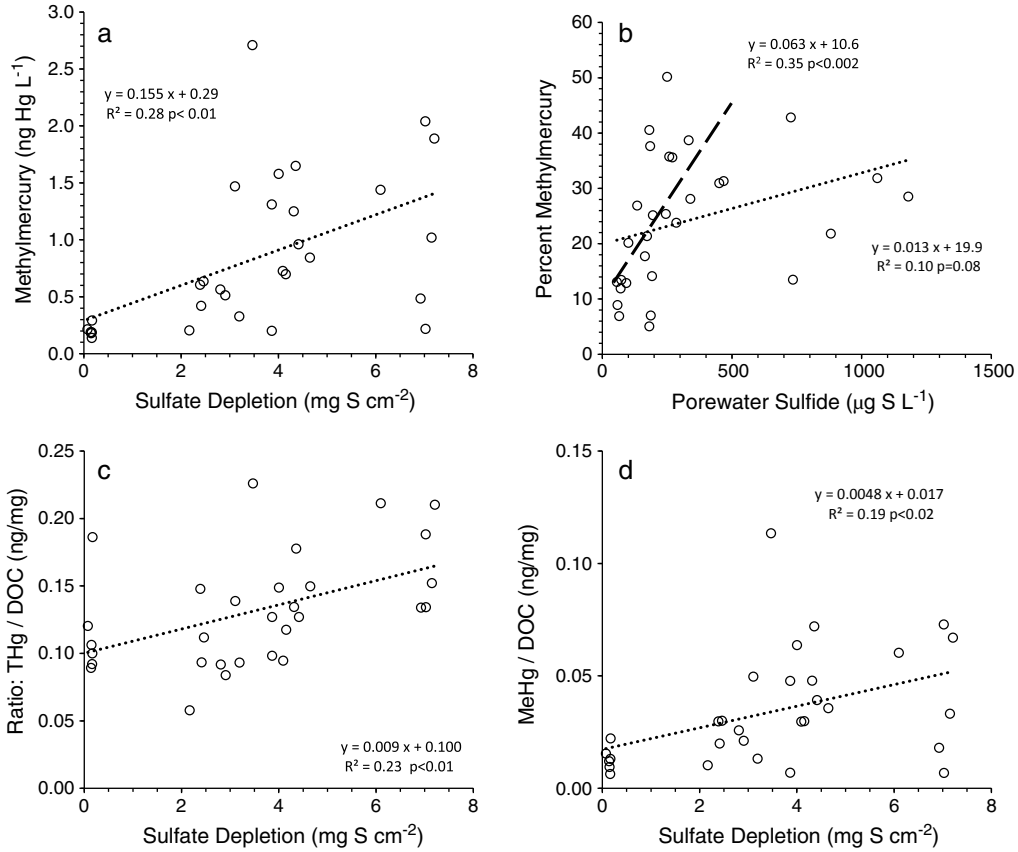

Figure 3. The response of surface water Hg variables to SO_4 depletion and the production of pore water sulfide, showing linear regressions. (a) MeHg as a function of SO_4 depletion; (b) percent MeHg as a function of pore water sulfide, showing regressions for all data (dotted line) and for the subset of data extending only to a pore water sulfide concentration of 468 µg S L^{-1} (dashed line); (c) ratio of THg to DOC as a function of SO_4 depletion; (d) ratio of MeHg to DOC as a function of SO_4 depletion.

THg, inorganic Hg (iHg), and MeHg all increased significantly with increased $(SO_4)_{Depl}$ (Table 1 and Figures 2b and 3a, $p < 0.0001$) and were greater in the highest sulfate amendment by factors of 2.6, 2.2, and 5.9, respectively (Table 1). The relative increase in THg (2.6-fold) is greater than that for DIC, DOC, TN, and TP, which range from 1.7 to 2.3-fold (Table 1). DOC enhances the solubility of both iHg and MeHg and can facilitate the movement of Hg from sediment into surface water (Ravichandran, 2004). The 5.9-fold increase in MeHg indicates that MeHg flux to surface waters was enhanced by sulfate loading disproportionately more than sedimentary release of THg (2.6-fold) and the increase in surface water DOC (1.7-fold).

The genes required to methylate Hg have been found in a wide variety of anaerobic bacteria, including SO_4-reducing bacteria, iron-reducing bacteria, and methanogens (Podar et al., 2015). Though some pure culture and experimental evidence exist for mercury methylation by other bacteria, extensive pure culture, experimental, and landscape-scale observations suggest SO_4-reducing bacteria dominate Hg methylation in many freshwater and marine environments. The relatively large increase in surface water MeHg in response to increased $(SO_4)_{Depl}$ in this experiment supports the assumption that MSR was responsible for most of the observed production of MeHg. It is likely that increased SO_4 loading to low-SO_4 aquatic systems with organic sediment will result in increased Hg methylation even though the relative importance of Hg methylation in the environment by different groups of bacteria is still a subject of debate (Paranjape & Hall, 2017).

If movement of DOC from sediment to surface water were the sole mechanism for the Hg increase in surface water, a constant Hg:DOC ratio would be expected on the $(SO_4)_{Depl}$ gradient. However, THg:DOC, iHg:DOC, and MeHg:DOC ratios in surface water are all significantly correlated with SO_4 depletion (Table S2 and Figures 3c and 3d). Therefore, all forms of Hg (THg, iHg, and MeHg) increase in surface waters more than

does DOC, indicating that a sulfate-induced enhancement of carbon mineralization may act in combination with either enhanced methylation or an enhanced capacity of DOC to carry Hg. Changes to the binding strength of the DOC in heavily S-impacted mesocosm sediment are possible, as thiol groups on DOC are dominant binding sites for Hg (Skyllberg, 2008). The dual role of organic carbon and sulfur in driving both the production of MeHg and the transport of MeHg could be responsible for the substantially larger maximum increase in MeHg:DOC ratio relative to the increase in the THg:DOC ratio (an average 206% increase relative to a 63% increase, Figures 3c and 3d), as postulated by Bailey et al. (2017).

Regnell and Hammar (2004) identified three MSR-driven processes that might cause mobilization of Hg from sediment in a wetland, (1) mineralization of organic matter; (2) extraction of iHg by reduced S compounds, which could be associated with mobilized DOC; and (3) enhanced production of MeHg, which is more mobile than iHg. They argued that enhanced production of MeHg explained THg mobilization in the minerotrophic peat bog that they studied. However, in this study, increases in surface water MeHg concentrations (Figure 3a) are not sufficient to explain the linear increase in THg observed in this experiment (Figure 2b) because most (67%) of the increase is iHg (Table 1). Some of the increase in surface water iHg could be the result of increased production of MeHg that moved to surface water and was subsequently demethylated. Regardless of the underlying mechanism, our observations clearly show increases in surface water Hg that were greater than the increases in C, N, and P (Table 3); this corroborates other studies (Bouchet et al., 2013; Merritt & Amirbahman, 2007; Regnell & Hammar, 2004) that suggest sediment Hg may be synergistically mobilized to surface waters through mineralization, methylation, and enhanced mobility with DOC.

Recent research has shown that in many ecosystems, higher concentrations of pore water sulfide may inhibit MeHg production through either thermodynamically or kinetically controlled reactions with inorganic Hg (Benoit et al., 2003; Hsu-Kim et al., 2013). We plotted %MeHg, rather than the MeHg concentration, against pore water sulfide because we are interested in identifying the pore water sulfide zone of greatest efficiency for the methylation and mobilization of mercury. In this experiment the MSR-driven mineralization of OM released THg to surface water in addition to producing pore water sulfide. Accordingly, because THg is not constant, plotting %MeHg is the most accurate way to identify peak methylation efficiency. In principle, the restricted bioavailability of Hg to methylating bacteria results in a maximum in MeHg production at intermediate concentrations of pore water sulfide. Consistent with previous research in sulfate-impacted freshwater ecosystems (Gilmour et al., 1998; Gilmour, Krabbenhoft, et al., 2007, Gilmour, Orem, et al., 2007; Bailey et al., 2017), MeHg production was most efficient at intermediate sulfide concentrations. In the control, where average sulfide was 69 $\mu g\ S\ L^{-1}$, MeHg averaged only 11% of THg in surface waters. In the intermediate SO_4 treatments, which had average sulfide concentrations of 224 and 393 $\mu g\ S\ L^{-1}$, MeHg production efficiency peaked significantly higher, at averages of 30% and 32%, respectively (Table 1). %MeHg declined to an average of 23% in the highest SO4 treatment, which had an average sulfide concentration of 728 $\mu g\ S\ L^{-1}$. Given the relatively great scatter in the relationship between %MeHg and sulfide (Figure 3b), it would be most defensible to conclude that the decrease in %MeHg began to occur somewhere between 300 and 700 $\mu g\ S\ L^{-1}$. There is a strong positive relationship ($p < 0.001$) between sulfide and %MeHg if the five sulfide concentrations greater than 727 $\mu g\ S\ L^{-1}$ are excluded from the regression (which leaves only sulfide concentrations less than 468 $\mu g\ S\ L^{-1}$, since there is a gap in sulfide concentrations; Figure 3b). Other studies have identified sulfide zones of peak methylation roughly comparable to that found here. In South Florida, Orem et al. (2011) found that sulfide ranging from 5 to 150 $\mu g\ S\ L^{-1}$ did not inhibit methylation but that sulfide concentrations greater than 1,000 $\mu g\ S\ L^{-1}$ did. In a subboreal Minnesota wetland enriched in SO_4 from mining discharge, Bailey et al. (2017) found that sulfide concentrations above ~650 $\mu g\ S\ L^{-1}$ inhibited methylation.

The relationship between surface water SO_4 and Hg methylation can be strongly affected by site-specific conditions. Because of the variable conversion of SO_4 in surface water to sulfide in pore water—primarily due to differences in OM and Fe availability (Pollman et al., 2017)—researchers have found a broad range in the SO_4 concentration associated with maximum efficiency of Hg methylation. For example, Orem et al. (2014) observed that two different areas in the Everglades Protection Area had peak surface water MeHg concentrations at SO_4 concentrations of 2 and 10–15 $mg\ L^{-1}$. In the mesocosms presented here peak surface water %MeHg was observed in the two sulfate treatments that averaged 59 and 93 $mg\ L^{-1}$ (Table 1).

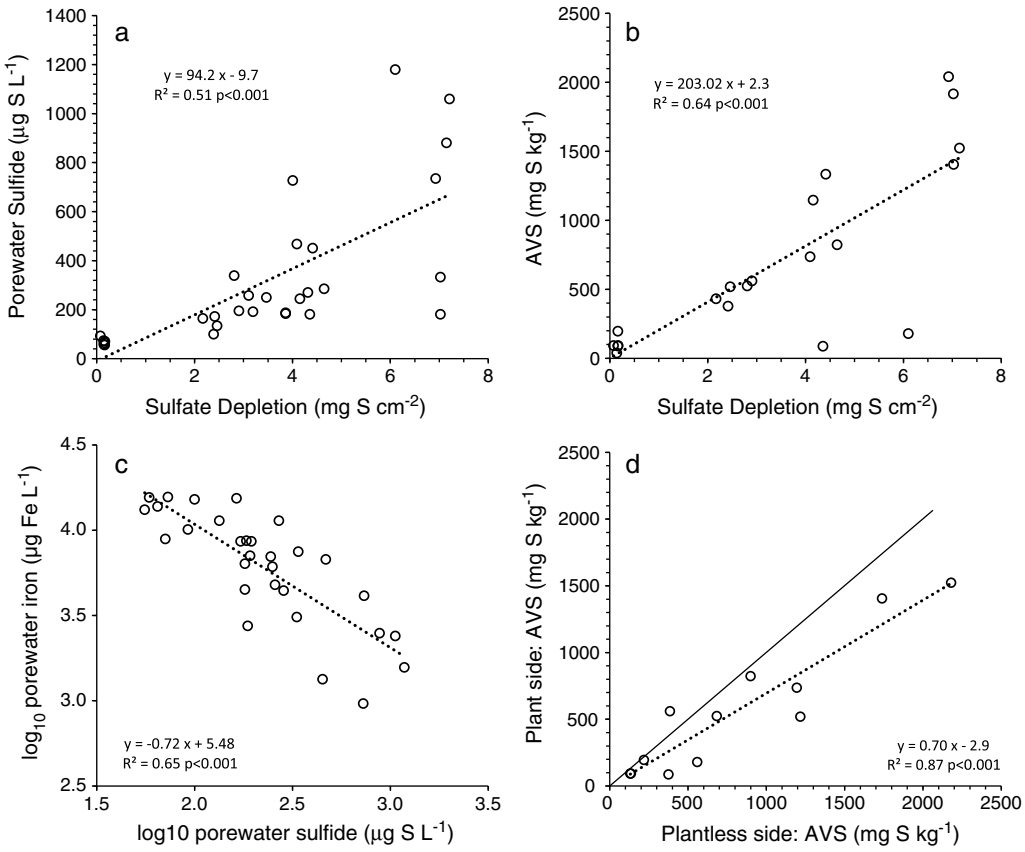

Figure 4. AVS and pore water sulfide, as related to SO_4 depletion, pore water iron, and presence of rooted plants. (a) Pore water sulfide as a function of SO_4 depletion; (b) AVS from the vegetated side of the mesocosms as a function of SO_4 depletion; (c) pore water iron as a function of pore water sulfide; (d) AVS compared between the vegetated side and nonvegetated side. The solid 1:1 line shows that in almost all mesocosms more AVS is found in the side without plants.

4.3. Effects of SO_4 Reduction on Pore Water and Sediment Sulfide

Pore water sulfide increased at higher $(SO_4)_{Depl}$, although with greater variance at higher $(SO_4)_{Depl}$ (Figure 4a), possibly as a result of variable oxidation of sulfide that may depend on the proximity of the Rhizon sampler to plant roots (Schmidt et al., 2011) or of variable bioturbation by invertebrates (Lawrence et al., 1982). When SO_4 is reduced through MSR, the sulfide produced has a number of nonexclusive potential fates: the sulfide could (1) be oxidized within the sediment; (2) remain in the sediment pore water as free sulfide; (3) diffuse into oxygenated surface water, to be oxidized; (4) react with metals in the sediment, forming insoluble precipitates (dominated by iron-sulfide compounds); or (5) be lost to the atmosphere as H_2S gas or as volatile organic sulfur compounds. Because precipitation reactions are fast relative to redox reactions and diffusion, most of the sulfide probably forms metal precipitates if metals are available. When precipitation dominates the fate of sulfide produced from MSR, the continuous reduction of SO_4 and precipitation of iron sulfides form quasi-steady states between surface water SO_4 and pore water sulfide (Figure S2b) and between pore water sulfide and pore water iron (Figures 3 and 4c). The overall mass of sulfide in the mesocosm sediment, quantified through analysis of AVS (from sediment in the vegetated area), is closely correlated with SO_4 depletion (Figure 4b) even though AVS may not include all the reduced sulfide in sediments. It is likely that most of the AVS in these sediments is present as an FeS precipitate because other metals are at low concentrations in these sediments, which came from a relatively pristine (unpolluted) lake (Fond du Lac Band, 2016; Pastor et al., 2017). Note that there are two mesocosms with especially low AVS concentrations (Figure 4b). It is possible that the AVS in the specific location in these mesocosms where sediment core samples were collected was influenced by

a spatially heterogeneous oxidization process (e.g., root oxygen or benthic invertebrates) that limited the accumulation of sulfide.

AVS was 30% lower in the vegetated side of the mesocosms, suggesting that wild rice released oxygen into the sediment, inhibiting the production of sulfide and/or decreasing sulfide concentrations through oxidation (Figure 4d; Wilcoxon paired test, $p = 0.007$). It is notable that this 30% difference developed in just one growing season, despite the previous 2 years of sulfate treatment. Pore water sulfide showed no statistically significant difference between the two sides owing to high variability within treatments. Numerous investigations have found that rooted aquatic plants release oxygen from their roots, a phenomenon that is usually interpreted as an adaptation to limit the toxicity of reduced chemical species in the pore water, especially sulfide (Lamers et al., 2013). Although oxygen release has been observed in white rice, *Oryza sativa* (Colmer, 2002), it has never been documented in wild rice, which is in the same tribe (Oryzeae) of grasses as white rice, and also develops aerenchyma (Jorgenson et al., 2013), plant structures that provide a low-resistance internal pathway for movement of oxygen to the roots. Since the growth and reproduction of rooted plants can be inhibited by sulfide (Pastor et al., 2017), there may be a tipping point of exposure to sulfide above which oxygen release is insufficient to mitigate phytotoxic effects, and the plant population declines over time, possibly to extirpation. In this experiment, in the third treatment year, the increase in pore water sulfide was the apparent cause of a decrease in the average number of wild rice stems from 17 in the control mesocosms to 3 in the highest-sulfate treatment mesocosms (Pastor et al., 2017).

4.4. Mesocosms as Models for Ecosystem-Scale Effects of SO_4 Reduction

Although mesocosms, as contained ecosystems, are useful because they mimic ecological and biogeochemical processes that occur in the field, extrapolating findings to nature is challenging when plastic walls have prevented exchange of water and materials (Petersen et al., 2009). These wall-based challenges are manifest in three phenomena in this experiment, (1) relatively long surface water residence times due to the lack of a constant throughflow; (2) the presence of the wall itself, which provides a surface for periphyton; and (3) lack of either overland or groundwater loading of external materials:

1. Relatively long surface water residence times: the increased loading of N, P, C, Hg, and MeHg to the surface water of the mesocosms was readily detected because the lack of hydraulic loading from a watershed minimized dilution and loss through the outflow. The impact of an increase in SO_4 loading on surface water concentrations of N, P, C, Hg, DIC, and DOC would be lower in waters with shorter residence times. For instance, Baker and Brezonik (1988), in modeling increases in alkalinity from atmospheric SO_4 loading, noted that net increases in alkalinity would be most important in waters with long residence times ($>$5 years) and that there would be little increase in alkalinity in waters with much shorter residence times ($<$1 year). However, the measured concentrations may not represent the maximum impact of MSR-driven mineralization because the mesocosm wall may enhance removal from the surface water (point number 2, below).
2. Presence of the mesocosm wall: the mesocosms have a relatively high ratio of wall and sediment surfaces to the volume of overlying water, enhancing the removal of surface water nutrients and Hg to periphyton or inorganic sinks such as iron oxyhydroxides. Natural aquatic systems have less proportional loss to surfaces. The quantitative estimates of internal loading of N, P, and Hg in response to MSR-induced carbon mineralization may have been underestimated by the measured surface water concentrations, given that significant loss of these constituents to periphyton may have occurred. In addition, THg was filtered prior to analysis, which would have removed any Hg associated with phytoplankton or other suspended particles.
3. Lack of either overland or groundwater loading of particulate and dissolved material, specifically iron: the availability of iron in sediment is a primary controller of the fate of MSR-produced sulfide (Pollman et al., 2017). In natural aquatic systems, iron would be supplied at a relatively constant rate from the system's watershed over the long term, although varying in magnitude from watershed to watershed (Maranger et al., 2006; Winter, 2001). This experiment was not an accurate long-term mimic of pore water sulfide concentrations because the external supply of iron was cut off at the inception of the experiment. With no loading of iron, but continued loading of SO_4, the continued production of sulfide would be expected to eventually consume all available Fe, allowing pore water sulfide levels to exceed those expected in a natural system at equivalent surface water SO_4 concentrations. This mesocosm experiment provides

evidence for just such a result. The experiment continued for 2 years after the 2013 sampling presented here. In the fifth year (August 2015) pore water sulfide was much greater than had been observed in 2013, and disproportionately so in the highest SO_4 treatment, which was most likely to consume available Fe. Between the 2013 and 2015, pore water sulfide increased in the control SO_4 treatment (about 7 mg SO_4 L^{-1}) from an average value of 69 μg L^{-1} in 2013 to 116 μg L^{-1} in 2015, a 68% increase. Pore water sulfide in the highest treatment (nominally 300 mg SO_4 L^{-1}, Table 1) increased from an average value of 728 μg L^{-1}in 2013 to 9,350 μg L^{-1} in 2015, a 1,184% increase (Pastor et al., 2017). In a survey of 108 Minnesota waterbodies with a wide range of surface water sulfate, only two exceeded a pore water sulfide level of 3,200 μg L^{-1} (Myrbo et al., 2017).

5. Conclusions

This study demonstrates that increased SO_4 loading to inland waters with organic-rich sediments can significantly increase the decomposition of sedimentary organic matter, which increases internal loading to surface water of the chemical constituents of organic matter, including DIC, DOC, P, N, and Hg. Associated changes include increased production of sulfide and methylmercury and increased alkalinity and pH. Any one of these changes could alone cause significant secondary changes in the structure of an aquatic ecosystem but, taken together, could cause a cascade of primary and secondary environmental changes: increased availability of nutrients (N and P), which can alter dominant plant species, organic carbon production, oxygen consumption, and redox; increased pore water sulfide, which can be toxic to benthic animals and plants; increased MeHg production, which can affect fish and other consumers in the aquatic food web; increased DOC, which can alter light transmission, thermal stratification, and aquatic chemistry; and increased DIC production, which increases alkalinity and pH, affecting aquatic chemistry and biota. Each of these changes resulting from higher surface water SO_4 and consequent increases in MSR has been documented in the literature, but the entire suite of associated changes in aquatic chemistry has not heretofore been demonstrated in an integrated fashion. The degree to which an increase in SO_4 loading affects the ecological structure of the receiving water will depend on the relative increases in N, P, DIC, DOC, Hg, MeHg, pH, and sulfide, which will be a function of background geochemistry and hydrology of the specific system. In this experiment, the changes in these parameters were linearly proportional to SO_4 reduction, which, in turn, was linearly proportional to the time-weighted average SO_4 concentration. The linear responses of the parameters to SO_4 additions suggest that ecologically significant changes may occur even when SO_4 concentrations are elevated only modestly and that dramatic changes may occur with higher sulfate loading.

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EXHIBIT 35

MPCA Allfish (mercury in fish tissue) data for O'Brien Lake, O'Brien Reservoir, and Swan Lake, through January 19, 2024.

MPCA Allfish Data (through 2024-01-19) Mercury in Fish Tissue
O'Brien Lake and Swan Lake

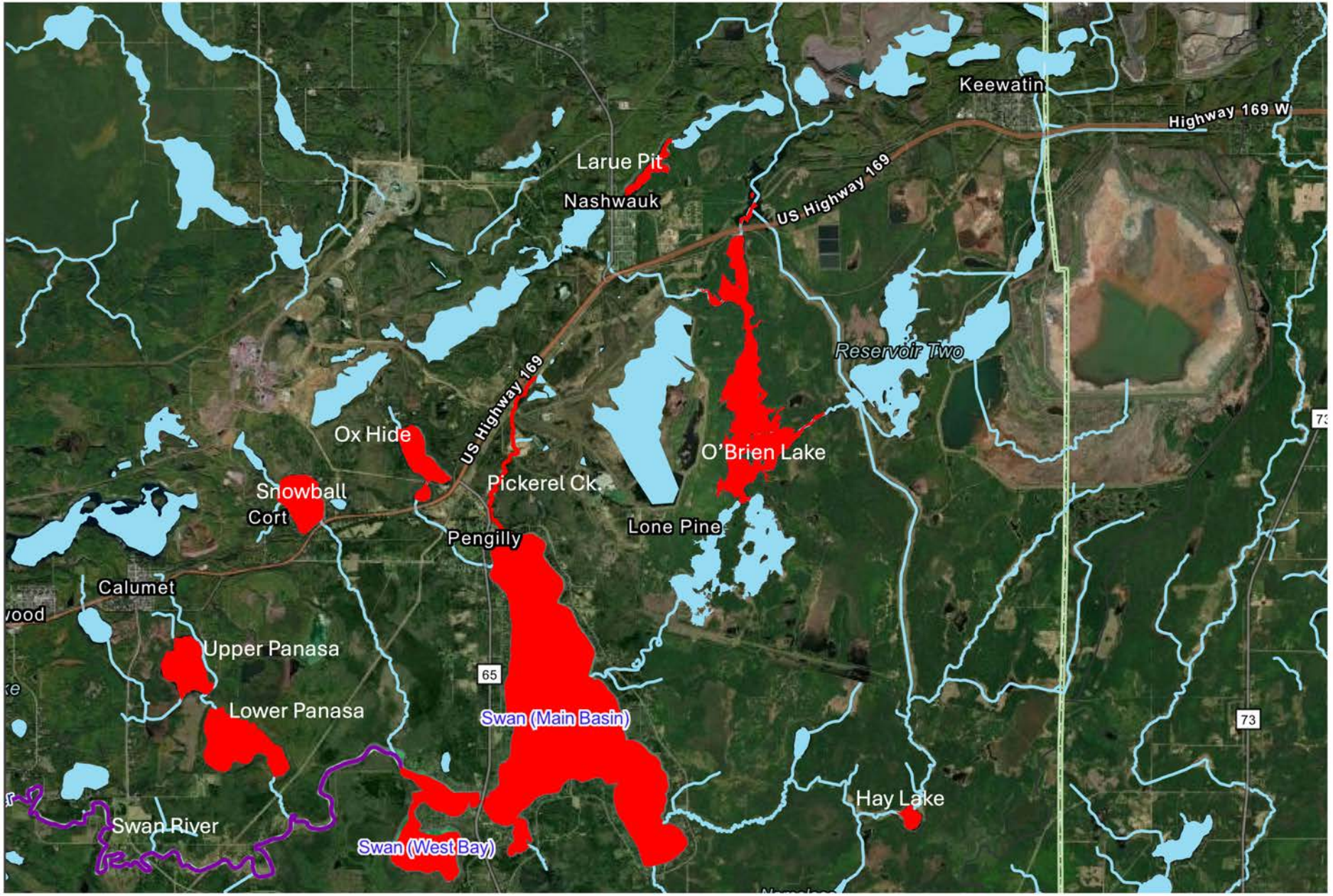
SAMPLENO	OWNER	WATERWAY	TYPE	LOCATION	DOWID	SYS_LOC_CODE	CTY	AREANEW	DATECOL	DATECOL2	YEARCOLL	SPEC	FCACAT	ANATHG	NOFISH	LGTHIN	WTLB	WTKG	AGE	AVG	HGPPM
930364	MN	O'BRIEN	Lake	2 MI SW OF SHWAUK, S OF HWY 169	31-0032-00	31-0032-01-201		Grand Rapids	19930625	6/25/1993	1993	BLG	1	FILSK	10	6.6	0.2				0.13
930365	MN	O'BRIEN	Lake	2 MI SW OF SHWAUK, S OF HWY 169	31-0032-00	31-0032-01-201		Grand Rapids	19930625	6/25/1993	1993	WTS	2	FILSK	1	18	2.7				0.098
930366	MN	O'BRIEN	Lake	2 MI SW OF SHWAUK, S OF HWY 169	31-0032-00	31-0032-01-201		Grand Rapids	19930625	6/25/1993	1993	NOP	2	FILSK	8	19	1.6				0.4
930367	MN	O'BRIEN	Lake	2 MI SW OF SHWAUK, S OF HWY 169	31-0032-00	31-0032-01-201		Grand Rapids	19930625	6/25/1993	1993	NOP	2	FILSK	5	21.4	2.3				0.58
930368	MN	O'BRIEN	Lake	2 MI SW OF SHWAUK, S OF HWY 169	31-0032-00	31-0032-01-201		Grand Rapids	19930625	6/25/1993	1993	NOP	2	FILSK	7	26.4	4.4				0.66
930369	MN	O'BRIEN	Lake	2 MI SW OF SHWAUK, S OF HWY 169	31-0032-00	31-0032-01-201		Grand Rapids	19930625	6/25/1993	1993	NOP	2	FILSK	2	32.1	7.9				0.74
																				AVG	0.4347
897800	MN	O'BRIEN RES. #4	Lake	AT SHWAUK	31-1225-00			Grand Rapids	19890727	7/27/1989	1989	BLC	1	FILSK	6	6.4	0.2				0.16
897801	MN	O'BRIEN RES. #4	Lake	AT SHWAUK	31-1225-00			Grand Rapids	19890727	7/27/1989	1989	NOP	2	FILSK	2	23	2.7				0.57
897802	MN	O'BRIEN RES. #4	Lake	AT SHWAUK	31-1225-00			Grand Rapids	19890727	7/27/1989	1989	WAE	2	FILSK	1	15.1	1.2				0.59
897803	MN	O'BRIEN RES. #4	Lake	AT SHWAUK	31-1225-00			Grand Rapids	19890727	7/27/1989	1989	WTS	2	FILSK	3	17.5	2.5				0.21
890396	MN	O'BRIEN RES. #4	Lake	RES. #4	31-1225-00			Grand Rapids	1989XXXX		1989	CRP	1	FILSK	6	6.4	0.2				0.16
890397	MN	O'BRIEN RES. #4	Lake	RES. #4	31-1225-00			Grand Rapids	1989XXXX		1989	WAE	2	FILSK	1	15.1	1.2				0.59
890398	MN	O'BRIEN RES. #4	Lake	RES. #4	31-1225-00			Grand Rapids	1989XXXX		1989	NOP	2	FILSK	2	23	2.7				0.57
890399	MN	O'BRIEN RES. #4	Lake	RES. #4	31-1225-00			Grand Rapids	1989XXXX		1989	WTS	2	FILSK	3	17.5	2.5				0.21
930347	MN	O'BRIEN RES. #4	Lake	AT SHWAUK, N OF HWY 169	31-1225-00			Grand Rapids	19930729	7/29/1993	1993	BLC	1	FILSK	6	7.7	0.3				0.17
930348	MN	O'BRIEN RES. #4	Lake	AT SHWAUK, N OF HWY 169	31-1225-00			Grand Rapids	19930729	7/29/1993	1993	WTS	2	FILSK	4	16.9	2.1				0.13
930349	MN	O'BRIEN RES. #4	Lake	AT SHWAUK, N OF HWY 169	31-1225-00			Grand Rapids	19930729	7/29/1993	1993	WTS	2	FILSK	2	19.9	3.3				0.27
930350	MN	O'BRIEN RES. #4	Lake	AT SHWAUK, N OF HWY 169	31-1225-00			Grand Rapids	19930729	7/29/1993	1993	NOP	2	FILSK	5	17.9	1.2				0.28
930351	MN	O'BRIEN RES. #4	Lake	AT SHWAUK, N OF HWY 169	31-1225-00			Grand Rapids	19930729	7/29/1993	1993	NOP	2	FILSK	8	21.8	2.6				0.53
930352	MN	O'BRIEN RES. #4	Lake	AT SHWAUK, N OF HWY 169	31-1225-00			Grand Rapids	19930729	7/29/1993	1993	NOP	2	FILSK	4	26.2	4.5				0.41
930353	MN	O'BRIEN RES. #4	Lake	AT SHWAUK, N OF HWY 169	31-1225-00			Grand Rapids	19930729	7/29/1993	1993	LMB	2	FILSK	3	9.9	0.5				0.28
930354	MN	O'BRIEN RES. #4	Lake	AT SHWAUK, N OF HWY 169	31-1225-00			Grand Rapids	19930729	7/29/1993	1993	LMB	2	FILSK	1	13	1.2				0.53
930355	MN	O'BRIEN RES. #4	Lake	AT SHWAUK, N OF HWY 169	31-1225-00			Grand Rapids	19930729	7/29/1993	1993	WAE	2	FILSK	1	14.1	0.9				0.37
930356	MN	O'BRIEN RES. #4	Lake	AT SHWAUK, N OF HWY 169	31-1225-00			Grand Rapids	19930729	7/29/1993	1993	WAE	2	FILSK	1	20	2.7				0.52
20132225	MN	O'BRIEN RES. #4	Lake	AT SHWAUK	31-1225-00		31	Grand Rapids	20130729	7/29/2013	2013	LMB	2	FILSK	1	11.8		0.41			0.475
20132226	MN	O'BRIEN RES. #4	Lake	AT SHWAUK	31-1225-00		31	Grand Rapids	20130729	7/29/2013	2013	LMB	2	FILSK	1	16.6		1.14			0.674
20132227	MN	O'BRIEN RES. #4	Lake	AT SHWAUK	31-1225-00		31	Grand Rapids	20130729	7/29/2013	2013	NOP	2	FILSK	1	21.9		1.32			0.51
20132228	MN	O'BRIEN RES. #4	Lake	AT SHWAUK	31-1225-00		31	Grand Rapids	20130729	7/29/2013	2013	NOP	2	FILSK	1	17.5		0.53			0.536
20132229	MN	O'BRIEN RES. #4	Lake	AT SHWAUK	31-1225-00		31	Grand Rapids	20130729	7/29/2013	2013	NOP	2	FILSK	1	19.3		0.86			0.649
20132230	MN	O'BRIEN RES. #4	Lake	AT SHWAUK	31-1225-00		31	Grand Rapids	20130729	7/29/2013	2013	NOP	2	FILSK	1	21.4		1.01			0.686
20132231	MN	O'BRIEN RES. #4	Lake	AT SHWAUK	31-1225-00		31	Grand Rapids	20130729	7/29/2013	2013	WTS	2	FILSK	5	17.1		0.94			0.061
20132232	MN	O'BRIEN RES. #4	Lake	AT SHWAUK	31-1225-00		31	Grand Rapids	20130729	7/29/2013	2013	YEP	1	FILSK	5	10.9		0.33			0.232
																				AVG	0.399
20132692	MN	SWAN	Lake	AT PENGILLY	31-0067-00	31-0067-00-100	31	Grand Rapids	20130819	8/19/2013	2013	NOP	2	FILSK	1	19.3		0.8			0.274
20132693	MN	SWAN	Lake	AT PENGILLY	31-0067-00	31-0067-00-100	31	Grand Rapids	20130819	8/19/2013	2013	NOP	2	FILSK	1	21.3		1.06			0.29
20132694	MN	SWAN	Lake	AT PENGILLY	31-0067-00	31-0067-00-100	31	Grand Rapids	20130819	8/19/2013	2013	NOP	2	FILSK	1	24.7		1.56			0.338
20132695	MN	SWAN	Lake	AT PENGILLY	31-0067-00	31-0067-00-100	31	Grand Rapids	20130819	8/19/2013	2013	NOP	2	FILSK	1	20		0.87			0.367
20132696	MN	SWAN	Lake	AT PENGILLY	31-0067-00	31-0067-00-100	31	Grand Rapids	20130819	8/19/2013	2013	NOP	2	FILSK	1	22.4		1.14			0.396
20132697	MN	SWAN	Lake	AT PENGILLY	31-0067-00	31-0067-00-100	31	Grand Rapids	20130819	8/19/2013	2013	NOP	2	FILSK	1	30.8		3.24			0.462
20132698	MN	SWAN	Lake	AT PENGILLY	31-0067-00	31-0067-00-100	31	Grand Rapids	20130819	8/19/2013	2013	NOP	2	FILSK	1	24.2		1.42			0.555
20132699	MN	SWAN	Lake	AT PENGILLY	31-0067-00	31-0067-00-100	31	Grand Rapids	20130819	8/19/2013	2013	NOP	2	FILSK	1	31.6		3.05			0.629
20132700	MN	SWAN	Lake	AT PENGILLY	31-0067-00	31-0067-00-100	31	Grand Rapids	20130819	8/19/2013	2013	WAE	2	FILSK	1	15		0.42			0.308
20132701	MN	SWAN	Lake	AT PENGILLY	31-0067-00	31-0067-00-100	31	Grand Rapids	20130819	8/19/2013	2013	WAE	2	FILSK	1	21.6		1.56			0.643

20132702	MN	SWAN	Lake	AT PENGILLY	31-0067-00	31-0067-00-100	31	Grand Rapids	20130819	8/19/2013	2013	WAE	2	FILSK	1	19.2		0.92			0.652
20132703	MN	SWAN	Lake	AT PENGILLY	31-0067-00	31-0067-00-100	31	Grand Rapids	20130819	8/19/2013	2013	WAE	2	FILSK	1	20.8		0.96			0.685
20132704	MN	SWAN	Lake	AT PENGILLY	31-0067-00	31-0067-00-100	31	Grand Rapids	20130819	8/19/2013	2013	WAE	2	FILSK	1	19.7		1.16			0.706
20132705	MN	SWAN	Lake	AT PENGILLY	31-0067-00	31-0067-00-100	31	Grand Rapids	20130819	8/19/2013	2013	WAE	2	FILSK	1	20.5		1.22			0.757
20132706	MN	SWAN	Lake	AT PENGILLY	31-0067-00	31-0067-00-100	31	Grand Rapids	20130819	8/19/2013	2013	WAE	2	FILSK	1	23.3		1.97			1.064
20132707	MN	SWAN	Lake	AT PENGILLY	31-0067-00	31-0067-00-100	31	Grand Rapids	20130819	8/19/2013	2013	WTS	2	FILSK	5	16.6		0.958			0.044
20132708	MN	SWAN	Lake	AT PENGILLY	31-0067-00	31-0067-00-100	31	Grand Rapids	20130819	8/19/2013	2013	YEP	1	FILSK	5	6.8		0.064			0.149
																				AVG	0.4894

WaterLegacy September 22, 2025 Comments on U.S. Steel Corp NPDES/SDS Permits for Keetac Mining Area (MN0031879) and Keetac Tailings Basin (MN0055948) and on U.S. Steel Corp Application for Variance from Wild Rice Sulfate Standard

EXHIBIT 36

Map of Additional Keetac Area Impaired Waters.


Keewatin
Highway 169 W
Larue Pit
Nashwauk
US Highway 169
US Highway 169
Reservoir Two
Ox Hide
O'Brien Lake
Snowball
Cort
Pickerel Ck.
Pengilly
Lone Pine
Calumet
Upper Panasa
65
Lower Panasa
Swan (Main Basin)
73
Hay Lake
Swan River
Swan (West Bay)