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Crandon Mining Company

7 N. BROWN ST., 3RD FLOOR
RHINELANDER, WI 54501-3161

Jerome D. Goodrich, Jr.
PRESIDENT

September 29, 1995

Mr. Bill Tans
Wisconsin Department of Natural Resources
Bureau of Environmental Analysis and Review
P.O. Box 7921
Madison, WI 53707

Mr. David L. Ballman, Ecologist
U.S. Army Corps of Engineers
St. Paul District
190 Fifth Street East
St. Paul, MN 55101

SUPERSEDED

Dear Mr. Tans and Mr. Ballman:

Re: Crandon Project - *Mine Permit Application*

Crandon Mining Company (CMC) is pleased to file the enclosed portions of its *Mine Permit Application* (MPA) for the Crandon Project, together with revisions to previously submitted sections. The additional sections of the report included with this submittal are:

Section 4.12	Environmental Protection
Section 4.13	Risk Assessment
Section 7	Monitoring Plan Through Operation
Section 8	Contingency Plan
Section 9	Emergency Notification
Section 10	Long Term Care

The additional MPA sections and revisions have been prepared on behalf of CMC by Foth & Van Dyke and Associates Inc. As noted on the attached distribution list, CMC has distributed the enclosed information to appropriate state and federal agencies, to local officials, and to various interested parties. It is our understanding that the Wisconsin Department of Natural Resources (WDNR) and the U.S. Army Corps of Engineers (USCOE) will be responsible for distribution to their appropriate staff members.

Also attached is a reference list with information indicating where to insert the revised pages and the enclosed new and revised report sections in the three ring notebook for the MPA previously provided. The list has been prepared to not only facilitate insertion of the additional information, but to also serve as a log and reference identifying changes made to the MPA by CMC throughout the permitting process. If subsequent revisions are made,

Telephone: (715) 365-1451

FAX: (715) 365-1457

they will be added to the attached list in sequential order and the list will be forwarded with the changes.

If you or your staff have any questions regarding the MPA, please contact me at (715) 365-1450.

Sincerely,

Jerome D. Goodrich, Jr.
President
Crandon Mining Company

JDG:mld2

Crandon Mining Company

7 N. BROWN ST., 3RD FLOOR
RHINELANDER, WI 54501-3161

Jerome D. Goodrich, Jr.
PRESIDENT

May 30, 1995

Mr. Bill Tans
Wisconsin Department of Natural Resources
Bureau of Environmental Analysis and Review
P.O. Box 7921
Madison, WI 53707

Mr. David L. Ballman, Ecologist
U.S. Army of Corps of Engineers
St. Paul District
190 Fifth Street East
St. Paul, MN 55101

Dear Mr. Tans and Mr. Ballman:

RE: Crandon Project - *Mine Permit Application*

Crandon Mining Company (CMC) is pleased to file the enclosed portion of its *Mine Permit Application* (MPA) for the Crandon Project, together with supporting appendices. Those sections of the report included with this submittal are:

Section 1	Introduction
Section 2	Completed Mine Permit Application Form with Attachments
Section 3	Financial Responsibility
Sections 4.1 to 4.11	Mining Plan
Section 5	Reclamation Plan
Section 6	Preliminary Water Budget

The MPA has been prepared on behalf of CMC by Foth & Van Dyke and Associates Inc. As noted on the attached distribution list, CMC has distributed the document to appropriate state and federal agencies, to local officials, and to various interested parties. It is our understanding that the Wisconsin Department of Natural Resources (WDNR) and the U.S. Army Corps of Engineers (USCOE) will be responsible for distribution of the document to their appropriate staff members.

The purpose of the MPA is to provide details relating to the plans and methods CMC intends to use to construct, operate and monitor the Crandon Mine and ancillary facilities. The MPA has been submitted to the WDNR and USCOE simultaneously with selected portions of the Project's Environmental Impact Report (EIR). As per previous discussions with the WDNR and the USCOE, CMC has submitted selected portions of the MPA and EIR at this time to allow the WDNR and the USCOE to begin work on the project's *Environmental Impact Statement* (EIS).

CMC currently anticipates that the additional sections of both the EIR and the MPA will be completed in July, 1995, at which time they will be submitted to your two agencies.

Telephone: (715) 365-1451

FAX: (715) 365-1457

A check in the amount of $10,000 to cover the cost of WDNR's review of the MPA will be provided under a separate letter. If you or your staff have any questions regarding the MPA, please contact me at (715) 365-1450.

Sincerely,

Jerome D. Goodrich, Jr.
President
Crandon Mining Company

JG:jcp

Enclosure

Crandon Mining Company

7 N. BROWN ST., 3RD FLOOR
RHINELANDER, WI 54501-3161

February 14, 1997

Mr. Bill Tans
Wisconsin Department of Natural Resources
Bureau of Environmental Analysis and Review
P.O. Box 7921
Madison, WI 53707

Mr. David L. Ballman, Ecologist
U.S. Army Corps of Engineers
St. Paul District
190 Fifth Street East
St. Paul, MN 55101

Dear Mr. Tans and Mr. Ballman:

Re: Crandon Project - *Mine Permit Application*

Crandon Mining Company (CMC) is pleased to file the enclosed update of its *Mine Permit Application* (MPA) for the Crandon Project. The update provides additional detail regarding the project's waste rock management plan.

The update has been prepared on behalf of CMC by Foth & Van Dyke and Associates Inc. As noted on the attached distribution list, CMC has distributed the enclosed information to appropriate state and federal agencies, to local officials, and to various interested parties. It is our understanding that the Wisconsin Department of Natural Resources (WDNR) and the U.S. Army Corps of Engineers (USCOE) will be responsible for distribution to their appropriate staff members.

The pages contained in this update need to be inserted into the MPA according to Items 36 through 46 on the attached reference list. This list serves as a log and reference identifying changes made to the MPA by CMC throughout the permitting process. Items 1 through 35 on the list were previously submitted. If additional revisions are made, they will be added to the attached list in sequential order and the list will be forwarded with the changes.

If you or your staff have any questions regarding the MPA, please contact me at (715) 365-1450.

Sincerely,

D. E. Moe

Don Moe
Technical/Permitting Manager
Crandon Mining Company

MLD2\93C049\GBAPP\43824\4000

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Crandon Mining Company

7 N. BROWN ST., 3RD FLOOR
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April 21, 1997

Mr. Bill Tans
Wisconsin Department of Natural Resources
Bureau of Environmental Analysis and Review
P.O. Box 7921
Madison, WI 53707

Mr. David L. Ballman, Ecologist
U.S. Army Corps of Engineers
St. Paul District
190 Fifth Street East
St. Paul, MN 55101

Dear Mr. Tans and Mr. Ballman:

Re: Crandon Project - *Mine Permit Application*

Crandon Mining Company (CMC) is pleased to file the enclosed update of its *Mine Permit Application* (MPA) for the Crandon Project. The update has been prepared at the request of Mr. Christopher Carlson of the Wisconsin Department of Natural Resources (WDNR) to clarify waste rock classification criteria.

The update has been prepared on behalf of CMC by Foth & Van Dyke and Associates Inc. CMC has distributed the enclosed information to appropriate state and federal agencies, to local officials, and to various interested parties according to the current MPA distribution list. It is our understanding that the WDNR and the U.S. Army Corps of Engineers (USCOE) will be responsible for distribution to their appropriate staff members.

The pages contained in this update need to be inserted into the MPA according to Items 47 and 48 on the attached reference list. This list serves as a log and reference identifying changes made to the MPA by CMC throughout the permitting process. Items 1 through 46 on the list were previously submitted. If additional revisions are made, they will be added to the attached list in sequential order and the list will be forwarded with the changes.

If you or your staff have any questions regarding the MPA, please contact me at (715) 365-1450.

Sincerely,

D. E. Moe

Don Moe
Technical/Permitting Manager
Crandon Mining Company

cc: Current MPA Distribution List

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Crandon Project Mine Permit Application
Log of Updates and Additional Information

Entry Number	Date Revision Issued	Page(s)	Document/ Section Number	Description
1	9/29/95	3 - 5	Log of Updates	Addition (Place Behind Cover Letter)
2	9/29/95	6 - 11	Distribution List	Updated (Place Behind Log of Updates and Additional Information)
3	9/29/95	ii - v	Executive Summary	Addition (Place Behind Title Page)
4	9/29/95	vi - xx	Table of Contents	Updated to Reflect 9/29/95 Revisions and Additions (Place Behind Executive Summary)
5	9/29/95	3	Table 1-1	Updated
6	9/29/95	18 & 18a	2.3	Skunk Lake Mitigation Facilities, etc. Added to Exemption List
7	9/29/95	27	Table 2-2	Delete Towns of Crandon, Monico and Pelican from Item D
8	9/29/95	29	Table 2-3	Skunk Lake Mitigation Facilities, etc. Added to Exemption List
9	9/29/95	37	4.5	Clarification Re: Waste Rock
10	9/29/95	45	4.8.5	Clarification of Primary Exhaust Point and Waste Rock Disposition
11	9/29/95	50	4.8.5.8 & 4.8.5.9	Clarification of Air Intake and Waste Rock Disposition
12	9/29/95	53	4.8.6.2 & 4.8.6.3	Clarification of Fixed Dust Collector Locations and Update of Groundwater Inflow Estimates
13	9/29/95	59	4.8.8.1	Clarification of Exhaust Point
14	9/29/95	70, 71 & 73	4.8.10	Update to make consistent with *Preliminary Engineering Report for Wastewater Treatment Facilities*
15	9/29/95	79 & 80	4.8.11.9	Include Description of Water Storage Tanks and Non-potable Wash Water Well
16	9/29/95	80a	4.8.11.11	Located Section on New Page

Log of Updates *(Continued)*

Entry Number	Date Revision Issued	Page(s)	Document/ Section Number	Description
17	9/29/95	85	4.9.2.7	Update Crusher Capacity
18	9/29/95	89	Table 4-9	Update Wastewater Treatment Reagent Consumption Data/Reagent Names
19	9/29/95	129 - 139	4.12	Added Environmental Protection Section
20	9/29/95	139 - 182	4.13	Added Risk Assessment Section
21	9/29/95	183 - 228	5	Reprinted Reclamation Plan due to Page Number Changes
22	9/29/95	193 - 195	5.6.1.2	Added Discussion Regarding Reflooded Mine
23	9/29/95	207	5.7.1.5	Added Reference
24	9/29/95	229 - 231	6	Added Updated Water Balance Data
25	9/29/95	232 - 253	7	Added Section
26	9/29/95	254 - 261	8	Added Section
27	9/29/95	262	9	Added Section
28	9/29/95	263 - 275	10	Added Section
29	9/29/95	276 - 279	11	Provided Updated Reference List
30	9/29/95	280	Figure Title Page	Update Page Number on Figure Title Page
31	9/29/95	—	Figure 4-28	Updated to Add TMA Well/Revise Potable Well Location
32	9/29/95	—	Figures 4-58 through 4-62	Add New Figures
33	9/29/95	—	Figures 6-1 through 6-3	Update Water Balances to Reflect Updated Mine Inflow Estimates

Log of Updates *(Continued)*

Entry Number	Date Revision Issued	Page(s)	Document/ Section Number	Description
34	9/29/95	—	Figures 7-1 through 7-8	Add New Figures
35	9/29/95	—	Figures 10-1 through 10-4	Add New Figures
36	2/14/97	5	Log of Updates	Updated
37	2/14/97	6-11	Distribution List	Updated
38	2/14/97	vii, viii, ix, xvi, xvii, xx	Table of Contents	Updated
39	2/14/97	50-51	Section 4.8.5.9	Updated waste rock storage information
40	2/14/97	61	Section 4.8.9.1	Updated terminology
41	2/14/97	63	Section 4.8.9.1.2	Added explanation of Table 4-3
42	2/14/97	63	Table 4-3	Updated waste rock and wastewater treatment solids quantities
43	2/14/97	70-70l	Section 4.8.9.3	Added new section
44	2/14/97	83	Section 4.9.2.3	Updated waste rock estimate
45	2/14/97	276-278	Section 11	Updated reference list
46	2/14/97	—	Appendix C	Added appendix
47	4/21/97	5	Log of Updates	Updated
48	4/21/97	70b-70c	Sections 4.8.9.3.4 and 4.8.9.3.5	Updated to clarify waste rock classification criteria

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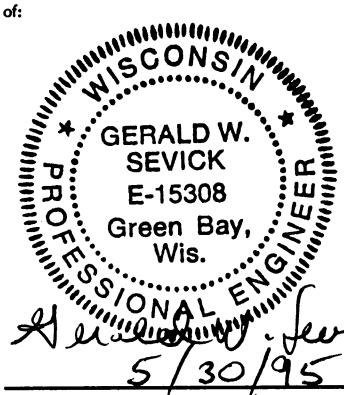
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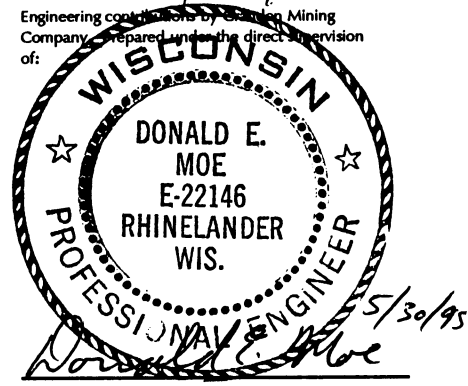
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Engineering contributions by Foth & Van Dyke and Associates, Inc. Prepared under the direct supervision of:



Engineering contributions by Crandon Mining Company. Prepared under the direct supervision of:



Mine Permit Application for the Crandon Project

93C049

Prepared for
Crandon Mining Company
Rhinelander, Wisconsin

Prepared by
Foth & Van Dyke and Associates Inc.

May 1995

Foth & Van Dyke 1995
2737 S. Ridge Road, P.O. Box 19012, Green Bay, Wisconsin 54307-9012, 414/497-2500, FAX: 414/497-8516

Executive Summary

Introduction

The Mine Permit Application (MPA) for the Crandon Project presents details relating to the plans and methods Crandon Mining Company will use to build, operate, monitor and reclaim the mine and related facilities. The mine permit, if granted, will regulate the removal, storage, handling and processing of ore, and the management of waste materials from mining. In addition to a detailed description of facilities, operations and environmental protection measures, the MPA covers the major areas listed below.

Project Overview

The Crandon ore body runs east-west in the Towns of Nashville and Lincoln in Forest County, extending to a depth of 2,000 feet. The 55 million ton ore body consists of two distinct types of mineralization, zinc ore and copper ore, and is of volcanic origin. Ore will be mined at a rate of 5,500 tons per day by underground methods, mainly blasthole open stoping followed by backfilling. Ore will be removed by controlled blasting, crushed underground, and hoisted to the surface for milling. The resulting ore concentrates will be shipped by rail out of state for smelting.

The total land area used by mine facilities will be about 550 acres. Mine plant site facilities will include a headframe, underground workings, an ore storage area, ore concentrating facility (mill), miscellaneous support facilities, water treatment facility, tailings management area (TMA), and water management features. The surface facilities will be concentrated on 128 acres next to the main production shaft. Part of this area will be used for buildings, roads, electric transmission lines and ancillary facilities. The remaining land will be either retained in its natural state or, if disturbed during construction, revegetated for erosion control and aesthetics.

The TMA will be located about one mile southeast of the plant site. It will be connected to the plant site by a corridor containing a TMA access road and tailings and reclaim water pipelines. The TMA will consist of four tailings cells engineered, built and operated for environmentally safe, long-term management of tailings. The tailings cells will be built and reclaimed in stages over the operating life of the mine and will ultimately occupy 355 acres.

The mine will be built, operated and reclaimed according to the following timetable:

Activity	Project Year
Construction	1-3
Operation	4-31
Closure/reclamation	32-35
Long-term care	36-75

Financial Responsibility

Crandon Mining Company (CMC) is a Wisconsin general partnership that was formed on September 13, 1993, by subsidiaries of Exxon Corporation and Rio Algom Limited to own, obtain permits for, develop and operate the proposed Crandon zinc-copper mine. CMC will have primary responsibility for compliance with the financial responsibility provisions of state law by making all financial commitments reasonably necessary to ensure the reclamation, long-term care, and long-term environmental integrity of the mine site and all related facilities. Such commitments will include one or more bonds, or one or more of the other financial security methods allowed by law.

Reclamation Plan

Reclamation will restore the site to a long-term, environmentally stable condition and return the plant site to productive use for forestry and recreation. Reclamation will be an ongoing process from construction through the operations phase. Whenever work is completed in a given area, reclamation in that area will start.

Final reclamation of the site will begin on completion of mining and ore processing. Salvageable equipment and material from the underground mine will be brought to the surface. Unsalvageable equipment will be cleaned and left underground. Accesses to the mine will be plugged with reinforced concrete. Surface facilities will be converted to other uses or removed. The site will be regraded and revegetated.

Each of the tailings cells will be reclaimed at the end of its operating life. Final reclamation will involve the capping of each cell with a composite clay and a synthetic geomembrane liner. Drainage from the top of each cell will be directed to natural area drainageways. The water treatment facility will be removed after it is no longer needed.

Risk Assessment

As required by state regulations, CMC prepared a detailed risk assessment, describing accidental health and environmental hazards that might possibly be associated with the mine. The risk assessment lists possible incidents, including spills of fuel, spills of reagents used in the milling process, truck or rail accidents involving materials being shipped to or from the mine, damage to mine facilities from floods, earthquakes, fires and storms, and failures of the mine's environmental control systems. Each incident is assigned a level of risk based on how likely it is to occur and what the impact would be if it did occur. Identified risks were found to be either negligible or minor. The results of the risk assessment appear in Section 6 of the MPA.

Mine Water Balance

The average groundwater inflow into the mine is projected at approximately 600 gallons per minute. The average discharge to the Wisconsin River is estimated at approximately 460 gallons per minute.

Monitoring Plan

CMC will conduct extensive environmental monitoring during mine construction and operation. Information gathered via the monitoring program will be used to detect unexpected conditions so that the cause can be identified and, if necessary, corrective action taken. The monitoring program will include:

- Regional groundwater level monitoring, designed to detect potential effects on water levels in local lakes, streams and wetlands.
- Tailings management area groundwater monitoring, designed to assess compliance with groundwater quality standards.
- Mine Site groundwater monitoring, designed to gather current information about groundwater near the mine, to be used after mine closure to assess compliance with groundwater quality standards.
- Plant site groundwater monitoring, designed to assess compliance with groundwater quality standards.
- Monitoring of the rate of groundwater inflow into the mine.
- Monitoring of the volume and quality of leachate pumped out of the tailings cells by way of the collection system.
- Monitoring of lakes and streams for water quality, lake levels, and stream flow rates.
- Monitoring of water levels and vegetation conditions in area wetlands.
- Monitoring of air quality.

Contingency Plan

The project contingency plan is designed so that CMC is prepared to respond quickly and effectively if the monitoring program were to detect a potential environmental problem related to the mine. The contingency plan lists specific steps CMC would take to investigate, evaluate and, if necessary, correct unexpected conditions that may affect groundwater, private wells, surface waters and wetlands.

Emergency Notification

The project risk assessment shows that there is a very low likelihood of any major incident at the mine, such as a major spill, an accidental detonation of explosives, or a fire. Nonetheless, CMC has prepared a list of appropriate federal, state and local government agencies to be contacted if such an event were to occur.

Long-Term Care and Maintenance

The long-term care period for the site will start immediately after the mine has been closed and reclaimed (approximately year 35). Long-term care and maintenance will document that project reclamation has been effective and that the land has been restored to an environmentally stable condition.

Long-term care includes inspection of the site; maintenance of land forms, vegetation and monitoring devices; and monitoring of groundwater, leachates from the TMA, surface waters, wetlands and terrestrial ecology.

After the 40 year long-term care period, CMC, by state law, is perpetually responsible for the routine care, maintenance and monitoring.

Mine Permit Application
Crandon Mining Company

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1 Introduction

Crandon Mining Company (CMC) is proposing to develop an underground zinc-copper mine in Forrest County, Wisconsin. Pursuant to Wisconsin Administrative Code (WAC) Chapter NR 132.05, a Notice of Intent to Collect Data and Detailed Scope of Study (NOI/SOS) for the Crandon Project was submitted to the Wisconsin Department of Natural Resources (WDNR) on February 15, 1994 by CMC. As part of further development of this project, numerous federal, state and local environmental, construction, building and safety permits and approvals need to be obtained. This submittal constitutes CMC's Mine Permit Application (MPA). This MPA is prepared in accordance with §144.85(3)(a), Wisconsin Statutes, and Section NR 132, WAC, and is submitted to the WDNR Mine Reclamation Section. The mining permit will regulate the storage, handling, processing, and transportation of concentrates and disposal of waste material resulting from the proposed mining operation.

This MPA is based on engineering and other environmental studies as they relate to the design, operation, closure and post-operational care and maintenance of the Crandon facilities. The material presented in this application is representative of the type and size of facilities to be constructed and operated as part of the Crandon Project. During final design it is likely that some modification in the engineering and operational details of the facilities and systems will occur.

The MPA is intended to be self-contained; however some cross-referencing to the Environmental Impact Report (EIR) and its appendices, is necessary. The referenced documents form part of the MPA but are not included in this permit application.

This MPA is organized into 11 sections. The first section is the introduction. The second section contains the completed WDNR "Mining Permit Application" form (Form 2700-4). Section 2 also includes or cites various attachments required on the application form. Section 3 addresses CMC's preferred method for providing financial security. Section 4 is the Mine Plan, which contains detailed information concerning the design, construction and operation of the Crandon Project facilities. An erosion control plan and risk assessment is also contained in Section 4. Sections 5 and 6 contain the proposed reclamation plan and water budget for the Crandon Project, respectively. Section 7 addresses environmental monitoring for the Crandon Project through the operation phase. Sections 8, 9, 10 and 11 address the contingency plan, emergency notifications procedures, long-term care and maintenance, and references, respectively.

Within this application there are numerous references to the "project area", "mine site", "plant site" and the "tailings management area". These terms have specific meanings as follows.

- Project Area - The project area is defined by the boundaries delineated on Figure 1-1.
- Mine Site - The mine site is defined by the limits of disturbance of project facilities within the project area.
- Plant Site - The plant site is generally defined as the area within the "mine site" that includes all mining, processing, concentrating, wastewater treatment, administrative, and storage facilities; portions of the railroad spur in the vicinity of the plant site; portions of the access road in the vicinity of the plant site; ventilation raises; and the

project's water supply well and its accompanying typical 30 foot wide pipeline line corridor. The plant site also includes all surface water runoff and storage basins constructed in its vicinity.

- Tailings Management Area (TMA) - The TMA is defined as the area within the "mine site" that includes the project's four tailings cells and berms, the reclaim pond, the reclaim water pipeline and access road corridors, and the contiguous borrow and storage areas. The TMA also includes all surface water drainage facilities constructed in its vicinity.

Figure 1-1 is a United States Geological Survey (USGS) topographic quadrangle map delineating the project area, which has a total area of approximately 2,700 acres. The plant site and TMA are approximately 128 acres and 355 acres in size, respectively.

Two additional areas located outside of the project area include the narrow corridor from the intersection of the site access road and State Trunk Highway (STH) 55 to the Wisconsin River in which the project's treated wastewater discharge line is to be located, and the project's wetland mitigation site located off-site in Shawano and Oconto Counties. The proposed location of the wastewater pipeline from the project area to the Wisconsin River is shown in Figure 1-2. Design information for the discharge pipeline to the Wisconsin River is included as part of the wastewater treatment system engineering report prepared pursuant to Wisconsin Administrative Codes. Design information relative to the wetland mitigation site is included as part of the Federal Clean Water Act Section 404 permit application forwarded to the USCOE. For completeness the description of the environmental aspects associated with these areas are included in the project's EIR.

A number of parallel applications have been (or will shortly be) submitted to the WDNR and United States Army Corps of Engineers (USCOE) in support of the Crandon Project permitting process. The major documents and permit applications are listed below:

- Environmental Impact Report
- Air Pollution Control Permit Application
- Industrial Wastewater Treatment Plant Permit Application
- Wisconsin Pollutant Discharge Elimination System Permit (WPDES)
- Groundwater Withdrawal Permit Application
- Water Regulatory Permits pursuant to Wisconsin Statute Chapters 30 and 31
- Water Regulatory Permit under Section 404 of the Federal Clean Water Act
- Feasibility Report and Plan of Operation for the Tailings Management Area

An attempt has been made during the preparation of these documents to avoid duplication. Therefore, this permit application refers to information provided in the above documents whenever possible.

Table 1-1 is a list of contributors for this MPA. Additional information including the previous Crandon Project submittals and the 1995 EIR were also utilized as a basis for this permit application.

Table 1-1

Mine Permit Application
List of Contributors

Crandon Mining Company
7 North Brown Street, 3rd Floor
Rhinelander, WI 54501-3161
(715) 365-1450

Foth & Van Dyke & Associates
2737 S. Ridge Road
P.O. Box 19012
Green Bay, WI 54307-9012
(414) 497-2500

GeoTrans, Inc.
1080 Holcomb Bridge Road
Building 100, Suite 300
Roswell, GA 30076
(404) 642-1000

Steffen Robertson and Kirsten (US), Inc.
3232 South Vance Street
Lakewood, CO 80227
(303) 985-1333

A. MacG. Robertson and Associates, Inc.
580 Hornby Street, Suite 902
Vancouver, B.C. Canada V6C 3B6
(604) 684-8072 (AR ext. #233)

Thresher & Son, Inc.
2828 Regent Street
Madison, WI 53705
(608) 223-0297

Dr. Richard W. Lawrence
Lawrence Consulting Limited
103-2298 West 1st Avenue
Vancouver, B.C. Canada V6K 1G1

Fugro-McClelland, Inc.
6 Maple Street, P.O. Box 1130
Northborough, MA 01532
(508) 393-6779

PACE Laboratories
1710 Douglas Drive North
Minneapolis, MN 55422
(612) 544-5543

WTD Drilling, Inc.
101 Alderson Street
P.O. Box 89
Schofield, WI 54476
(715) 359-7090

Inman-Foltz & Associates, Inc.
8612 Highway 51 North
Minocqua, WI 54548
(715) 356-9485

Aero-Metrics
4708 North 40th Street, P.O. Box 449
Sheboygan, WI 53081-0449
(414) 457-3631

Prairie Restoration, Inc.
P.O. Box 327
Princeton, MN 55371
(612) 389-4342

2 Completed Mine Permit Application Form with Attachments

Crandon Mining Company's completed and signed MPA form for the Crandon Project appears on the following pages. The various attachments or information that are requested on the application form are addressed below. Included in Table 2-1 is a key to the location of NR 132.06, Application to Mine, NR 132.07, Mining Plan, and NR 132.08, Reclamation Plan requirements. The key identifies pertinent sections of the Wisconsin Administrative Code, and provides the location of the text within this MPA where the information can be found.

2.1 Legal Description

The Crandon ore body is located in Forest County, Wisconsin. The civil land survey location is Section 25, Township 35 North, Range 12 East, Town of Nashville, and Section 30, Township 35 North, Range 13 East, Town of Lincoln. This area is illustrated on Figure 1-1. The project site is located five miles south of the city of Crandon and two miles east of STH 55. The site is one-quarter mile north of Little Sand Lake and one mile south of Swamp Creek. Mine surface facilities will be located directly north of the ore body. The proposed site layout is shown in Figure 2-1. Access will be from a proposed new service road from STH 55 northwest of the site. A railroad spur serving the site will be connected northeasterly to the existing Wisconsin Central Limited Railroad. The project's tailing management area (TMA) will be located approximately one mile southeast of the plant site.

State of Wisconsin
Department of Natural Resources
Mine Reclamation Section
Box 7921
Madison, WI 53707

MINING PERMIT APPLICATION
ss. 144.80 - 144.94, Wis. Stats., and
Chapter NR 132, Wis. Adm. Code
Form 2700-4 Rev. 11-92

INSTRUCTIONS:
Please submit 25 copies of this application and other necessary documents in reproducible form to the above address. Assistance in completing this application and other associated work is available from the Mine Reclamation Section, Department of Natural Resources, Madison, WI.

SECTION A - GENERAL INFORMATION

1. Name of Applicant
Crandon Mining Company

2. Street or Route
7 North Brown Street, Third Floor

City, State, Zip Code
Rhinelander, WI 54501-3161

3. Applicant is (√ one)
- ☐ Individual
- ☐ Sole Proprietorship
- ☒ Partnership
- ☐ Corporation
- ☐ Other (Explain) _____

4. Is Applicant a ☐ Division or ☐ Subsidiary of Another Corporation
- ☐ Yes (If Yes, State Name and Address of Parent Corporation)
- ☒ No

Crandon Mining Company is a Wisconsin general partnership formed by subsidiaries of Exxon Corporation and Rio Algom Limited. See MPA Section 3 for details.

5. If Applicant is a Corporation, is it Incorporated Under Wisconsin Law
☐ Yes ☐ No

6. If Applicant is Incorporated Outside Wisconsin, Does it Hold a Valid Certificate of Authority to do Business in Wisconsin Issued by the Secretary of State
☐ Yes ☐ No

7. Attach a legal description of the mining site and delineate the area on a United States geological survey topographic quadrangle map(s). The Map(s) shall be at a scale of 1:24,000 wherever available and at a scale of 1:62,500 elsewhere.

8. Attach a list of names and addresses of each owner of land within the mining site and each person known by the applicant to hold any option or lease on land within the mining site and all prospecting and mining permits in this state held by the applicant.

9. Provide evidence that the applicant has applied for necessary approvals and permits under all applicable zoning ordinances and that the applicant has applied for all necessary approvals, licenses or permits required by the Department.

10. Attach information related to the regulatory compliance history of the applicant or related person in accordance with s. 144.85(3)(e), Wis. Stats.

11. Attach information relating to whether unsuitability may exist for surface mining to the extent not fully considered in s. 144.84, Wis. Stats.

12. Attach an itemized statement showing the estimation of the cost to the state of reclamation.

13. Attach descriptions of land contiguous to the proposed mining site which the applicant owns, leases or has an option to purchase or lease.

14. Attach information related to the minimization of disturbance to wetlands in accordance with s. NR 132.06(4), Wis. Adm. Code.

15. Attach a proposed monitoring and quality assurance plan consistent with the requirements of Chapters NR 132 and NR 182, Wis. Adm. Code, and s. 1.11, Wis. Stats.

The Department may require the submission of additional information if it feels that such information is necessary to complete the Mining Permit Application.

SECTION B - FINANCIAL RESPONSIBILITY

1. Attach one copy each of the applicant's and parent company's (where applicable) most recent annual report and most recent Form 10-K as filed with the Securities and Exchange Commission. If these are not available, attach a report of the applicant's current assets and liabilities and other necessary data to establish that the applicant is competent to conduct mining in a manner consistent with the requirements and purpose of ss. 144.80 - 144.94, Wis. Stats.

2. Attach an explanation and supporting documentation of how the applicant will comply with the financial responsibility provisions of s. NR 132.09, Wis. Adm. Code.

SECTION C - FEE

Enclose a fee of $10,000.00 to cover the initial costs of evaluating the operator's mining permit application. Upon completion of its evaluation, the Department shall adjust this fee to reflect the actual cost of evaluation less any fees paid for the same services to satisfy other requirements.

SECTION D - MINING AND RECLAMATION PLANS

1. Attach a mining plan prepared in accordance with s. 144.85(3)(a), Wis. Stats., and s. NR 132.07, Wis. Adm. Code.
2. Attach a reclamation plan and timetable prepared in accordance with s. 144.834, Wis. Stats., and s. NR 132.08, Wis. Adm. Code.

SECTION E - CERTIFICATION

I hereby certify that the information contained in this application is true and correct to the best of my knowledge, and belief. I agree to furnish such further information as may be required by the Department of Natural Resources to complete this application.

Dated Rhinelander (City) Wisconsin (State), this 30th day of May, 19 95.

(Signature of Responsible Official) PRESIDENT (Title)

Table 2-1

NR 132.06 through 132.08 Information Key

Code	Description	Location of Information
NR 132.06 Application to Mine		
NR 132.06(1)	No person may engage in mining or reclamation at any site not covered by a mining permit and written authorization to mine per NR 132.09(3).	Acknowledged
NR 132.06(2)	25 copies of MPA shall be filed with WDNR (one reproducible copy). Further copies to: • Clerk of county, city, village, town. • County or municipal library.	Cover letter
NR 132.06(3)	The application shall be accompanied by the following:	See below
NR 132.06(3)(a)	$10,000 fee.	Acknowledged, submitted with MPA
NR 132.06(3)(b)	Mining plan per NR 132.07.	MPA, Section 4 (Mining Plan)
NR 132.06(3)(c)	Reclamation plan per NR 132.08.	MPA, Section 5 (Reclamation Plan)
NR 132.06(3)(d)	Monitoring and quality assurance plan per NR 182, § 1.11.	MPA, Sections 7 (Monitoring Plan Through Operation) and MPA, Section 10 (Long Term Care and Maintenance)
NR 132.06(3)(e)	A list of names and addresses of each person with option or lease on land within mine site.	Table 2-2 (Land Ownership)
NR 132.06(3)(f)	Evidence that necessary approval, permits and licenses have been received or applied for.	MPA, Section 2.3 (Approvals & Exemption Requests)
NR 132.06(3)(g)	Bond forfeiture information of applicant.	MPA, Section 2.4 (Bond & Operations In Other States)
NR 132.06(3)(h)	Unsuitability of surface mining to extent covered in § 144.84.	MPA, Section 2.5 (Suitability)
NR 132.06(3)(i)	Reclamation cost.	MPA, Section 2.6 (Reclamation Costs, Summary) and MPA, Section 5.12 (Reclamation Costs)
NR 132.06(3)(j)	Description of contiguous land owned, leased, or optioned by applicant.	MPA, Section 2.7 (Description of Contiguous Land)
NR 132.06(3)(k)	Other information department may require.	
NR 132.06(4)	To meet NR 1.95 directives and rules the following standards apply:	See below

Table 2-1 *(Continued)*

Code	Description	Location of Information
NR 132.06(4)(a)	Site selection objective to select viable site that would result in least overall adverse environmental impact.	EIR, Section 3.10 (Wetlands) EIR, Section 4.2.9 (Wetland Impacts) MPA, Section 2.8 (Minimization of Wetland Disturbance) TMA, Section 10.1 (Alternative Site Evaluation)
NR 132.06(4)(b)	Identify and analyze various alternatives with regard to environmental acceptability as result of § 1.11 and other laws.	EIR, Section 4 (Impact Analysis)
NR 132.06(4)(c)	Applicant to identify and department analyze viable site with least overall adverse environmental impact which would also avoid wetlands (or least wetland acreage affected).	EIR, Section 3.10 (Wetlands) EIR, Section 4.2.9 (Wetland Impacts) MPA, Section 2.8 (Minimization of Wetland Disturbance)
NR 132.06(4)(d)	The use of or affecting of wetlands for mining activities are presumed to be unnecessary unless the applicant demonstrates, taking into account economic, environmental, technical, recreational and aesthetic factors, that the site proposed for use:	See below
NR 132.06(4)(d)(1)	Constitutes a viable use.	EIR, Section 4.2.9 (Wetland Impacts)
NR 132.06(4)(d)(2)	Is the alternative which causes the least overall adverse environmental impact.	EIR, Section 4.2.9 (Wetland Impacts)
NR 132.06(4)(d)(3)	Will be used in a manner so as to minimize loss of wetlands and net loss of the function of those wetlands, other wetlands, or other waters of the site.	EIR, Section 3.10 (Wetlands) EIR, Section 4.2.9 (Wetland Impacts) MPA, Section 2.8 (Minimization of Wetland Disturbance)
NR 132.06(4)(e)	These rules apply to existing site per § 144.44(4)(a) and 144.92(2).	See below
NR 132.06(4)(f)	The department shall give special consideration to a site that the degree of improvements cannot be accomplished without affecting wetlands.	EIR, Section 3.10 (Wetlands) EIR, Section 4.2.9 (Wetland Impacts) MPA, Section 2.8 (Minimization of Wetland Disturbance)
NR 132.06(4)(g)	Applicant shall assist in evaluation of environmental impacts as mandated herein. The following wetlands, functions and values shall be considered except as provided in par.(h).	See below
NR 132.06(4)(g)(1)	Biological functions.	EIR, Section 3.10 (Wetlands) EIR, Section 4.2.9 (Wetland Impacts)

Table 2-1 *(Continued)*

Code	Description	Location of Information
NR 132.06(4)(g)(2)	Watershed functions.	EIR, Section 3.10 (Wetlands) EIR, Section 4.2.9 (Wetland Impacts)
NR 132.06(4)(g)(2)(a)	Hydrologic support functions.	EIR, Section 3.10 (Wetlands) EIR, Section 4.2.9 (Wetland Impacts)
NR 132.06(4)(g)(2(b)	Groundwater Function.	EIR, Section 3.10 (Wetlands) EIR, Section 4.2.9 (Wetland Impacts)
NR 132.06(4)(g)(2)(c)	Storm and flood water storage.	EIR, Section 3.7 (Surface Water) EIR, Section 3.10 (Wetlands)
NR 132.06(4)(g)(2)(d)	Shoreline protection.	EIR, Section 3.7 (Surface Water)
NR 132.06(4)(g)(2)(e)	Other watershed functions in assessment of a particular wetland to the performance of watershed functions which influence the physical, chemical and biological properties related to waters, the following shall be considered:	EIR, Section 3.7 (Surface Water) EIR, Section 3.8 (Aquatic Biology) EIR, Section 3.10 (Wetlands) EIR, Section 4.2.9 (Wetland Impacts)
NR 132.06(4)(g)(2)(e)(1)	Density and distribution of plants.	EIR, Section 3.10 (Wetlands) EIR, Section 4.2.9 (Wetland Impacts)
NR 132.06(4)(g)(2)(e)(2)	Area, depth and basin shape.	EIR, Section 3.10 (Wetlands) EIR, Section 4.2.9 (Wetland Impacts)
NR 132.06(4)(g)(2)(e)(3)	Hydrologic regime.	EIR, Section 3.7 (Surface Water) EIR, Section 3.10 (Wetlands) EIR, Section 4.2.9 (Wetland Impacts)
NR 132.06(4)(g)(2)(e)(4)	Physical, chemical and biological properties of water and soil.	EIR, Section 3.7 (Surface Water) EIR, Section 3.10 (Wetlands) EIR, Section 4.2.9 (Wetland Impacts)
NR 132.06(4)(g)(2)(e)(5)	Relationship of wetland size to watershed size.	EIR, Section 3.7 (Surface Water) EIR, Section 3.10 (Wetlands) EIR, Section 4.2.9 (Wetland Impacts)
NR 132.06(4)(g)(2)(e)(6)	The number and size of other wetlands remaining in that watershed.	EIR, Section 3.10 (Wetlands)
NR 132.06(4)(g)(2)(e)(7)	Topography of watershed.	EIR, Section 3.5 (Geology and Soils) EIR, Section 3.7 (Surface Water) MPA, Figure 1-1 (Site Topography) EIR, Section 4.2.9 (Wetland Impacts)

Table 2-1 *(Continued)*

Code	Description	Location of Information
NR 132.06(4)(g)(2)(e)(8)	Position of the wetland within the watershed relative to springs, lakes, rivers and other waters.	EIR, Section 3.7 (Surface Water) EIR, Section 3.10 (Wetlands) EIR, Section 4.2.9 (Wetland Impacts)
NR 132.06(4)(g)(2)(e)(9)	Land use practices and trends within the watershed or the likelihood of nutrient, sediment or toxin loads increasing.	EIR, Section 3.10 (Wetlands) EIR, Section 3.12 (Land Use and Zoning) EIR, Section 4.2.9 (Wetland Impacts)
NR 132.06(4)(g)(3)	In assessing the recreational, cultural and economic potential of a particular wetland, the following should be considered:	See below
NR 132.06(4)(g)(3)(a)	Wetland type.	EIR, Section 3.10 (Wetlands) EIR, Section 4.2.9 (Wetland Impacts)
NR 132.06(4)(g)(3)(b)	Size.	EIR, Section 3.10 (Wetlands) EIR, Section 4.2.9 (Wetland Impacts)
NR 132.06(4)(g)(3)(c)	Suitability and compatibility for the different types of recreational uses.	EIR, Section 3.10 (Wetlands) EIR, Section 4.2.9 (Wetland Impacts)
NR 132.06(4)(g)(3)(d)	Legal access.	MPA, Section 2 (Mine Permit Application)
NR 132.06(4)(g)(3)(e)	Assessibility without damage to other wetland values or functions.	EIR, Section 3.10 (Wetlands) EIR, Section 4.2.9 (Wetland Impacts)
NR 132.06(4)(g)(3)(f)	Proximity to users.	MPA, Section 2.8 (Minimization of Wetland Disturbance) EIR, Section 3.10 (Wetlands) EIR, Section 4.2.9 (Wetland Impacts)
NR 132.06(4)(g)(3)(g)	Position in relation to lakes, rivers and other waters.	EIR, Section 3.6 (Groundwater) EIR, Section 3.10 (Wetlands) EIR, Section 4.2.9 (Wetland Impacts)
NR 132.06(4)(g)(3)(h)	Whether it provides a habitat for or produces species of recreational, cultural or economic interest.	EIR, Section 3.10 (Wetlands) EIR, Section 4.2.9 (Wetland Impacts)
NR 132.06(4)(g)(3)(i)	Whether products of some wetlands (*e.g.*, wild rice, fur bearers, fish) have a special cultural value and/or provide a significant portion of the economic base for the people in the region.	EIR, Section 3.14 (Socioeconomics) EIR, Section 4.2.9 (Wetland Impacts) EIR, Section 4.2.13 (Socioeconomic Impacts)
NR 132.06(4)(g)(4)	Scarcity of wetland type.	EIR, Section 3.10 (Wetlands) EIR, Section 4.2.9 (Wetland Impacts)

Table 2-1 *(Continued)*

Code	Description	Location of Information
NR 132.06(4)(g)(5)	Aquatic study areas, sanctuaries and refuges.	EIR, Section 3.8 (Aquatic Biology) EIR, Section 3.10 (Wetlands) EIR, Section 4.2.9 (Wetland Impacts)
NR 132.06(4)(g)(6)	The ecosystem concept in a regional context.	EIR, Section 3.10 (Wetlands) EIR, Section 4.2.9 (Wetland Impacts)
NR 132.06(4)(h)	All wetlands that are to be used by the proposed activity shall be inventoried and analyzed pursuant to this chapter. The use of such wetlands shall be de minimis and, therefore, exempt from further application of this section, if the applicant demonstrates the following by a preponderance of evidence:	See below
NR 132.06(4)(h)(1)	Wetlands to be used are or can be made to be sufficiently hydrologically isolated from the surface and underground waters of the state that no violations of applicable laws and regulations would result.	EIR, Section 3.10 (Wetlands) EIR, Section 4.2.9 (Wetland Impacts)
NR 132.06(4)(h)(2)	The wetlands are not special or unique utilizing the results of the analysis made pursuant to this chapter.	EIR, Section 3.10 (Wetlands) EIR, Section 4.2.9 (Wetland Impacts)
NR 132.06(4)(h)(3)	The area of wetlands to be used shall not exceed 5 acres.	MPA, Section 2.3 (Approvals and Exemption Requests) MPA, Section 2.8 (Minimization of Wetland Disturbance)
NR 132.06(5)	The burden of proof to establish compliance with the requirements of this chapter shall be on the operator.	Acknowledged
NR 132.06(6)	The hearing procedure outlined in §144.836 stats shall govern all hearings on the operator's mining permit application.	Acknowledged
NR 132.07 Mine Plan		
NR 132.07(1)	Detailed map per §144.85(3)(a).	Figures 1-1, 2-1, among others

Table 2-1 *(Continued)*

Code	Description	Location of Information
NR 132.07(2)	Details of nature, extent and final configuration of proposed excavation and mining site including: • Tailings-location and total production. • Other mine refuse. • Overburden-nature and depth.	TMA, Section 4.1 (Estimated waste types and quantities to be stored) TMA, Section 5.0 (Geological and Hydrogeologic Conditions) TMA, Section 6.1.2 (Facility Description) MPA, Section 4.8.9.1.2 (Figure 1-1) MPA, Section 4.8.9.1.1 EIR, Section 3.5 (Geology and Soils)
NR 132.07(3)	Details of proposed operating procedures (may reference documents submitted per NR 182) including:	See below
NR 132.07(3)(a)	Mining operation sequence.	MPA, Section 4.8 (Description of Facilities) MPA, Section 4.9 (Operations)
NR 132.07(3)(b)	Handling of overburden material.	MPA, Section 4.8.5.9 (Pre-production Ore and Waste Storage Area)
NR 132.07(3)(c)	Tailings production, handling and final disposition.	TMA, Section 4.0 (Waste Characterization and Analysis, NR 182.08(2)(b)(1).) MPA, Section 4.9.3 (Mill Operating) MPA, Sections 4.9.4.5.1 (Tailings Transport System)
NR 132.07(3)(d)	Ore processing including milling concentrating, refining, etc.	MPA, Section 4.9.3 (Mill Operations)
NR 132.07(3)(e)	Final product storage, loading and transportation.	MPA, Section 4.9.3.4 (Concentrate Handling and Load Out)
NR 132.07(3)(f)	Groundwater and surface water management techniques, including: • Erosion prevention. • Drainage control. Detailed water management plan showing: • Source. • Flow path. • Storage volumes. • Release points.	MPA, Section 4 MPA, Section 4.8.4 (Aesthetics and Landscaping) Reclamation Plan, Section 5 (Erosion Control Techniques for Use During Facility Construction) MPA, Section 4.10 (Erosion Control) MPA, Figure 4-22, Figures 4-49 thru 4-52, Figures 4-53 thru 4-56

Table 2-1 *(Continued)*

Code	Description	Location of Information
NR 132.07(3)(g)	Plans for water resulting from the operation for: • Collection. • Treatment. • Discharge.	MPA, Section 4.8.6.3 (Mine Drainage System) MPA, Section 4.8.10 (Wastewater Treatment) MPA, Section 4.9.4 (Wastewater Treatment and Exchange) MPA, Section 4.9.6.2 (Treatment of Sanitary Wastes) MPA, Section 6.0 (Preliminary Water Budget)
NR 132.07(3)(h)	Plans for air quality protection per §144.30 through §144.426.	Air Pollution Control Permit
NR 132.07(3)(i)	Risk assessment with contingency measures.	MPA, Section 4.13 (Risk Assessment)
NR 132.07(3)(j)	Public and agency notification measures of hazardous conditions.	MPA, Section 9.0 (Emergency Notification Procedures)
NR 132.07(3)(k)	Surface facilities description.	MPA, Section 4.8 (Description of Facilities)
NR 132.07(3)(l)	Description of all geological/geotechnical investigations and drilling programs.	EIR, Section 3.5 (Geology and Soils) TMA, Section 5 (Description of the Existing Environment)
NR 132.07(4)	Minimum standards.	See below
NR 132.07(4)(a)	Grading and stabilization of excavation.	MPA, Section 4.8 (Description of Facilities) MPA, Section 4.9 (Operations) MPA, Section 4.10 (Erosion Control)
NR 132.07(4)(b)	Grading and stabilization of deposits of mining refuse.	MPA, Section 4.8.5.9 (Pre-production Ore and Waste Storage Area) MPA, Section 4.10 (Erosion Control)
NR 132.07(4)(c)	Stabilization of merchantable by-products.	MPA, Section 4.9 (Operations)
NR 132.07(4)(d)	Adequate diversion and drainage of water from mining site to prevent erosion and contamination of surface and groundwater.	MPA, Section 4.9.4 (Wastewater Treatment and Discharge) MPA, Section 4.10 (Erosion Control)
NR 132.07(4)(e)	Backfilling of excavations where procedures will not interfere with mining operations and will not:	MPA, Section 4.9.2.8 (Backfill Handling Underground) MPA, Section 5.6.1.2 (Mine Closure)
NR 132.07(4)(e)1	Cause change in groundwater quality.	See above
NR 132.07(4)(e)2	Adversely affect public health or welfare.	See above

Table 2-1 *(Continued)*

Code	Description	Location of Information
NR 132.07(4)(f)	Handle and store all materials in an environmentally sound manner [ref. NR 182.08(2)(b)].	MPA, Section 4.8 (Description of Facilities) MPA, Section 4.9 (Operations) MPA, Section 4.10 (Erosion Control)
NR 132.07(4)(g)	Removal and stockpiling of topsoil with environmental considerations and reclamation.	MPA, Section 4.8.11.6 (Topsoil and Mulch Storage Area) MPA, Section 4.10.5.1 (Topsoil Removal and Preservation)
NR 132.07(4)(h)	Maintain adequate vegetation where feasible to prevent erosion.	MPA, Section 4.10 (Erosion Control) MPA, Section 5.0 (Reclamation Plan)
NR 132.07(4)(i)	Impoundment of water, where necessary, in a safe and environmentally-acceptable manner.	MPA, Section 4.8 (Description of Facilities) MPA, Section 4.9 (Operations) MPA, Section 4.10 (Erosion Control) MPA, Section 6.0 (Preliminary Water Budget)
NR 132.07(4)(j)	Adequate planning of site to achieve aesthetic standards over entire mine site, ref. §132.17 and §132.18(5).	MPA, Section 4.8.4 (Aesthetics and Landscaping) MPA, Section 5 (Reclamation Plan)
NR 132.07(4)(k)	Identify and prevent pollution as defined in §144.01(10), Stats. from leaching waste materials in accordance with state and federal solid waste laws and regulations.	TMA, Section 6.0 (Design Report NR 182.09(2)(c).) MPA, Section 4.8 (Description of Facilities) MPA, Section 4.9 (Operations)
NR 132.07(4)(l)	Identify and prevent significant environmental pollution as defined in §144.01(3), Stats.	MPA, Section 4.12 (Environmental Protection)
NR 132.07(4)(m)	Maintain appropriate emergency procedures to minimize damage to public health and safety and welfare and the environment from events in NR 132.07(3)(i).	MPA, Section 4.13 (Risk Assessment) MPA, Section 8 (Contingency Plan) MPA, Section 9 (Emergency Notification)
NR 132.07(5)	Submit plan for a preblast survey to be submitted prior to any blasting.	MPA, Section 4.11 (Preblast Survey)
NR 132.08 Reclamation Plan		
NR 132.08	The reclamation plan for the mining site shall include the following:	See below
NR 132.08(1)	Detailed information and maps on the reclamation procedures including:	MPA, Section 5 (Reclamation Plan)
NR 132.08(1)(a)	Manner, location, sequence and anticipated duration of reclamation.	MPA, Section 5 (Reclamation Plan)
NR 132.08(1)(b)	Ongoing reclamation procedures during mining operations.	MPA, Section 5 (Reclamation Plan)

Table 2-1 *(Continued)*

Code	Description	Location of Information
NR 132.08(1)(c)	Proposed interim and final topography and slope stabilization.	MPA, Section 4.10 (Erosion Control) MPA, Section 5.0 (Reclamation Plan) MPA, Figures 5-2 thru 5-4 (Plant Site) MPA, Figures 5-5 thru 5-9 (TMA Site)
NR 132.08(1)(d)	Proposed final land use and relationship to surrounding land and land use.	MPA, Section 5-4 (Final Land Use) MPA, Figure 5-1
NR 132.08(1)(e)	Plans for long-term maintenance of mining site including:	See below
NR 132.08(1)(e)(1)	Monitoring of wastes and ground and surface water quality.	MPA, Section 7 (Monitoring during Operation) MPA, Section 10 (Long-Term Care and Maintenance)
NR 132.08(1)(e)(2)	Names of persons legally and operationally responsible for long-term maintenance.	MPA Section 10.5 (Long-Term Care and Maintenance)
NR 132.08(1)(f)	Projected costs of reclamation, including estimated cost to the state of fulfilling the reclamation plan.	MPA Section 5.12 (Reclamation Costs)
NR 132.08(2)	Evidence satisfactory to the department that the proposed reclamation will conform with the following minimum standards:	See below
NR 132.08(2)(a)	All toxic and hazardous wastes, refuse, tailings and other solid waste shall be disposed of in conformance with applicable state and federal statutes or regulations.	TMA Total Report MPA Total Report
NR 132.08(2)(b)	All tunnels, shafts or other underground openings shall be sealed in a manner which will prevent seepage of water in amounts which may be expected to create a safety, health or environmental hazard, unless the applicant can demonstrate alternative uses which do not endanger public health and safety, and which conform to applicable environmental protection and mine safety laws and rules.	MPA, Section 5.6.1.2 (Mine Closure)
NR 132.08(2)(c)	All underground and surface runoff waters from mining sites shall be managed, impounded or treated so as to prevent soil erosion to the extent practicable, flooding, damage to agricultural lands or livestock, damage to wild animals, pollution of ground or surface waters, damage to public health or threats to public safety.	TMA, Section 6.9 (Surface Water Control System - Tailings Management Area) MPA, Section 4.10 (Erosion Control) MPA, Section 5.0 (Reclamation Plan)

Table 2-1 *(Continued)*

Code	Description	Location of Information
NR 132.08(2)(d)	All surface structures constructed as a part of the mining activities shall be removed, unless they are converted to an acceptable alternate use.	MPA, Section 5.0 (Reclamation Plan)
NR 132.08(2)(e)	Adequate measures shall be taken to prevent significant surface subsidence, but, if such subsidence does not occur, the affected area shall be reclaimed.	MPA, Section 5.6.1.2 (Mine Closure)
NR 132.08(2)(f)	All topsoil from surface areas disturbed by the mining operation shall be removed and stored in an environmentally acceptable manner for use in reclamation.	MPA, Section 4.8.11.6 (Topsoil and Mulch Storage Area) MPA, Section 4.10.5.1 (Topsoil Removal and Preservation)
NR 132.08(2)(g)	All disturbed surface areas shall be revegetated as soon as practicable after the disturbance to stabilize slopes and prevent air and water pollution, with the objective of re-establishing a variety of plants and animals indigenous to the area immediately prior to mining, unless such re-establishment is inconsistent with the provisions of S.144.81(15), Stats. Plant species not indigenous to the area may be used if necessary to provide rapid stabilization of slopes and prevention of erosion, if such species are acceptable to the department, but the ultimate goal of re-establishment of indigenous species shall be maintained.	MPA, Section 5.0 (Reclamation Plan)
NR 132.08(3)	If it is physically or economically impracticable or environmentally or socially undesirable for the reclamation process to return the affected area to its original state, the reasons therefore and a discussion of alternative conditions and uses to which the affected area can be put.	MPA, Section 4.7.3 (Reclamation Plan Overview) MPA, Section 5.0 (Reclamation Plan)

Table 2-1 *(Continued)*

Code	Description	Location of Information
NR 132.08(4)	If the anticipated life and total area of the mineral deposit are of sufficient magnitude as determined by the department, a comprehensive long-term plan showing, in detail satisfactory to the department, the manner, location and estimated sequential timetable for reclamation of the entire area of contiguous land which will be affected by mining and which is owned, leased or under option for purchase or lease by the operator at the time of application. When a mineral deposit lies on or under the lands of more than one operator, the department shall require the operators to submit mutually consistent comprehensive plans.	MPA, Section 5.0 (Reclamation Plan) MPA, Section 10.0 (Long-Term Care and Maintenance)

MPA = Mine Permit Application
EIR = Environmental Impact Report
TMA = Tailings Management Area Feasibility Report/Plan of Operation

Prepared by: JBH1
Checked by: PAE

2.2 Owners Information

Names and addresses of land ownership within the project area and each person known to hold any option or lease on the land within the mining site held by CMC are shown on Table 2-2. Land ownership for the project area is delineated on Figures 2-2 and 2-3. CMC currently holds a Metallic Mineral Exploration Permit in the state of Wisconsin at the time of this submittal.

2.3 Approvals and Exemption Requests

CMC is holding discussions with Forest County, the Towns of Lincoln and Nashville, and the City of Crandon, each of which has zoning authority associated with the mining project. Oneida County and the Town of Crescent may also have zoning authority relating to the discharge pipeline from the mine site to the Wisconsin River. CMC will submit copies of local agreements with the jurisdictions within Forest County and zoning approvals from other jurisdictions to WDNR when they are obtained.

The following permit applications have been, or will shortly be, filed with the WDNR:

- Air Pollution Control Permit Application
- Industrial Wastewater Treatment Plant Permit Application
- WPDES Permit Application
- High Capacity Well Permit Application
- Water Regulatory Permits under Wisconsin Statutes Chapters 30 and 31
- Water Regulatory Permit under Section 404 of the Federal Clean Water Act
- Tailings Management Area Feasibility Report/Plan of Operation

It is the intent of CMC to submit applications for all WDNR permits required to begin construction prior to the Final Environmental Impact Statement (FEIS) issued by the State of Wisconsin and USCOE.

Table 2-3 contains a list of exemptions that are being requested by CMC under Wisconsin Administration Codes NR 132.19 and NR 182.19. These exemptions are necessary for several reasons. First, NR 132 could be read as requiring a formal exemption whenever a proposed mining activity will use more than 5 acres of wetlands. As demonstrated in the MPA and in the EIR, CMC has taken all feasible steps to avoid, minimize, and mitigate wetland impacts.

Second, several formal exemptions are necessary because the railroad spur and access road will cross over Swamp Creek, and because the railroad spur will pass within 1000 feet of Skunk Lake. It will be over 800 feet away at its closest approach. In addition, the Skunk Lake mitigation plan includes a pipeline and discharge structure that will be constructed within 1000 feet of Skunk Lake. As shown in this MPA and in the EIR, these facilities have been sited and designed to avoid, minimize, and mitigate all potential environmental impacts.

Third, NR 182.075(1)(d)5 requires that primary and secondary drinking water parameters be analyzed as part of TMA baseline monitoring. CMC is requesting an exemption from the requirement to test for the following parameters because they are unrelated to mining activities or are not pertinent to groundwater quality evaluations. Primary parameters for which an exemption is requested are organic substances, turbidity, radioactivity, asbestos, fluoride and bacteria. Secondary parameters consist of color, corrosivity, foaming agents (MBAS), and odor.

Fourth, NR 182.07(f) requires that no waste site be located within 1,200 feet of any public or private water supply. CMC is requesting an exemption from this requirement to allow the construction of a proposed TMA well within 350 feet of the TMA. This non-potable well is required to supply water to the TMA construction materials processing facilities and for other TMA related construction needs.

All of these requested exemptions are consistent with the purposes of NR 132 and NR 182, and none would violate any applicable federal or state environmental law or rule.

Table 2-2

Crandon Mining Company Properties (Fee, Purchase Option, Mining Lease or Easement) Within the Crandon Project Area Boundary

A) For Land Within the Project Area Boundary

Location	Description
Forest County	
T35N-R12E	
Section 23:	A tract of land 200 feet wide, being 100 feet on both sides of a center line, out of the N1/2NE1/4, said center line described as beginning at a point on the east boundary line of Section 23 approximately 620 feet south of its northeast corner, thence in a westerly direction in a straight line to a point in State Highway 55, said point being 320 feet south of the north line of said Section.
Section 24:	A tract of land 200 feet wide, being 100 feet on both sides of a center line, out of the N1/2N1/2, said center line described as beginning at a point on the east boundary line of said Section 24 approximately 772 feet south of the northeast corner of said Section 24, which is also approximately 478 feet north of the southwest corner of the NW1/4NW1/4 of Section 19, T35N-R12E, thence in a westerly direction from a turning point 1,462.4 feet south of the north line and 903.6 feet west of the east line of said Section 24 with a radius of 1,084.3 feet to a point in said center line 820 feet west of the east boundary line of Section 24, and 378 feet south of the north line of said Section 24, thence in a westerly direction in a straight line across the N1/2N1/2 of Section 24 to a point 620 feet south of the northwest corner and on the west boundary line of said Section 24.
Section 25:	E1/2 NE1/4SW1/4 SE1/4SW1/4, except that part of SE1/4SW1/4 lying south of the highway which runs between State Highway 55 and Little Sand Lake;
Section 36:	W1/2NE1/4 NE1/4NE1/4 Government Lot One, except the following described tract: Commencing at the southeast corner of said Government Lot One, thence South 36° 11′ West along the lake 51.8 feet; thence North 3° 19′ West parallel to the east line of said Government Lot 1, a distance of 129.5 feet to the place of beginning; thence South 83° 1′ West, a distance of 100 feet; thence South 4° 57′ East, a distance of 165 feet; thence South 42° 49′ East, a distance of 46.5 feet; thence North 36° 11′ East, a distance of 100 feet; thence North 3° 19′ West parallel to the east line of said Government Lot, a distance of 129.3 feet to the place of beginning.

Table 2-2, *continued*

A) For Land Within the Project Area Boundary	
Location	Description
T35N-R13E	
Section 19:	SW1/4
	SW1/4SE1/4
	S1/2NW1/4SE1/4
	E1/2SE1/4 being that part south and east of Swamp Creek.
	A tract of land 200 feet wide, being 100 feet on both sides of a center line, out of the W1/2NW1/4NW1/4 of said Section 19. Said center line described as beginning at a point on the west line of the NW1/4NW1/4 of said Section 19, which beginning point is 478 feet north of the southwest corner of the NW1/4NW1/4 of said Section 19 and 772 feet south of the north line of Section 24, T35N-R12E, thence in a southerly direction from a turning point which is 1,462.4 feet south of the north line and 903.6 feet west of the east line of Section 24, T35N-R12E, with a radius of 1,084.3 feet to the center line, to a point on the south line of the NW1/4NW1/4 of said Section 19, which point is 178 feet east of the southwest corner of the NW1/4NW1/4 of said Section 19.
	A tract of land 200 feet wide, being 100 feet on both sides of a center line, out of the W1/2SW1/4NW1/4 of said Section 19. Said center line described as beginning at a point on the north line of the SW1/4NW1/4 of said Section 19, 178 feet east of the northwest corner of the SW1/4NW1/4 of said Section 19; thence in a southerly direction in a straight line a distance of 1,320 feet to a point on the south line of the SW1/4NW1/4 of said Section 19, which point is 178 feet east of the southwest corner of the SW1/4NW1/4 of said Section 19.
Section 20:	NE1/4NE1/4, except the west 5 acres of the N1/2NE1/4NE1/4
	E1/2NW1/4NE1/4, excepting 1½ acres beginning at the northeast corner of said 16th section thence running west on the north line of said 16th section 264 feet, thence south parallel with the east line 264 feet, thence east parallel with said north line 264 feet, thence north on said east line 264 feet to the place of beginning;
	SW1/4NW1/4NE1/4
	S1/2/NE1/4NW1/4
	SE1/4NW1/4
	E1/2SW1/4NW1/4
	W1/2SW1/4

Table 2-2, *continued*

A) For Land Within the Project Area Boundary	
Location	Description
Section 28:	SW1/4
Section 29:	All
Section 30:	All
Section 31:	All, except that part of Little Sand Lake located in said Section, and except the following described tracts or lots of land: (1) That part of Government Lot One commencing at the meander corner as now set at the southwest corner of Government Lot One on the north side of Little Sand Lake; thence North 2° 30′ West along the west line of said Government Lot One, a distance of 359.0 feet to an iron stake; thence North 45° 27′ East, a distance of 110.3 feet to an iron stake and place of beginning for describing this parcel; thence North 45° 47′ East, a distance of 100 feet; thence South 44° 33′ East at right angles to the north line, a distance of 200 feet to the shore of Little Sand Lake; thence southwesterly along the lake shore, a distance of 100 feet measured at right angles to the east line; thence North 44° 33′ West, parallel with the east line, a distance of 206.0 feet to the place of beginning. (2) That part of Government Lot Three commencing at the east one-quarter corner of said Section 31 marked by an iron pipe; thence South 89° 22′ East 1,342.29 feet along the east-west ¼ line to the ⅛ corner marked by an iron pipe; thence North 0° 58′ West 1,340.32 feet to a 1/16th corner marked by an iron pipe; thence South 88° 58′ West 1,476.60 feet to a meander corner marked by an iron pipe near the shore of Little Sand Lake to the place of beginning; thence meandering along the lake, South 58° 28′ East 100.00 feet; thence South 44° 09′ East 100 feet to an iron pipe; thence North 86° 26′ East 619.82 feet to an iron pipe on the easterly right of way of Valician Drive; thence North 7° 21′ West 100 feet; thence South 88° 58′ West 618.52 feet to the place of beginning. (Also known as the "Public Access" Lot as shown on the Plat of Valician Shores recorded in Volume II of Plats, Page 28, as recorded in the office of the Register of Deeds for Forest County, Wisconsin.)

Table 2-2, *continued*

A) For Land Within the Project Area Boundary	
Location	Description
	(3) That part of Government Lot Four commencing at the east ¼ corner of said Section 31; thence South 89° 22′ West 2,684.58 feet to a point, being the center ¼ corner of said Section 31, marked by an iron pipe; thence South 0° 38′ East 909.01 feet along the east line of said Government Lot Four; thence South 79° 58′ West 102.42 feet; thence South 58° 07′ West 679.28 feet to an iron pipe near the shore of Little Sand Lake; thence meandering along the lake, North 58° 58′ West 100.00 feet; North 71° 00′ West 100.00 feet; South 70° 51′ West 90.00 feet; thence North 50° 42′ West 80.00 feet to an iron pipe and the place of beginning; thence leaving said lake shore North 48° 10′ West 679.04 feet; thence North 44° 00′ West 220.00 feet; thence North 76° West 150.00 feet to a point on the cul-de-sac; thence running westerly along said cul-de-sac to a point where said cul-de-sac intersects the north line of Lot Nine of Valician Shores Division 2; thence South 60° 42′ West 494.17 feet to an iron pipe near the shore of Little Sand Lake; thence meander along the lake South 41° 29′ East 259.00 feet; thence South 26° 52′ East 220.00 feet to an iron pipe and the place of beginning. (Also known as Lots 9, 10, 11 and 12 of Plat of Valician Shores Division 2 recorded in Volume II of Plats, Page 29, as recorded in the office of the Register of Deeds for Forest County, Wisconsin.)
Section 32:	All
Section 33:	NW1/4
	S1/2SW1/4
	NW1/4SW1/4
T34N-R13E	
Section 5:	N1/2N1/2NE1/4
	N1/2 of Government Lot One
	Government Lot Two

Table 2-2, *continued*

B) Surface Ownership of Property Within the Project Boundary

Grace Rudloff
R.R. 2
Crandon, WI 54520

Gary Bradley, et al.
701 North Central Avenue
Crandon, WI 54520

American Can Company
P.O. Box 790
Green Bay, WI 54305

Richard M. Connor, Jr.
P.O. Box 95
Laona, WI 54541

Forest County
County Courthouse
Crandon, WI 54520

Crandon Mining Company
7 North Brown Street
Rhinelander, WI 54501

Joseph A. Verlotta, et ux.
11364 West 77th Street
LaGrange, IL 60525

Gerald K. Solper
1427 Porlier Street
Green Bay, WI 54301

William Freye, et ux.
N8690 Firelane 6
Menasha, WI 54592

James E. Campshure, et ux.
1056 Holzer Street
Green Bay, WI 54505

Thomas M. Mihalko, et al.
Route 1, Box 801
Crandon, WI 54520

Milhalko Land and Logging Company, Inc.
Route 1, P.O. Box 801
Crandon, WI 54520

Raymond Hoffman, et ux.
Route 1, Box 583
Crandon, WI 54520

Ruth M. Dietzler
3164 Cornell Street
Appleton, WI 54915

Herman E. Pallen
4445 West Howard
Greenfield, WI 53220

Beverly Dix
2048-A South 35th Street
Milwaukee, WI 53215

William A. Betters
N427 Railroad Street
Appleton, WI 54915

Florence A. Yeager
2810 Cheyenne Drive
Freeport, IL 61032

John Lund
P.O. Box 2872
Kodiak, AK 99615

Mary Lund
1528 Sellery Street
Middleton, WI 53562

Ellen Cary
1287 B, Livernois Road
Rochester, MN 48306

John B. Hess
Route 1, Box 157
Laona, WI 54541

Alicia A. Bradley, et vir.
Route 1, Box 762
Crandon, WI 54520

Leo Zelechowski, et al.
RR 2, Box 384
Crandon, WI 54520

Delmar Pennington, Trustee for Pennington Trust
RR3, Box 309
Elkhorn, WI 53121

Table 2-2, *continued*

C) For Land Along the Pipeline Route

Location	Description
Easement* of various widths within right of way of the Town, County, State and U.S. roads described as follows:	
Forest County	
T35N-R12E	
Section 23:	Commencing at a point in the NW1/4NE1/4 of said Section 23, on State Highway 55 which point is 320 feet south of the north line of said Section 23, thence northerly along State Highway 55 to the north line of said Section 23;
Section 14:	Thence northerly along said State Highway 55 through the intersection of Forest County Airport Road, thence northerly along said State Highway 55 to the north line of said Section 14;
Section 11:	Thence northerly along said State Highway 55 through the intersection of Forest County Road "B" at Sherman Corners, thence northeasterly along said State Highway 55 to the north line of said Section 11;
Section 2:	Thence northerly along said State Highway 55 through the intersection of a Town Road Lemke Road running east at the south line of said Section 2, thence northeasterly along said State Highway 55 on the east line of said Section 2 to the intersection of Forest County Road "S", thence northerly along said County Road "S" to the north line of said Section 2;
T36N-R12E	
Section 35:	Thence northerly along said County Road "S" through the intersection of Town Road Kendall Lane and Town Road Lakeview Road, to the north line of said Section 35;
Section 26:	Thence northwesterly along said County Road "S" to the intersection of U.S. Highway 8, thence westerly along said U.S. Highway 8 to the west line of said Section 26;
Section 27:	Thence westerly along said U.S. Highway 8 to the west line of said Section 27;
Section 28:	Thence westerly along said U.S. Highway 8 to the west line of said Section 28;
Section 29:	Thence westerly along said U.S. Highway 8, crossing the Wolf River to the west line of said Section 29;
Section 30:	Thence westerly along said U.S. Highway 8, through the intersection of Old Yocum Road and Cole Road, thence westerly along said U.S. Highway 8 crossing Mud Creek to the west line of said Section 30;

Table 2-2, *continued*

C) For Land Along the Pipeline Route	
Location	Description
Oneida County	
T36N-R11E	
Section 25:	Thence westerly along said U.S. Highway 8 to the west line of said Section 25;
Section 26:	Thence westerly along said U.S. Highway 8 to the west line of said Section 26;
Section 27:	Thence westerly along said U.S. Highway 8 through the intersection of Slyzewski Road, thence westerly along said U.S. Highway 8 to the west line of said Section 27;
Section 28:	Thence westerly along said U.S. Highway 8 through the intersection of Brown's Road; thence westerly along said U.S. Highway 8 to the west line of said Section 28;
Section 29:	Thence westerly along said U.S. Highway 8 through the intersection of County Road "V" and a Town Road on the south side of said U.S. Highway 8, and U.S. Highway 45 on the north side of said U.S. Highway 8, crossing Monico Creek, and crossing the old Chicago and Northwestern Railroad right-of-way (abandoned); thence westerly to the west line of said Section 29;
Section 30:	Thence westerly along said U.S. Highway 8 through the Town of Monico, through the intersections of U.S. Highway 45 and Wisconsin STH 47, south of Venus Lake, and through the intersection of Lake Road, thence westerly along said U.S. Highway 8, which is also STH 47, to the west line of said Section 30;
T36N-R10E	
Section 25:	Thence westerly along said U.S. Highway 8 through the intersection of Old Road, thence westerly along said U.S. Highway 8 to the west line of said Section 25;
Section 26:	Thence westerly along said U.S. Highway 8 to the west line of said Section 26;
Section 27:	Thence westerly along said U.S. Highway 8 through the intersection of Old Road, crossing Neptune Creek, thence westerly along said U.S. Highway 8 to the west line of said Section 27;
Section 28:	Thence westerly along said U.S. Highway 8 to the west line of said Section 28;
Section 29:	Thence westerly along said U.S. Highway 8 on the north line of said Section 29, to a point near its northwest corner;
Section 20:	Thence northwesterly along said U.S. Highway 8 to the west line of said Section 20 near its southwest corner;

Table 2-2, *continued*

C) For Land Along the Pipeline Route

Location	Description
Section 19:	Thence northwesterly along said U.S. Highway 8, crossing the North Branch of the Pelican River through the intersection of Hay Meadow road to the west line of said Section 19 near its northwest corner;
T36N-R9E	
Section 24:	Thence westerly along said U.S. Highway 8 to the west line of said Section 24 and the intersection of U.S. Beltline 8;
Section 23:	Thence westerly along said U.S. Beltline 8 to the west line of said Section 23 and near the northwest corner;
Section 22:	Then Westerly along said U.S. Beltline 8 to the north line of said Section 22 to a point near its northeast corner;
Section 15:	Thence northwesterly along said U.S. Beltline 8 through the intersection of County Road and the intersection of Old Road and crossing the Pelican River, thence northwesterly along said U.S. Beltline 8 to the west line of said Section 15;
Section 16:	Thence northwesterly along said U.S. Beltline 8 to the north line of said Section 16 near its northwest corner;
Section 9:	Thence northwesterly along said U.S. Beltline 8 and through the intersection of Rangeline Road to the west line of said Section 9;
Section 8:	Thence westerly along said U.S. Beltline 8 through the intersection of County Road "G" and the intersection of Julia Road, to the west line of said Section 8;
Section 7:	Thence northwesterly along said U.S. Beltline 8 to the west line of Section 7;
T36N-R8E	
Section 12:	Thence westerly along said U.S. Beltline 8 to the intersection of said U.S. Beltline 8 and STH 17, thence southwesterly along STH 17, between the Wisconsin River and Lake Julia, to the south line of said Section 12;
Section 13:	Thence southerly along State Highway 17 through the intersection of Boyce Road, near the southwest corner of said Section 13, to the south line of said Section 13;
Section 23: Section 24:	Thence southerly along said State Highway 17 near the line between said Sections 23 and 24 to the south line of Section 23 or 24, near the southeast corner of said Section 23 or the southwest corner of said Section 24;
Section 25: Section 26:	Thence southerly along said State Highway 17 near the line between said Sections 25 and 26 to the southwest corner of said Section 25 or the southeast corner of Section 26 and the intersection of Lassig Road and Hat Rapids Road;

Table 2-2, *continued*

C) For Land Along the Pipeline Route

Location	Description
Section 26: Section 35:	Thence westerly along Hat Rapids Road near the line between said Sections 26 and 35 through the intersection of a Town Road, thence westerly along said Hat Rapids Road to the west line of said Section 26 at its southwest corner and the northwest corner of Section 35;
Section 27: Section 34:	Thence westerly along said Hat Rapids Road near the line between said Sections 27 and 34 to the Wisconsin River.

D) Surface Ownership of Property Corridor Pipeline

Town of Nashville
Route 1
Crandon, WI 54520

State of Wisconsin
Department of Transportation
North Hanson Lake Road
Rhinelander, WI 54501

Forest County
County Highway Department
County Courthouse
Crandon, WI 54520

Oneida County
County Highway Department
County Courthouse
Rhinelander, WI 54501

Town of Crescent
Crescent Town Hall
Rhinelander, WI 54501

Table 2-2, continued

E) For Land Associated with the Replacement Wetlands

Location	Description	Surface Ownership of Property
Shawano County		
T27N-R17E		
Section 5:	NE1/4NE1/4, except a tract described as beginning at the southeast corner of said NE1/4NE1/4, thence north along the east section line a distance of 660 feet, being the south 660 feet of the NE1/4NE1/4, and, except that part conveyed to Shawano County for road purposes, being: Commencing at the southeast corner of the Quarter-Quarter corner of Section 5, thence North 05° 35′ 32" West along the section line a distance of 660 feet; thence westerly parallel with the south line of said Quarter-Quarter 40 feet to the beginning of said reference line; thence North 05° 35′ 32" West 45.66 feet; thence North 11° 18′ 10" West 100.50 feet; thence North 05° 35′ 32" West 1,100 feet; thence North 00° 07′ 06" East 100.50 feet; thence North 05° 35′ 32" West to the north line of said Quarter-Quarter section and end of said line. NW1/4NE1/4, except a tract described as beginning at the southeast corner of the east 1/16 corner of Section 5, thence north 660 feet being the south 660 feet of the NW1/4NE1/4.	Helen M. Garrity James W. Garrity Patrick T. Garrity 2165 South Broadway Green Bay, WI 54304
Oconto County		
T28N-R17E		
Section 32:	S1/2SW1/4SE1/4, S1/2SE1/4SE1/4, except County Road "R"	Helen M. Garrity James W. Garrity Patrick T. Garrity 2165 South Broadway Green Bay, WI 54304

* To be acquired by CMC.

Prepared by: CMC
Checked by: KPB

Table 2-3

List of Requested Exemptions

Exemption Requested	Code Reference
Utilize more than five acres of wetlands for project facilities including portions of the access road plant site, railroad spur, TMA access road and TMA.	NR 132.06 (6) (h) (3)
Locate portion of railroad spur and Skunk Lake mitigation pipeline and discharge structure within 1,000 feet of navigable lake.	NR 132.18 (1) (b)
Locate portion of railroad spur within 300 feet of navigable river.	NR 132.18 (1) (c)
Locate portion of access road within 300 feet of navigable river.	NR 132.18 (1) (c)
Delete selected primary and secondary drinking water standards from TMA baseline monitoring.	NR 182.075 (1) (d) 5
Locate TMA within 1,200 feet of proposed TMA non-potable well.	NR 182.07 (f)

Prepared by: PAE
Checked by: JWS

Although the area of wetland disturbance has been significantly lowered from the 1985 submittal, more than five acres of current wetland will be utilized for the project. Section 2.8 discusses minimization of disturbance of wetlands. The area of wetland disturbance includes areas designated as access road, railroad spur, TMA access road and the TMA.

2.4 Mining Bond and Related Information Concerning Operations in Other States

There has been no occurrence of any of the following within ten years before the date of this application:

(a) A forfeiture by CMC, by any of CMC's general partners, or by any "related person" to CMC [as that term is defined in Section 144.81(17m), Stats., and construed to include Exxon Corporation and Rio Algom Limited] of a mining reclamation bond that was sufficient to cover all costs of reclamation and was posted in accordance with a permit or other approval for a mining operation in the United States.

(b) A felony conviction of CMC, any "related person" to CMC (see parenthetical note above), or an officer or director of CMC (construed to include the members of CMC's Management Committee) for a violation of a law for the protection of the natural environment arising out of the operation of a mining site in the United States.

(c) The bankruptcy or dissolution of CMC or a "related person" to CMC (see parenthetical note above) that resulted in the failure to reclaim a mining site in the United States in violation of a state or federal law.

(d) The permanent revocation of a mining permit or other mining approval issued to CMC or a "related person" to CMC (see parenthetical note above) where the permit or other mining approval was revoked because of a failure to reclaim a mining site in the United States in violation of state or federal law.

2.5 Suitability

Information relating to whether unsuitability exists for surface mining to the extent not fully considered in Wis. Stats., s.144.84, is not applicable to this application because the Crandon Project will be an underground mine.

2.6 Reclamation Costs

The estimated reclamation costs for the project are shown below in Table 2-4. The detailed worksheets for the reclamation costs are shown in Section 5.12 of this application. No credit has been taken for the recovery and sale of equipment and salvageable materials. Based on CMC experience, the salvage value is estimated to be approximately $8 million.

Table 2-4

Reclamation Cost Summary

Reclamation Period	Estimated Cost (1995 $)[1]
Year 3	$816,000
Year 12	4,852,000
Year 23	6,564,000
Year 28	4,140,000
Year 35	12,232,000
Year 75	2,353,000
Total Estimated Reclamation Costs	**$30,957,000**

[1]Costs from Table 5-12 rounded to the nearest $1,000.

Prepared by: MRS
Checked by: JBH1

2.7 Description of Contiguous Land

A description of land contiguous to the proposed mining site which the applicant owns, leases or has an option to purchase or lease, is shown in Table 2-2.

2.8 Minimization of Disturbance to Wetlands

In accordance with NR 132.06(4), a primary goal of the Crandon Project site selection process was the selection of sites that would result in the least overall adverse environmental impact. Avoidance of wetlands, to the extent practicable, was a primary consideration used to locate the plant site (minimizing facilities), TMA facilities, and access corridors.

Included in Section 4 of the Crandon Project EIR, is an evaluation of siting alternatives. This evaluation includes a summary of the previous investigation of project facility alternatives as well as a detailed description of the currently proposed project. Substantial reductions in the extent

of wetlands to be taken were made as part of the site design prepared in 1994 and 1995. This resulted in the reduction of wetland losses within the mine site from 65.4 acres as proposed for the 1986 project to the current project planned disturbance of approximately 29.5 acres. The most substantial reduction has been made at the TMA facility with approximately 36 fewer acres to be taken. Other project features, including the access road, railroad spur, and TMA access road/pipeline corridor have not been altered significantly from the originally proposed route. A discussion of wetland impacts associated with the original 1986 proposed wastewater discharge line and the 1995 proposal is presented in Appendix 3-2 of the EIR.

Figure 2-4 shows the location of wetlands in relation to the proposed sites for the Crandon Project facilities. Wetland acreages are illustrated on Figure 2-5. Table 2-5 presents a comparison of wetland disturbance relating to the major components of the project as previously proposed versus the current proposal. A more detailed discussion of wetland impacts is presented in Section 4 of the EIR.

CMC believes that the location and design of project facilities will create the least overall environmental impacts and also minimize direct impact to wetlands. However, as noted in NR 132.06(4), in some cases it is virtually impossible to select sites that are most favorable for all facilities, taking into account all pertinent environmental and social factors, without some impacts on wetlands. As a result of these effects, the Crandon Project facilities have been sited in compliance with the requirements of NR 132.06(4), including to the extent practicable, the minimization of wetland impacts.

Table 2-5

Minimization of Wetland Disturbance

Project Facilities	Area of Wetland Disturbance	
	Previous Project[1]	Current Project[2]
Plant Site	0.0	.28
TMA and Reclaim Pond	57.70	21.79
Access Road	3.2	3.91
TMA Access Road/Tailings Transport Pipeline Corridor	0.6	0.47
Railroad Spur	3.9	3.05
Total	65.4	29.5

1 WDNR, 1986 FEIS
2 Foth & Van Dyke

Prepared by: PAE
Checked by: RFS

2.9 Monitoring and Quality Assurance Plan

Monitoring for the Crandon Project as presented in this report is to consist of two elements. The first element involves monitoring during the construction, operation, reclamation and closure phases of the project. The operating phase of the project is the period of time from the end of construction related work to the end of mine production life. That point in time is equivalent to the completion of site closure for typical NR 182 facilities. This monitoring element is discussed in Section 7.0 of this report.

The second element involves monitoring to verify the progress and success of reclamation. A discussion of the reclamation activities and monitoring is presented in Sections 5 and 10 of this report, respectively.

The proposed monitoring plans for this project have been prepared in accordance with Wisconsin Administrative Code, Chapters NR 132 and NR 182. The methods of ground or surface water sample collection, preservation and analysis will be in accordance with the appropriate provisions of the mining permit and the Wisconsin Administrative Code. In accordance with NR 182.135, applicable laboratory test results submitted to the WDNR for this project shall be performed by a laboratory certified or registered under NR 149.

CMC will develop an updated laboratory quality assurance plan for the project. This updated plan will be forwarded to the WDNR prior to commencement of on-site construction activities or before collection of 12 months of baseline groundwater data. On-site monitoring activities conducted between the time this application is submitted and the submission of the updated laboratory quality assurance plan will be accomplished using quality assurance procedures outlined in the NOI/SOS (Foth & Van Dyke, February 1994), including any updates.

2.10 Fee

A check dated April 28, 1995, for ten thousand ($10,000) dollars, drawn on the Associated Bank, Crandon, Wisconsin, has been submitted separately to WDNR to cover the costs of the review of this application.

3 Financial Responsibility

CMC is a Wisconsin general partnership that was formed on September 13, 1993 by subsidiaries of Exxon Corporation and Rio Algom Limited to own, obtain permits for, develop, and operate the proposed Crandon zinc-copper mine. CMC carries out its business operations in accordance with the Wisconsin Uniform Partnership Act, Ch. 178, Wis. Stats, and a September 13, 1993 Partnership Agreement. CMC has four general partners: Crandon Mining Company and Exxon Minerals Development Corporation, both of which are wholly owned subsidiaries of Exxon Corporation; and Rio Crandon, Inc. and Northwoods Resources, Inc., both of which are wholly owned subsidiaries of Rio Algom Limited.

To the extent allowable by law, all financial and environmental responsibility requirements will be undertaken by, and will be in the name of, the general partnership itself (CMC). CMC will thus have primary responsibility for compliance with the financial responsibility provisions of Wis. Stats. § 144.441(2), 144.443, and 144.86, by making all financial commitments reasonably necessary to ensure the reclamation, long-term care, and long-term environmental integrity of the mine site and all related facilities. Such commitments will include:

- One or more bonds, or one or more of the other financial security methods allowed by § 144.443(3) and 144.86(1), guaranteeing the availability of sufficient funds for the closure, reclamation, and long-term care of the mine site and all related facilities. To the extent allowable by law, these commitments will be met through self-bonding or through satisfaction of the net worth requirements established by the Department as provided in § 144.443(4).

- A certificate of insurance, or evidence that CMC has satisfied state or federal self-insurance requirements, affording adequate personal injury and property damage protection, as required by § 144.86(2).

As Exxon Corporation and Rio Algom Limited are the parent corporations of the general partners of CMC, and thus subject to Wis. Stats. § 107.30 - 107.33 and 144.442 - 144.443, the most recent annual reports of Exxon and Rio Algom are included in Appendix A.

CMC proposes that the mining permit be used as the vehicle for addressing, to the extent practicable, the details of all appropriate financial commitments necessary to ensure the reclamation, long-term care, and long-term environmental integrity of the mine site and all related facilities. Addressing these details in the mining permit will enable CMC and the WDNR to provide for enhanced cost-efficient environmental protection, to resolve any issues concerning financial responsibility, and to reassure the citizens of Wisconsin that the long-term care and environmental integrity of the mine site and all related facilities have been carefully planned and accounted for. Therefore, although § 144.86(1) does not require CMC to finalize its financial commitments until after a mining permit has been approved by the Department, CMC believes that these commitments should be addressed and resolved in connection with the mine permitting process itself.

4 Mining Plan

4.1 Background

An airborne electromagnetic survey conducted in the early 1970s by Exxon Minerals Company (EMC) identified an anomaly in the vicinity of Skunk Lake, Forest County Wisconsin. An extensive exploratory drilling program encountered a sulfide ore deposit. This deposit is located two miles east of STH 55 on Little Sand Lake Road, approximately five miles south of the City of Crandon. The general site location is illustrated on Figure 4-1.

The extent and quality of the mineralization was delineated by a surface drilling program. In 1978, EMC submitted to the WDNR a Notice of Intent to collect data to support a mining permit application. During the mid 1980s, EMC or its successor company submitted the permit applications to the WDNR, and in 1986, the WDNR issued a Final Environmental Impact Statement (FEIS) regarding the proposed Crandon Project. Subsequently, EMC withdrew its permit applications due to depressed metal prices.

In the fall of 1993, subsidiaries of Exxon Corporation and Rio Algom Limited formed Crandon Mining Company, a Wisconsin general partnership, with the intent to secure the necessary permits to develop the Crandon Project. On February 15, 1994, CMC filed with the WDNR a *Notice of Intent to Collect Data and a Detailed Scope of Studies* to support a mining permit application with the WDNR. Since the issuance of that document, numerous additional project studies have been completed. These studies, combined with applicable information from previous studies, are detailed in the EIR.

4.2 General Project Overview

The Crandon ore body is an east-west striking deposit located in Townships of Nashville and Lincoln, in Forest County. Figure 4-2 shows the limits of the project area, the mine site, the plant site, and the TMA.

The 55 million-ton ore body will be mined by underground methods using primarily blasthole open-stoping with delayed backfilling. The location of the ore body dictates the location of the main production shaft and the ventilation shafts. The ore body is composed of two distinct types of mineralization, zinc ore and copper ore, and is of volcanic origin.

The Crandon Project will include a headframe, underground facilities, surface plant facilities including an ore storage area, an ore concentrating facility, miscellaneous support facilities, an explosives storage area, a wastewater treatment plant, a TMA, and water management features. The plant surface facilities will be concentrated in an area of approximately 128 acres adjacent to the main production shaft. A portion of this area will also be used by buildings, roadways, transmission access and ancillary facilities. The remaining area will either be retained in its natural state or, if disturbed, will be re-vegetated for erosion control and aesthetics.

As depicted on Figure 4-2, the TMA will be located in an area approximately one mile southeast of the plant site. The plant site facilities will be connected by a corridor containing the access road and tailings and reclaim water pipelines. The TMA facility, consisting of four tailings cells, will be engineered, constructed and operated for the environmentally safe long-term management of tailings generated from the milling of ores. The tailings cells will be constructed and

reclaimed in stages over the operating life of the mine and will ultimately occupy about 355 acres. A portion of this area will be used by a pipeline, access road and reclaim pond. The area surrounding this facility will either be retained in its natural state or, if disturbed, will be landscaped for erosion control and aesthetics. The total area of disturbance within the boundaries of the mine site is approximately 550 acres.

4.3 Regional and Local Settings

The site area is underlain by Precambrian bedrock and is in the seismically stable Southern Province of the Canadian Shield. The surficial deposits are glacial till in origin. These are divided into till, coarse and fine grained outwash and lacustrine (lake bottom) deposits. The surficial topography is primarily the result of the latest glacial age and is characterized by southwest trending ridges and valleys.

The site lies within the Wolf River-Lake Winnebago-Fox River-Green Bay drainage basin. The highest monthly stream discharge on the Wolf River typically occurs in April when snowmelt runoff is highest, and is lowest in January and February when precipitation is retained on the ground as snow. The area is characterized by northern hardwood forest interspersed with lakes and wetlands. The streams transport only a small amount of sediments due to the forested nature of the surrounding area, the granular nature of the soils, moderate slopes, low stream velocities, and many lakes and wetlands which serve as sediment catchment basins.

Groundwater occurs primarily in the glacial materials. Regional groundwater flow is generally from east to west. A stratified layer of glacial outwash consisting of sand and gravel is the primary aquifer. This layer is located below a surficial till layer, and at some locations is separated from the bedrock by a layer of less permeable material which is glacial till and saprolite, a highly weathered bedrock which has been altered to form clays or iron oxides.

The land use and land cover within the study area (which is the land within an approximate 100-square-mile area around the plant site) is as follows: forestry, 76.5 percent; recreation (which includes water bodies and wetlands), 11.8 percent; residential, 6.4 percent; agricultural, 5.0 percent; and transportation, less than one percent. Approximately 18 percent of the land in the regional study area is publicly owned.

The majority of the residences in the area live in the City of Crandon or in areas located along lake shores. There is also a relatively high concentration of residences along STH 55 at the village of Mole Lake and in the Mole Lake Sokaogon Chippewa Community. There are no commercial or retail facilities in or immediately adjacent to the site area. There is one airport approximately four miles northwest of the project site and south of the City of Crandon. In addition, the Wisconsin Central Limited Railroad passes east of the site in a north-south direction approximately two miles from the project site. The area contains the visual amenities common to northern Wisconsin. Lakes and streams, forestlands, and gently rolling terrain contribute to the scenic diversity of the area. Seasonal attractions include the autumn leaf colors, winter snow scapes scenes, and spring flora. There are no state parks, Wisconsin Scientific or Natural Areas, or National Natural landmarks in or near the area.

4.4 Geology

The Crandon deposit, which consists of both zinc and copper ore, is of volcanic origin. The minerals were deposited during the Precambrian era, about 900 to 2,500 million years ago. The deposit was formed on the ocean floor by fluids of volcanic origin. Some of the materials deposited by the volcanic system were mineral laden fluids, which accumulated in low spots on the ocean floor. Continued accumulation of other volcanic materials and sediments occurred which buried the sulfide deposit. Later, a mountain building phase occurred in the region, which tilted the volcanic layers and the deposit to a near vertical position. The more recent geological process which affected the deposit has been related to Pleistocene glaciation, which buried the deposit under unconsolidated glacial material.

The ore body itself is long and tabular with an approximate width of 100 feet (N-S) and strike length of 4,900 feet (E-W). Based on exploratory drilling to date, the ore body extends to an approximate depth of 2,200 feet. It is composed of two distinct mineralization types, zinc ore and copper ore. The zinc ore is primarily composed of sphalerite (zinc sulfide) interbedded with pyrite (iron sulfide), chalcopyrite (copper sulfide), and galena (lead sulfide). The copper ore lies stratigraphically below the zinc ore deposit, and consists primarily of pyrite, chalcopyrite, and quartz. The interpreted geologic stratigraphy and ore body configuration are shown on Figures 4-3 and 4-4, respectively.

The host rock in the hanging wall and in the foot wall of the ore body consists of a series of volcanic rocks, fine tuffs (solidified volcanic ash), debris flow (ocean floor and volcanic-derived sediments), breccia (blocky, angular particles) and lapilli tuffs (gravel sized volcanic material). Overlying the bedrock and ore body is a sequence of unconsolidated glacial sands, clays, and gravels. The rock in contact with the unconsolidated glacial overburden is weathered. The amount of weathering in the bedrock ranges from simple staining in deeper bedrock, to extreme weathering which reduced the rock to a clay-like material called saprolite. The saprolite is at the bedrock-glacial-till contact.

The glacial overburden consists of interbedded and co-mingled glacial till, which is material deposited directly by the glacier, and glacial outwash deposited by streams emanating from the glacier. These glacial deposits are found in various thicknesses in this area ranging from 75 feet thick to over 250 feet thick.

4.5 Geological/Geotechnical and Waste Characterization Investigations

Numerous geological, geotechnical, and hydrogeological investigations have been completed for the project. Details regarding these studies as they relate to project permitting, are described in the project's EIR and other related permit applications such as the TMA Feasibility Report/Plan of Operation. Examples of these studies include, but are not limited to, the following:

- Delineation drilling to define the limits of the ore body.
- Waste characterization tests to define the characteristics of mining by-products.
- Bedrock and glacial pump tests to provide hydrological information on mine groundwater inflow.

- Tailings consolidation testing and slope stability analyses for the TMA.
- Soil investigations to characterize the surficial soils.
- Investigations to characterize the nature of the area lake beds.

Four major groups of waste materials will potentially be generated during the development and operation of the mine. Those materials include: overburden; waste rock; tailings; and both wastewater treatment and reclaim pond solids. A detailed discussion of the generation and characterization of these materials in contained in Section 3.5.5 of the EIR.

Overburden wastes will be produced during the construction of the mine and its facilities. Past studies have shown that the geochemistry of the soils above the mine site do not reflect the mineralization within the crystalline bedrock that begins at a depth of about 100 feet below the land surface. Therefore, overburden was not tested during the present environmental investigation.

Waste rock will be generated during the preproduction and operational phases of the mine. The waste rock that will be generated during the preproduction phase will be brought to the surface where it will either be used for construction purposes in an application where it will not be in direct contact with vehicular traffic or placed in a controlled facility, depending upon the results of leaching studies performed on these materials.

Preproduction waste rock will be derived from the hanging wall rocks to the north of the ore body. These rocks are part of the Skunk Lake, Rice Lake and Mole Lake Formations. Based on past and current studies, it is expected that most of the preproduction waste rock will not produce acidic drainage and will leach only minute quantities of substances. Such waste rock will be referred to as Type I waste rock throughout the remainder of this report. Some of the preproduction waste rock is expected to have the potential to produce acidic drainage and/or will leach greater quantities of substances. Such waste rock will be referred to as Type II waste rock throughout the remainder of this report.

In general, waste materials and ore will be either Type I or Type II in the long term depending upon the relative abundance and proportions of sulfide minerals to acid neutralizing minerals within the rock. However, in the short term, waste materials will be Type I or Type II depending upon the relative kinetics of reactions of these two groups of minerals. A material will be termed Type I only if it can be demonstrated to be nonreactive over the long term.

Most of the Type I waste rock is expected to be generated during the development of the production shaft, ventilation shafts and raises, development drifts connecting the mining areas to the production shaft, internal access ramps, and equipment storage and service facilities. One of the goals of the waste characterization program is to determine if the potential Type I waste rock generated during the preproduction and operating phases of the project can be used in surface construction, such as construction aggregate, where this material would be in direct contact with soils at the site.

Type II waste rock will likely be generated during the preproduction and operating phases of the project. This material will be mainly generated during the development of the stope accesses. Type II waste rock generated during mine development will be transported to the surface and stored in a lined facility. During operations, a portion of the Type II waste rock will remain

underground as backfill. The Type II waste rock brought to the surface may be used in construction of TMA facilities where the waste rock can be isolated from the surficial environment via liners and covers. Type II waste rock that is not used in the construction process will be placed in the TMA.

Tailings materials will be generated as a result of the primary beneficiation of ore at the site. Permanent placement of tailings will occur both in the mine and in the TMA, both of which are engineered facilities.

Current mine plans call for backfilling depleted stopes with a coarse tailings fraction consisting of material larger than 10 to 15 microns in diameter, and the placement of a fine fraction typically smaller than 10 to 15 microns in diameter in the TMA. During mine operations, backfilling depleted stopes with whole tailings may occur. Normally during mine operations, coarse tailings, which are considered to be free draining, will be pumped into mined-out stopes. When required, normal Portland cement (NPC) will be added to coarse tailings before they are placed in the stopes. Approximately 60 percent of the backfilled stopes will contain cemented tailings. The remaining 40 percent will contain uncemented tailings. When backfilling is not required underground, whole tailings will be pumped to the TMA.

All tailings materials pumped to the TMA will be in the form of slurries with varying solids contents, depending upon the nature of the tailings pumped. For example, fine tailings will have a 12 to 30 percent solids content, while coarse and whole tailings will have solids contents ranging from 40 to 50 percent. The liquid portion of the slurries will primarily be process water.

Coarse tailings will be pumped to the mined-out stopes in the form of a slurry consisting of 60 to 70 percent solids. Whole tailings, if used for backfilling, will be pumped to the mined-out stopes in the form of a paste consisting of 70 to 80 percent solids. The use of whole tails as backfill is a potential backfilling option. Its application to the Crandon Project can not be fully assessed until after site operations begin. Waste rock generated during mining operations will also be used to backfill the mined-out stopes. It is estimated that about three percent of the backfill material will consist of waste rock.

Treatment of mine drainage waters, and on occasion process water from the TMA, using the planned combined lime and sulfide treatment processes, will produce solids. Both wastewater treatment and reclaim pond solids will be placed with tailings materials in the TMA.

Reclaim pond solids will consist of fine particulate matter that has been transferred to the reclaim pond during the management of water levels within the TMA cells. The reclaim ponds act as settling basins for this material, which would otherwise enter the recycled water returned to the mine process facilities. Reclaim pond solids will be similar to the fine tailings materials, with the exception that the reclaim pond solids will contain smaller proportions of pyrite and greater proportions of clay minerals and quartz than the fine tailings, due to the differential settleability of these minerals. For the purposes of the project's environmental investigations, reclaim pond solids will be considered equivalent to fine tailings, even though they will be less reactive than the tailings. Therefore no separate testing of reclaim pond solids was necessary.

Radiological testing and asbestiform mineral determinations were completed as part of the project waste characterization work (EIR, Section 3.5.5). The results of this work are highlighted in the following paragraphs.

Radiological Testing. Extensive radiological analyses were performed on the fine tailings, ore and waste rock during the environmental investigations completed in the 1970s and 1980s. The results of these tests, conducted and verified by several organizations, showed that the referenced materials contain less uranium, thorium and radium, and have lower radioactivity, than nearby unmineralized crystalline rock. Although no additional radiological analyses are necessary to further characterize these materials, uranium analyses were performed as part of the bulk chemical analyses, and during the first few leachate samples collected from each material being reacted. There were no definite detects of uranium in any of these samples. Definite detects are considered those that are three times greater than the instrumental detection limit for single-digit detection limit.

Asbestiform Minerals. Thin sections of selected ore and waste rock samples were prepared during past project environmental investigations and examined by optical microscopy for the presence of asbestiform minerals. This work, which was verified by the Wisconsin Geological and Natural History Survey, found no asbestiform minerals in the analyzed samples. Samples of fine tailings material were examined by transmission electron microscopy by a laboratory recommended by WDNR. No asbestiform minerals were found in the fine tailings material.

4.6 Overview of Environmental Setting

The Crandon Project EIR presents a detailed discussion of the project area's regional and local setting, historical and archaeological features, climate, meteorological and air quality, geology, groundwater, surface water and sediments, aquatic and terrestrial biology, ambient noise levels, land use, aesthetics, and socioeconomic characteristics. The reader is referenced to the EIR for details regarding these topics.

4.7 General Description of Proposed Project

The MPA has been prepared in accordance with the Wisconsin Statutes §144.25(3)(a) to inform government agencies and public of the project, and the principles and objectives of design and operational management.

The primary objective of the proposed Crandon Project is to profitably mine and process the zinc-copper ore in the Crandon deposit in an environmentally-acceptable fashion. Project environmental objectives are: (1) to plan, construct and operate the project using sound industrial practices, within the conditions and standards prescribed by the State of Wisconsin, local zoning requirements and applicable federal laws, and (2) to site and operate the plant and tailings facilities so that impacts to the environment are avoided or minimized, and mitigated, if they pose a threat to public health and welfare. Accordingly, a number of alternative mining, processing, and waste management strategies have been evaluated, with the purpose of identifying the alternative that best minimizes risk and environmental impacts. A discussion of the findings of these evaluations can be found in the project's EIR.

4.7.1 Site Location

The Crandon ore body is located in Forest County, Wisconsin. The civil land survey location is Section 25, Township 35 North, Range 12 East, Town of Nashville, and Section 30 , Township 35 North, Range 13 East, Town of Lincoln. This area is illustrated on Figure 1-1.

The plant site is located five miles south of the City of Crandon and two miles east of STH 55 and the Mole Lake Indian Reservation. The site is approximately one-quarter mile north of Little Sand Lake and one mile south of Swamp Creek. As shown on Figure 1-1, access will be from a proposed new service road from STH 55 northwest of the site. A railroad spur serving the site will be connected northeasterly to the existing Wisconsin Central Limited Railroad. The project's TMA will be located approximately one mile southeast of the plant site.

4.7.2 Land Ownership and Use

In the project area and its vicinity, CMC holds about 2200 acres of surface land in fee, has agreements for purchase of an approximate additional 1800 acres, and has easements on about another 10 acres. This acreage includes the area needed for the construction of the plant site and TMA facilities, the railroad corridor northeast to the existing rail line, the common corridor for the access road, power line, and pipeline wastewater discharge, northwest to STH 55, and the buffer area around these sites.

CMC also has an agreement to purchase approximately 100 acres of land in Shawano and Oconto Counties, on which it plans to locate a replacement wetland. Additionally, CMC will be obtaining approximately 37 miles of pipeline easements for the proposed wastewater discharge pipeline from the plant site to the Wisconsin River near Rhinelander, Wisconsin.

4.7.3 Reclamation Plan

The goal of the project's reclamation plan is to restore the side to a long-term environmentally stable condition, and to return the land to beneficial, productive uses. This includes reestablishing a variety of indigenous species of grasses and plants in the project area that will not require maintenance after certification of reclamation activities at the site.

Various strategies will be used to achieve the reclamation goal. The first will be to use a phased approach where reclamation will actually begin during construction (first three years) and continue intermittently throughout the project operations phase. The second strategy will be to use grasses and forbs in open areas along with savannahs (grasses and trees) to initiate and to establish native species of grasses and woody plants. The third strategy under consideration, would be to plant grasses and forbs from seed and to harvest the initial plantings for seeding in the subsequent phases of reclamation. A fourth strategy, also under consideration, would be to plant woody plants from commercial stock at various stages of growth.

Upon completion of mining, reclamation activities will continue in accordance with Wisconsin Statute §144.875, which requires that the operator notify the WDNR and commence stabilization of the mining site. Reclamation of the site will occur on an ongoing basis from construction through the operating phase. After final reclamation, the area will be used for forestry and recreation.

Final reclamation of the plant site will begin upon completion of mining and ore-processing. Some equipment and material from the mine will be brought to surface. That left underground will be drained of oils and lubricants. Accesses to the underground mine will be plugged with reinforced concrete. Surface facilities may be converted to other uses where possible. If not, they will be removed. The site will be graded and revegetated.

Settling basins and water storage ponds may be drained and reclaimed. Each cell of the TMA will be reclaimed upon completion of its operating life. Final capping and re-vegetation of the last cell of the TMA will occur late in the sequence of project reclamation.

The wastewater treatment plant will be removed after it is no longer required. Salvageable equipment will be removed, and scrap and treatment solids will be hauled off-site for disposal. Reclamation of the on-site roads, the access road and the railroad spur will be dependant upon the final site use. Utilities that service other customers along the route to the mine will be left in place. The portion of the utilities that extend onto the mine site will be removed if aboveground, or remain in service depending upon the final use of the site. Below-ground piping will be purged, capped and left in place, when no longer in service. A long-term care and maintenance plan will be implemented following site closure.

4.8 Description of Facilities

The following is a description of the Crandon Project facilities. The construction description and methods will form part of this facility description. Operation methods of these facilities are described in Section 4.10.

4.8.1 Plot Plan

The plant surface facilities will be located in the area adjacent to the main production shaft. The layout of these facilities, shown in Figure 2-1, will require an area of about 128 acres. The principal structures at the plant site will be the mine headframe, hoist and compressor room, coarse ore storage, the concentrator building, and the services building. The latter will house the surface shops, warehouse, offices and change room facilities. In addition, the project site will include the freshwater make-up and potable water facilities, electrical substation, and ancillary buildings. A wastewater treatment plant will be provided to treat excess mine waters that cannot be used on site. This water will be treated to meet water quality standards and discharged to the Wisconsin River.

Two temporary storage pads will be constructed to the north of the headframe for the independent storage of about 1,050,000 tons of pre-production ore and waste rock. The ore will be processed after the mill start-up period. Type I waste rock will be used as construction aggregate. Type II waste will be used as riprap within the TMA.

A 115 kv overhead electrical transmission line, a six inch natural gas pipeline, and a telephone link will be provided by connection to local utilities. Process water will be recycled from the tailings basin. Potable water will be supplied from a well located immediately southwest of the plant site. Facility sanitary wastewater will be treated on-site and the effluent pumped to the TMA along with the mill tailings. The TMA facility, southeast of the plant site, will consist of four tailings cells constructed and reclaimed in stages during the life of the operation.

4.8.2 Project Schedule

Detailed engineering, procurement of equipment and construction will commence upon receipt of the necessary local, state and federal approvals and permits. It is anticipated that the necessary approvals would be received in late 1996, and construction would be completed by the fourth quarter of 1999. Ore extraction would be completed over a 28-year period. Final site

reclamation would be accomplished within a four-year period from the date on which mining and processing are completed.

4.8.2.1 Operating Schedule

The mill will operate 24 hours per day, for 365 days per year, while the mine will operate on either a five-day or seven-day-per-week schedule. Production through the mill will average 5,500 tons per day (TPD), or approximately 2 million tons per year (MTPY). Mine production is scheduled to commence in the fourth quarter of 1999 after the installation of the underground crusher, which will permit ore to be crushed before it is hoisted from the mine. Concentrator production will start when construction of the concentrator and all process related equipment is completed and turned over to the operating staff of CMC by the construction contractor(s). Backfill operation in the mine will start as soon as the concentrator facilities are completed and an empty underground stope is ready to receive fill.

The operational life of the mine could be affected by certain factors that would require temporary shutdown of production operations. Temporary plant shutdowns are defined as those periods during which actual mine and/or surface plant operations cease, but all facilities are maintained in start-up readiness. During such periods mine water pumping, wastewater treatment, stabilizing the TMA, environmental control and monitoring and similar activities would continue uninterrupted.

A variety of events and situations could cause temporary suspension of operations for durations varying from one day to several years. Short shutdown (i.e., one month or less) might be caused by extreme weather conditions, equipment failure, or scheduled facilities maintenance or modification. A cessation for longer periods may result from labor disputes, either local or by an essential supplier/carrier, or other factors. Nonetheless, all necessary environmental control and monitoring equipment will continue to operate during such periods to assure compliance with all applicable permit conditions. The ultimate ramification of such events may be the extension in real time of mine and facility operations and reclamation.

4.8.2.2 Construction Schedule

The construction schedule as shown in Figure 4-5 depicts the key underground mine development activities and construction and installation of process equipment for the concentrator and wastewater treatment facilities. The sequencing of this construction will facilitate the early development of containment facilities, wastewater treatment and other environmental protection systems.

The duration of the construction phase of the project is controlled by the time required to develop the main production shaft, and to develop the requisite underground level and stope development and ore handling facilities to sustain the concentrator. The sequence of critical activities for mine development consists of:

- site preparation of the shafts;
- sinking shaft collars to bedrock;
- establishment of permanent electric power;
- erection of the main production shaft headframe;
- installation of sinking hoist and excavating shafts to appropriate levels;

- development and installation of crusher, water handling systems and loadout facilities; and
- development of initial stoping blocks and ore handling facilities.

Approximately 36 months will be required to complete the above. The sequencing of the surface facility construction will be initially governed by the requirement to provide support services to the mine and to install environmental protection systems for early plant construction. The sequencing of critical activities is as follows:

- surface drainage system to hold surface runoff from the disturbed areas of the site;
- mine wastewater treatment facilities, including discharge pipeline;
- installation of permanent power;
- construction of access roads;
- construction of TMA; and
- construction of railroad access.

The planned sequence and estimated duration of the principal construction activities are shown in Figure 4-5. The schedule may vary depending upon the season when construction is started. Schedule delay may also occur as a result of inclement weather, labor disputes, delays in equipment deliveries, field design modification and other contingencies.

4.8.3 General Site Preparation

Clearing and grubbing of the plant site, access road, railroad corridor, and the TMA will be the first construction activities at the site. All clearing and grubbing activities will be preceded by or be performed concurrently with the site erosion control techniques as described in Section 4.10 of this report.

All merchantable material, nominally trees greater than three inches in diameter measured three feet above the ground, will be salvaged from the disturbed areas and will be removed from the site by a contractor. Tree stumps and brush will be chipped, mulched and stockpiled at the plant site and TMA for use in land reclamation, which will occur progressively during the operating period of the mine. Some stumps may be buried on-site in natural depressions that are not wetlands.

The clearing, grubbing, rough and final site grading will be performed using traditional earth-moving equipment similar to what may be found on other construction job sites. Rough and final site grading will use dozers, scrapers, loaders, graders and compactors. Dust and erosion control techniques will be widely used to prevent soil loss and the minimization of fugitive dust emissions. The salvaged topsoil and mulch will be hauled to a storage area east of the headframe. After placement, this area will be seeded to prevent wind erosion of these stockpiles.

Plant site preparation will be conducted in two stages. Initially, the site will be cleared of trees and shrubs and then rough graded. Those areas not required for early construction activities will be re-stabilized with mulch grass seed to control erosion and runoff. Final grading of these seeded areas will be conducted in accordance with the construction schedule shown in Figure 4-5.

Temporary facilities such as construction offices for the construction management and its contractors, storage and laydown areas, workshops, a concrete batch plant, electric power,

potable water, and sanitary facilities will be required at the site until permanent buildings are completed. The location and type of temporary structure will be controlled by CMC.

Sand Lake Road will be upgraded and used for access during early construction until the permanent access road is constructed. A temporary parking area on the plant site will be provided for commuting workers until a permanent parking lot is completed during the second year of construction.

Fire protection for temporary construction facilities will be provided by a fire truck stationed on-site which will be able to pump from the process water storage basin or other available surface water. A permanent water loop will be completed during the second year of construction and will increase the effectiveness of the fire truck by providing the availability of fire hydrants throughout the site.

Potable and construction water will be provided by on-site wells now in existence and new wells to be installed during the first year of construction. A high-capacity well permit application will be submitted to the WDNR to cover the construction and operation of a well that will supply potable water during the construction phase of the Crandon Project. This new well will be located southwest of the plant site, and will also be the primary potable water supply well during the mine operating period.

In accordance with applicable regulations and good construction practices, chemical toilets will be provided during the early construction period. Sanitary waste will be collected and disposed of off-site by an approved contractor. A sanitary waste system will be completed during the early construction phases and sanitary wastewaters will be treated at that facility. The use of chemical toilets will continue throughout the construction period because some work locations will not be conveniently sited near permanent toilet facilities.

During the first six months of the construction period and until the plant substation is completed, temporary on-site power will be furnished from the Wisconsin Public Service Commission with a three phase, three (3) MW power line from Mole Lake via Sand Lake Road, as well as by one, two- to three-MW natural gas/propane-fired site generator. By month seven, the main 115 kv power line will have been installed, and the first 13.8 kv/4.16 kv transformer energized.

A perimeter fence enclosing the plant site will be installed by the end of year one. A cleared area on each side of this fence will be established. All temporary fencing erected by the contractor will be approved by CMC and removed when no longer needed.

4.8.4 Aesthetics and Landscaping

Consideration was given during the planning of the facilities to achieve the aesthetic standards as prescribed by NR 132.17 and 132.18. The site contains most of the visual amenities that are common to northern Wisconsin. The project facilities will impact these aesthetics to a minor degree. Visually, the most prominent feature of the facility will be the main production shaft headframe. As outlined in the project's EIR, the visual impact of this structure's projection above the horizon will be minimal.

Landscaping of the plant site area with trees and grasses will moderate the appearance of the surface facility site area. A phased approach to reclamation activities will allow vegetation growth and aid in erosion control.

4.8.5 General Mining Overview

Underground mining methods will be used to extract the ore due to the relatively deep, narrow and nearly vertical orientation of the deposit. The principal mining method will be mechanized blasthole open-stoping with delayed backfill. This proven system allows efficient and selective mining at relatively high production rates. The mine plan is based on an ore production rate of 5,500 tpd, resulting in an annual ore production of approximately 2,000,000 tons.

Access to the mine will be through the 22- to 26-foot diameter central services and production shaft. This shaft will provide for movement of employees and general mine services, and initially will exhaust air from the mine. A second shaft will be sunk on the eastern end of the ore body. This 16- to 19-foot diameter shaft will serve as a fresh air intake to the mine. During the development phase of the mine, this east ventilation shaft will be used to hoist waste rock from the mine. A third shaft will be excavated in the last year of the construction period to provide additional ventilation as the mine extends to the west. When completed this shaft will serve as the primary exhaust point for mine air.

Electric, pneumatic, diesel, and electric/hydraulic equipment will be used underground to achieve design production rates. Broken ore will be transferred to an underground crusher. During normal mine operations, rock crushed to eight inches, or less, will be conveyed from the crusher chamber to the production shaft for hoisting to the surface. Skips will hoist the ore and discharge into an enclosed bin attached to the production headframe. Ore material from the bin will be transferred by belt conveyor to the ore storage stockpile. During the production period, approximately one-half of the development waste rock will remain underground and will be dumped directly into the mined-out stopes. The other one-half will be hoisted to the surface.

The coarser fraction of the mill tailings will be slurried back into the mine to fill the mined-out stopes. Cement will be added to the tailings as needed to provide strength. The cemented backfill will provide ground support and allow maximum extraction from the ore body.

An underground maintenance shop will be constructed adjacent to the ramp which interconnects each mining horizon. Most major repairs and routine servicing of equipment will be performed in this shop. A refueling station will be sited adjacent to this maintenance shop. In addition to the underground workings, the mine surface facilities will include a headframe/collar house, hoist room/compressor house and ventilation facilities.

4.8.5.1 Development Plan

Mine development will be divided into the following phases:

- The first phase has a duration of about 18 months and consists of three months of site preparation and mobilization of the shaft sinking contractor. Site preparation will begin after receipt of all permits and construction approvals.

- Following mobilization and site preparation, mine development during the next 15 months will commence with simultaneous sinking of the east ventilation shaft and the

main production shaft. The east shaft will be completed to a depth of 1,100 to 1,500 feet, and will be equipped for mine development rock hoisting by a temporary loading pocket installed at the lowest level in the shaft.

- The second phase of development, lasting about 18 months, will result in completion of the main production shaft to a depth of approximately 2,200 feet, and the installation of the underground crushing system. Mine development on the various levels will be carried out primarily from the east shaft until the main shaft is in operation. An internal mobile equipment access ramp will connect these levels.

4.8.5.2 Production Mining

Mine production will begin with ore extraction on the 900 and 1,350 levels simultaneously. The mine development and production plan is based on the following criteria:

- early production of ore at above average grades;
- production from areas with good rock mechanics characteristics and low potential for water inflow; and
- production from areas with good metallurgical recovery.

Figures 4-6 through 4-8 illustrate a conceptual layout for the initial underground development workings and the crusher/conveyor position.

4.8.5.3 Mining Methods and Production Approach

Blasthole open-stoping is a cost-effective, safe and efficient mining method. Backfilling the mined out stopes will ensure maximum ore extraction and minimum dilution.

Several alternatives to the blasthole open-stoping technique may be required during the mine life as rock characteristics vary within the ore deposit. This will be true particularly near the upper portions of the deposit where the ore body has been subjected to weathering and the ground conditions are less competent. For these areas, other mining methods, including vertical crater retreat and cut-and-fill methods, may be considered.

Ore body entries will be driven at 150 to 300 foot vertical intervals. Nominal dimensions of the stopes will be 75 feet along strike, 300 feet in height, and 100 feet in ore body width. Top-hammer or down-the-hole hammer drills will be used to drill four- to six-inch diameter blastholes on approximately 12-foot by 12-foot center spacing for production stope blasting.

A typical stope will contain approximately 250,000 tons of ore in situ. At the annual production rate of 2,000,000 tons of ore, about eight stopes will be mined each year. It is estimated that mine production will result in six to eight active stopes at any one time.

Mined-out stopes will be backfilled with mill tailings and mine development waste rock. Tailings material from the surface plant will be dewatered to approximately 60 to 70 percent solids and delivered underground through two dedicated boreholes, each with a capacity of approximately 100 tons per hour. Cement will be added to the backfill as needed to meet ground support

requirements. The backfill delivery pipelines will be intercepted on mine levels with polyethylene lines for lateral delivery and distribution to the mined-out stopes. Waste rock from development will be put directly into the mined-out stopes, thus reducing the need to crush and hoist this material.

Broken ore will be removed from the stope drawpoints by load-haul-dump (LHD) mobile equipment and trammed to ore passes located in the hanging wall of the ore body. The ore passes will be spaced along the strike of the ore body to provide an average production haul distance of approximately 300 to 400 feet.

All ore and surplus waste rock will be crushed underground in a jaw crusher to eight inches top size. The crusher will discharge into a small surge bin prior to being loaded onto the conveyor running to the main production shaft. Two bins will be located near the production shaft for storage of crushed ore and waste ahead of skip hoisting operations. The shaft will be equipped with skips for hoisting crushed rock to the surface. A double-drum, production hoist will be installed on surface at the production shaft to hoist the rock skips.

The ventilation air requirements for the 5,500 tpd operation are estimated to be 700,000 cubic feet per minute (cfm). The ventilation needs were determined for active working areas, such as production locations and development headings, as well as air volumes required for other areas of mine activities, including the crusher area and the mobile equipment shop.

The east ventilation shaft will serve as the main downcast airway to the mine. Initially, intake air will be exhausted through the main production shaft and this will prevent icing up of the main shaft during the winter months. An air heating system will be provided at the east ventilation shaft. Upon completion of the west exhaust raise, an estimated 650,000 cfm will be exhausted up this shaft and 50,000 cfm will discharge up the main production shaft.

Utilities will consist of underground power, compressed air and communications. Electrical power will be distributed underground using a 13.8 kv main system. Substations located on the various levels will step the power down to 4160 V or other voltages, as needed. Emergency power will be provided and connected to certain emergency equipment, (typically main ventilation fans, dewatering pumps, and the emergency hoist). The compressed air requirements may be satisfied by the use of portable compressors located on the mining levels where necessary.

4.8.5.4 Production Shaft Headframe and Collar House

A steel or concrete headframe will be constructed over the collar for the main production shaft, and a 22- to 26-foot diameter vertical shaft will be sunk to a depth of approximately 2,500 feet below collar elevation.

Initial mine construction with development of the main production shaft and east ventilation shaft will occur concurrently using typical mine construction techniques. The collars of each shaft will be stabilized and hydraulically controlled by ground freezing or other suitable techniques, followed by the excavation of overburden. Excavation of the loose material will be done conventionally and then clammed to surface using a surface-mounted crane. Weathered subcrop, including bedrock, may be drilled and blasted, and then hoisted to surface. As excavation advances vertically, a concrete liner will be installed to stabilize the walls. This concrete liner will form the inside diameter of the shaft, and will extend to a depth into the

competent bedrock sufficient to develop a firm connection into bedrock. At the interface of the bedrock and the overburden, inert grout may be pumped under pressure through holes in the collar and into the rock and glacial formations to provide a watertight seal.

If freezing is used, the stabilizing ice wall will be formed by closed circuit circulation of a cooling fluid (typically calcium-chloride brine) through a circular pattern of vertical pressure-tested steel cased boreholes containing inner down-flow tubes. Monitoring wells will also be installed to measure groundwater levels, ground temperatures, and for detection of brine leakage.

Once excavation and lining of a shaft collar is complete, the protective ice wall and the surrounding soils will be allowed to thaw. Abandonment of the freeze pipes will include:

1. removal of brine for off-site disposal by the freezing contractor;

2. clean water flushing of freeze pipes;

3. mechanical perforation of freeze pipe casings at the soil-rock interface at the hole bottom; and

4. displacement of freeze pipes flushing water with neat cement grout delivered from the surface.

When the collar section of the main shaft and east ventilation shaft are completed, a headframe structure will be erected over each shaft. For the main production shaft, this will be a permanent steel or concrete headframe, while a steel development hoisting headframe will be installed on the east ventilation shaft. Conventional shaft sinking by drilling and blasting techniques will then commence at the main production shaft and the east shaft concurrently.

During this 15-month construction period, water inflow into the shafts will be limited to less than 10 gpm. Shaft water will be pumped to the wastewater storage ponds. These ponds will be constructed of native clay and lined with a geomembrane using traditional construction techniques. The wastewater storage ponds, northwest of the production shaft will be completed and available for use to receive the shaft construction water when sinking into bedrock begins. It is estimated that, at most, only about 45 percent of this wastewater storage pond capacity of 15 million gallons would be required to store all the shaft drainage water.

The main production/service headframe will house the sheave wheels for the surface mounted drum-type mine production and service hoists (Figure 4-9). The headframe will have a height of approximately 165 feet above grade and will include sheave enclosures, the ore and waste bins at ground level and the collar house adjacent to the structure.

Two skips hoisted by the production hoist will empty minus eight inch ore/waste rock into the enclosed headframe storage bins. A bottom bin discharge gate will feed onto a conveyor belt which will then transfer ore to the coarse ore storage. A baghouse will be used to capture fugitive dust emissions from the top of the bin and at the discharge feeder at the bin bottom as ore is fed onto the conveyor.

Personnel, equipment and materials will access the main shaft through the headframe collar house at the surface elevation. This facility will provide a staging area for personnel, equipment

and materials in readiness for shaft transport. Mine services, such as compressed air, water, and electrical cables, will also enter the shaft through the headframe.

A sump will be excavated adjacent to the bottom of the completed shaft to collect water draining from the mining levels above. Pumps installed in this sump will transfer the collected water to a larger main sump installation on a level above the shaft bottom for eventual pumping to the surface. Shaft conveyances will include two rock hoisting skips and a personnel and materials service cage.

During the initial development waste rock and ore will be hoisted through the east shaft.

4.8.5.5 Main Production Hoist and Compressor House

Mine production and service hoisting equipment will be housed in a building adjacent to the main production shaft (Figure 4-9). A double drum hoist will be installed for ore/waste rock hoisting with skips in balance. The personnel and materials service cage hoist will also be a surface mounted unit.

The construction of the headframe, collar houses and hoist rooms will be typical steel erection and cladding techniques similar to any surface industrial facility and in accordance with applicable state and federal requirements.

4.8.5.6 Mine Ventilation System

During the second phase of mine development, the east ventilation shaft will be equipped with fan(s) and heater facilities to supply approximately 700,000 cfm of tempered air to the underground workings. This facility will also serve as a second means of egress from the mine.

Fresh air will enter the mine through the east ventilation shaft. Controlled amounts will be drawn from this shaft on each operating level, distributed to the various working places, and collected in the exhaust air drifts which will ultimately conduct the return air to the surface through the main production shaft or west exhaust raise. Two ventilation fans will be installed on the surface near the top of the downcast air shaft. These centrifugal fans, having total capacity of approximately 700,000 cfm will provide fresh air to the underground workforce.

A system of secondary booster fans may be installed underground at appropriate points in the ventilation system to assure proper distribution and control of the air flow through all active working places. Additionally, smaller auxiliary fans and air ducts will be used to transport fresh air to mine areas that are not on a completed ventilation circuit. Ventilation doors and regulators will also be used where necessary to control the air streams to each level. The ventilation system will be regularly monitored and adjusted as necessary to maintain adequate levels of ventilation in all parts of the mine. Ventilation distribution and the control of mine air quantities and quality will be in accordance to the Mine Safety and Health Administration and Wisconsin Mining regulations.

During the winter months, air entering the downcast shaft will require heating to 40-45°F. This will be accomplished by a system of direct-fired, natural gas-fueled heaters installed at the surface air intake of the east ventilation shaft. The ambient air temperature in the underground

mine workings will average approximately 55°F year round. The heating plant will be designed for a heating capacity of approximately 70,000,000 BTU/hr.

4.8.5.7 Exhaust Ventilation

During initial pre-production mine development, the main shaft will exhaust air from all mining levels and upcast air through the headframe. As mining progresses westward, an additional 16-19 foot diameter west exhaust raise will be mined to discharge approximately 650,000 cfm of air from the mine. The initial development of this shaft will require freezing or other means of stabilizing of the overburden from surface into the competent bedrock. After the collar is installed on the west shaft, the remainder of the shaft will be excavated by either conventional drilling and blasting or by raise drilling.

4.8.5.8 Mine Air Intake and Heating Plant

Two large ventilation fans will be installed at the east ventilation shaft collar. The facility will ultimately downcast air at approximately 700,000 cfm. The fans will be installed in parallel, and each will have a motor operated damper which will facilitate isolating it from the air flow when work on the fan is required, or when a smaller volume of air is needed in the mine. These units, coupled with the natural gas heaters, will be mounted on a concrete slab housed in a prefabricated steel structure.

4.8.5.9 Pre-production Ore and Waste Rock Storage Area

During the various stages of pre-production mine development, waste rock and ore will be produced. Waste rock will consist predominantly of quartz and other silicate minerals (chlorite, sericite, plagioclase) and small, but varying amounts of pyrite.

During initial pre-production mine development, most of the waste rock will be brought to the surface and either stockpiled on the pre-production storage pad if it is Type II waste rock or if it is Type I, it will be used as a construction aggregate as described in Section 4.5. During production, Type II waste rock will be principally generated on an annual basis. It will be used as underground roadbed material, mine backfill, and as riprap within TMA cells. Initially, Type II waste rock will be delivered to the lined pre-production ore storage pad and used as needed for riprap in the tailings basins.

Two storage areas will be located to the north of the main production shaft to store pre-production ore and waste rock hoisted to the surface during pre-production mine development. The two storage areas combined will have the capacity to store approximately 1,050,000 tons of uncrushed waste rock and ore of a maximum size of 24 inches. One, a lined storage facility, will have the capacity to store approximately 450,000 tons of ore and Type II waste rock. The prepared surface pad located east of the lined storage area will have the capacity to store up to 600,000 tons of Type I waste rock, although it is not expected that all this capacity will be needed.

The pre-production ore and Type II waste rock storage area has been designed to accommodate the maximum amount of these materials to be hoisted from underground during pre-production and will occupy a total area of eight acres (Figure 4-10).

For the ore and Type II waste rock, a central ridge will divide the preproduction ore storage area on the north-south axis. Each side of the pad slopes away from the center and is bounded by berms with runoff collection ditches which route water to a lined surface drainage basin. The base of the pre-production ore storage pad will consist of a compacted layer of existing soil overlain by a geomembrane liner. A till protective layer will be placed over the geomembrane. Water from this area will drain to wastewater basin No. 5 sited southwest of this impoundment area. These drainage basins are sized to hold the volume of water from a 25-year, 24-hour storm event.

The second storage area, approximately 10 acres in size, will be cleared, grubbed and rough site graded to act as a construction lay down area and to hold Type I waste rock. This material will be reused as a construction aggregate. The storage area will be developed by ramping to an elevation of approximately 30 to 40 feet above the base grade. Resulting side slopes will be 1.5:1 or 2:1, depending on material. Runoff from this storage area will be routed to a temporary runoff basin No. 3, immediately north of this storage area.

Ore and waste rock hoisted during the pre-production period will be loaded into trucks by chute from the headframe bins and hauled to the appropriate storage area. At mill start-up, the run of mine ore from the stockpile area will be processed through a temporary crushing plant. The crushed ore will then be hauled by truck to the coarse ore storage, dumped into a hopper, and conveyed into the coarse ore storage area. During facility construction, the Type I waste rock will be crushed and used as construction material, and the Type II waste rock will be used in the TMA cells. Fugitive dust emissions that may result from loading, hauling, crushing, and dumping will be controlled by engineering controls or by the use of water sprays.

4.8.6 Underground Mine Facilities Description

The mine preproduction period of three years will be controlled by the time to fully develop the main production shaft and underground crusher station (Figure 4-8) and mine workings. Within this primary time frame there will be two additional activities, namely sinking and equipping the east air shaft for development hoisting, and mine level development for preparation of the initial stopes.

4.8.6.1 Mine Development Schedule and Sequence

There will be two discrete construction phases during the 36 months required to develop the Crandon Project. Each phase will have distinct characteristics which define its duration. The two phases of the mine development schedule as shown in Figure 4-5 are described below.

4.8.6.1.1 Phase I - Shaft Sinking

During the first 18 months of construction, the mine contractors will commence development of the primary mine access and ventilation openings. These facilities will include the main production/service shaft and the intake air/development hoisting shaft/east ventilation shaft which will be used for the initial level development of the mine. The duration of Phase I is defined by the critical path for sinking and equipping the east ventilation shaft to the depth of 1,100 to 1,500 feet.

Each of the two primary mine openings will require construction of a concrete collar through the partially saturated glacial overburden which blankets the site. Ground freezing, or other suitable techniques, will be employed to stabilize the overburden prior to collar excavation and lining. Once the concrete collars are complete to competent bedrock, the surrounding frozen overburden will be allowed to thaw.

Collar construction for the main and east ventilation shaft will be the initial site activities. These collars will be developed simultaneously to expedite project completion, after which the collar for the west ventilation raise will likely be installed. Following completion of the main production and service shaft collar, the permanent steel or concrete tower headframe will be constructed. A shaft sinking hoist will then be installed on an unfurnished lower floor of the headframe structure. Conventional shaft sinking methods will be used to excavate the 22-26 foot diameter shaft. By the end of the Phase I construction period, the main shaft will have advanced to a depth in excess of 1,200 feet, including excavation of the mine level stations.

The first phase of mine construction will conclude when the east ventilation shaft is available for development rock hoisting duty. This 16-19 foot diameter shaft will have been conventionally sunk to a depth of 1,100 to 1,500 feet, including mine level station excavations, in parallel with the main shaft construction. The headframe and hoist installed for Phase I construction will be modified for use as the mine development man and materials hoist throughout the subsequent mine construction time period.

4.8.6.1.2 Phase II - Level Development

Main shaft sinking continues on a seven day per week schedule, while actual mine level development will begin from the east shaft on a similar seven days per week basis. Men and materials handling to support the crews will be provided by the development hoisting gear installed for the east intake air shaft during the first phase of construction.

Ventilation for the initial level mining will be provided through intake air pipes installed in both shafts. It is estimated that a total of four drifting crews per shift as well as the main shaft sinking crew will be employed during this construction phase. Drifts will be advanced on three mine levels, and interconnected by the mobile equipment access ramp. These three mine levels will encompass the stoping blocks targeted for initial mine production. The primary objective during entry on each level will be to advance the headings to the west to connect with the main production shaft. Phase II of mine construction will end with completion of the main shaft. At this point, a partial mine ventilation circuit will have been established, providing 300,000 to 400,000 cfm of fresh air for expanded mine level development activity.

The second objective during this phase of development will be to advance the levels westward for the early development of the west exhaust air raise to the surface. This development will establish the initial stoping blocks for ore extraction. Stopes will be prepared for initial production, as shown on the accompanying Figure 4-11.

During this latter stage of pre-production development, the main production shaft will be complete to its final depth and the crusher station, ore/waste bins, loading pocket and water sumps will be excavated. The installation of crusher conveying system, skip loading facilities, and pumping system will also be completed. The ventilation capacity will be upgraded to the design-rated capacity of 700,000 cfm with the completion of the west exhaust raise.

4.8.6.2 Mine Rock-Handling System

The rock-handling system for the mine will be designed to handle a total of 2.2 million tons per year of ore and waste rock (2 million tons of ore and 0.2 million tons of waste).

As shown on Figure 4-8, ore and waste will be transported to the dump points on the various levels by trucks or LHDs. At the dump points, rock will pass through a "grizzly" (heavy steel frame with nominal two-foot by three-foot wide openings that allow the properly sized rock to pass through) to storage bins directly above the crusher. Any oversize material will be broken by use of a pedestal-mounted rock breaker. Rock will be withdrawn from the coarse rock storage bins and fed into the crusher. The flow of rock into the crusher will be controlled through the use of rock gates or mechanical feeders.

The coarse rock will be reduced in size in the jaw crusher to approximately eight-inch top size. The crushed rock will fall into a surge bin located below the crusher. Crushed rock will be withdrawn from the base of the surge bin by mechanical feeders and loaded onto a conveyor that will transfer the rock to the production shaft. At the shaft, the conveyor will discharge into a loading pocket which will be used to load the skips, which are hoisted up the shaft.

All rock excavations for the above facilities will use conventional drilling and blasting. Ground support will be installed as necessary to provide stable long-term openings in the rock. Dust control measures will be employed at all rock transfer points and will include fixed dust collectors at the crusher and crushed ore and waste rock bins, and dust suppression sprays at other locations.

4.8.6.3 Mine Drainage System

The predicted steady state rate of groundwater inflow to the mine ranges from approximately 350 to 1,150 gallons per minute (gpm). Figure 4-12 depicts a mine drainage schematic and water balance. For purposes of designing the underground mine water handling systems, a maximum expected inflow rate of 1,150 gpm was used based on no control of mine inflow. However, during mine development and operation, practical efforts will be made to control and reduce the rate of groundwater inflow.

Groundwater inflow to the mine will be collected in two separate systems. First a non-contact groundwater interceptor system may be installed on the uppermost mining levels if the volumes of such water are sufficient to justify it. The collected water would then be pumped to surface separately. Second, a mine drainage water collection system will consist of a sump and pump station near the bottom of the main shaft. Mine drainage water, which has been used in the mining process or has contacted the ore, will be pumped to the wastewater treatment plant. Groundwater inflow to the mine will predominantly be through weathered bedrock structures. The intensity and lateral extent of the bedrock weathering diminishes with depth. Initial mine production has been planned for the lower mining levels which are well below the weathered zones. Therefore, groundwater inflows to mine workings during the early years of mine production are expected to be very limited and localized. When these flows are low, it may be more practical to collect and pump both contact and non-contact water from the same sumps at the lower levels of the mine.

4.8.6.4 Mine Dewatering and Groundwater Inflow Control

Groundwater inflow will vary during the different stages of mine construction and operation. The proposed mining plan for the Crandon Project avoids entry into weathered zones during the initial operations, therefore deferring maximum expected inflow rates. During the initial operations, groundwater inflow is expected to be minimal and localized, occurring through isolated bedrock fractures that have limited capacity to move water. During this period, water probe holes will be advanced into the weathered bedrock areas to de-pressurize and dewater them. The water removed in this fashion will primarily be stored water which will be withdrawn at rates that can be effectively managed at the project's wastewater treatment plant. A more detailed description of this process follows.

As mine development progresses upward from the early developed areas (Figure 4-6), exploratory diamond drilling techniques will be used to identify active underground water courses prior to advancing the mine face. These techniques will be employed throughout the mine to identify and drain stored water. Flows encountered on the uppermost active mine level will be captured by interceptor drill holes, and the water will be contained to avoid contamination by mining operations on levels below and to reduce pumping head. Typically, groundwater interception holes will form conical fans in the weathered rock above the development openings, thus increasing the radius of the openings as line sink drains. A conceptual cross-section of the groundwater interceptor system showing the collection methodology is presented in Figure 4-13. Standard rock grouting techniques, typically using neat cement, may also be used for local inflow control during the early mine years to limit total mine pumpage.

Groundwater collected from water probe holes or other drill holes placed specifically for inflow interception will be routed to a clean water sump and pump station near the main shaft on an upper mine level. The collected groundwater will typically be pumped to the wastewater treatment plant on the surface. However, a portion of the water may be retained underground for distribution as mine utility water.

Groundwater seepage that is not captured by the interceptor system will infiltrate the mine workings and ultimately be recovered in the main sumps along with the mine's potable, utility and backfill drainage water. Normal mine drainage collection will begin on each mine level where groundwater seepage, utility water and backfill drainage will be ditched to small local sumps excavated in the drift wall. Water from the local mine level sumps will be piped or drained through boreholes to collection sumps on main mine levels, and ultimately to the main mine sumps located adjacent to the production shaft on a lower level.

The main mine sumps and pump station will generally be arranged as indicated on Figure 4-14. Sumps will consist of downgrade excavations in the wall rock adjacent to the pump station. These will function as pumping reservoirs with an outlet end bulkhead containing the pump suction pipes.

The above described mine dewatering and groundwater inflow control methodology represents common mining practice. Each of the methods discussed has been successfully applied in mines around the world. No special or first time applications of new methods are proposed or needed for the Crandon Project.

4.8.6.5 Mine Electrical Power Systems

Electrical power will be supplied to the underground mine facilities from a surface substation at 13.8 kv. In the event of a power outage on the surface, auxiliary power will be supplied from on-site generators to maintain essential services. Power will be stepped down to the required voltage by various load centers distributed throughout the mine. Some load centers, such as those for the fans and pumps, will be permanently installed. Other load centers servicing mobile equipment, such as electric-hydraulic drills will be semi-portable and will be relocated periodically. Below is a representative list of all major mine equipment requiring electrical power:

- Production Hoist
- Escape Hoist
- Auxiliary Mine Fans
- Conveyor & Feeders
- Electric/Hydraulic Drills
- Surface Compressors
- Cage Hoist
- Centrifugal Fans
- Jaw Crusher
- Pumps
- Booster Compressors
- Raiseboring Machine

4.8.6.6 Communications System

The mine communication system will consist of a telephone and possibly a radio system. These systems will be extended on the various mine levels to lunchrooms and other key areas such as the maintenance shop. The systems will allow communication to and from surface and between various areas of the mine.

4.8.6.7 Mobile Maintenance Facilities

Daily service and inspection, periodic preventive maintenance, component replacement, and repair of mobile mining equipment will be conducted in an underground mobile equipment service shop. This area will resemble a surface truck garage. All mobile and portable mining equipment will have access to this shop by the main ramps which interconnects all mining levels. Lubricants and hydraulic oils will be stored in this shop. This shop can be isolated by fire doors at all entrances and interlocked with sensors. The underground maintenance facility will be equipped with overhead crainage, welders, and a parts supply warehouse.

4.8.6.8 Sanitation Facilities

Underground sanitation facilities consistent with modern Mine Safety and Health Administration (MSHA) approved facilities will be provided at several locations on each level in the mine within walking distance of most work locations.

4.8.6.9 Water Supply Facilities

Potable water will be distributed through the mine by bottled water and dispensed underground on a daily basis. The source of potable water will be the surface fresh water well used to supply potable water to the plant site. Alternatively, water could be piped down the shaft to the work places.

4.8.6.10 Fuel Handling and Storage

Diesel fuel oil will be used to supply the needs of the underground mining equipment and surface mobile equipment. Two bulk storage tanks sized at 15,000 gallons each will be located above grade on the eastern edge of the plant parking lot for storage of fuel oil. Truck access will be provided to the fuel oil storage tank area. Pumps and pipelines will be designed to permit safe unloading of the trucks.

In the unlikely event of a tank rupture, the spilled fuel would be totally contained within a dike. If such an event should occur, the spilled fuel will be pumped to a tanker truck for disposal at an approved disposal location off-site or to a reprocessor, if appropriate. The fuel handling and storage system will be designed and built in accordance with state and federal codes.

A fueling station will be provided for dispensing fuel to surface mobile equipment. This station will be located adjacent to the fuel oil batch tanks. The fueling station will have one diesel fuel tank and one gasoline tank, both of which will be above grade. The fueling station will be designed and built in accordance with applicable state and federal codes. Temporary bulk propane storage tanks and vaporizers will be constructed as part of the surface plant to provide back-up for the on-site generators and to serve as back-up for mine air heating in the event of a natural gas interruption. The bulk propane storage will be located west of the 2.5-3.0 MW standby generator facility.

Diesel fuel will be transferred from either of two 15,000-gallon surface storage tanks into a 3,000-gallon underground mine drop tank sited adjacent to the surface storage tanks. Transfer pump(s) will be mounted adjacent to the bulk storage tanks on a steel structure at the same elevation of the crest within the bermed area. Fuel can then be metered through a one-inch steel pipe inserted inside a cased borehole to a 4,000-gallon underground mobile equipment storage tank, located near the underground mine shop. The underground mobile equipment facility tank will be located within a concrete dike with sufficient capacity to contain 110 percent of the tank and pipeline content. A schematic of the underground fuel delivery system is shown in Figure 4-15. Valves controlling the filling and emptying of these tanks will be interlocked with the receiving tank in the underground fuel station.

This underground tank will have a fuel dispensing pump, valving, and level sensors. The tank will be located in a bedrock excavation behind a concrete retaining wall. Any spilled fuel will be collected within a concrete sump, filtered and recycled to the fuel tank or brought to surface for disposal. The diesel fuel station will have a foam generator for fire suppression. Individual vehicles will either be refueled at the fuel station by pumping directly from the storage tank or fuel will be hauled to remote parts of the mine in a tank truck.

4.8.6.11 Personnel Facilities

Lunch rooms will be strategically located on each mine level within walking distance of most work locations. Some of these areas will be multi-purpose, serving as first aid stations, communications centers, meeting and training locations, and/or marshalling points. These facilities will be supplied with portable water.

4.8.7 Mill

A 5,500 ton-per-day concentrator will process ore to recover valuable minerals as concentrates of zinc, copper and lead. Primary crushed ore will be hoisted to surface and dumped in a bins located in the headframe. The ore will be transferred by a covered conveyor to a coarse ore storage facility.

The coarse ore stockpile will have a live capacity of about 11,000 tons or equivalent to two days' production. Ore will be reclaimed from the stockpile by feeders located under the stockpile which discharge to a covered conveyor belt that feeds the mill. The mill feed belt will discharge to a semi-autogenous grinding (SAG) mill where water is added. The slurried ore from the SAG mill will discharge to a screen. Any oversize material will be recycled by conveyor back to the SAG mill. Provisions will be made for the future installation of a gravity separation circuit and a pebble crushing circuit if required. A ball mill will be used for secondary grinding of the slurried ore. Screen undersize and ball mill discharge material will be pumped to a set of cyclones. Cyclone underflow will normally return to the ball mill but provisions will be made to allow partial recycling to the SAG mill. Cyclone overflow will contain 35 to 40 percent solids and have a size distribution of 80 percent minus-200 mesh.

Cyclone overflow will flow to an aerator-conditioner in the first stage of the flotation circuit. Following conditioning, a combined copper/lead rougher flotation concentrate will be produced. After regrinding and one flotation cleaning step, the combined concentrate will be treated in a copper/lead separation circuit where lead will be depressed and copper floated using selective reagents. The froth from the copper/lead separation will be the final copper concentrate. The lead in the copper/lead separation tailings will be reactivated, floated and cleaned to produce a final lead concentrate.

Tailings from the copper/lead rougher and cleaner flotation will be pumped to the zinc circuit where the slurry will be conditioned to selectively activate the zinc minerals. Flotation cells will be used to produce a final zinc concentrate. Flotation tailings will be refloated to produce a primary scavenger concentrate and a final tailing. The primary scavenger concentrate will be reground before reflotation in secondary cells to produce additional final zinc concentrate and a tailing which will be refloated in scavenger cells to produce final tailings. The secondary scavenger concentrate will be joined with the primary scavenger concentrate for regrinding and reflotation. Flexibility for circuit changes will be provided in the zinc circuit to accommodate ore grade variations and changes in mineralogy. Tower mills may be used for regrinding the rougher and scavenger concentrates.

Dewatering of the three concentrates will be accomplished in thickeners followed by pressure filtration. After filtering, the concentrates will be loaded into rail car containers or trucks, or when necessary, stored for subsequent loadout by front-end loader. The projected moisture content of the concentrates is between eight and ten percent.

Final tailings from the zinc roughers will be cycloned to produce sands for the mine backfill plant. The remaining fines will be pumped to the tailings cell. The concentrator design incorporates proven modern technology, and will include complete on-steam analysis integrated with state-of-the-art instrumentation and process control technology.

Laboratory facilities will be located in or adjacent to the concentrator. If temporary laboratory facilities are needed for the two years prior to completion of the mill facilities to allow analyses of ore and waste samples from mine development and water quality samples, it will be accommodated in trailers or contracted to an outside lab.

Table 4-1 shows a typical equipment list found within the mill concentrator facility.

Table 4-1

Mill Facilities Typical Equipment List

Operation	Equipment Description
Ore Preparation	
Coarse Ore Handling	Conveyor to Coarse Ore Stockpile Coarse Ore Feeder Belts Conveyor: Coarse Ore to SAG Mill Dust Collector
Ore Beneficiation	
Grinding	SAG Mill Ball Mill Screens Slurry Pumps
Backfill Preparation	Cyclones Cement Silo Feeders Mix Tanks Distribution Pumps
Flotation	Flotation Cells Flotation Columns Pumps and Conditioners Cyclones Regrind Mills Pumps
Reagent Preparation	Mix Tanks and Agitators Transfer Pumps Holding Tanks Metering Pumps
Concentrate Thickener	Thickeners
Filtration and Loadout	Filters Conveyors Pumps

4.8.8 Mill Construction

Excavation of the foundations, erection of walls and the pouring of slabs for the concentrator building will commence at about month 16, as shown in the construction schedule (Figure 4-5). Principally this building will be a structural steel frame with insulated structural walls and roof. The installation of electrical and mechanical processing equipment will commence following structural steel erection and the installation of major process components. The typical equipment required during this construction includes backhoes, bulldozers, lifting cranes, graders, dump trucks, earth compactors, and material conveyors.

4.8.8.1 Coarse Ore Storage

After ore is hoisted to the surface, a covered conveyor will discharge ore to the covered coarse ore storage area. The stockpile will hold approximately two days of mill feed or approximately 11,000 tons. A concrete tunnel below the stockpiles will house feeders for reclaiming the ore. The feeders will discharge to the main conveyor which will transport ore directly to the SAG mill.

This ore storage area will have a base constructed of compacted till and coarse granular waste rock over the reclaim tunnel feeders. Surface drainage at this covered facility will be controlled with external diversion ditches and the runoff being directed to wastewater storage basins No. 6 and 7.

An insertable dust collector will be located on top of this covered structure and will exhaust to the ambient air.

4.8.8.2 Concentrator Facilities

The recovery of concentrates from the ore will take place in a concentrator building shown in Figure 2-1, located northwest of the mine production shaft. The equipment required for the extraction of zinc, copper, and lead minerals from the ore will be housed in this building. The facility will involve grinding, flotation, thickening, filtering, and concentrate storage/loadout.

Electrical power, utilities, heating, and ventilation will be provided in the building, as required. Large overhead doors will provide access into the primary grinding section, reagent storage area, and to the railroad access provided to the concentrate loadout section. The SAG mill in a closed circuit with a ball mill will reduce the rock to a size where liberation of valuable mineral particles from the gangue material can take place. The flotation circuits will selectively separate and concentrate the zinc, copper, and lead minerals into three concentrate products. The facility will also include thickeners and filters for dewatering the concentrate produced.

Provisions to contain slurry spills will be available throughout the mill building. Process spills will be restricted to confined areas, collected in floor sumps, and pumped back into the appropriate process equipment so that the minerals can be recovered. Spills in corridors containing process pipes will be channeled into drainage trenches, collected in sumps, and returned to the process. In addition, draindown sump capabilities will be provided to handle approximately 24,000 gallons of tailings slurry water.

Any accidental spills within the reagent mix area will be collected. Reagent storage and preparation facilities are designed with the criteria that any spills are to be contained for recovery and reused. The bulk storage facilities outside the mill building are designed to contain any spills as well as the total contents of a bulk tank should a rupture occur.

The control room or rooms will be located such that grinding and flotation operations can be observed visually by the control room operator. All process equipment will be tied into the control room which include start-up warning alarms, electrical and mechanical interlocks, emergency stop switches, and various process alarms. Necessary equipment will be installed to monitor all aspects of the grinding, flotation, and concentrate dewatering processes. Computer control devices and graphic displays of the process with equipment running condition will be in the control room areas.

The heating system for the concentrator building will consist primarily of self-contained natural gas heaters that will be installed throughout the building's production area. Local ventilation will be provided by exhaust fans. Some recovered low grade heat, electric heat and air conditioning will also be utilized. Other buildings on the surface will also have self-contained heating units where required.

Laboratory facilities will be located in or adjacent to the concentrator building. A metallurgical laboratory will be provided to prepare samples for chemical analyses and to perform both routine and non-routine metallurgical testing for process performance evaluation and control. An analytical laboratory will provide chemical analyses to support process evaluation and control work, analyze drill samples from underground ore samples, and provide analyses for concentrate shipments.

An environmental laboratory will provide monitoring capabilities including analyses of water discharge samples, samples from groundwater monitoring wells, and analysis of dust samples. Specialty work like biological studies and analysis of ambient air and workplace monitoring samples will likely be done by outside contractors. The concentrator facilities will be built using conventional construction techniques for typical steel erection and exterior cladding. Foundations and slabs on grade will be concrete. Equipment installation will follow typical industrial practices.

4.8.8.3 Backfill Preparation Facility

The chosen underground mining method requires backfill to stabilize the peripheral in-place rock after ore is removed. Backfill materials will include classified mill tailings and development waste rock. Use of a backfill type mining method provides for long term mine area rock mass stability, allows more complete extraction of the ore body, and minimizes the amount of waste rock and mill tailings requiring surface management. The backfill preparation will include pumps and cyclones to recover coarse tailings, cement storage silos, a batch mixing tank, and a storage tank and pumps to deliver the prepared backfill slurry to the underground mine. All backfill preparation and distribution systems will be sited in the concentrator. Boreholes will be located in the mill floor, when possible, which will provide for containment of any spills within the concentrator building. Any backfill spills will be washed to a containment sump and repumped to the batch mix tank.

Approximately 40 percent of the dry mill feed tonnage will be recovered as backfill and returned to the mine for deposition into the mined out stopes. Classified mill tailings at a nominal +10 micron split will be the major constituent of mine stope backfill material, amounting to 90 to 95 percent of all fill placed. Mill tailings prepared as mine backfill product should possess the following qualities:

- the ability to be transported hydraulically at relatively high (60 to 70 percent by weight) slurry densities;
- in-place percolation rate and drainage characteristics which will preclude both hydrostatic head development during placement and high residual moisture content;
- low in-place compressibility, to provide appropriate support to stope walls; and
- development of adequate strength, when mixed with small portions of cement (less than 10 percent by weight), to be self-supporting when exposed by removal of adjacent stope rock.

The backfill plant product will be prepared for mine delivery at a slurried density of 60 to 70 percent solids by weight. It will be a free draining backfill when uncemented. Cemented fill will be produced by addition of cement/water slurry in the concentrator. Type I Portland cement will be used. A 10:1 coarse tailings-cement ratio will sufficiently stabilize the in-place backfill such that it will be self-supporting for normal mine stope dimensions. It is likely that the ratio of cement to coarse tailings can be reduced to 30:1.

4.8.9 Waste Management Facilities

4.8.9.1 Mine/Mill Solid Waste Types and Volume

As described below, during mining and processing of ore, solids in the form of refuse and mining and processing wastes, such as waste rock, tailings, wastewater treatment plant solids and laboratory wastes will be generated.

4.8.9.1.1 Refuse Generation

An estimate of refuse generation in tons and cubic yards from the various waste streams at the Crandon Project facility during construction, operation, closure and reclamation is shown in Table 4-2. The estimates have been developed taking into consideration the requirements of Wisconsin Act 335 and typical mining practices.

Table 4-2

Refuse and Waste Generated During Construction, Operation and Closure (Without Post-Closure Recycling)

Phase	Item/Description	Basis	Annual Tons	Annual CY	Project Life Tons	Project Life CY
Refuse(1)						
Initial Construction	Refuse generated by the construction work force	5.0 lbs/prsn/dy, 26 dys per mo.	295	590	890	1780
Construction	Refuse generated by mill/mine construction work force	2 x 80 tons (160 cy) =	80	160	320	640
Operation		5.0 lbs/prsn/dy, 26 dys/mo, 336 mos (28 yrs), 450 staff	350	700	9,830	19,660
Closure	Refuse generated by mill/mine closure	5.0 lbs/prsn/dy, 26 days/mo, 48 mos (4 yrs), 130 staff	100	200	405	810
		Subtotal			11,445	22,890
Waste						
Construction	Non-recyclable waste from construction activities					
	• Dry wall*	waste rate - 20 percent*	--	--	--	30
	• Insulation*	waste rate - 5 percent*	--	--	--	145
					Subtotal	175
Operations	Non-recyclable waste from plant operation					
	• Waste metals		--	--	42	8
	• Conveyor belting*		4	3	120	90
	• Rubber base & piping*		2	4	60	120
	• U/G supplies & packaging*		1	4	30	120
		Subtotal	7	11	252	338
Closure	Non-recyclable waste from plant shut down					
	• Insulation (43,000m^2)*				--	2,870
	• Dry wall (9,000m^2)*				--	150
	• Metal siding and roofing and fencing				207	38
		Subtotal				3,058
		Total CY (site life) =				26,461

CY = cubic yards, assume waste in place is 1,000 lbs/cy.
* from Hansen letter to WDNR, 11/9/84.
Waste available for recycling equals 11,455 tons.
(1) Subject to recycling under Wisconsin Act 335.

Prepared by: REM
Checked by: JBH1

4.8.9.1.2 Mining and Processing Waste Generation

Mining and processing waste generation is based on the amount of development waste rock and ore mined at the site. The ore body is estimated at 55 million tons. This reserve was used in estimating mining and processing waste volumes. In addition to tailings generated as a result of ore processing, waste rock will be generated in developing the mine, stopes and shafts. Table 4-3 outlines estimated mining and processing waste types and quantities over the duration of the project.

Table 4-3

Mining and Processing Waste Types and Quantities

Material	Quantity (tons)	Final Disposition
Tailings	22,000,000 22,000,000	Mine Backfill TMA
Waste Rock[‡] Type I Type II	 610,000 650,000	Construction Aggregate, TMA Fill Material Layer, TMA Riprap, etc.
Wastewater Treatment Solids	100,000	TMA
Laboratory Waste	280	TMA

‡ Material to be hoisted to the surface. See Section 4.8.9.3 for a description of planned material use.

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Approximately 50 percent of the tailings generated as part of ore processing will be returned to the mine as backfill for the mined out stopes. The remaining 50 percent will be deposited in the project's TMA. A description of these two processes can be found in Sections 4.9.2.8 and 4.8.9.2 of this report, respectively. Details regarding the TMA can be found in the project's May 1995 *Tailings Management Area Feasibility Report/Plan of Operation* and addenda (Foth & Van Dyke, 1995b, 1996a 1996b, and 1997). A detailed discussion of the project's waste rock management plan is presented in Section 4.8.9.3 of this report.

4.8.9.1.3 Recycling Plan

A recycling program will be implemented throughout the project's life. There are two distinct sources of recycling components from the CMC facility. The two sources are: primarily scrap metals from the plant and refuse recyclables. The plant recyclables for the most part consists of scrap metal from operations and refurbishing of equipment. The refuse recyclables will consist of the waste stream components mandated by Wisconsin Act 335 such as paper, glass, plastic, aluminum and tin.

The scrap metal recyclable component of the waste stream will be collected throughout the approximately 35-year life of the facility. Projected scrap metal quantities were taken from estimates[1] developed for the project in 1984. In contrast to scrap metal recycling, it has been assumed that the refuse recycling component will be collected only during the operations life of the CMC mine and mill.

The scrap metals recycling component during operation and closure is anticipated to have a total quantity of approximately 18,111 tons over the life of the project (Table 4-4). For the mine, it is estimated that based on equipment use, operation rates and typical scrap rates, approximately 32 tons of scrap metal will be recycled annually during operations. The mine scrap metal will be generated from drill steel, piping, rock bolts, hoist cables, crusher liners, chute liners, and mobile equipment parts (buckets). Similarly, based on equipment use, operation rates and typical scrap rates, the mill is likely to generate 344 tons of recyclable scrap metal. The mill scrap metal will be generated from piping, crusher liners, chute liners, screens, and mill liners. The plant scrap metal recycling operations will consist of returning the material to the vendor or selling them to scrap dealers.

The process of collecting refuse recyclables will consist of using source collection bins. Source collection bins or "blue boxes" are typically an integral part of refuse recycling operations. Refuse recycling will consist of separate collection bins for recyclable paper, glass, plastics and refuse metals. The blue boxes are usually rectangular bins or barrels that can be easily moved with one person lifting or rolling them.

Source collection bins will be located throughout the mill, wastewater treatment plant, mine and ancillary facilities (buildings) of the complex in specific areas where operations or work functions generate a recyclable refuse component. An estimate of the recyclable portion of project refuse is contained in Table 4-5.

CMC personnel will transport the source collection bins to a larger central collection bin from each respective building. The transportation of the material from the source bins to a central facility bin for each recyclable component may occur at a regular interval or when the source bins become full.

CMC will provide a systematic collection schedule for each refuse recyclable component from each building central collection point. The inter-building pickup and delivery system is responsible for collecting the refuse recyclables and transferring them to a central stockpile located south of the wastewater storage basin No. 5 for the entire complex. This facility will be constructed with a composite liner. The stockpile will continue to increase until the volume is determined to be sufficient quantity for economic pickup by a commercial recycler.

[1]Hansen, B.J., November 9, 1984. Letter to Gary Kulibert, Wisconsin Department of Natural Resources.

Table 4-4

Recyclable Metals in Waste Stream
Construction, Operations and Closure Period

Item	Estimated Quantity Used in Construction Phase (Tons)	Assumed Recyclable Rate (Percent)	Construction Phase Recyclable Quantity (Tons)
Construction Waste			
• Reinforcing Steel	2,240	97	2173
• Structural and Building Steel	5,600	99	5544
• Metal Siding and Roofing	840	95	798
• Metal Liner Panel	160	95	152
Subtotal for Construction Phase			8667

Item	Estimated Quantity Generated Per Year (Tons)	Assumed Recycling (Percent)	Annual Recycled (Tons)	Operating Phase Recycled Quantity (Tons)	Closure Phase Recycled Quantity (Tons)
Operations					
• Scrap Metal From	36	90	32	972	-
Mine	382	90	344	10,314	-
• Scrap Metal From Mill					
Subtotal for Operation Phase			376	11,286	
Closure					
• Access Road Bridge	32	100			32
Girders					
• Railroad Bridge	20	100			20
Girders	621	100			621
• Railroad Tracks	3	100			3
• Guardrails	34	100			34
• Fencing	5,000	100			5,000
• Structural and Building					
Steel	840	80			672
• Metal Siding and					
Roofing					
• Metal Liner Panel	160	80			128
• Tracks (at plant Site)	250	100			250
• Fencing (at plant Site)	72	90			65
Subtotal for Closure Phase					6,825
Subtotal for Operations and Closure					18,111
Total Recyclable Metals from Construction, Operations and Closure Phases					26,778

Prepared by: REM
Checked by: JBH1

Table 4-5

Recoverable Fraction of Refuse For 35 Year Construction Operation and Closure Period

Materials	Percent by WT[1]	CMC Waste Stream [2] (tons)	Percent of Material Recoverable[3] (Minimum)	Recoverable Tons
Paper and Paper Board	21.6	2,472	31	766
Paper Packaging	18.2	2,084	3	63
Glass	7.1	812	22	178
Metals (Non-Durable)	0.1	12	0[4]	0
Metals (Durable)	5.8	664	6.8	45
Metals (Packaging)	2.7	309	45	139
Plastics (Durable)	2.3	263	10	26
Plastics (Non-Durable)	2.6	297	38	113
Plastics (Packaging)	3.2	366	18	66
Rubber and Leather	2.6	297	0[4]	0
Other Non Food Product Wastes	7.5	859	0[4]	0
Food Wastes	7.2	824	0[4]	0
Yard Wastes	17.6	2,015	20	403
Misc. Inorganic Wastes	1.5	171	0[4]	0
Totals	100.0	11,445		1,799

[1]Percent by weight of each material within waste stream, from USEPA, 1990, Figure 14.
[2]Tons of each material in CMC waste stream.
[3]Percent of material recoverable for recycling or composting from Table 34, USEPA, 1990.
[4]Materials with 0 percent of recoverable material are not typically recycled in Wisconsin and are not banned by Act 335.

Prepared by: PAE
Checked by: JBH1

4.8.9.2 Facilities Description

4.8.9.2.1 Refuse Handling Area

A solid waste transfer area shown in Figure 4-16 will be used for refuse storage and collection. The area will contain the refuse storage/transportation devices supplied by a contract vendor. Operation of this facility is discussed in Section 4.9.

4.8.9.2.2 Tailings Management Area

The primary function of the TMA will be to provide for environmentally compatible surface containment of the tailings generated from the mining and processing of the ore. The performance objectives for the TMA were developed based on a review and through understanding of MEND[2] tailings management criteria, applicable Wisconsin laws and regulations, and CMC's reclamation goals which are defined below.

1) To design, construct and operate the facility using sound industrial practices and in compliance with the standards prescribed by the State of Wisconsin.

2) To design the facility to avoid, minimize and mitigate impacts to wetlands, to eliminate impacts from surface water flows, and to achieve isolation from groundwater.

3) To the extent practicable, minimize the amount of required long-term care activities through the application of effective design, operation and reclamation features.

4) To limit oxidation in and solute release from the tailings mass through:

   - the placement of tailings at a high pH, with excess alkalinity to minimize the potential for acid generation during operation;
   - limiting oxygen entry into tailings during the operating and post-closure period;
   - the design of a composite base liner system to limit percolation rates; and

5) The design of a final cover which meets the following objectives:

   - limits oxygen entry into the tailings mass,
   - limits infiltration of precipitation into the tailings mass, using a hydraulic barrier of equal or less permeability compared to the TMA base liner,
   - provides a stable surface which can meet reclamation requirements,
   - provides an erosion-resistant surface.

An overview of the design and operation of the TMA is presented below. Specific design details are contained in the TMA Feasibility Report/Plan of Operation which conforms to the requirements of NR 182. Nearly all of the material placed in the TMA will be ground rock produced during the milling process. The TMA will consist of earthen cells constructed primarily

[2]Mine Environment Neutralization Drainage Program.

from site area soil materials. The cells will be lined with a composite low-permeability soil component and a 60 mil thermoplastic geomembrane liner with a leachate collection system on the cell bottom and extending part way up the sidewalls above the cell base grade. The facility will be sized to provide life-of-mine storage capacity for tailings, Type II waste rock, reclaim pond solids, and wastewater treatment plant solids.

The TMA is designed to meet groundwater quality and other standards prescribed by applicable statutes and administrative codes. The TMA design includes the following major elements:

- Located to be separated from groundwater and surface water.
- 3:1 (Horizontal to Vertical) construction of interior and exterior slopes of compacted on-site glacial till soils.
- A composite liner consisting of a low-permeability soil member and a thermoplastic geomembrane liner.
- A leachate collection system covering the bottom of the cell and part way up the interior slopes.
- A two percent base grade slope on the leachate collection system.
- A composite final cover consisting of the following components from top to bottom.
    - topsoil,
    - rooting layer,
    - drainage layer,
    - thermoplastic geomembrane liner,
    - low permeability soil liner, and
    - soil grading layer.

The components are designed to collectively provide long-term containment and environmental protection.

Figure 4-2 shows the location of the TMA in relation to the plant site, the access road, the railroad spur, and the adjacent water reclaim pond. Four tailings cells with a total surface area of approximately 220 acres inside the crests will be used over the productive life of the mine. The total area of the cells to the outside toe of the embankments is approximately 355 acres. The four cells will range in size between approximately 46 acres to 71 acres, and will be sequenced in construction, operation, and reclamation to accommodate the production of tailings from the mine.

In the event of planned or unplanned stoppages of tailings transport water, draindown sumps have been included in the plan at the low end of the line to drain and contain tailings and transport water. The facility has been designed to have an approximate earthwork balance during construction, operation, and closure; that is, most soils required for facility construction can be obtained from excavations within the tailing cell areas. Some limited quantities of fill required for final reclamation contouring will require the development of a 20-acre borrow area

north of the TMA. Temporary storage of imported clay and other materials will also occur during the TMA construction and operations.

Site preparation for the TMA will be completed in phases so that only the area actually required for the initial operating phase will be cleared and grubbed. Site preparation will involve the clearing and grubbing, separation of marketable timber, chipping or disposal of tree stumps and brush and the stockpiling of suitable topsoil for future use.

An approximate seven acre construction staging area will be established for each TMA cell immediately after site clearing and grubbing work is completed. Located within the construction staging area will be an equipment laydown area and soil a processing plant to be used for producing soils of various grain size characteristics for use in TMA construction. The construction staging area will be located within the TMA footprint for the first three TMA cells. For the last TMA cell the staging area will be located near the TMA borrow area.

Hydric soils will be salvaged during TMA cell construction and used as top dressing on the embankments.

4.8.9.2.3 Tailings Transport and Reclaim Water System

As shown on Figure 4-2 an access road will lead from the plant facilities to the TMA. The road will provide service access to the tailings slurry pipeline and reclaim water pond. The road will be 22 feet wide. It will be an aggregate surfaced road. The aggregate will be crushed Type I waste rock or it will be supplied by a commercial aggregate supplier in the area.

The area along the access road alignment will be cleared and grubbed to a width of approximately 60 feet. Topsoil will be stockpiled and reused to finish the drainage ditches along the road. Excess topsoil will be stockpiled and used during reclamation after mine closure.

The slurried mill tailings will be transported to the TMA through a surface pipeline. Reclaimed water from the TMA will be pumped to the mill through a surface pipeline. Pipes at the TMA will be routed along the crests of the engineered dam structures and will discharge tailings in a ring manner around the basin. Reclaimed water will be withdrawn from the center of each cell through a pump barge system and discharged to the reclaim pond. The access road from the plant area to the TMA will share a common corridor with the pipeline system.

Access roads will be provided on the crest of the embankments for inspection and to facilitate periodic maintenance of the pipelines. The access roads will be surfaced with crushed rock or granular materials to provide an all-weather surface. The embankment crests are designed to accommodate a minimum 12-foot-wide access road. In some sections of the basin, the embankment crest will carry the tailings and water reclaim pipelines.

From the mill to the TMA, the pipeline system will be erected on surface in a lined containment ditch. In the event of a system interruption, two draindown sumps for the tailings and reclaim water will be located at the mill and at the low point of the TMA access road. A portion of the pipeline within the plant site will be graded towards the mill. The balance of the 4,800 foot pipeline will drain to a sump at the low point adjacent to the road. In addition, the tailings line constructed in a lined ditch will eliminate drainage to the surrounding environment. Pumps for returning reclaim water to the mill site will be located near the reclaim pond. The pipeline

systems will include an approximate 16-inch inside diameter thick-walled high density polyethylene (HDPE) tailings slurry pipeline and an approximate 12-inch inside diameter HDPE reclaim water return pipeline.

Routine monitoring of the tailings pipeline will enable early detection and repair of pipeline leaks, if should they occur. Flow meters located on the ends of the pipeline (one near the mill and one near the TMA) will enable the operator to detect leaks in the pipeline and shut the system down. Test spools of pipe flanged into the tailings pipeline will be checked periodically for pipeline wear. The pipeline route will be inspected frequently to detect any unusual conditions that may affect the pipeline operation.

4.8.9.2.4 Draindown Sump

Pipe drain and spill/drainage collection facilities will be provided both at the mill and at the low point in the pipeline system to collect spills that could occur due to leaks in the pipe, and to provide storage when the pipe is blocked and must be drained. The sumps have been sized to contain two full tailings pipeline volumes, which is equivalent to approximately 100 and 450 cubic yards for the mill and low point drawdowns, respectively. Ditch grades sufficient to cause all spilled tailings to flow to the collection points are not practical, therefore some accumulation of solids within the ditch at a leakage or spill location would be experienced. Such accumulations, should they occur, will be mechanically removed and transported to the TMA. Solids or liquids removed from the draindown sumps or ditch will be placed in the TMA.

Direct precipitation into the pipeline ditch will flow to the draindown sump where it can be removed for transfer to the TMA. The ditch cross-section will include above-grade berms, as shown on Figure 4-17, to prevent surface water run on. At drainage crossings, surface water flows will be passed beneath the pipeline ditch via culverts.

4.8.9.3 Waste Rock Management Plan

4.8.9.3.1 General

CMC is in the process of updating Section 3.5.5 of its May 1995 Crandon Project *Environmental Impact Report* (EIR) (Foth & Van Dyke, 1995a) pertaining to the characterization of the materials to be placed in the TMA. The update will provide information concerning the characteristics of waste rock produced during the pre-production and production phases of mine development. This section provides an explanation of the methods that will be used to classify and manage waste rock during mining, an estimate of the quantity of waste rock by type expected to be hoisted to the surface, and an explanation of the expected uses and disposition of this waste rock.

4.8.9.3.2 Plan Objective

The objective of the waste rock management plan is to define the criteria and procedures that will be used during mine development to segregate waste rock into material that will not produce acid rock drainage and will leach only minute quantities of substances; and material that has the potential to produce acid rock drainage. The former material will be classified as Type I waste rock and the latter as Type II waste rock. The characteristics which distinguish Type I and Type II waste rock are described in the update to Section 3.5.5 of the project's May 1995 EIR.

Most of the Type I waste rock is expected to be generated during the pre-production development of the production shaft, internal ramps, underground maintenance shops, ventilation shafts and raises, and crosscuts to the ore body. Type I waste rock brought to the surface is proposed to be used as construction aggregate, road base and as fill in the fill material layer below the grading layer during TMA final cover placement.

Type II waste rock will be principally generated during the advancement of lateral hanging wall drifts. These development drifts will be mined adjacent to the Crandon formation and will provide a means of access to the ore body through crosscuts. During pre-production development when Type I waste rock cannot be segregated underground, it will be classified as Type II material. Type II waste rock will be hoisted to the surface and either temporarily stored in a lined facility north of the plant site for use as a construction material (e.g., riprap) within the lined area of the TMA cells or hauled directly to the TMA for placement with the tailings. Type II waste rock not hoisted to the surface will be placed in mined out stopes underground and used as backfill.

The waste rock management plan detailed below provides estimated quantities of both Type I and Type II waste rock, their sequence of production, their sequence of use, temporary storage location, and temporary storage period.

4.8.9.3.3 Overview of Site Geology

A detailed discussion of the bedrock and ore body geology are included in Section 3.5 of the project's EIR (Foth & Van Dyke, 1995a). An overview of these features is presented below.

The Crandon deposit trends east-west and dips steeply northward and is located in a conformable assemblage of recrystallized flows, pyroclastics, clastics, and associated sedimentary rocks. The lithologies range from felsic to mafic in composition. Stratigraphic tops face north as indicated by relict depositional features. Hydrothermal alteration and mineral zoning patterns support this stratigraphic interpretation.

The Crandon zinc deposit occurs within the Crandon Formation. The Crandon Formation is an interbedded unit up to 300 feet thick consisting of fine tuff horizons, argillites, sulfide bands, and chert. Locally, the argillites and tuff horizons may contain some sulfide. All rocks beneath the Crandon Formation are referred to as the stratigraphic footwall rocks. All rocks above the Crandon Formation are referred to as the stratigraphic hanging wall rocks.

The footwall rocks immediately beneath the Crandon Formation consist of a thick sequence of tuff with interbedded coarse volcanic debris. These rocks were locally flooded with quartz, chalcopyrite, and pyrite, which make up the stringer sulfide ore of the deposit.

Two ore types have been identified in the Crandon deposit: zinc and copper sulfides. The zinc ore, on the hanging wall (or north) side of the deposit, consists of conformable, syngenetic, sulfide-bearing sedimentary units within the Crandon Formation. The ore typically consists of discontinuous laminae of sphalerite in massive or laminated pyrite. Laminae of chalcopyrite and/or galena are less common. Crosscutting epigenetic stringer sulfide ore occurs stratigraphically beneath (i.e., in the footwall of) the zinc sulfide. This mineralization occurs in either chalcopyrite-pyrite-milky-white quartz or pyrite-sphalerite-chalcopyrite veins. This ore is

interpreted to have been formed by uprising hydrothermal fluids that were trapped by, and moved laterally beneath, the Crandon Formation.

The combined mineral zones are tabular and appear conformable with the stratigraphy for approximately 4900 feet east-west along strike. The average thickness of the combined mineral zones is approximately 100 feet. Mineralization begins at the subcrop. Economic grade material has been drilled to a depth of approximately 2200 feet beneath the surface.

4.8.9.3.4 Type I and Type II Waste Rock Segregation Criteria

Access to the mine will be through a main production/service shaft located north of the ore body in the Skunk Lake, Rice Lake, and Upper Mole Lake hanging wall formations. Ancillary facilities like the crusher, ramp, crosscuts to the ore body, garage, etc. will also be sited in these formations. Underground lateral development drifts will be located in the Lower Mole Lake formation and will access the ore body from the main production shaft at 200-300 foot vertical intervals. The lateral extent of mine level development at any given time will depend upon the need for access to mining blocks, internal ore and waste passes and ventilation raises.

During pre-production and during mining, the segregation of Type I and Type II waste rock will be made primarily based upon the sulfur content present within the waste rock formation. Type II waste rock will be defined as waste rock with a sulfur content above the value outlined in the update to Section 3.5.5 of the EIR, or waste rock generated during time periods when segregation of Type I and Type II waste rock is not practical (i.e. prior to ore and waste rock pass development). All other waste rock will be Type I material. The sulfur content of the waste rock will be established using one or both of the following techniques:

1. Geological review of diamond drill hole log data from holes completed prior to mine development and holes completed during mining to define ore grades to determine percent sulfur content within a waste rock block.

2. Visual inspection by a qualified geologist of the face of each active working development heading prior to blasting to determine the percentage of sulfur in the development drift face. The total percentage sulfur in the drift face will be determined by estimating the background sulfur content in the waste rock block based on diamond drill hole log data and visually evaluating the block and adding the weighted contribution of the sulfur from any veins/veinlets or horizons present in the face.

To assess the efficacy of using a visual inspection technique as a segregation method, an evaluation was performed by A.J. Erickson, Jr. (1996), a mining geologist, to determine the significance of sulfide mineralization that may be encountered during pre-production development. A copy of his report is included in Appendix C.

In his report, Mr. Erickson concludes that with the exception of the region of the Skunk Lake Formation, and excluding the Lower Mole Lake Formation, sulfide identified to date in hanging wall units above the Crandon zinc deposit consist of sporadic very thin crosscutting low sulfide content quartz-carbonate veins or veinlets, and occasional strata-bound horizons which contain small amounts of disseminated sulfide, or very rarely thin, more massive material. As indicated in drill holes, neither of these two types of occurrences show any significant lateral continuity. Occurrences are localized and small, and unlikely to contribute a significant amount of sulfide material to waste rock generated during early development.

Near surface portions of the main production shaft will be developed in the lower part of the Skunk Lake Formation, generally stratigraphically below and south of the zone of low grade sulfide mineralization in that unit. Subsequent development of this shaft and the attending mine workings will be largely in the lower sulfide bearing Rick Lake and Upper Mole Lake Formations. The Lower Mole Lake Formation, where development is proposed, may include somewhat more abundant veinlets or discontinuous lenses or bands of sulfide material; however, the existing drill hole data indicates that these are extremely localized and are unlikely to contribute any significant quantities of sulfides in the waste.

Tables 3 through 10 in Mr. Erickson's report illustrate the contributory effect of sulfide veins/veinlets to the overall characteristics of the waste rock to be generated by the project. These tables show the relationship of the areas of the sulfide banded material with their estimate of sulfide content, to the total area of excavated material to be generated in drifts or crosscuts, ramps, or shafts. The tables are based on a background grade material of 0.1, 0.2, 0.5, and 0.7 percent sulfide. The first two values, 0.1 and 0.2, are most likely; 0.5 is perhaps locally present, and 0.7 percent is rare and not likely to represent typical material. Vein/veinlet or horizon sulfide content in the tables ranges from 0.5 percent to 100 percent, while the thickness of the vein/veinlets or horizons ranges from 0.1 inch to 192 inches (16 feet) for headings and 120 inches (12 feet) for shafts. The tables provide a weighted average for the sulfide content of waste rock to be generated in the development workings which has background ranges from 0.1 to 0.7 percent sulfide and intersect veins/veinlets or horizons of varying thickness and sulfide content. For example, for a development drift (13 feet x 16 feet) with a background sulfide concentration estimated to be 0.5 percent based on diamond drill hole (DDH) data, the weighed average sulfide content is 0.7 percent for a development face containing a 7-inch wide band of 5 to 7 percent sulfide content.

4.8.9.3.5 Methods for Waste Rock Segregation During Mine Development

Pre-Production Mine Development

During pre-production mine development the waste rock segregation criteria discussed above will be used to identify Type I and Type II materials at the development drift face. During blasthole drilling, a mining geologist will inspect the development face in accordance with the method described above and review available diamond drill log data to make a determination of waste rock type. Material classified as Type I waste rock will be blasted, segregated, trammed and dumped into the orepass system for hoisting to the surface. Material classified as Type II waste rock will be blasted, segregated, trammed and dumped into the waste pass system for hoisting to the surface.

During the initial shaft development for both the east and main shafts, segregation and management of waste rock will be performed using the same criteria. Prior to ore and waste rock pass development, mining activities will be occurring at several locations underground. At times it may be difficult to physically segregate Type I and Type II waste rock underground due to the development schedule. If the two waste types cannot be kept separate, all waste rock will be deemed to be Type II waste for these periods. With the completion of the ore/waste pass development, segregation will be maintained.

Production Mine Development

During the mine production period, generated waste rock will either be used underground in the backfilling of underground stopes or it will be hoisted to the surface. Waste rock to be hoisted to the surface will be classified using the criteria outlined in Section 4.8.9.3.4 above. The two types of waste rock will be segregated by storing them underground and then independently transferring each type to the surface using the waste rock pass system.

4.8.9.3.6 Updated Mine Waste Rock Generation Estimates

A summary of the estimated amount of waste rock to be hoisted to the surface was previously presented in Table 4-3 above. A detailed discussion of the estimated amount to be hoisted to the surface by year follows.

Table 4-5a was prepared based on the current mine plan as the best estimate of the amount of waste rock which will be hoisted to the surface from the formations expected to be encountered during the pre-production mining years 1 through 3, and the production mining years 4 through 25. It is currently projected that year 25 will represent the last year waste rock is expected to be hoisted to the surface. The table was prepared assuming that during years 4 through 25, 50 percent of the waste rock from the mine development will remain underground as backfill material. Table 4-5a divides the mined rock into Type I and Type II based on estimated sulfide mineral content and the results of the project's waste characterization studies (Foth & Van Dyke, 1995a). The table shows that approximately 612,000 tons of Type I waste rock will be available for use in general site construction, and approximately 650,000 tons of Type II waste rock will be available for construction or placement internal to the TMA cells. Estimates of the volume of waste rock to be hoisted have been calculated using a hoisted broken bulk density of 111.3 pounds per cubic foot (Hansen, 1984). The estimated volume of Type I waste rock is 407,000 cubic yards. The estimated volume of Type II waste rock is 433,000 cubic yards.

4.8.9.3.7 Type I Waste Rock Use

Table 4-5a shows that Type I waste rock will be generated primarily in the mine pre-production phase (i.e., years 1 through 3). Type I waste rock may be used by CMC in the following project related construction applications:

- as subbase grade crushed aggregate for the access road, plant site roads, and TMA access road;
- as railroad spur ballast and subballast;
- as aggregate for the concrete required for surface and subsurface construction;
- as aggregate for asphalt pavement; and
- as crushed aggregate base course material for the access road, plant site roads, and TMA access road.

Table 4-5a

Estimated Waste Rock to be Hoisted to the Surface[1]

Year[2]	Type I (tons)[3]	Type II (tons)[3,4]	Totals (tons)[3]
1	34,000	4,000	38,000
2	271,000	21,000	292,000
3	160,000	178,000	338,000
4	91,000	59,000	150,000
5	56,000	51,000	107,000
6	—	31,000	31,000
7	—	28,000	28,000
8	—	25,000	25,000
9	—	22,000	22,000
10	—	23,000	23,000
11	—	23,000	23,000
12	—	16,000	16,000
13 - 25[5]	—	169,000	169,000
Totals	612,000	650,000	1,262,000

[1] Based on CMC's current mine plan and CMC's best estimate of mine waste rock production. Production in tons is calculated assuming an in-situ rock density of 177.3 lbs/cf.
[2] Years 1 through 3 represent the pre-production period, years 4 and on the mine production period.
[3] Tons rounded to the nearest thousand.
[4] For years 4 through 25, approximately 50 percent of the mine waste rock generated will remain underground and is therefore not included in this table.
[5] Based on an estimated generation rate of 13,000 tons per year of waste rock hoisted to the surface during years 13 though 25.

Prepared by: REM
Checked by: PAE

In addition to the above, CMC also believes Type I waste rock can be used as part of the fill material for the TMA final cover construction. Fill material is to be placed above the final tailings surface and below the grading layer. Table 4-5b contains an estimate of the quantities of Type I waste rock that could be used. Comparing this table to the estimated production of Type I waste rock shown in Table 4-5a, shows more Type I waste rock could be used if it were available.

Table 4-5c compares the amount of Type I waste rock to be hoisted to the surface per year and the potential quantity that could be used per year. This comparison shows that production is greater than use through year 5 of the mine's project life. As a consequence, CMC intends to stockpile the excess Type I waste rock in the construction material storage area at the mine site for use at a later date. Table 4-5c also provides information showing the annual and cumulative amounts of Type I waste rock that would be stockpiled.

4.8.9.3.8 Type II Waste Rock Use

The use of Type II waste rock for construction will be restricted to use within the containment area of the TMA cells. The containment area is defined as the composite lined portion of the site which is covered with the composite cover system. The potential use of Type II waste rock and the estimated quantities for each use are provided in Table 4-5d. It is anticipated that Type II waste rock will be used as riprap on the base and sideslopes of the TMA cells.

Table 4-5e compares an estimate of the yearly amount of Type II waste rock that will be hoisted to the surface and the quantity of Type II waste rock that could be used per year in TMA construction. This comparison shows that the production of Type II waste rock is greater than the potential use, especially during the first half of the project's life. To maximize the use of Type II waste rock as riprap, CMC intends to stockpile Type II waste rock periodically in the lined pre-production ore storage area at the mine site. The maximum period of storage would be 3 years. Type II waste rock hoisted to the surface at a rate greater than what can be used for TMA riprap in a 3-year period will either be used to provide a riprap layer thicker than called for in the design or be deposited directly within the TMA with the tailings. Table 4-5e also contains a material balance that shows how much Type II waste rock will be placed in and taken out of storage on an annual basis and how much will be deposited within the TMA with the tailings. A review of Table 4-5e shows:

- It is planned to use approximately 327,000 tons of Type II waste rock as riprap within the TMA cells.
- Type II waste rock storage is limited to a maximum of 3 years.
- The tonnage contained in the Type II waste rock storage stockpile at any given time will range from approximately 4,000 to 79,000 tons, or 3,000 to 53,000 cubic yards.
- Approximately 70 percent of the Type II waste rock will be hoisted to the surface in the first 10 years of the TMA site life, meaning that the majority will be placed in TMA cells 1 and 2.

Table 4-5b

Potential Type I Waste Rock Construction Uses[1]

Year[2]	Description of Use	Tons	
1	Coarse Aggregate For Concrete		32,000[1]
2	Plant Site Access Road	118,000	
	Coarse Aggregate For Concrete	32,000[1]	
	Railroad Spur	55,000	
	Year 2 Subtotal		205,000
3	TMA Access Road	11,000	
	Stage I Berm Road	3,000	
	Year 3 Subtotal		14,000
6	Stage II Berm Road		3,000
8	Stage III Berm Road		3,000
12	TMA 1 - Final Cover Grading Layer		404,000[3]
14	Stage IV Berm Road		3,000
18	Stage V Berm Road		3,000
22	TMA 2 - Final Cover Grading Layer		531,000[3]
24	Stage VI Berm Road		3,000
27	Stage VII Berm Road		3,000
31	Stage VIII Berm Road		3,000
	Total		1,207,000

[1] The total coarse aggregate required for concrete is estimated at 64,000 tons. For this table it is assumed that equal amounts of concrete aggregate are required during each of the first two years of the pre-production period.
[2] Years 1 through 3 represent the pre-production period, years 4 and on the mine production period.
[3] Assumes Type I waste rock use as fill material placed over the final tailings surface and below the grading layer.

Prepared by: REM
Checked by: PAE

Table 4-5c

Annual Type I Waste Rock Production and Estimated Use

Year[1]	Type I Production (tons)	Type I Use[2] (tons)	Type I to Stockpile (tons)	
			To Stockpile	Cumulative
1	34,000	32,000	2,000	2,000
2	271,000	205,000	66,000	68,000
3	160,000	14,000	146,000	214,000
4	91,000	—	91,000	305,000
5	56,000	—	56,000	361,000
6	—	3,000	—	358,000
8	—	3,000	—	355,000
12	—	355,000[3]	—	—
Totals	612,000	612,000	—	—

[1] Years 1 through 3 represent the pre-production period, years 4 and on the mine production period.
[2] Quantities and uses for Type I waste rock from Table 4-5b.
[3] The fill material of the final cover of TMA 1 requires 404,000 tons, however, only 355,000 tons of Type I is available.

Prepared by: REM
Checked by: PAE

Table 4-5d

Potential Type II Waste Rock Construction Uses

Year[1]	Description of Use	Tons[2]
3	Stage I Base Riprap	93,000
8	Stage III Base Riprap	104,000
9	Stage II Sideslope Riprap	8,000
18	Stage V Base Riprap	64,000
20	Stage IV Sideslope Riprap	10,000
24	Stage VII Base Riprap	69,000
25	Stage VI Sideslope Riprap	8,000
31	Stage VIII Sideslope Riprap	9,000
	Total	365,000

[1]Years 1 through 3 represent the pre-production period, years 4 and on the mine production period.
[2]Calculated assuming an in-place density of 125 pcf.

Prepared by: REM
Checked by: PAE

Table 4-5e

Type II Waste Rock Hoisted to the Surface and Estimated Use

Year[1]	Type II Production (tons)	TMA Use[2] (tons)	Temporary Storage[3] (tons)		Deposition in TMA (tons)	
			Year	Cumulative	Year	Cumulative
1	4,000	—	4,000	4,000	—	—
2	21,000	—	21,000	25,000	—	—
3	178,000	93,000	—	—	110,000	110,000
4	59,000	—	—	—	59,000	169,000
5	51,000	—	20,000	20,000	31,000	200,000
6	31,000	—	31,000	51,000	—	200,000
7	28,000	—	28,000	79,000	—	200,000
8	25,000	104,000	—	—	—	200,000
9	22,000	8,000	—	—	14,000	214,000
10	23,000	—	—	—	23,000	237,000
11	23,000	—	—	—	23,000	260,000
12	16,000	—	—	—	16,000	276,000
13	13,000	—	—	—	13,000	289,000
14	13,000	—	—	—	13,000	302,000
15	13,000	—	13,000	13,000	—	302,000
16	13,000	—	13,000	26,000	—	302,000
17	13,000	—	13,000	39,000	—	302,000
18	13,000	52,000[4]	—	—	—	302,000
19	13,000	—	—	—	13,000	315,000
20	13,000	10,000	—	—	3,000	318,000
21	13,000	—	13,000	13,000	—	318,000
22	13,000	—	13,000	26,000	—	318,000
23	13,000	—	13,000	39,000	—	318,000
24	13,000	52,000[5]	—	—	—	318,000
25	13,000	8,000	—	—	5,000	323,000
26	—	—	—	—	—	323,000
27	—	—	—	—	—	323,000

Table 4-5e *(Continued)*

Year[1]	Type II Production (tons)	TMA Use[2] (tons)	Temporary Storage[3] (tons)		Deposition in TMA (tons)	
			Year	Cumulative	Year	Cumulative
28	—	—	—	—	—	323,000
29	—	—	—	—	—	323,000
30	—	—	—	—	—	323,000
31	—	—[6]	—	—	—	323,000
Totals	650,000	327,000				323,000

[1] Years 1 through 3 represent the pre-production period, years 4 and on the mine production period.
[2] Type II waste rock uses from Table 4-5d.
[3] Type II waste rock temporary storage will be within the pre-production ore/waste rock storage area located north of the plant site.
[4] Stage V base riprap requires 64,000 tons, however, only 52,000 tons will be available.
[5] Stage VII base riprap requires 69,000 tons, however, only 52,000 tons will be available. Prepared by: REM
[6] Stage VIII sideslope riprap requires 9,000 tons, however, no waste rock will be available. Checked by: PAE

CMC has used the following principles as guidelines in developing its surface management plan for Type II waste rock.

- Type II waste rock will only be placed within the lined area of TMA cells.
- Type II waste rock will be stored in a lined area with surface water management features used to collect contact water and ultimately direct it to the project's wastewater treatment plant.
- The temporary storage of Type II waste rock will be for a period of 3 years or less.
- All Type II waste rock not used for construction purposes internal to the TMA will be deposited with tailings in a currently active TMA cell.

4.8.9.3.9 Waste Rock Storage

As stated in Section 4.8.5.9 above, two storage areas will be constructed on the project's mine site north of the main production shaft. One area will be a lined facility on which pre-production ore and Type II waste rock will be stored. The second will be an unlined area used for the storage of Type I waste rock. Both areas will have a surface water management system. Precipitation falling within the perimeter of the areas will be collected and directed to water management basins.

As also stated in Sections 4.8.5.9 and 4.8.9.3.2 above, the Type I waste rock to be placed on the unlined storage pad will be used as a construction aggregate. This has been described in greater detail in Section 4.8.9.3.7 of the MPA. Sections 4.8.5.9 and 4.8.9.3.2 further state that the

Type II waste rock to be placed on the lined pre-production ore storage pad will be used in the TMA as riprap.

Chapter NR 182.02(10), Wis. Admin. Code, provides that "Mining wastes used in the reclamation or construction of facilities and structures on mining or prospecting sites or for backfilling an underground mine or a prospecting excavation shall be exempt from the requirements of ss. 144.43 to 144.47, Stats., and this chapter but shall comply with the review and approval requirements of ss. 144.80 to 144.94, Stats., and ch NR 131 or 132." Chapter NR 182.04(30), Wis. Admin. Code, further provides that ore is not a mining waste regulated under NR 182.

Given i) the fact that ore is not a mining waste; ii) the planned use of Type I and II waste rock as specified in the MPA; and iii) the provisions of NR 182.02(10); it is CMC's opinion that both the lined pre-production ore storage area and the unlined construction storage area are subject to the requirements of Chapter NR 132, Wis. Admin. Code. For this reason, CMC has designed the storage pads to meet the requirements of Chapter NR 132 and has provided the required design information for these facilities in its MPA.

4.8.10 Wastewater Management

A general overview of the project's wastewater management system is presented below. A more detailed description of the system can be found in the project's *Preliminary Engineering Report for Wastewater Treatment Facilities* submitted to the regulatory review agencies under separate cover.

The wastewater treatment system and the water storage ponds will be constructed in the initial construction phase as shown in the construction schedule (Figure 4-5). The wastewater treatment facilities will consist of the wastewater treatment system, surface water runoff basins, and discharge lagoons (Figure 2-1). The surface water runoff basins and the wastewater storage basins will be constructed during the first phase of construction. The wastewater treatment plant which will be located adjacent to the concentrator will be constructed so that it is available by the time that level development begins underground in month 20 per Figure 4-5 of the MPA. Concurrently, the discharge lagoons and associated discharge pumps and piping will be constructed. Surface water runoff basin Nos. 1, 2 and 3 (Figure 2-1) will consist of compacted native soil with earthen berms. Typical earth-moving equipment will be used to excavate the basins and build the berms.

Water that has been processed through the wastewater treatment system will be pumped to one of two discharge lagoons located in the northwest area of the plant site. The lagoons, as shown

in Figure 4-18, have a retention time of approximately 24 hours prior to discharge. This will enable sampling of the treated water prior to discharge.

4.8.10.1 Wastewater Treatment System

Crandon Project wastewaters generated during operation of the mine and mill will primarily include mine drainage, pre-production ore storage runoff and contact runoff from the plant site. These wastewaters will be collected in wastewater storage basin Nos. 6 and 7, and then pumped to the wastewater treatment system prior to discharge. Treatment will include lime and sulfide precipitation, filtration and neutralization. In addition, during operation non-contact runoff will be generated. Non-contact runoff will not be treated by the wastewater treatment system. Instead, it will be routed to runoff basin Nos. 1, 2 and 3, and discharged to on-site drainageways.

During construction, a total of five basins will be used for construction runoff from the plant site, a total of five basins will be used for construction runoff from the TMA, and one basin will be used for construction runoff from the tailings pipeline ditch/TMA access road. Also during operation, sanitary wastewater will be generated and treated in an on-site sewage treatment plant.

Figure 4-19 is a schematic of the project's water management system which shows the inter-relationship between the various wastewater streams and water sources for the mining and milling processes during operation of the mine and mill. The system has been developed specifically for the Crandon Project. The process has been designed to maximize water recycle. The water balance represents average flow rates based on metallurgical, geological and hydrogeological testing. The flows are based on an average ore processing rate of 5,500 tons per day. Each of the major sources of wastewater within this system are discussed in more detail in the following sections. A more detailed discussion of the project's overall water balance is included in Section 6 of this report.

4.8.10.1.1 Mine Drainage

Mine drainage water will consist utility water, mine contact water, uncemented backfill tailings drainage water, and cemented backfill tailings drainage water. The largest contributor to mine drainage water will be mine inflow. Inflow will initially consist of the drainage of water currently stored in the available pore space within the ore body and surrounding bedrock. Stored water removal will be conducted in a controlled fashion during the initial years of mining.

The second component of inflow will be a combination of water that leaks vertically from the glacial overburden through the till and massive saprolite into the mine workings and water that migrates through the bedrock laterally into the mine workings. This component of inflow will occur once the mine is fully developed and mining takes place in the weathered ore. This is expected to occur in year two or three of the production life of the mine. Based on the regional groundwater modeling work it is estimated that the range of mine inflow that should be used for wastewater treatment system sizing is as follows:

Low Range Estimate	350 gpm
Best Engineering Judgement Estimate	600 gpm
Practical Worst Case Estimate	1,150 gpm

Current mine planning involves mining below the weathered zone in basically dry areas of the mine for the first three to four years of operation. During the first year of this period a series of intercept drill holes will be advanced up into weathered areas of the bedrock and ore body to begin the controlled removal of stored water. Current estimates indicate that it will take one to two years to remove stored water at an extraction rate of approximately 750 gpm. As stored water is removed leakage from the overburden through the till and massive saprolite will begin. Initial leakage rates will be low, but they will steadily increase throughout stored water removal, approaching steady state leakage rates at the time the removal of stored water is completed.

As shown in the mine drainage schematic, Figure 4-12, water sources in the mine are estimated at 750 gpm from inflow, 5 gpm from potable water and 245 gpm as backfill water. The flows to be pumped from the mine are estimated to consist of 375 gpm of intercepted groundwater of which 150 gpm is recycled as mine utility water and 375 gpm of contact groundwater. The backfill operation will result in an estimated 95 gpm as retained moisture while 45 gpm is retained with and hoisted in the ore. The net evaporation from the mine ventilation is estimated to be 40 gpm. The total amount of water pumped from the mine will be approximately 820 gpm under average flow conditions.

Groundwater that migrates into the mine will be intercepted in the upper levels of the mine with a portion potentially used for mine utility water. The groundwater that is not used will be pumped to the surface. If the water quality is acceptable and meets all permit requirements, it may be discharged without treatment. This water may also be mixed with other wastewater streams and treated before either discharge or recycle. The final alternative for this water may be to recycle it back to the mill without treatment.

Groundwater not collected by the interceptor system will be collected in the mine sumps located on each mine level or drained by gravity to a main mine sump, where it will be combined with the groundwater used as mine utility water. This combined mine water will be pumped to the water storage basin located northwest of the shaft, where it will be combined with other wastewater streams requiring treatment. After treatment, this stream would be discharged through the permitted outfalls.

4.8.10.1.2 Mill Water

Under average flow conditions, approximately 2,200 gpm of water enters the mill in the form of pump gland seal water, reagent preparation water, water retained in the ore and recycled process water. Water is used in the mill in all processing steps (e.g. grinding, flotation, etc.), in reagent preparation, and for pump seal water.

Most of the zinc flotation tailings stream will be pumped to the backfill preparation facility where the coarse and fine tailings will be separated. A portion of the coarse tailings will be used as the backfill in the mine. The remainder of the coarse tailings stream will be pumped to the tailings cell. The fine tailings will also be pumped to the tailings cell.

While the capability exists to provide make-up water to the mill, the use of this water will be limited to reagent preparation, pump seal water, and uses which require a higher-quality water supply. Other mill water uses do not require a higher-quality water, so the water from concentrate thickener overflows and the reclaim pond will be recycled through the process water tank. This process provides flexibility during start-up by allowing water that will have

accumulated in the reclaim pond, or mine water, to be used for the concentrator. Large quantities of fresh water will not be needed for start-up.

4.8.10.1.3 Tailings Management and Reclaim Water Storage

Under average conditions flows to the sand/fine tailings separation process from the mill will equal 2912 gpm. From the sand/fine tailings separator, 247 gpm will be used to transport coarse tailings to the mine for use as backfill. The remaining 2,665 gpm will be used to transport fine tailings to the TMA. At the TMA the water will ultimately be decanted and pumped to the reclaim pond.

An estimated 2681 gpm of reclaim pond water will be returned to either the process water tank for direct recycle to the mill or the water storage basin Nos. 6 and 7 for treatment prior to eventual recycle or discharge. The difference between the volume of water entering the TMA and being pumped from the reclaim pond relates to the differences between precipitation and evaporation, and water retained in the tailings, etc.

Both the tailings cell and the reclaim pond will have direct inflow during rain events and both will lose water to evaporation. The quantity of water gained or lost in this fashion is a function of pond size; however, over an average calendar year, precipitation is greater than evaporation.

The tailings cell is to be used as a settling pond for the fine tailings and other site generated solids. This is the first step in the water recycle process. Due to the addition of lime in the concentrator building, the pH in the line to the tailings cell will be in the range of 9.5 to 10.0.

The reclaim pond, in conjunction with the tailings cell is sized to provide surge capacity for all process related facilities. The cell will also provide additional time for the settling of fine tailings and other solids.

4.8.10.1.4 Sanitary Wastewater

Sanitary wastewater will be generated at toilets, showers, and other similar facilities throughout the site. The wastewaters will be collected and routed by gravity to a lift station, and then pumped to a sewage treatment plant. The treatment plant will be located as shown on Figure 2-1.

A sequencing batch reactor activated sludge treatment process will be used, with disinfection of the effluent. Figure 4-20 is a schematic flow diagram of the treatment process.

The treatment plant will operate at an average flow rate of 20,000 gallons per day, based on a total of 400 persons on-site at 50 gallons/day-person. Treated wastewater discharged from the treatment plant will be sent to the tailings pump box for transfer to the TMA. The bio-solids will be hauled from the site by a contractor.

4.8.10.1.5 Miscellaneous Wastewater

Wastewater flow rates from shops used throughout the facility are estimated at 6 gpm. This water will be discharged to the tailings pump box for transfer to the TMA. The wastewater generated in the shops throughout the site will include small amounts of grease and oil, solvents,

metal shavings, other particulate materials and wash water. This wastewater will be passed through traps or oil/water separators. The wastewater generated in the laboratory will originate from water used in ore analysis and washing.

4.8.10.1.6 Plant Site Wastewater Storage Basins

As shown in Figure 2-1 three contact wastewater storage basin designated as basin Nos. 5, 6 and 7, are located in the northwest corner of the plant site.

Wastewater storage basin No. 5 is located south of and adjacent to the pre-production ore storage area, and is dedicated to that area. The area serviced is shown in Figure 4-21. The contact runoff from the pre-production ore storage area will be collected through a series of ditches and pipes and transported to wastewater storage basin No. 5 by gravity flow.

During operation, wastewater storage basin Nos. 6 and 7 will receive potentially contact runoff from an area which includes the concentrate thickeners, the pump house, the reagent bulk storage, the lubricant storage, the cold storage, the covered coarse ore storage, the equipment laydown areas, the roof of the concentrator building, the roof of the wastewater treatment plant building, and the fuel station. This area is shown on Figure 4-22.

During the construction period, basin No. 7 will store the water pumped from the shaft-sinking operations, basin No. 5 will be used to handle runoff from the pre-production ore storage area, and basin No. 6 will be used to handle construction runoff from a portion of the plant site.

Each basin will require an excavation as part of their construction. Topsoil will be stripped and temporarily stockpiled. The topsoil will be used to finish the outside slopes of the surrounding berms. Soil excavated to form each basin will be used to build up the surrounding berms or permanently stockpiled and saved for reclamation work. The basins will be constructed of a composite liner of clay and geomembrane to prevent seepage (Figure 4-21). During construction, surface drainage will be diverted to one side of the basin for settling prior to discharge.

4.8.10.1.7 Non-contact Runoff

During operation, non-contact runoff will be generated in areas where water will not come into contact with process equipment, materials or chemicals. This includes runoff generated in the topsoil storage area, the mulch storage area, roadways to and from the complex, railroad lines to and from the complex, the parking lots, the main substation, the roof of the service building, the area adjacent to the discharge lagoon, and other undisturbed areas shown on Figure 4-22.

In the plant site area, three runoff basins have been designed to direct the flow into non-contact runoff or sedimentation basins. Surface water drainage patterns within the plant site are illustrated in Figure 4-23. Water from the basins will be discharged to on-site surface water drainageways. Plans and sections of each basin are shown on Figures 4-24, 4-25, and 4-26.

In addition, five runoff basins, numbered consecutively 8 through 12 will be ultimately constructed around the perimeter of the TMA. The outflow from these non-contact basins will be discharged directly to natural drainageways.

A draindown sump (basin No. 4) will be located along the tailings pipeline ditch/access road. During operation, this basin will be used to collect precipitation and other waters collected in the ditch. The wastewater collected in this basin during operation will be transported to the TMA. During construction of the tailings pipeline ditch and the TMA access road, this basin will be used to handle construction runoff, with the outflow from this basin discharged to on-site drainageways.

4.8.10.1.8 Construction Runoff

Activities that will generate run-off include construction of roadways, the TMA, pipelines, railroad lines, mill facilities, aboveground mine facilities, and ancillary plant site facilities. Laydown of equipment and storage of materials used for construction of the mine, mill and TMA will also generate runoff during construction. Typically runoff from disturbed areas can be high in suspended solids. In the early stages of construction, erosion will be controlled through the use of silt screens and temporary water detention systems. Both require frequent inspection, maintenance and solids removal. As the runoff basins are brought on-line, construction runoff will be diverted to these basins. Section 4.10 details project erosion control plans to be implemented to achieve compliance with stormwater standards.

4.8.11 Ancillary Facilities

Ancillary facilities include the access road and railroad spur to the site, the administrative and services building, fuel storage handling, sanitary waste treatment facility, explosives magazines, and transportation and power distribution facilities required to support the operation of the plant complex. These facilities are shown on Figure 2-1.

4.8.11.1 Railroad Spur

A railroad spur will be required to service the plant site. The railroad spur will be routed from the main Wisconsin Central Limited trunk line northeast of the plant site. The spur will consist of a single track approximately 2.7 miles long and will include one 900-foot long siding located near the connection to the trunk line. A single span bridge to carry the track over Swamp Creek will be constructed of prestressed concrete girders supported on concrete abutments.

Construction of the railroad spur will be completed in years two and three of the project. Construction activities will include: (1) clearing and grubbing, (2) installation of 2.7 miles of railway spur track, including culverts, bridge construction, crushed aggregate ballast and final site grading, and (3) application of topsoil and hydroseeding. Based on preliminary engineering work, an estimated 18 acres will be cleared and grubbed within the right of way. Assuming nine inches of suitable topsoil throughout the cleared area, approximately 20,000 cubic yards of topsoil will be stripped and stockpiled. Most salvaged topsoil will be applied to the spur line side slopes prior to seeding. Any unused topsoil will be hauled to the permanent topsoil stockpile at the plant site for reuse in reclaiming disturbed areas.

Rail track will be provided in the plant complex for concentrate loading and handling of bulk materials and supplies. A diesel locomotive will be used intermittently to move railcars within the plant site and between the site and sidings. The design of the railroad allows normal railroad maintenance practices to be followed for the railroad spur line. Because the spur line will be

new, maintenance will primarily relate to erosion control and control of vegetation in the right-of-way.

4.8.11.2 Access Road

A two-lane three-mile long access road will be constructed and completed in year two. Clearing and grubbing will commence immediately after approval. Rough site grading and erosion control will be completed by the sixth month. A single span bridge constructed of prestressed concrete girders supported by concrete abutments will carry the road across Swamp Creek.

The road will connect with STH 55 and proceed southeasterly to the plant site. The road will be contained in an approximate 100-foot wide corridor. The main electrical power line, treated wastewater discharge line, the natural gas line, and the telephone link to the plant site will be located adjacent to the road within the corridor. A bituminous concrete pavement at an estimated quantity of 260 cubic yards will be underlain by coarse crushed aggregate base. The access road will be posted as a private road leading to the Crandon Project. No gates or guards are planned at the STH 55 intersection.

The right-of-way corridor for the new access road will be cleared and grubbed of trees and shrubs prior to rough site grading. Existing topsoil will be stripped and saved from all cleared and grubbed areas along the access road. Based on preliminary engineering for the access road, approximately 35 acres in the corridor needs to be cleared and prepared. Assuming an average depth of nine inches it is estimated that a total of 29,000 cubic yards of topsoil will be available for stockpile and reuse. Suitable areas along the right-of-way will be chosen to temporally stockpile the topsoil. All temporary soil stockpiles will be enclosed by silt fences.

Roadways will be built up using selected cut materials from within the road alignment. A base of well-graded material will then be placed and compacted. It is anticipated that this base will be acquired from a commercial source or alternatively Type I waste rock will be used. Construction processes for the pavement will follow normal industrial practices.

Construction of this access road also includes topsoiling and hydroseeding the disturbed areas along the corridor. Most salvaged topsoil will be applied to the road side slopes prior to seeding. Any unused topsoil will be hauled to the permanent topsoil stockpile at the plant site.

4.8.11.3 Parking and Gate House

The employee and visitor parking area will be located south of the service building. The parking area will be constructed from a compacted till and gravel base. The parking area will drain to a surface drainage basin No. 1 located to the south of the parking area. A gate house will be on the north side of the parking area to control access into the plant site. A fire truck and an ambulance will be housed in the vicinity of the gate house.

4.8.11.4 Services Building

The services building will house major shops, garage, warehouse, employee changeroom and shower facilities, and managerial, administrative, engineering and technical support staff offices. The shops and warehouse will provide service support and maintenance for the plant process

equipment and mobile equipment. The warehouse will stock maintenance and replacement parts and tools used for maintenance of plant equipment.

Excavation of the foundations, erection of walls and the pouring of slabs for the service building will commence in the third month, as shown in Figure 4-5 of the construction schedule. The building will be a structural steel frame with insulated structural walls and roof.

4.8.11.5 Storage Areas

As discussed below a number of permanent storage areas will be established during various stages of construction. All structural storage areas will be sited on a base of compacted till, and will have a gravel surface.

A lubricant storage building will be located east of the headframe. Lubricants, solvents and degreasers for both the mine and mill will be stored in the lubricant storage building. The building will not be heated. The building floor will be concrete without floor drains. There will be no long-term storage of large quantities of these materials. The building and contents will be inspected daily and any spills will be cleaned manually as required. The design, construction, and use of this building will be in accordance with applicable federal, state, and local requirements.

A cold storage building will be used to store miscellaneous mechanical parts such as pump impellers and casings, some larger motors, tires for the mobile fleet, and mechanisms for flotation cells. The building will be used to store those parts that do not require heated storage, are too large and cumbersome to keep in the warehouse area of the service building, or which cannot be stored outside.

A covered storage area will be located on the east side of the plant site. This structure will be an open shed type facility for storing specialty pipe, pipe couplings and fittings, and other parts that need to be kept in a covered facility for easy retrieval at any time of the year.

An area south of the covered storage facility and south of the railroad spur line will be used for storage of timber, steel, pipe, and other bulk materials that can be stored outside. These materials will be used in the mine and mill operations.

A pre-engineered building will be constructed east of the headframe (Figure 2-1). This building will be used for storage of drill cores.

The area located northwest of the topsoil stockpile will be used as an equipment laydown area. Runoff will be directed to an oil/water separator before it will be directed to one of the wastewater storage basins. After rough site grading this area will be graded with Type I waste rock to allow storage of construction materials and supplies.

A truck scale will be located on the main access road at the approach to the gate house. The purpose of this scale will be to weigh shipments of bulk materials such as grinding balls, fuel oil, and reagents. A railroad scale will be located on the track east of the concentrate loadout area. The purpose of this scale will be to weigh car loads of concentrate prior to shipment and to weigh incoming bulk materials.

4.8.11.6 Topsoil and Mulch Storage Area

A topsoil storage area is proposed to be located east of the core processing and storage building. The topsoil storage area will encompass approximately 5.5 acres. This area will be cleared and graded to provide drainage. Topsoil from the entire plant area will be stockpiled here during the initial grading of the site. It is estimated that 100,000 cy of topsoil will be stockpiled for final reclamation. Topsoil stripping will be done with standard earth-moving equipment such as scrapers and bulldozers. The topsoil stockpile will be reseeded with a native grass seed mixture. Topsoil stockpiling for the TMA facility is discussed in the TMA Feasibility and Plan of Operation Report.

4.8.11.7 Power Supply Facilities

Electrical power for the Crandon Project will be delivered at 115 kv from the Wisconsin Public Service Corporation (WPSC) power grid serving the area to a main substation located within the plant site (Figure 2-1). The main substation will include terminating structures, switching structures, power circuit breakers, and transformers for reducing the 115 kv to 13.8 kv and 4.16 kv. The required medium voltage switch gear will be located within the substation.

The 115 kv power line from WPSC will originate from the Venus substation approximately 18 miles from the Project site. The transmission line may follow one of a number of routes shown on Figure 4-27. WPSC will be responsible for construction of the transmission line to the terminal structure of the main substation. This power line will be installed during the first seven months of the project construction, and will provide power during the remainder of the construction and operation phases.

The 13.8 kv and 4.16 kv power will be distributed to major points of use within the plant site through an underground or cable tray distribution system. At the major points of use, distribution substations will be installed where the 13.8 kv will be reduced to 4.16 kv or 440 volts. The TMA will be supplied at 13.8 kv or 4.16 kv from the main distribution system. This power circuit will be underground or in cable trays within the plant site and overhead on wooden poles from the east boundary of the plant site to the TMA.

During loss of power from the 115 kv system, it will be necessary to supply emergency power to certain equipment. On-site generators will be available to supply emergency power. These will be located at the main substation. During final design, consideration will be given to moving these generators near the mine air intake to allow the use of waste heat for heating the mine air. The generators will be used to supply a portion of the construction power. During operations, the generators will be operated to reduce peak power demands, and provide power for critical needs during main line outages.

The outdoor substations consist of high-voltage switchgear, mineral oil filled oil transformers, and main circuit breakers. The secondary circuit breakers within the main enclosed switchroom will in turn feed the appropriate motor control centers located in the process areas. The outdoor substations will be mounted on concrete pads over a large grounding mat. The areas will be fenced as required by code. Electrical power demand has been estimated for the project as shown in Table 4-6.

Table 4-6

Electrical Power Demand

Phase	Time in Months	Peak Electrical Load (MW)
Construction	0 - 4	0.0 - 1.0
	5 - 12	1.5 - 3.0
	13 - 18	3.5 - 5.0
	19 - 24	5.5 - 6.0
	24 - 30	6.5 - 8.0
	30 - 36	9.0 - 12.0
Operations	36 - 39	13.0 - 18.0
	39 - Ongoing	20.5

Prepared by: CMC
Checked by: DEM

Natural gas will be used for heating of the underground mine ventilation air, for general heating of buildings and facilities, and as fuel for the on-site generators. Natural gas will be supplied by WPSC from an existing pipeline running generally east-west approximately eight miles north of the plant site. A six inch pipeline extension will be constructed from the existing pipeline to a metering station within the plant site. The gas will be distributed by underground pipeline from the metering station to the points of use in the plant site.

4.8.11.8 Explosives Storage Magazine

An explosives magazine and storage area will be located approximately 1,800 feet north of the point where the railroad tracks enter the project site (Figure 2-1). An area for parking and storing loaded trailers will be included within a fenced security area. Separate areas will be provided for storage of explosives and blasting caps. An earthen barricade will be constructed between the area containing explosives and caps and the area for parking trailers with other blasting agents. The construction and arrangement of this facility will be in accordance with all applicable codes and will comply with the required separation distances from plant structures.

4.8.11.9 Water Supply/Fire Water Facilities

Potable water will be supplied by a newly constructed well to be located approximately 0.6 mile southwest of the plant site. This well will provide potable and fire water as well as mitigation water for Skunk Lake. Figure 4-28 illustrates the proposed potable water supply well and pipeline routing location. From the supply well, underground piping will carry the water to a potable water tank housed external to the water distribution pumphouse (Figure 2-1). A separate system of pumps and pipelines will distribute the potable water to points of use within the plant facilities. It is not anticipated that treatment of this water will be required; however, a chlorinator treatment system will be provided and available for use, if necessary.

A non-potable water supply well will be constructed adjacent to the TMA to allow withdrawal of water for wash plant operations for TMA construction materials preparation. Non-potable well

use will be limited to the initial construction period and periodic construction activities that will occur approximately every third year during subsequent TMA cell construction.

The potable well and distribution piping will be designed in compliance with NR 812 and ILHR 82, respectively. As required under these codes, the potable water distribution system will be periodically tested for bacteriological quality. Additional information on the proposed potable and non-potable water facilities for the project is presented in the project's high capacity well permit application.

A potable water tank of approximately 50,000 gallon capacity will be located above ground adjacent to the pump house as shown on Figure 2-1. In addition, a fresh/fire water tank of approximately 250,000 gallon capacity will also be located adjacent to the pump house.

4.8.11.10 Construction Material (Nonmetallic)

The primary nonmetallic materials needed for construction of the project will consist principally of concrete, asphalt, road base aggregate, railroad ballast, and clay for the soil liner components for the TMA and other basins as summarized in Table 4-7 below.

Table 4-7

Construction Materials

Item	Quantity
Concrete (includes surface and underground)	51,000 yd^3
Base Course (includes access road and in-plant roads)	32,000 yd^3
Subbase (includes access road and in-plant roads)	37,700 yd^3
Asphalt Pavement	9,700 yd^3
Railroad Ballast (includes spur and siding)	41,700 tons
Railroad Subbase	13,700 tons
Clay (TMA1 - Stage I only)*	73,000 yd^3

*In-Place Quantity.

Prepared by: CMC
Checked by: DEM

Sand and aggregate for the above items could be supplied from local sand and gravel contractors if the Type I waste rock from pre-production development is not suitable. Suitable construction materials obtained from mine waste will be crushed and graded by a temporary on-site crushing and screening plant located within the construction materials storage area. A concrete batch plant will be located on the project construction site to provide concrete for the surface buildings and underground mine construction. Clay will be supplied from one of several commercial vendors.

4.8.11.11 Temporary Facilities

The need for temporary facilities for construction will be minimized by making use of permanent facilities wherever possible. However, some temporary structures will be required. Temporary facilities, such as construction offices for CMC and the contractors, storage and workshop buildings for contractors, a concrete batch plant, potable water, electric power, and sanitary facilities will be required at the site until permanent buildings are completed. The location and type of temporary buildings and facilities (Figure 2-1) will be controlled by CMC to ensure appropriate siting and quality of structures.

4.9 Operations

4.9.1 Schedule

The mill operating schedule for the Crandon Project will be 24 hours per day, nominally at 365 days per year and availability of 92 percent. The mine operating schedule will be either on a five-day or seven-day schedule.

Mine production commences when installation of the underground crusher is complete and crushed ore is hoisted from the mine. Concentrator production will start when construction of the concentrator and all process equipment is completed and turned over to CMC by the construction contractors.

4.9.2 Mine Operation

The primary mining method will be mechanized blasthole open stoping with delayed backfill. However, other mechanized variations of stoping and cut-and-fill stoping methods may also be used. Production blasting will be performed at the end of the shift. Broken ore will be removed from drawpoints by load-haul-dump (LHD) equipment and hauled to dump points. At the rated capacity, about eight stopes will be operating in the mine simultaneously to produce the average 5,500 tons of ore per day. This will require approximately ten LHDs in operation at one time.

Fresh air will be provided to maintain an adequate working environment underground, to dilute the diesel exhaust, and control emissions as specified by applicable codes. At points where dust may be produced, water sprays or atomizers (water/compressed air) will be used to suppress dust before it reaches the main ventilation air streams.

After all the ore is removed from a stoping block, the stope will be backfilled to provide support for the wall rock before the adjacent blocks are mined. This will maximize the recovery of the remaining ore and ensure stability of the rock mass during operations and after abandonment. Further, it will minimize the need for surface storage of tailings waste. The stoping operation does not require personnel to enter the large open stopes at any time. All drilling operations will be conducted in the crosscut drifts above the stoping block. Ore will be removed by LHD equipment from each stope drawpoint at the base of the stoping block.

If required, all accessible areas will be rock-bolted. Alternative means of roof support will be used as dictated by the rock structure. On the uppermost levels where the ore and host rock may be somewhat altered by weathering, mechanized cut and fill mining methods may be employed.

4.9.2.1 Mining Equipment

The proposed mining method will employ mobile mining equipment in the unit operations including drilling, blasting, mucking, and support services. Low profile loaders used for the transport of rock will be diesel-powered rubber-tired units. Development and production drilling equipment will be electric-hydraulic units. In addition to the primary production equipment, ancillary equipment such as crawler-mounted production drills, booster compressors, raise boring machines and portable mine power centers may be required. Major mobile and portable

equipment types are listed in Table 4-8. Diesel emission will be controlled by the installation of catalytic converters and/or ceramic exhaust filters.

Materials required for mine operations, machinery, and mobile equipment will enter the mine through the main production/service shaft. The service hoist will be designed to accommodate the heaviest and largest mechanical components required to develop and operate the mine. The larger mobile mining vehicles may be disassembled for conveyance underground.

4.9.2.2 Level Development

The nearly vertical dipping ore body will be divided into main horizontal mining levels. These lateral levels will be developed at 300-foot intervals down the main production shaft and will be located in the hanging wall or footwall horizons. These development drifts will be designed to provide access to the ore horizon. These lateral levels will be sized at approximately 12 feet high by 16 feet wide to provide adequate clearance for the vehicles used in the mining process and adequate ventilation along these pathways. The layout of a typical main level plan is shown on Figure 4-7.

Table 4-8

Typical Underground Mining Equipment

		No. of Units Available for Production	Total No. of Units
A.	**Diesel-Powered Mobile Equipment**		
	Load-haul-dump (LHD) (8 yd^3)	10	17
	Haulage Truck (40 ton)	1	2
	Scissor Lift Service Truck	1	3
	Utility Flat Bed Truck	1	3
	Explosives Carrier	3	5
	Lubrication/Service Truck	1	2
	Personnel Carriers	2	3
	Utility Tractor	4	6
	Emergency Vehicle	1	1
	Forklift (three to six ton)	2	3
	Road Grade/Dozer	1	2
B.	**Drilling Equipment**		
	Elect-Hydraulic Drill Jumbo	3	5
	Pneumatic Drill Jumbo	1	2
	Stope Blasthole Drill	3	5
	Longhole Drill	1	2
	Rockbolting Jumbo	3	5
	Raisebore Machine	1	1

Table 4-8 *(Continued)*

	No. of Units Available for Production	Total No. of Units
C. Portable Mining Equipment		
Auxiliary Air Compressors		6
Diamond Drill (Electric/Hydraulic)		2
Grouting Pump Unit		1
Electrical Substations/Transformers (based on number of levels)		8
Auxiliary Pumps		6
Auxiliary Ventilation Fans		30
Stopers/Jacklegs		10
Shotcrete Machine		1

Note: Table 4-8 represents a typical equipment listing for a mine of this design. The actual type of equipment used may vary.

Prepared by: CMC
Checked by: KPB

4.9.2.3 Mine Development

Development drifts will be located in the hanging wall and/or footwall of the ore body and will provide access to the ventilation raises, the main shaft, and the ore body, as shown in Figure 4-7. The lateral extent of a level development at any given point in time will depend upon the need to access new mining blocks. An underground ramp will connect mine levels to allow for ease of movement of mobile equipment for maintenance purposes, supplies, and personnel throughout the mine. This centrally located decline is also shown schematically on Figure 4-6.

Much of the preliminary mine development will be done in the bedrock outside the ore horizon with the development of shaft openings and main level drifts to the ore horizon, thus producing waste rock. The amount of waste rock produced at any given time will vary depending upon the number of headings being advanced in waste versus ore. It is estimated that over the life of the mine 1.7 million tons of waste rock will be produced. As discussed in Section 4.8.9.3, approximately 1.26 million tons will be hoisted to the surface, with the rest remaining underground. During the operating phase, uncrushed waste rock will be retained in the mine and used as coarse stope backfill. Handling of waste rock from the development faces will be similar to that for ore.

4.9.2.4 Stope Development

For production purposes the ore body will be divided into mining blocks or stopes. Stoping blocks will be accessed at the top by level crosscuts to the ore body for drilling, blasting and backfilling and at the bottom by level crosscuts for removal of broken ore (Figure 4-11).

Stopes will average approximately 300 feet in height by 75-150 feet along strike and will vary with the average width of the ore body, being approximately 100 feet. The average stoping block will contain an estimated 250,000 tons of ore. At a mining rate of 2.0 million tons per year, it is estimated that about eight stopes will be depleted annually.

In the uppermost mining levels where the ore and host rock may have been somewhat weakened by surficial weathering, mechanized cut-and-fill mining methods may be employed. These methods may involve removal of horizontal lifts of ore approximately 13-16 feet thick. The void created by each horizontal mining pass is then backfilled prior to mining the next lift. This approach will limit the span of unsupported stope walls, and thereby will ensure safe working conditions. Less than 10 percent of the ore body may require use of this secondary, but conventional, mining method.

Once a stoping block has been completely emptied, it will be backfilled to provide support for the wall rock before the adjacent blocks are mined. This will allow maximum recovery of the adjacent ore and ensure stability of the rock mass during operation and after abandonment.

Surface subsidence will be prevented by use of the following techniques:

- A permanent pillar of rock averaging about 100 feet thick, directly below the glacial overburden, will be left in place and will not be mined.
- All stope blocks will be backfilled after the ore is extracted.
- Between five to ten percent of the potentially minable ore may be left in place as pillars.

4.9.2.5 Explosives

During operation of the mine, several days' supply of blasting materials will be stored in underground magazines. Materials stored will include water gel explosives, cartridge emulsion, ammonium nitrate/fuel oil (ANFO) blasting agents, detonating cord, and electrical and/or nonelectric blasting caps. Explosives and detonators will be stored in separate magazines constructed and located in accordance with applicable State and Federal mine safety regulations. Magazine excavations will be clearly identified.

4.9.2.6 Ore Transport Systems

Ore will be removed from the stopes at drawpoint levels, using rubber-tired, diesel-powered LHD units. Typically, ore will be transported by an LHD to steeply dipping ore passes leading down to the crusher level. Ore and waste passes will be spaced at convenient locations along the ore body to limit the haulage distance. A schematic representation is presented on Figure 4-8.

On the bottom levels, 40 ton trucks will be loaded with ore and/or waste. Trucks will dump into coarse feed bins over the crusher. Some use of conveyors will also be considered in this area. Mechanical feeders will be used to direct the contents of the bin at a controlled rate to the primary crusher.

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4.9.2.7 Underground Primary Crusher and Skip Facilities

A jaw crusher will be installed near the bottom of the main shaft (Figure 4-8). Ore will be fed to this crusher by mechanical feeders. This crusher will be capable of crushing ore or waste rock at rate of approximately 500 tons per hour. Crushed material will discharge to a surge bin immediately below the crusher. A discharge feeder will feed the crushed ore from a bin to a conveyor which will move the material horizontally to the main production shaft. Crushed ore will be loaded into the shaft skips which then will be hoisted to the surface.

A dust control system will be provided for the underground crushing system. Collection duct work from the surge bin feeder, crusher, and crusher discharge will be manifolded to a dust collector. Dust collected in this system will be discharged onto the main conveyor. Dust control at the skip loading facility and other transfer points will be with water sprays.

4.9.2.8 Underground Backfill

Mine backfilling will begin when the first stope is mined out. The backfill will consist primarily of the coarse fraction of the mill tailings, but will be supplemented with waste rock retained underground. Cemented and/or uncemented backfill slurry containing approximately 60-70 percent solids will be pumped underground through boreholes fitted with four to six inch diameter distribution pipes. The backfilling operations will normally be conducted to coincide with the mining schedule.

Fill will be poured into a stope through openings near the top and will be retained at the bottom by a bulkhead. Drainage facilities will be placed in the stope before filling commences to collect and carry backfill drainage water from the stope to collection sumps.

The tailings backfill will be supplemented by waste rock coming from the development drifts in the mine, thus eliminating the need to crush and hoist that material to the surface. Cement will be added to the backfill when needed to provide stability so that the column of fill will stand unsupported and enable complete removal of the ore in the adjacent stope. On average, the ratio of cement to backfill material will be about 1:10. Ratios of cement as rich as 1:5 may be used in specific situations where higher structural strength is desired, such as in the formation of a floor of sill upon which mobile equipment will subsequently operate. However, ratios of cement as lean as 1:20 or 1:30 may be tested to determine its structural capabilities. About one-third to one-half of the total fill placed in the mine will contain cement.

Waste rock from development headings will be within a size range from sand grains to 24 inches. Most will likely be in the range of six to 18 inches. When this material is used in the stope backfill process, it will be placed before or during the hydraulic placement of tailings fill. The hydraulically placed fill will flow into and fill the interstices between the rock fragments.

As an alternative to making the backfill in a stope self-supporting by adding cement, uncemented fill may be retained by leaving a rib pillar of rock between the fill and the adjacent stope. This pillar would typically have a minimum thickness of 10 percent of the hanging wall to footwall width of the stope, or 10 feet, whichever is greater.

4.9.2.9 Mine Safety Systems

The mine will be constructed to operate in accordance with applicable federal and state mine safety regulations. Safety systems will include the following:

- Back-up electrical generators will be maintained on-site to provide essential services in the event of a power interruption.

- The emergency warning system used to notify personnel underground will utilize a distinctive odor agent which, when released into both the fresh air ventilation stream and the mine compressed air system, will quickly permeate the mine workings, thus alerting underground personnel of an emergency.

- Fire prevention is a prime consideration in the design and engineering phase of the mine. A fire extinguisher or other form of suppression system will be installed on all mobile equipment. In addition, fire doors of fire resistant materials will be provided at shaft stations, the main mobile equipment repair shop, fueling bays, or other locations as necessary. Also, the mine utility water supply system will be designed to be readily used for fire control.

- Portable hand-held dry chemical fire extinguishers will be located adjacent to transformer installations, fueling bays, the shop, lunchrooms and at other strategic locations throughout the mine. Larger fire extinguishers will be stored near the main mobile equipment shop for use there or for transport to a remote location. Mine rescue apparatus with the necessary ancillary equipment will be located on the surface for use by properly trained mine rescue teams.

- First aid supplies will be stored underground in strategic locations and will also be available on surface. All employees will receive emergency first aid training. An ambulance will be located on-site.

4.9.3 Mill Operations

The concentrator will initially process the zinc ore to recover the minerals as concentrates of zinc, copper, and lead. The copper ore will be processed after the depletion of the zinc reserves.

In the process of liberation and separation of minerals from the ore, the concentrator will include the following:

1. ore handling, grinding and classification;
2. flotation and regrinding;
3. reagent preparation;
4. concentrate handling;
5. mine backfill preparation;
6. process control; and
7. spillage control.

Varying ore grades will cause the amount of material recovered as concentrates and as tailings to vary. The design capacities for most components will be for the average throughput plus a

15 percent contingency to allow for routine and non-routine shutdown. The production objective is the average ore throughput expressed on an annual basis of 2,000,000 tons per year, which is equivalent to approximately 5,500 tpd.

4.9.3.1 Ore Handling, Grinding and Classification

The ore will be crushed underground in the primary crusher to eight inches or less. Crushed ore will be hoisted to surface and conveyed to a covered coarse ore storage facility. The function of the coarse ore storage is to provide surge capacity between the mine and the concentrator and to provide a supply of ore to operate the concentrator during periods when, for any reason, the mine is not in production. The live storage capacity of the stockpile is 11,000 tons of ore.

Coarse ore will be reclaimed from the stockpile using feeder belts beneath the piles. These belt feeders will discharge to the main conveyor which will convey ore to the semi-autogenous grinding (SAG) mill. A SAG mill is a large horizontal cylindrical drum with steel liners that grind the ore by the tumbling action of both steel balls, water and ore. Regrinding of the remaining coarse particles of the ore will be performed utilizing a ball mill. As the ball mill rotates and the slurry passes through the mill, the impact and abrasion of the steel balls will reduce the ore size and liberate the minerals.

The entire ore handling facility from the mine headframe through coarse ore storage, and grinding will be completely covered. There will be no contact water runoff from the ore handling facility. Any drainage water collected in the sumps of the coarse ore storage facility will be pumped back to the mill circuits. Fugitive dust from the dry handling of ore will be entrained by dust collectors at points where material transferring occurs.

4.9.3.2 Flotation and Regrinding

The sulfide mineral particles will be separated from the ore slurry using a selective flotation process. Selective flotation is the process in which specific sulfide mineral particles adhere to air bubbles, float to the surface of the ore slurry and form a froth which collects on the top of the slurry. The froth is then removed from the slurry. By the use of various reagents, the mineral may be made to either adhere to an air bubble or be retained in the slurry. The use of these reagents permits the selective separation and recovery of the zinc, copper, and lead sulfides as separate concentrates from the gangue.

To ensure maximum liberation of the zinc, copper, and lead minerals, the rougher and scavenger flotation concentrates will be reground. The regrind mills will be used in closed circuit with the classifiers which will separate the fine and coarse particles; with the fine particles pumped to the flotation circuit and coarser particles back to the regrind mills for further grinding.

Copper-Lead and Lead Flotation Circuits - A schematic flowsheet for copper-lead and lead flotation is shown on Figure 4-29. After grinding, aeration, and conditioning with reagents, the ore slurry will be fed into the distributor feeding several banks of flotation cells. This flotation step will produce a copper-lead rougher concentrate which requires further processing. The tailings from the copper-lead rougher flotation will pass to a scavenger flotation stages in which additional copper and lead minerals will be recovered separately.

The copper-lead rougher and scavenger concentrate will be pumped to a regrind circuit containing a tower mill and cyclone classifier. Upon regrinding of the concentrate, the copper minerals will be separated from the lead minerals by another stage of flotation. The copper concentrate will then be pumped to the copper cleaning circuit for two stages of copper cleaning floatation. The copper tailings will then be pumped to a lead circuit to produce a lead concentrate. During the mining and processing of the copper ore, lead concentrate may or may not be produced, depending on the grade of lead in the copper ore.

Zinc Flotation - A schematic flowsheet for the zinc circuit is shown on Figure 4-30. The tailings from the copper-lead circuit will contain zinc from the ore and will be pumped to the zinc circuit. The ore from these circuits will be pumped to the zinc rougher cells. The zinc concentrate from these cells will be pumped to cyclone classifiers where the undersize particles report to the cleaner flotation cells for recovery of zinc concentrate. The oversize particles of this concentrate will be pumped to a regrind circuit containing a tower mill. From the zinc cleaner the concentrate will report to the zinc thickener.

4.9.3.3 Reagent Preparation and Storage

This facility will be designed for preparation of reagents required in the concentration process and will store enough prepared reagents to ensure continuous operation of the concentrator. The types, approximate quantities, and typical storage containers of reagents to be stored and used in the mill are shown in Table 4-9. Lime and sodium sulfide required in the water treatment plant will also be supplied from this area.

The reagent storage and handling areas will be designed to keep reagents segregated and allow for employee safety in the transport and preparation of bulk reagents. Non-returnable reagent containers, such as bags, will be disposed of in a licensed solid waste facility. All recyclable drums will be neutralized, cleaned, and returned to the vendor.

4.9.3.4 Concentrate Handling and Loadout

The final flotation concentrates produced will contain 25 to 35 percent solids by weight with the balance being water. These slurries will be pumped to concentrate thickeners as the first step in the dewatering process. The thickened underflow from each concentrate thickener will contain 55 to 60 percent solids by weight and will be further dewatered using semi-continuous pressure filters. These filters can produce concentrate filter cakes with residual moisture levels of approximately eight to 10 percent by weight.

The filtered zinc concentrate will normally be loaded directly into railcars using conveyor belts located beneath the filters. When railcars are not available, the conveyor belts beneath the filters can be bypassed and the concentrate can be placed in a temporary storage area or a storage bin. Concentrates will normally be shipped from the mine site in covered railcars at an estimated rate of ten cars per day. Delivery requirements, empty car availability, and weather will cause variances from normal shipping frequency and in the number of cars per shipment. Loaded cars will be shipped to North American refining facilities or to port facilities for shipment to overseas destinations. It is possible that concentrates could be trucked to their destination.

Table 4-9

Typical Reagent Storage Data

Reagent	Primary Use	Estimated Monthly Consumption (tons)	
		Minimum	Maximum
Concentrator			
Sulfur Dioxide	Depressant	38	62
Copper Sulfate	Activator	60	159
Sodium Cyanide	Depressant	5	18
Polypropylene Glycol Methyl Ether (Dowfroth 250)	Frother	2	2
Xanthate Salts	Collectors	6	14
Sodium Carboxymethyl Cellulose (Starch)	Depressant	8	28
Sodium Dichromate	Depressant	12	34
Sodium Silicate	Depressant	34	35
Activated Carbon	Absorbent	19	29
Methyl Isobutyl Carbinol (MIBC)	Frother	6	13
Calcium Oxide (Lime)	pH Modifier	333	478
Percol 155 (Acrylate/Acrylamide Polymer)	Flocculent	6	9
Thionocarbamate (1-3 percent Isopropanol)	Frother	3	4
Sodium Diisobutyldithio-phosphinate	Frother	2	2
Zinc Sulfate	Depressant	18	35
Wastewater Treatment			
Hydrated Lime[1]	pH Modifier	2	32
Sodium Sulfide	Metals Precipitation	0.1	9
Sulfuric Acid	pH Modifier	0.8	7
Coagulant Polymer	Flocculent	0.05	0.9
Skunk Lake Mitigation Water Treatment			
Sulfuric Acid	Ion Exchange Regenerant	1	3
Sodium Hydroxide	pH Modifier	0.1	0.3

[1] Hydrated lime will be used in the wastewater treatment facility (WWTF) during the period before the mill is constructed. After the mill is constructed, the WWTF will use slaked lime produced in the mill.

Prepared by: RJC1
Checked by: JWS

4.9.3.5 Mine Backfill Preparation Facilities

The underground mining method requires backfill to maximize ore recovery. The backfill material to be used is primarily the coarse fraction of the mill tailings. A cyclone classification process will be used to recover the coarse fraction of the mill tailings. The process used for recovering backfill sands from the flotation tailings and the method for storing and handling the sands are shown on Figure 4-31.

The backfill preparation plant will include pumps and cyclones to recover the coarse tailings, a cement storage tank with feeder, a batch mixing tank, and pumps to deliver the prepared backfill mix to the mine. The surface backfill system will be in two separate but adjacent locations. The backfill cyclone system will be located in the concentrator building; which will include a batch mixing tank and the backfill delivery pumps. Cement storage tanks will be located outside the concentrator building.

Limited storage capacity of backfill sands (about 750 tons) will be provided in storage tanks located near the backfill mixing plant. A pump will transfer the sand-slurry to the backfill mixing tank for addition of cement as needed before transfer to the mine. The storage system can repulp at about 60-70 percent solids, and provides a close control of density.

4.9.3.6 Mill Water Balance

Block flow diagrams showing the water balance for average minimum and maximum flows for the mill and related facilities are discussed in Section 6 of this report. This balance is based on the average ore throughput of 5,500 tons per day and is not intended to show all mine and surface facilities.

4.9.3.7 Process Control Facilities

The control room or rooms will be located such that grinding and flotation operations can be observed visually by the control room operator. All process equipment will be tied into the control room, and include start-up warning alarms, electrical and mechanical interlocks, emergency stop switches, and various process alarms. Necessary equipment will be installed to monitor all aspects of the grinding, flotation, and dewatering processes. Computer control devices and graphic displays of the process with equipment running condition will be in this area.

4.9.3.8 Spills and Odors

Provisions to contain slurry spills will be available throughout the mill building. Process spills will be restricted to confined areas, collected in floor sumps, and pumped back into the appropriate process equipment so that the minerals can be recovered. Any spills in the reagent storage and preparation area will be recovered in such a manner that they can still be used as intended. The bulk storage facilities outside the mill building are designed to contain any spill as well as the total contents of a bulk tank, should a leak occur.

The concentrator building will contain an overflow system to handle major spills that cannot be contained by floor sumps and containment berms. Spills reaching the overflow systems will exit the northwest side of the building and flow through a lined ditch and culvert system to wastewater storage basin No. 7, as shown in Figure 4-23. This basin will be lined with a

composite soil and geomembrane liner. The basin will be equipped with a pump for transferring decanted water from spill material to the tailings pumping system or back to the mill for re-use.

Some odors will occur in the reagent mix area when xanthates are being mixed. These odors will dissipate rapidly and will not be discharged to the atmosphere by the building ventilation system in detectable amounts. Liquid sulfur dioxide will be metered directly from the bulk storage tank to the various addition points. Once added to the ore slurries, sulfur dioxide will dissolve rapidly to form a weak acid solution and will not be emitted to the atmosphere as gaseous sulfur dioxide.

4.9.3.9 Lubrication

Lubricants for the mechanical equipment will include greases and oils as specified by the equipment manufacturers. Waste oil and grease that is collected will be retained in drums or holding tanks and returned to the supplier or a contractor for reprocessing or disposal.

4.9.3.10 Laboratory Facilities

Environmental and process related laboratory facilities will be constructed as part of the concentrator facility.

The assay laboratory will perform analytical work on all mine and mill processes, as part of the quality control of the ore hoisted from underground and of various metallurgical circuits within the concentrator process. In addition, the laboratory will also perform environmental analysis on air and water samples. It is possible that some of these samples may be shipped to an off-site laboratory.

The assay laboratory is primarily a wet chemistry laboratory focusing on metal digestion analysis. Acid solutions generated during these analyses will be discharged to an acid neutralization basin prior to discharge to the tailings basin. Any regulated wastes and organic compounds or other wastes will be collected in a separate waste system and recovered from the facility by a qualified contractor.

The second laboratory is a metallurgical laboratory where geological and metallurgical samples are prepared for analysis. Any waste produced from this laboratory will be removed and discharged to the SAG mill feed circuit. These quantities are relatively small and can be recycled in the circuit. This laboratory will also have an area where small bench scale testing can be performed on the flotation circuit. Any waste produced from this area will consist principally of slurried ore and reagents. These wastes will be discharged to the tailings pump box for transport to the TMA.

4.9.4 Wastewater Treatment and Discharge

A process flow diagram of the wastewater treatment system is shown on Figure 4-32. As discussed in Section 6, treatment will be required for a total of 664 gpm of wastewater for discharge under average conditions, based on the best engineering judgement rate of mine inflow of 750 gpm. Influent flows to the wastewater treatment system during normal operation will include the following:

- mine drainage;
- intercepted groundwater;
- contact runoff from the plant site;
- runoff from the pre-production ore storage area; and
- to the extent that precipitation exceeds evaporation, water from the reclaim pond if inflow to the mill water circuit occurs in excess of the water use needs of the mill.

Treated wastewater will be pumped to the discharge lagoons which are located immediately west of wastewater storage basin Nos. 6 and 7. Prior to discharge from the lagoons, the treated wastewater will be tested and then pumped by a pipeline for discharge to the Wisconsin River near the Hat Rapids Dam. The route of the pipeline is shown on Figure 1-2.

The wastewater treatment system will be provided with on-line instrumentation to measure and monitor the treated wastewater. In addition, samples of the discharge from the lagoon system will be collected and analyzed in accordance with the WPDES Permit for the facilities. The quality of the wastewater to be discharged will meet the effluent standards established by the WDNR.

In the event of a short-term shutdown of the wastewater treatment system, untreated wastewater will be stored in wastewater storage basin Nos. 6 and 7. In the unlikely event that the wastewater treatment system had to be completely shut down for an extended period, wastewater will be pumped to the reclaim pond, the tailings cell, or both. The capacity of the smallest tailing cell, TMA 3, is capable of storing approximately 9.7 million gallons per vertical foot during the first phase of filling. This translates to approximately six days storage per vertical foot at annual average wastewater flow rates.

4.9.4.1 Wastewater Reuse

Water at the site will be recycled and reused for the processes at the mill which use water, such as cooling, preparation of reagents used in the mill, water for mill equipment glands and seals, water for ore grinding, transporting sands to the mine for backfilling of stopes, and transporting tailings to the tailings cell.

Water in the reclaim pond will normally be recycled back to the mill for use in the process which can use this water. Intercepted groundwater will be collected separately from contact mine water and will normally be used as the source of utility water used in the mine. Intercepted groundwater can also be reused as a supply for seal/gland water and reagent preparation water used in the mill.

4.9.4.2 Wastewater Treatment Solids

Clarifier solids and filter backwashes will be the waste products of the wastewater treatment system. Such wastes will be pumped to the TMA along with the mill tailings. The solids in these wastes from the wastewater treatment system will consist primarily of silt from suspended solids

in the mine water and metal hydroxides from lime precipitation. Other minor constituents will include metal sulfide precipitates.

The wastewater treatment system is scheduled for completion at the end of month 18 of construction. Prior to completion, the solids which will be produced from wastewater treatment system will be stored in wastewater storage basin Nos. 6 and 7. These solids will be small in volume. No separate solids containment area within the basin is planned.

4.9.4.3 Wastewater Management During Construction, Operation and Closure

Water balances for construction, start-up, and project closure cannot be readily shown because they represent periods when conditions will change continuously. Figures 4-33 and 4-34 show conceptually how water will be handled during two general phases in construction. Figure 4-35 shows how water will be handled during normal operations.

Figure 4-33 shows how water will be handled during the first phase of construction, from about months one through 18. Runoff or sedimentation basin Nos. 1, 2 and 3 are scheduled to be completed during the eighth month and will remain in use throughout the life of the project as part of the erosion control system. They will serve to remove sediments from construction runoff and control the direction and rate of discharge of the runoff. There is some potential for oil to come into contact with the water from the east ventilation shaft and the main shaft development. Therefore those wastewaters will be collected and sent to an oil/water separator prior to discharge to wastewater storage basin No. 6.

Figure 4-34 shows how water will be handled during the latter phase of construction. Runoff basin Nos. 1, 2 and 3 will continue to receive construction runoff from non-contact areas of the project site. Runoff that has been in contact with ore or Type II waste rock from the pre-production ore storage area will be collected in wastewater storage basin No. 5 and pumped directly to the reclaim pond or, alternatively, to wastewater storage basin Nos. 6 and 7 for treatment by the wastewater treatment system prior to discharge to the Wisconsin River. The maximum runoff volume for the pre-production ore storage area will be 43,200 gallons per day. That figure is based on collection of runoff from a 25-year, 24-hour storm.

The volume of contact water from mine development will gradually increase. This water will be sent to wastewater storage basin Nos. 6 and 7 and pumped to the wastewater treatment system for treatment as necessary. Storage in wastewater storage basin Nos. 6 and 7 will also provide a source of water, if needed, for mill start-up.

There may be some differences in the quality of the mine water between early and mature operations. During early operations mine backfill drainage will make up a larger portion of the total mine water flow than during mature operations. This is due to the projected slow buildup of mine water inflow to the steady state-flow rate.

During the initial two years of mine production the ore throughput to mill will gradually increase from 3,300 tpd to 5,500 tpd, and water flows to and from the tailing cell and reclaim pond will be gradually increasing until they approach the flow rates predicted for operating at normal capacity. There should be no major difference in the ability of the wastewater treatment system to meet the effluent limitations as progress is made from start-up to normal mill capacity.

A precise water balance for project closure cannot be developed at this point, but the water management concepts can be discussed. Water will continue to be pumped from the mine until all salvageable equipment has been removed and mine closure operations have been completed. Water pumped from the mine will continue to be treated. Water from the tailing cell will be pumped to the reclaim pond as in the operational phase of the project. Water will be pumped from the reclaim pond at a controlled rate to wastewater storage basin Nos. 6 and 7, then pumped to the wastewater treatment system for treatment prior to discharge. The wastewater treatment system will continue to operate during reclamation as long as there is water requiring treatment prior to discharge.

4.9.4.4 Tailings Management Area

The engineering design, construction, and reclamation plans for the TMA are detailed in the Tailings Management Area Feasibility Report and Plan of Operation. Operation of the TMA will include the placement of tailings in the cells, maintenance of the equipment associated with the tailings transport system, and water recovery from the tailings cells. The following discussion gives a brief review of the TMA facilities. The TMA will consist of four cells constructed, operated, and reclaimed in sequence. A plan view of the TMA is shown on Figure 4-36. Design data for each cell is shown in Table 4-10. Except for short periods of time when an operating cell is nearly filled with tailings and the next cell is prepared and ready to accept tailings, only one tailing cell will be in operation at any one time.

At full production, approximately 2,200 tons per day of tailings will be pumped to the TMA. Tailings will be transported to the TMA in a water slurry at approximately 12 to 30 percent solids by weight. Transport flow in the pipeline will be at an approximate rate of 3,000 gpm. The tailings slurry will be deposited around the perimeter of the each basin. The discharge points will be moved to optimize storage within the facility. The tailings will establish a beach in the cells as they deposit with an approximate 0.5 percent slope. At the downstream end of the slope, water will pool and cover approximately 50 to 75 percent of the cell area, depending upon which cell is in service. A central floating pump barge system will be erected for the dewatering of tailings water. This water will be pumped to the reclaim pond. The estimated cell water depth of three to five feet is consistent with the decant water pumping rates planned.

The size of the TMA is based on the amount of tailings that cannot be reused in the mine. The ore reserves are estimated to be 55 million tons. This reserve estimate was used in sizing the TMA. Of this mass, about 40 percent would be placed in the TMA, primarily in the form of fine tailings. Based on an estimated final average in-place density of 97 pounds per cubic foot, a tailings storage volume of about 17.1 million cubic yards has been calculated.

In addition to the tailings, the design has allowed for an additional 13 to 15 percent contingency volume for more reserves, 700,000 cubic yards for the solids produced from the wastewater treatment system, and 70,000 to 250,000 cubic yards of waste rock. Allowing for these additions, a total volume of about 20.5 million cubic yards is provided. As the tailings are deposited in the cells, they will form sloping beaches that result in unused cell storage volume of approximately 13 percent. Final stages of deposition will require the tailings to be discharged from the central dyke. During this stage water will be reclaimed from the sides using a pump barge.

Freeboard above the normal water level when the cell is full has been designed to meet the requirements of NR 182. According to the requirements of NR 182.11(1)(q), a three foot

Table 4-10

Design Data for Individual TMA Cells

Cell Number	Capacity cu. yd ($\times 10^6$)	Site Life (years)
TMA 1	4.0	6
TMA 2	7.8	10
TMA 3	3.9	6
TMA 4	4.8	6
Total	20.5	28

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Checked by: NXP

freeboard is sufficient to prevent overtopping of waves for the 100-year, 24-hour rainfall event and accompanying high winds. Based on the expected final tailings surface slopes and the cell water pools, actual cell freeboard will be five feet above the normal maximum tailing cell water levels.

An area southeast of the plant site will be used for the TMA. This area primarily lies in Sections 29 and 32, T35N, R13E in Forest County. The major characteristics of this area are: (1) an extensive upper soil layer of relatively low permeability till; (2) low groundwater gradients; (3) the depth from the existing ground level to the groundwater table ranging from approximately 60 to 130 feet, with the distance from tailing cell bottom to groundwater of approximately 15 to 40 feet; and (4) no domestic use of groundwater within the compliance boundary area of the TMA.

The inside and outside slopes of the cell embankments will be three horizontal to one vertical (3H:1V). The glacial till soils to be used in the embankments are excellent construction soils and could be placed at steeper slopes if desired. The 3H:1V outside slopes were chosen with aesthetic consideration for the reclaimed facility. The 3H:1V inside slopes have been chosen primarily for construction considerations of the composite soil and geomembrane liner and other seepage control system layers. With these flat slopes, conventional equipment can be used to construct the seepage control system and meet required quality control objectives.

All of the tailings cells will have a bottom drain system above the tailings liner to collect and remove seepage water. Figure 4-37 shows a configuration of the underdrain system with a filter layer, a drain layer, and a collection pipe over the composite soil and geomembrane liner.

The base of the tailings cells and the composite soil layer has been designed to slope at a two percent grade from the common internal embankment toward the upstream toe of the external embankment.

The thickness shown for the filter and drain layers, 24 inches and 24 inches, respectively, have been conservatively chosen to satisfy all design requirements and to provide an adequate protective cover thickness for the liner. The composite soil mixture has a thickness of 12 inches and has been selected to afford a measure of redundancy to the liner performance. At the tailings surface, in the center of each cell, water will be allowed to pond to a convenient operating depth before transfer to the reclaim pond system. The details of this transfer or decant system are shown on Figure 4-38. Discharge pipes will pump water from the underdrain perimeter collection pipeline to the top of the embankment crest. At the cell crest, it will be combined with the decant water for transfer to the reclaim pond system.

The surge capacity in each of the tailing cells, above highest normal water levels, is in all cases greater than that required from a storm and wave run-up standpoint. In an emergency, if the surge capacity in the reclaim ponds was not sufficient, the tailing cells can be used to temporarily store water.

4.9.4.5 Water Reclaim System

An important feature of the proposed facility will be the reclaim of water for ore processing. The tailings cell will ensure the ability to successfully recycle water to the mill. The primary functions of the reclaim pond are as follows:

1. Provide water surge capacity for all process-related surface facilities; and

2. Allow sufficient residence time for natural evaporation, oxidation, and biological processes to occur and thereby control the concentrations of certain chemical constituents in the water to be recycled to the mill.

The reclaim pond is designed for a capacity of 3,500 gpm for three days, or 15 million gallons. The reclaim pond will have a depth of 20 feet. The pond has a design freeboard of three feet above maximum operating water level. The pond will also settle out fine particulates. Organic compounds (collectors and frothers) in the water will be reduced by the residence time in the pond, which will assist in successful recycle of water to the concentrator.

All embankment materials, with the exception of lining and rock slope facing materials, will consist of the soil excavated from the pond interiors. The reclaim pond embankment slopes will be three horizontal to one vertical (3H:1V). The reclaim pond will use a composite soil liner and a 60 mil geomembrane liner.

4.9.4.5.1 Tailings Transport System

The tailings slurry will be transported from the concentrator building to the TMA through an approximately 16-inch inside diameter high density polyethylene (HDPE) above ground pipeline. The location of the pipeline is shown on Figure 4-39. The pipeline will be constructed within a lined ditch. A 22 foot wide access road will be located next to the pipeline for service and maintenance. Pumps used for pumping the tailing slurry in the pipe will be located in the pump house shown in Figure 2-1.

4.9.4.6 Tailings Water Pumping System

Location of the main features of the water handling systems at the TMA are shown on Figure 4-40. A floating barge connected to an access bridge will be used to connect pumps on shore to a suction pipe located on the barge. These pumps will move the water from the TMA to the reclaim pond where another set of pumps will convey the water back to the concentrator.

4.9.4.7 Storage Basin Solids

Throughout operation, solids may settle in the wastewater storage basins. This will consist of fine sediments that settle during retention of the water. If required during operation and during final project reclamation, the solids will be collected and placed in the TMA.

Suitable solids removal methods are available that would not damage the pond liner while still allowing continued pond operation. A small floating suction dredge with depth control on the suction head could be used. In practice, it would not be practical to remove a small depth of solids (1.0 foot). These solids could be incorporated into the grading layer planned as the first step in reclamation of the tailings cell.

4.9.5 Mine/Mill Refuse Management Operations

Mine/mill refuse management will consist of a central collection area and individual collection points within the plant facility. It is anticipated that a CMC employee or a contract service will collect refuse from the individual collection points and move it to a central collection area located in the north-central area of the plant site. The refuse will be collected by a licensed contract waste hauler from the central collection area and removed from the site to a licensed refuse disposal facility.

During construction an area within the construction staging area will be used for sorting and reuse of construction materials. The collection and recycling of scrap construction material will be handled by contract scrap dealers. Refuse recycling will be accomplished using source separation and a contract recyclable material hauler.

4.9.6 Ancillary Facilities Operations

4.9.6.1 Potable Water Operations

The potable water system will be separate from all other water systems in the plant site. A separate 100 gpm well, pump, pumphouse, fresh water tank, and distribution system will be provided for potable water. Treatment of the potable water probably will not be required. However, if some treatment is needed, a chlorinator treatment system will be provided.

The potable water system will supply a nominal demand of approximately 20 gpm based on a workforce and visitor estimate of approximately 400 people, each with a 50-gallon-per-day water requirement. The operation of the well pump will be controlled by level switches in the fresh water tank. The project's high capacity well permit application provides more detail on the operation of the potable water supply well.

4.9.6.2 Treatment of Sanitary Wastes

A sewage treatment plant will handle sanitary wastes from the surface facilities and underground mine. The waste from the surface facilities will be transported to the system via a buried pipe system. Containerized waste from the underground will be transported to the surface in the mine cage for disposal in the system. The total average daily flow of sanitary wastewater has been estimated to be 14 gpm.

The system will consist of a small factory manufactured-treatment plant using an activated sludge process with extended aeration. The plant design will be tailored to the specific hydraulic and BOD/TSS loadings for the project. The plant will include zones for flow equalization, aeration, clarification, sludge storage, and disinfection. A separate sludge holding tank to reduce the frequency of sludge removal will also be included.

The plant effluent will discharge through a pipeline to the tailings pump box and thence to the TMA. The location of the sewage treatment plant is shown on Figure 2-1. Solids generated in the sewage treatment plant will be pumped as necessary by a licensed private contractor for proper disposal.

4.9.6.3 Fuels

Fueling facilities will be operated such that the quantities of fuel dispensed to the underground systems or to vehicles above or below ground are recorded. These records will probably take the form of simple use charts at each dispensing station. The use records in combination with the fuel delivery invoices will allow the cross checking of use versus purchase and thus determine fuel loss due to evaporation or spillage.

4.9.6.4 Topsoil Storage

Topsoil from the plant site will be stored as described in Section 4.8.11.6. Topsoil from the TMA will be stored as described in the TMA Feasibility Report and Plan of Operations. Low ground pressure equipment will be used on the topsoil stockpile. This type of equipment will minimize the level of compaction of the soil, thus allowing it to retain its properties. The native grasses may require mowing during each of the first two to three years following seeding. This activity will help with the establishment of the native species and minimize the invasion of undesirable species. After the first few years, the mowing schedule may be reduced to once every three to five years to reduce the fire hazard.

4.10 Erosion Control

4.10.1 Background

The proper handling of surface water runoff to control erosion has been considered during planning of each phase of the mine construction, operation and reclamation. Many studies and reports have been completed in the past to detail the erosion control practices required for proper storm water management for the mine facilities, chief among them being EMC (Parsons), 1982, *Erosion Control Plan*, and EMC, 1985, *Revised Mine Plan*. Portions of these and other references are used here, unabridged or modified, to supplement the erosion control discussions presented below.

This section of the MPA contains information and descriptions of nonpoint source control techniques to be used to control erosion during the construction, operation and reclamation phases of the Crandon Project. The techniques are based upon an analysis of the types and sources of nonpoint source pollution within the project area. The five published references listed below provided the basis for much of the information presented.

- U.S. Department of Agriculture, Soil Conservation Service, Madison, Wisconsin, 1972, *Minimizing Erosion in Urbanizing Areas.*

- Novotny, Vladimir, and Gordon Chesters, 1981, *Handbook of Nonpoint pollution Sources and Management*: Van Nostrand and Reinhold Company, New York.

- U.S. Department of Agriculture, Soil Conservation Service, College Park, Maryland, 1975, *Standards and Specification for Soil Erosion and Sediment Control in Developing Areas.*

- U.S. Environmental Protection Agency, 1973, *Processes, Procedure and Methods to Control Pollution Resulting from All Construction.*

- Wisconsin Department of Natural Resources, 1990, *Wisconsin Construction Site Best Management Practice Handbook.*

The erosion controls outlined in this chapter will provide a basis for project compliance with the Federal Water Pollution Control Act (PL 92-500) and with its 1977 Amendments (PL 95-217), known as the "Clean Water Act." The WDNR administers the Clean Water Act regulations through the Wisconsin Pollutant Discharge Elimination System (WPDES) permitting process.

4.10.2 Mechanics of Erosion

Erosion is the displacement of soil particles through natural forces. Common erosive forces include wind, ice and the various forms of water action. Water action can displace soil particles when flow velocities reach the erodible velocity of a given soil, when wave forces exceed the shore stability, and when raindrops impact an unprotected soil surface. Potential for such erosion is dependant on the type of soil, surface slope, vegetal cover, soil moisture content, amount and intensity of applied water, and other factors.

All of the forces working to displace soil particles and cause erosion are difficult to control, but the effect of these forces can be minimized with various engineering techniques. As the techniques used to control water induced erosion will be effective for other types of erosion as well, these techniques will be addressed. Critical to the level of protection against erosion is the amount or quantity of water against which erosion protection is needed. As such, a discussion of quantification of storm water runoff is included in this section.

4.10.3 Design Storms - Quantification of Runoff

While an erosion control technique may be effective for a given soil during moderate runoff condition caused by a light rain, it may not be effective during heavy runoff caused by a more severe storm. A measure of effectiveness, then, can be related to a type or severity of storm

event. Common engineering practice uses the "design storm" as this measure of effectiveness or level of performance.

The design storm to be used for the plant site to determine the potential for runoff and associated erosion is the 25-year, 24-hour duration rainstorm. The rainfall intensity for this design storm is 0.18 inches per hour. The 25-year recurrence period was chosen to be conservative and because the larger size of the planned sedimentation basins will allow much greater removal of sediments and increased infiltration, as well as assuring adequate size to handle the maximum storm event during the operation of the facility. For more severe rainfall events, up to the 100-year, the facilities will provide "emergency spillways" or other means of passing or storing the runoff waters without causing failure of the drainage systems.

The surface drainage sedimentation basins used during project operation have been sized to contain runoff volumes from a 25-year, 24-hour rainfall event. As part of the erosion control planning, the plant site will be developed so these surface drainage basins will be available from initial conception to provide temporary erosion control protection. Similarly, these basins will be used throughout early post-construction reclamation until final vegetation is established and the soils have stabilized. At that time, the sedimentation basins may be removed and the areas revegetated. During construction, the early post-construction, and reclamation phases, temporary erosion control measures will be used in areas that do not drain to sedimentation basins. Measures to be applied are summarized in Table 4-11.

Table 4-11

Erosion Control Methods Applicable to the Construction Phase

Soil Stabilization and Permanent Measures	Contingency Measures
Topsoil Removal and Preservation	Sandbag Sediment Barrier
Vegetative Stabilization	Temporary Diversion Berms
Hydromulching	
Sheet Piling	
Jute or Paper Matting	
Sod Mats	
Diversion Berm	
Retaining Wall With Interim Measures	
Sedimentation Basins	
Riprap	
Slope Bench	
Slope Serration	
Silt Fences	
Straw Bales	

Prepared by: MDL
Checked by: JBH1

4.10.4 General Engineering Methods For Erosion Control

Stormwater runoff, with its erosion potential, occurs when developing a site over many acres. The affects of erosion can be reduced by actions to reduce the erosion potential protecting the soil from the runoff forces, and by preventing any sediment-laden runoff from leaving the site. Sedimentation basins provide "treatment" to the runoff, discharging sediment-free waters from the site, while vegetative cover helps protect soils from the erosive forces.

Soil surfaces require some type of vegetation or artificial cover to reduce erosion and associated sediment yields. To initially establish vegetation successfully on disturbed soil, it is important that the soil slopes be mechanically stable, the area be protected from concentrated storm water runoff, and the soil surface stabilized with a mulch or a combination of mulch with a chemical soil stabilizer. On long slopes, it may be necessary to reduce the segments of decreasing elevation with a system of diversion berms or bench terraces.

Erosion control is a pre-requisite to creating conditions favorable for plant growth. Design criteria for soil erosion and sediment control applicable to construction and mining sites have been described by the USDA-Soil Conservation Service (1972), U.S. Highway Research Board (1973), U.S. Environmental Protection Agency (1975, 1976a, 1976b), and State of Wisconsin (1981).

Erosion control criteria should have these objectives:

- Minimization of areas in the site which discharge runoff without "treatment" in a sedimentation basin.
- Temporary control of sediment until more permanent structures and/or vegetation are established.
- Detention of storm waters on the construction site and the release of sediment-free waters at non-erosive velocities.
- Use of diversion terraces, berms or swales to divert water from the construction site.
- Establishment of cut-and-fill slopes as flat as feasible, consistent with the strengths of soil involved. Slope stability depends on length and steepness, soil strength, moisture content, density, and other factors.

Although various techniques, temporary or permanent, can be used for soil erosion control during the construction phase, some will be predominant during development of the plant surface facilities, reclaim ponds, TMA, railroad spur, and access road. These techniques include diversion berms, filter fabric, sediment traps/straw bale filters, sedimentation ponds, slope benches, and riprap. A summary of the advantages and other considerations associated with these measures, together with additional erosion control criteria has been compiled by the U.S. Highway Research Board (1973) and is presented in Table 4-12.

Table 4-12

Summary of Soil Erosion and Sediment Control Methods During Construction

Treatment Practice	Advantages	Considerations
Roadway Ditches		
Check Dams	Maintain low velocities. Catch sediment. Can be constructed of logs, shot rock, lumber, masonry, or concrete.	Close spacing on steep grades. Require clean-out. Unless keyed at sides and bottom, erosion may occur.
Sediment Traps/Straw Bale Filters	Can be located as necessary to collect sediment during construction. Clean-out often can be done with on-the-job equipment. Simple to construct.	Little direction on spacing and size. Sediment disposal may be difficult. Specifications must include provisions for periodic clean-out. May require seeding, sodding, or pavement when removed during final clean-up
Sodding	Easy to place with a minimum of preparation. Can be repaired during construction. Immediate protection.	Requires water during first few weeks. Sod not always available. Will not withstand high velocity or severe abrasion from sediment load.
Seeding with Mulch and Matting	Usually least expensive. Effective for open areas and ditches with low flow velocities.	Will not withstand medium to high flow velocities.
Paving, Riprap, Rubble	Effective for high velocities. May be part of the permanent erosion control effort.	Cannot always be placed when needed because of construction traffic and final grading and dressing. Initial cost is high.
Roadway Surface		
Crowning to Ditch or Sloping to Single Berm	Directing the surface water to a prepared or protected ditch minimizes erosion.	None - should be part of good construction procedures.
Compaction	The final lift of each day's work should be well compacted and bladed to drain to ditch or berm section. Loose or uncompacted material is more subject to erosion.	None - should be part of good construction procedures.
Aggregate Cover	Minimizes surface erosion. Permits construction traffic during adverse weather. May be used as part of permanent base construction.	Requires reworking and compaction if exposed for long periods of time. Loss of surface aggregates can be anticipated.
Seed/Mulch	Minimizes surface erosion.	Must be removed or is lost when construction of pavement is commenced.

Table 4-12 *(Continued)*

Treatment Practice	Advantages	Considerations
Temporary Silt Fence	Simple to construct and remove. Other advantages similar to straw bale filters.	Requires cleanout and maintenance. Other considerations similar to straw bale filters.
Cut Slopes		
Berm at Top of Cut	Diverts water from cut. Collects water for slope drains/paved ditches. May be constructed before grading is started.	Access to top of cut. Difficult to build on steep natural slope or rock surface. Concentrates water and may require channel protection or energy dissipation devices. Can cause water to enter ground, resulting in sloughing of the cut slope.
Diversion Dike or Berm	Collects and diverts water at a location selected to reduce erosion potential. May be incorporated in the permanent project drainage.	Access for construction. May be continuing maintenance problem if not paved or protected. Disturbed material on berm is easily eroded.
Slope Benches	Slows velocity of surface runoff. Collects sediment. Provides access to slope for seeding, mulching, and maintenance. Collects water for slope drains or may divert water to natural ground.	May cause sloughing of slopes if water infiltrates. Requires additional R.O.W. Not always possible due to rotten material, etc. Requires maintenance to be effective. Increases excavation quantities.
Slope Drains (pipe, paved, etc.)	Prevents erosion on slope. Can be temporary or part of permanent construction. Can be constructed or extended as grading progresses.	Requires supporting effort to collect water. Permanent construction is not always compatible with other project work. Usually requires some type of energy dissipation.
Seeding/Mulching	The end objective is to have a completely grassed slope. Early placement is a step in this direction. The mulch provides temporary erosion protection until grass is rooted. Temporary or permanent seeding may be used. Mulch should be anchored. Larger slopes can be seeded and mulched with smaller equipment if stage techniques are used.	Difficult to schedule high production units for small increments. Time of year may be less desirable. May require supplemental water.
Sodding	Provides immediate protection. Can be used to protect adjacent property from sediment and turbidity.	Difficult to place until cut is complete. Sod not always available. May be expensive.
Slope Pavement, Riprap	Provides immediate protection for high risk areas and under structures.	Expensive. Difficult to place on high slopes. May be difficult to maintain.

Table 4-12 *(Continued)*

Treatment Practice	Advantages	Considerations
Temporary Cover	Plastics are available in wide rolls and large sheets that may be used to provide temporary protection for cut or fill slopes. Easy to place and remove. Useful to protect high risk areas from temporary erosion.	Provides only temporary protection. Original surface usually requires additional treatment when plastic is removed. Must be anchored to prevent wind damage.
Serrated Slope	Lowers velocity of surface runoff. Collects sediment. Holds moisture. Minimizes amount of sediment reaching roadside ditch.	May cause minor sloughing if water infiltrates. Construction compliance.
Fill Slopes		
Berms at Top of Embankment	Prevent runoff from embankment surface from flowing over face or fill. Collect runoff for slope drains or protected ditch. Can be placed as a part of the normal construction operation and incorporated into fill or shoulders.	Additional coordination and effort is required from construction operators to place final lifts at edge for shaping into berm. Sediment build-up and berm failure may occur if proper construction and maintenance does not take place.
Slope Drains	Prevent fill slope erosion caused by embankment surface runoff. Can be constructed of full or half section pipe, bituminous, metal, concrete, plastic, or other waterproof material. Can be extended as construction progresses. May be either temporary or permanent.	Permanent construction as needed may not be considered desirable by contractor. Removal of temporary drains may disturb growing vegetation. Energy dissipation devices are required at the outlets.
Fill Berms or Benches	Slows velocity of slope runoff. Collects sediment. Provides access for maintenance. Collects water for slope drains. May utilize waste.	Requires additional fill material if waste is not available. May cause sloughing. Additional R.O.W may be needed.
Seeding/Mulching	Timely application of mulch and seeding decreases the period a slope is subject to severe erosion. Mulch that is cut in or otherwise anchored will collect sediment. The furrows made will also hold water and sediment.	Seeding season may not be favorable. Not 100 percent effective in preventing erosion. Watering may be necessary. Steep slopes or locations with high velocities may require supplemental treatment.
Protection of Adjacent Property		
Brush Barriers	Use slashing and logs from clearing operation. Can be covered and seeded rather than removed. Eliminates need for burning or disposal off R.O.W.	May be considered unsightly in urban areas.

Table 4-12 *(Continued)*

Treatment Practice	Advantages	Considerations
Straw Bale Barriers	Straw is readily available in many areas. When properly installed, they filter sediment and some turbidity from runoff.	Require removal. Subject to vandal damage. Flow is slow through straw requiring considerable area.
Sediment Traps	Collect much of the sediment spill from fill slopes and storm drain ditches. Inexpensive. Can be cleaned and expanded to meet need.	Do not eliminate all sediment and turbidity. Space is not always available. Must be removed (usually).
Sedimentation Basins	Can be designed to handle large volumes of flow. Both sediment and turbidity are removed. May be incorporated into permanent erosion control plan.	Require prior planning, additional R.O.W. and/or flow easement. If removal is necessary, can present a major effort during final construction stage. Clean-out volumes can be large. Access for clean-out not always convenient.
Energy Dissipators	Slow velocity to permit sediment collection and to minimize channel erosion off project.	Collect debris and require cleaning. Require special design and construction of large shot rock or other suitable material from project.
Level Spreaders	Convert collected channel or pipe flow back to sheet flow. Avoid channel easements and construction off project. Simple to construct.	Adequate spreader length may not be available. Sodding of overflow berm is usually required. Must be a part of the permanent erosion control effort. Maintenance forces must maintain spreader until no longer required.
Plastic Filter Sheet	Permit good drainage and control of soil particle movement. Cost and long-term effectiveness.	Variability in effectiveness between products. Requires careful installation for long-term effectiveness.
Construction Dike	Permits work to continue during normal stream stages. Controlled flooding can be accomplished during periods of inactivity.	Usually requires pumping of work site water into sediment pond. Subject to erosion from stream and from direct rainfall on dike.
Cofferdam	Work can be continued during most anticipated stream conditions. Clear water can be pumped directly back into stream. No material deposited in stream.	Expensive.
Temporary Stream Channel Change	Prepared channel keeps normal flows away from construction.	New channel usually will require protection. Stream must be returned to old channel and temporary channel refilled.
Riprap	Loosely placed rock or sacked sand with cement or stone easy to stockpile and place. Can be installed in increments as needed.	Expensive.

Table 4-12 *(Continued)*

Treatment Practice	Advantages	Considerations
Temporary Culverts for Roads	Eliminate stream turbulence and turbidity. Provide unobstructed passage for fish and other water life. Capacity for high flow can be provided with storm water flowing over the roadway.	Space not always available without conflicting with permanent structure work. May be expensive, especially for larger sizes of pipe. Subject to washout if proper overflow spillways not properly placed.
Rock-lined Low-level Crossing	Minimizes stream turbidity. Inexpensive. May also serve as ditch check or sediment trap.	May not be fordable during rainstorms. During periods of low flow passage of fish may be blocked.
Borrow Areas		
Selective Grading and Shaping	Water can be directed to minimize off-site damage. Flatter slopes enable mulch to be cut into soil.	May not be most economical work method for contractor.
Stripping and Replacing of Topsoil	Provides better seed bed. Conventional equipment can be used to stockpile and spread topsoil.	May restrict volume of material that can be obtained for a site. Topsoil stockpiles must be located to minimize sediment damage. Cost of rehandling material.
Dikes, Berms, Diversion Ditches, Settling Basins, Sediment Traps, Seeding and Mulch	See other practices.	See other practices.

Source: EMC, 1986 Revised Mining Permit Application, Table 3.5 "Summary of Soil Erosion and Sediment Control Methods During Construction" (page 3-64).

Checked by: MDL

4.10.5 Erosion Control Techniques

Specific erosion control techniques to be applied on the Crandon Project are presented in this section. These methods were selected based on the climatic conditions, soils, and vegetation in the plant area and in relation to the proposed construction phasing. A description of where each method is to be used is found in the following text. Some of the erosion control methods were developed for possible application on steeper banks which may be encountered during road and railroad construction. The contingency methods described are for use on areas where experience has shown that storms reduce the effectiveness of other erosion control methods.

4.10.5.1 Topsoil Removal and Preservation

The Crandon Project will comply with Wisconsin Admin. Code NR 132.08(2)(f), which requires that all topsoil from surface areas disturbed by mining operations be removed and stored in an environmentally acceptable manner for use in subsequent reclamation.

The major soil series present in the project area is the Goodinon-Wabeno Complex and is described as having "poor" topsoil characteristics. The official description of the term "poor" is "Soils treated as poor are very sandy soils, very firm clayey soils, soils with suitable layers less than eight inches thick, soils having large amounts of gravel, stones or soluble salt, steep soils and poorly drained soils."

The construction plan that has been developed for the project assumes topsoil will generally be salvaged to a depth of about nine inches. This material will be stabilized during construction, stored, and reused during reclamation.

Although NR 182.04(50) does not include "peat humus" in the definition of topsoil, it will form a valuable material for the generation or sustenance of plant growth. Therefore, where applicable, peat humus will be salvaged during construction activities and used during reclamation.

Stockpiling of the topsoil horizon at the first stage of grading for application to finished grades will occur at the southwest area of the plant site shown in Figure 4-41. Topsoil will be removed from disturbed portions of the mine area. Stripped topsoils will be used to dress berms and other project features that will be vegetated as part of site construction activities or used to build the topsoil stockpile. Approximately 100,000 cubic yards of topsoil will be salvaged into the topsoil stockpile. The stockpiles will be vegetated to minimize erosion.

Topsoiled slopes will be seeded with prairie seed mix pursuant to the reclamation plan to minimize damage from wind, water, and/or human disturbance. When used along sideslopes, grass seed mixes have a long-term advantage over other revegetation methods in providing locally adapted seed stock with low maintenance requirement (no added water, fertilizer, humus, or cutting needed). In the short-term, this method does not provide quick uniform ground cover as do grass and legume mixtures. However, the grass and legume mixtures compete with native successional vegetation for nutrients, light, moisture, and soil space.

4.10.5.2 Vegetation, Seeding, Fertilization and Mulching

A healthy establishment of vegetal cover is essential to control erosion. Different soil type and slope conditions require different vegetation considerations. Be it temporary or permanent,

construction phase or reclamation, vegetative stabilization must be established to provide proper erosion control.

4.10.5.2.1 Species Selection

Species selection for erosion control during the construction phase will be dependent upon the proposed life of the area concerned. Where an area is likely to be exposed for the period May to October only, species which exhibit rapid establishment and growth may be seeded, depending upon specific site conditions. Examples of such species include oats (*Avena sativa*), rye (*Secale cereale*), and perennial rye grass (*Lolium perenne*) (Table 4-13).

Table 4-13

Species for Use in Soil Stabilization

Species	Purity Min. Percent	Germination Min. Percent	Mixture Portions Percent (No. 30)
Kentucky Bluegrass	85	80	10
Creeping Red Fescue	97	85	30
Improved Turf Type Tall Fescue	98	85	25
Fults Salt Grass	98	85	10
Improved Fine Perennial Ryegrass	96	85	15
Empire Birdsfoot Trefoil	95	80	10

Prepared by: BFW
Checked by: JBH1

Erosion control during the period October to May is equally as important as from May to October. Construction areas having exposed soils that will not be disturbed from October to May will be stabilized in late summer or early autumn with grass-based seed mixtures. These seed mixtures will be supplemented with mulch and/or soil surface stabilizers to enable establishment of vegetative cover prior to the non-growing season. Vegetative cover will be established as early as possible on these areas so that the soils are stabilized and erosion potential is minimized.

Exposed surfaces requiring surface stabilization for periods longer than those mentioned above will be seeded with either native or introduced species as described in Section 5, Reclamation. Surfaces formed during construction, which will exist for the duration of the project, but which will be disturbed during final recontouring, will be seeded according to the following guidelines:

- Where the surface is to form part of a formal landscaped area, a general all-purpose grass mixture (fine fescue, see Section 5) will be established and maintained until such time as non-herbaceous species are introduced.

- Where the surface is to form part of a landscape having a natural appearance and where colonization of the surface area by native species is not detrimental to operational procedures, a seed mixture chosen from the native species list in Section 5 will be established.

- Where erosion control is required, but colonization by native species would be deemed detrimental to operational procedures, DOT seed mixture No. 30 will be established.

Exposed surfaces formed during construction and for which the established grade will remain as part of the final topography at closure will also be seeded with mixes described in Section 5. Such mixtures are considered to be permanent, self-sustaining and maintenance free. However, infrequent maintenance practices of mowing or herbicide spraying may be imposed to control native shrub and tree invasion where such invasion is considered undesirable. Reduction or elimination of maintenance practices several years before abandonment will permit native plant species to become established and provide a natural transition for the vegetation cover on these surfaces to a vegetative cover approaching that of the surrounding area. As detailed plans are completed for erosion control during construction and for implementation of reclamation as mining operations begin, consideration will be given to the need or desirability for using other forage-type species identified.

4.10.5.2.2 Seeding

During the construction phases of the project, seeding will be undertaken using both hydro-seeding and mechanical methods. Specific site characteristics, but primarily slope, will determine which method is selected. The optimum seeding period for legume-based seed mixtures is April to June, whereas the optimum period for grass-based seed mixtures is August and September. Where completion of construction of various facilities does not permit an optimum seeding time, temporary erosion control methods will be used.

4.10.5.2.3 Mulches and Soil Surface Stabilizers

Numerous types of mulches and soil surface stabilizers can be used when hydro-seeding. Selection will be dependent upon the recommendation of a reclamation specialist, cost and availability.

4.10.5.2.4 Fertilizer Use

Establishment of forage type plant species for purposes of erosion control may require fertilizer applications to achieve a satisfactory vegetative cover. However, data obtained from preliminary evaluations of the vegetation potential of the Crandon Project site soil indicate that higher levels of fertilizer application may not always be required.

As major project facilities are constructed and the areas associated with, or adjacent to, these facilities are graded and ready for establishment of vegetative cover, soil samples will be taken

and analyzed to determine the most appropriate fertilizer application. Each of these areas also will be analyzed (i.e., topography, exposure, drainage and future use) to determine the best seed mixture and practice for seeding.

The proposed seed mixtures that will be most commonly used for temporary erosion control are also composed of species tolerant of low soil fertility. Fertilizer requirements for non-herbaceous vegetation, whether planted directly into subsoils or into topsoil applied over subsoil, will follow the general recommendations for such practice by the USDA-Soil Conservation Service and State of Wisconsin.

4.10.5.3 Vegetative Stabilization

Vegetative stabilization is the general method for short and long-term slope stabilization using selected plant materials. This method is proposed to reduce short-term erosion and enhance the long-term natural succession revegetation which will control erosion. Table 4-14 lists the general vegetation methods that will be used on site for the various slopes that will be encountered.

Table 4-14

Application of Vegetation Methods*
Step-by-Step Description of Vegetation Methods

	Site Condition	Operation in Order of Performance
A	Small slopes with gradients as steep as 2:1	Grass and legume seed selection Seedbed preparation, by hand Broadcasting seed, hand labor Straw mulch, hand punching Maintenance Fertilizer
B	Small slopes with gradients as steep as 4:1	Grass and legume seed selection Seedbed preparation by machine Drilling seed Straw mulch by machine Maintenance Fertilizer
C	Small slopes with gradients as steep as 2:1	Grass and legume seed selection Seedbed preparation, some hand labor Hydromulching Hydroseeding, combined with hydromulching Maintenance Fertilizer
D	Slopes with gradients as steep as 2:1	Vegetation plant selection Planting Maintenance Fertilizer

Table 4-14 *(Continued)*

Site Condition	Operation in Order of Performance
E Unstable drainageways as steep as 2:1	Grass and legume seed selection Seedbed preparation, some hand labor Broadcasting seed by machine Straw mulch, machine punching Matting in drainageways Maintenance Fertilizer
F Small slopes as steep as 2:1	Grass and legume seed selection Seedbed preparation, some hand labor Hydroseeding Maintenance Fertilizer
G Small slopes as steep as 2:1	Grass and legume seed selection Seedbed preparation, some hand labor Broadcasting seed, by machine Straw mulching, by machine Jute matting Maintenance Fertilizer
H Large slopes as steep as 2:1	Grass and legume seed selection Seedbed preparation, some hand labor Wattling Hydromulch Hydroseeding, combined with hydromulching Vegetative planting Maintenance Fertilizer
I Large slopes as steep as 2:1	Grass and legume seed selection Seedbed preparation, some hand labor Wattling Hydroseeding Vegetative planting Maintenance Fertilizer
J Large slopes as steep as 2:1	Grass and legume seed selection Seedbed preparation, some hand labor Wattling Hydroseeding Straw mulch Jute matting Vegetative planting Maintenance Fertilizer

Table 4-14 *(Continued)*

	Site Condition	Operation in Order of Performance
K	Slopes needing mechanical stabilization	Slope stabilization Grass and legume seed selection Seedbed preparation, moderate hand labor Hydromulch Hydroseeding, combined with hydromulching Vegetative planting Maintenance Fertilizer
L	Slopes needing mechanical stabilization	Slope stabilization, as needed Grass and legume seed selection Seedbed preparation, moderate hand labor Hydroseeding Vegetative planting Maintenance Fertilizer
M	Slopes needing mechanical stabilization	Slope stabilization, as needed Grass and legume seed selection Seedbed preparation, moderate hand labor Broadcasting seed, by hand Straw mulch, machine method Jute matting Vegetative planting Maintenance Fertilizer
N	Slopes to 20 feet long as steep as 2:1	Grass and legume seed selection Seedbed preparation, moderate hand labor Hydromulch Hydroseeding, combined with hydromulching Vegetative planting Maintenance Fertilizer
O	Slopes to 20 feet long as steep as 2:1	Grass and legume seed selection Seedbed preparation, moderate hand labor Hydroseeding Straw mulch Jute matting Vegetative planting Maintenance Fertilizer

Table 4-14 *(Continued)*

	Site Condition	Operation in Order of Performance
P	Slopes to 20 feet long as steep as 2:1	Grass and legume seed selection Seedbed preparation, moderate hand labor Broadcasting seed Vegetative planting Maintenance Fertilizer

* Designations indicate the specific Best Management Practice to use, in the exact sequence in which the work is to be performed, except the fertilizer which is to be used is always specified last.

Note: Typical representation, refinements may be made in final design.

Source: Engineering-Science, 1980

Prepared by: BFW
Checked by: JBH1

Annual grasses and legumes are recommended for quick cover and rapid, temporary protection. Perennial grasses and legumes are used for continued protection, as are wattling (willow bundles), shrub, and tree plantings. A listing of plants to be used in revegetation of the plant area is presented in Section 5 of the MPA.

All grass, legume, herb, shrub, and tree stock used in revegetation in the plant area will be of demonstrated viability and effectiveness in erosion control and soil stabilization. Trees and shrubs will provide lasting vegetative stabilization and protection after the grasses and legumes decline. Native shrubs, trees, and herbs will be used to maintain the biological integrity of the area being revegetated and increase the likelihood of survival.

The application of topsoil to exposed cuts and fills will enhance long-term regrowth of natural seedstocks. This method of replanting is often superior to extensive planting of potted material. Plants which develop are of local variety and therefore well adapted to the area environmental conditions.

Soil surveys will be conducted for each revegetation site or area. Several revegetation sites will be inspected and tested for the following parameters: soil depth, pH, percolation, water holding capacity, and nutrient levels. Specific fertilization specifications recommended by the soil specialist will be incorporated into the vegetation process.

When soil pH is less than 5.5 (moderately acidic), seedling establishment may be retarded. To establish a more favorable soil pH, lime or other acceptable soil conditioners will be applied. Some seed requires pretreatment prior to planting. Seed suppliers will be contacted to ascertain this need and to acquire treated seed. Shrubs and trees may be seeded or planted from bare root or potted stock.

Initial watering will be supplied wherever needed. Soil will be wetted at time of planting. Water will not be applied at rates which result in erosion of the soil surface or damage to planted or seeded areas. Revegetation work will be accomplished between May 1 and September 15 of a

given year. Early spring is the most favorable period, just after peak spring runoff. Late fall plantings will require maintenance and further revegetation in the following spring, but a late fall planting with mechanical stabilization is preferable to leaving a site bare over a winter. South-facing slopes will be seeded only in springtime or summer. North-facing slopes may be seeded in fall. Work will be scheduled to minimize the time of exposure of bare soil and partially completed work.

Final selection of vegetative plantings will be based on adaptation of the plants to the soils and climate, suitability for the specific use, ease of establishment, longevity or ability to reseed, and the maintenance required. Most introduced plants require a high level of maintenance while adapted native plants generally require less cultural treatment for maintenance. On steep slopes and other inaccessible areas, it is preferable to select plants requiring little or no maintenance.

Earth-moving activities such as heavy cutting, filling and grading are generally performed in several stages; they may be interrupted by long periods during which the land lies idle and is subject to accelerated erosion. Also, final land grading may be completed during a season not favorable for immediate establishment of permanent vegetation. Such sites can be temporarily stabilized by establishment of rapid-growing annual grasses. These grasses provide quick protective cover and can later be worked into the soil when the site is prepared for establishing permanent vegetation. When it is not practical to plant temporary vegetation, mulch materials will be used to provide the required protection. When areas are ready for planting to perennial cover, special care will be taken in selecting the types of plants to use. The species of plants recommended presume non-irrigated.

Topsoil salvaged from the site at the beginning of grading operations will be placed on the finished grade to a depth of four to six inches. Existing vegetation will remain undisturbed where possible. Fertilizer will be applied immediately prior to seeding. Seeding of grasses, legumes, shrubs and trees may be accomplished at the same time, or any of these seed types may be sown separately. Mixture proportions can be accurately managed and a uniform planting at the correct rate can be achieved. Fertilizer of the specified formulation will be applied at the rate specified for conditions as tested at the plant site. Seeding will be conducted as quickly as possible upon completion of grading at a construction site. Hydroseeding involves placing seed, fertilizer, a tacking agent and water with a small amount of dyed wood fiber into a tank and agitating the mixture into a uniform slurry.

Broadcasting seed provides an effective method of scattering seed uniformly. If the seed is properly covered with soil and appropriate mulches are applied, germination and establishment are generally better from broadcasted seed than from seed sown by hydroseeding, but not as good as the germination and establishment from drilled seed due to the difficulty of properly covering all of the seed on any but the most ideal sites. However, broadcasting seed is approximately equivalent to hydroseeding in effectiveness. On ideal sites, hydroseeding is equally effective in uniformly scattering seed as is broadcasting seed, but is not as good as drilling seed. However, it is appropriate to more different sites, and it can provide more uniform application rates than broadcasting.

4.10.5.4 Hydromulching

Some soil surfaces can best be protected with application of a hydromulch most often in conjunction with hydroseeding to provide erosion control. Table 4-12 lists the site conditions where hydromulching should be considered.

Hydromulching is the application of plant fiber mulch and tacking agent in a slurry with water. Options available with this method which are recommended for the project include application of fertilizers, native seed mix and, on steeper slopes, either straw or matting. The purpose of hydromulching is to uniformly and economically apply a temporary stabilization material (wood fiber, straw or seed-free hay) and water to a bare slope or other bare area. Hydromulch will be combined with hydroseeding as a revegetation method to provide long-term stabilization. This method plus topsoil application and vegetative stabilization are the primary control methods at the site. Hydromulching will be applied to areas which are within approximately 200 feet of a road or other area which can be reached by truck.

Hydromulching can be combined with seed and fertilizer as a revegetation method. The mulch will remain up to two years, but loses much of its effectiveness after the first year. Revegetation is needed to provide continued stabilization. Hydromulching will be used only on physically stable slopes (natural angle of repose or less). When seeding is combined with hydromulching, fertilizer of the specified formation will be included at the specified rate.

Plant fiber may be dyed to aid in uniform placement. Dye will not stain concrete or painted surfaces nor injure plant or animal life when applied at the manufacturer's recommended rate. Application of the slurry will proceed until a uniform cover is achieved. The applicator will not be directed at one location for a measurable period of time so that soil erosion may be avoided.

Hydromulched slopes will be inspected periodically for damage due to wind, water or human disturbance. Damaged areas will be repaired immediately using either hydromulching at the original specifications or straw mulch.

Hydromulching is an effective method of increasing water retention, and thereby reducing erosion, for six months to one year. Beyond one year the effectiveness diminishes unless combined with hydroseeding. Initial and short-term effectiveness for sediment reduction will achieve 70 to 100 percent reduction in sediment generation from the slope compared to the bare slope. Nutrient reduction, the removal of water transported nutrients from mulch adsorption or enhanced infiltration, is estimated to be 50 to 70 percent for six months. Long-term effectiveness is greatly enhanced when combined with topsoil reapplication.

4.10.5.5 Sheet Piling

Sheet piling is a temporary metal piling driven into the ground between stream crossings and bridge piers or approaches. The purpose of sheet piling is to catch runoff and materials from construction of bridge piers or approaches to prevent materials or sediments from entering the stream. This technique will be used for the road and railroad crossings of Swamp Creek.

The sheet pile is placed before any grading is done on the approaches. It is removed after the slope is stabilized (one year minimum). Standard metal sheet pile will be used. After slope stabilization, the materials which have accumulated in back of the piling will be removed.

This technique is very effective in controlling runoff of large sediments and construction materials. Some suspended materials may escape through the joints of the sheet pile; however, the increased infiltration caused by the water holding capability of the sheet pile will remove suspended solids and nutrients through infiltration and settling similar to a temporary detention dike.

4.10.5.6 Jute or Paper Matting

Jute or paper matting is used in some applications for erosion control to provide slope stabilization, erosion control and protection of mulches from wind or water damage.

Jute or paper matting may be used on road/railroad construction for steeper slopes with topsoil application, hydromulching, and vegetative stabilization. Jute or paper matting can be applied over straw, wood fiber, hydromulch or manure mulches where runoff quantities and velocities from slopes greater than 4:1 exist or where there are large tributary drainages flowing over the site. It may be applied alone as an alternative to straw or wood fiber mulches on flat sites for dust control and seed germination enhancement, but will not be applied alone on slopes greater than 8:1 where runoff quantities are high.

Jute and paper matting are heavy fiber nets which are generally purchased in rolls and are attached to slopes by wired U-shaped staples to provide a uniform covering. This covering protects mulches, provides additional water-holding capacity, and aids in moderating environmental fluctuations near the ground surface, as does a mulch. Greater integrity of a mulched area results from the use of this covering than from any other single method, such as punched straw.

The soil must be reasonably smooth. Gullies and rils must be filled and compacted. Rocks or other obstructions which rise above the level of the soil and mulch must be removed. Slope stabilization will be used where necessary to achieve the slope design criteria. Application will be as specified below for maximum effectiveness. The details for installation are shown in Figure 4-42. Individual rolls will be applied vertically to the slope. Sides of rolls will overlap at least 4 inches. Rolls will have at least a three foot overlap with the uphill roll overlaying the downhill roll.

Staples will be made of wire 0.091 inches in diameter or greater, U-shaped with legs at least six inches in length and with a one inch crown. Longer staples are required in loose or sandy soils. Staples will be driven perpendicularly into the slope face, and will be spaced approximately five feet apart down the sides and center of the roll. Spacing between staples at the upper end of a roll or at the end overlap of two rolls will not exceed one foot.

Matting will be continued beyond the edge of the mulched or seeded area at least one foot at the sides and three feet at the top and bottom of the area. If existing vegetation or structures mark the boundaries of the area, the matting will be continued into the stable vegetated area or the edge of the structure. The upper end of the matting at the top of the area will be buried in a trench at least eight inches deep. The matting will make uniform contact with the slope face underneath. No "bridging" of rills or gullies is recommended.

Jute or paper matting acts similarly to straw mulch or hydromulch. Sediment reduction for up to six months is 70 to 90 percent, with 40 to 60 percent expected for up to two years and 10 to

30 percent beyond two years. Nutrient reductions are estimated at 50 to 70 percent for six months, 20 to 50 percent for up to two years, and 0 to 10 percent beyond two years, Tahoe Regional Planning Agency (1979), and less quantitatively, Novotny (1981).

4.10.5.7 Sod Mats

Sod mats are rolls of well developed grass used for immediate protection of slopes. The purpose of these mats is to immediately reduce erosion on steeper slopes and during periods of heavy rainfall. This method is most effective for control of erosion during March, April and early May when warm rains cause snow and ice melt resulting in maximum runoff on slopes which have no established cover.

Sod requires a good seedbed with either topsoil application or humus addition. Growth and establishment are aided by liming and fertilizing at rates appropriate to the specific site requirements. The strips of sod mat will be applied across the slope, anchored to the soil, and on south facing or dry slopes, watered during the summer.

The sod will be moist when cut and will be cut straight on the sides and square at the ends. Depth of mat varies with type of grasses as follows:

- Bluegrass - 0.75 to 1.25 inches
- Brome - 1.50 to 2 inches

Sod will be applied as soon after cutting as possible and sod joints will be staggered as in laying bricks. Extend coverage two feet over top of slope and bury leading edge to encourage flow over the mat. All holes between mats will be filled with topsoil. Staples (wire U-shaped) aid in providing good soil contact with sod roots for establishment. During dry periods when first established, slow application of water may be required, especially on south facing slopes.

The sod mats will be inspected for damage following a heavy rainfall and repaired when required. Mowing may be done to provide aesthetic enhancement. A regular application of fertilizer may also be needed to maintain sod growth and development.

Sod matting is the most effective method for quickly controlling erosion and sedimentation. The grass material will very effectively remove nutrients, suspended solids to some degree and most sediments.

4.10.5.8 Diversion Berm

A diversion berm is an earth dike constructed along the bottom of cut or fill slopes to intercept runoff. This method is used to retain overland flow from slopes and reduce downstream erosion.

The diversion berm method, as applied at the plant site, includes the berms within and along the perimeter of the site. This method is used on all slopes which may receive runoff from the upslope area, and is generally used during construction to retain runoff from graded or disturbed areas and divert the flow to sedimentation basins. This will be the first erosion control measure applied during construction and will include initial grading of the railroad beds during the first year of construction. This method will also be used at the toe of slopes from the road and railroad beds where they intersect wetlands to prevent sedimentation of the wetlands.

Diversion berms will be placed to intercept all runoff from above or below cut and fill slopes to prevent collected runoff from flowing onto slope faces below, thereby reducing downslope erosion. A recommended design is shown in Figure 4-43. The detention area must be able to percolate expected runoff and diverted runoff must not overtop the berm. For grades in excess of two percent or for large flows, the diversion channel will be mechanically stabilized with a concrete, asphalt, or riprap lining placed to enhance vegetal cover where erosive velocities might occur.

The diversion berm consists of a trench and a dike. The trench will be constructed using a dozer blade or hand tools to dig below the topsoil layer. The dike will be compacted at regular intervals. Materials for the dike will be free of mulch or organic material (no topsoil). After construction, the faces will be covered with topsoil to promote vegetation cover.

Berms will be inspected after each major storm to locate any damaged areas and repairs should be completed before the next storm. Channel obstructions will be removed.

The effectiveness of this method depends on the size and stabilization of the slope above, and maintenance of the catch basin channel. It is most effective for removing large sediments during the early phases of stabilization.

4.10.5.9 Retaining Wall With Interim Measures

A retaining wall may be constructed across a slope to support a terrace to prevent erosion on extensive cuts. This method is used to stabilize extreme cuts and minimize surrounding soil disturbance due to terracing or sloping alternatives. The only anticipated maintenance would be to repair damage to the wall from equipment. The retaining wall method is at least 95 percent effective in controlling sediment runoff after completion of construction. If backfill is limited and effectively revegetated, effectiveness can approach preconstruction conditions within two years.

4.10.5.10 Sedimentation Basin

A sedimentation basin is a temporary or permanent basin constructed in conjunction with a detention dam. This method is used to trap and store sediment contained in surface runoff and to serve as a flow detention facility for reduction of peak runoff.

Detention structures will be used to temporarily contain storm water to trap sediment in runoff from construction sites. Larger structures located on the north and south sides of the plant site will provide substantial reduction of peak runoff as well as sediment removal.

The example design (Figure 4-44) will provide a basin to detain construction runoff and sediments and slowly discharge flows to a stabilized area below the basin. The structures will become part of the drainage system for the area following completion of construction until they are no longer needed. Sedimentation basins covered by this control technique will be limited to drainage areas not exceeding 50 acres. The 25-year storm interval was used to design the basins, with emergency spillway capabilities to the 100-year storm event.

Design of each sedimentation basin as shown in Figure 4-44 was based upon the total tributary drainage area to each. Vegetation will be planted on all embankment slopes, borrow areas or

any other areas disturbed during construction. An antivortex device will be installed on the top of the standpipe. An antivortex device is a thin, vertical plate normal to the centerline of the dam and firmly attached to the top of the standpipe. A trash rack consisting of reinforcing bars, six inches on center will be welded across the top of the standpipe.

Pipes through embankments will be provided with antiseep collars. All basins will have a minimum of one antiseep collar which is a watertight barrier attached to the pipe blocking all potential flow through the backfilled material and extending to the sides of the pipe trench. The sediment trap will have drain-down perforations to slowly eliminate the entire stored water volume to prevent insect breeding and maintain adequate live storage.

The minimum capacity for the emergency spillway will be that required to pass the peak flow associated with the 100-year design storm. Protection of the embankment and emergency spillway by riprap, vegetative, or other suitable means will be provided. Sedimentation basins will be cleaned when the effective storage capacity of runoff drops below 0.3 inches per acre of drainage area. The elevation corresponding to this level will be determined and given in the detailed design as part of the final landscape design plan.

Areas under the embankment and any structural works will be cleared, grubbed and the topsoil stripped to remove all trees, vegetation, roots, or other objectionable material. To facilitate cleanout and restoration, the pool area (measured at the top of the pipe spillway) will be cleaned of all brush, trees or other debris. The fill material will be free of roots, woody vegetation, oversized stones, rocks exceeding six inches in diameter, or other objectionable materials. The embankment will be raised and compacted to design elevation. The movement of the hauling and spreading equipment over the fill will be controlled so that the entire surface of each lift will be traversed by not less than one tread track of the equipment or compaction will be achieved through use of a roller.

The standpipe must be rigidly and securely fastened to the barrel and the bottom of the standpipe must be sealed (watertight). The pipe spillway will discharge at ground elevation below the dam. All pipe joints must be securely fastened and watertight. When sediments fill up to 30 percent of the height of the drainage standpipe, the basin will be mechanically cleared and the materials transported to an appropriate storage location.

This method is most effective when the basins are sized for major storms such as the 25-year, as they have been for this project. The larger size allows maximum settling of sediments and suspended materials. Infiltration is also enhanced, which will remove nutrients.

4.10.5.11 Riprap

Riprap involves the use of stabilizing blankets comprised of large rocks placed on a slope or ground surface to be protected from surface water erosion. This method is used to protect banks and roads from erosion, maintain stream capacity, and prevent downstream sedimentation. This will be used in conjunction with wing walls on the bridges for all stream crossings at the road or railroad. Riprap will be used at road or railroad stream crossings at the project area to enhance stabilization of all emergency spillways, pipe discharges, and in specific locations throughout the project area where flow velocities are such that riprap is deemed necessary to control erosion.

Consideration must be given to sizing of stream crossing structures to handle water flows from the entire contributing drainage area of the given stream or conveyance facility. The location of riprap placement will be determined by the elevation and location of moving water around or next to conveyance structures such as ditches, retaining walls, etc. Trees and other debris must be cleared from the water conveyance structure (bridge, box culvert, ditch, etc.) after major storms to prevent alteration or blockage flow and subsequent loss of facilities. This method contributes to the roughness of the flow channel which slows the flow rate of the waterway (Novotny, 1981). Used with proper design, this method is very effective in controlling erosion and providing slope stability.

4.10.5.12 Slope Bench

A slope bench is a gently sloping surface at the base of steeper slope (Figure 4-45). This method is used to retain material eroded from the slope. The slope bench method may be used as necessary in steeper cuts of the road or railroad during construction, and will be used for erosion control on all newly constructed cut slopes. For benches constructed along roadways with a grade steeper than five percent, the steepness of the bench slope must be increased above two percent to prevent lateral water movement behind the area parallel to the roadway. The entire slope face, including the bench, will be revegetated with an appropriate method.

The bench will be revegetated as required to maintain vigorous growth and stabilize new materials sloughed from upslope. Material deposited on the bench will not be removed unless the quantity present will cause sloughing into the adjacent roadway surface.

The effectiveness of this method depends on the upslope area and degree of slope as well as the slope of the bench itself. Benches with good grass cover are most effective in removing sediments and nutrients.

4.10.5.13 Slope Serration

Slope serration is the construction of approximately 10 inch horizontal steps on the entire face of a cut slope. The purpose of slope serration is to provide stabilized benches on which vegetation can grow.

The slope serration method may be used for road and railroad erosion control as necessary. Serration is limited to slopes in medium to highly cohesive soils or in soft rock which can be excavated without ripping. Slope angle will be gentle (4:1 or less) to permit access by heavy equipment.

A dozer, equipped with a special blade containing a series of 10 inch square grooves and positioned at the same angle as the cut, will serrate the slope along the contours. Serrations will be approximately horizontal but may parallel the roadway grade if it is less than two percent.

Excavation of each series of serrations will be in the opposite direction from the preceding one to minimize buildup of loose material at the ends of the steps. Loose material collected at the ends of steps will be removed and the ends blended into the natural ground surface.

A slope bench will be constructed at the bottom of the slope face. Revegetation will be accomplished within seven days following slope serration using appropriate methods. Topsoil will

be applied before serration. The serrations will be inspected periodically for damage from surface runoff and seepage. Revegetation will be accomplished as required on serrated slopes with excessive sloughing. This method will increase the infiltration of runoff from a slope and therefore decreases the surface runoff and nutrient loads. No quantitative data on the percent of effectiveness are available but it is estimated to have between two to five percent increase in overall effectiveness when combined with other methods.

4.10.5.14 Contingency Method: Sandbag Sediment Barrier

Temporary sediment barriers or diversions will be constructed of sandbags. Such barriers will be built to retain sediment on-site by slow storm runoff and causing the deposition of sediment at the barrier.

Sandbag barriers do not provide a high degree of filtration but are valuable for emergency control. They can be used only for minor flows and to temporarily control spot failures on slopes where other methods were used or before other methods have been implemented.

Sandbag sediment barriers are used as training berms to direct or divert runoff flows, or as barriers to collect and store runoff from spot failures of other control methods. After every use, sandbag sediment barriers will be inspected, damaged bags replaced, and trapped sediment removed.

4.10.5.15 Contingency Method: Temporary Diversion Berms

This method is identical to the diversion berm previously described but is constructed during storms or immediately following to prevent sedimentation from small areas where slope failure occurs.

4.10.5.16 Silt Fence

Silt fencing is often used as a perimeter barrier and to prevent or minimize sheetwash, rills and small gullies from carrying sediment off site. A geofabric, typically woven, embedded into the soil on the bottom and held up by wood or other suitable stakes makes up a common silt fence. This structure, when properly constructed, holds back soils being carried off site in a water stream. Often, silt fences are constructed around the perimeter of a site to protect erosion off-site through overland flow or to redirect the flow of site waters to appropriate facilities, such as runoff basins or straw bale discharge structures. Construction details for a silt fence are shown in Figure 4-46.

4.10.5.17 Straw Bales

Straw bales are used in drainage channels and ditches to slow runoff and trap sediment. Straw bales are staked in strategic locations to provide a barrier to sediment transport. Used as ditch checks or perimeter downslope protection, this temporary facility can be a valuable tool in controlling erosion. Details for a straw bale installation are shown in Figures 4-47 and 4-48.

The bales may be anchored to the ground with fence posts, steel pins or by other means, particularly in those areas where concentrated runoff may cause excessive erosion. Straw bales

may be used in conjunction with fiber fabric in areas where runoff from the construction zone may concentrate.

4.10.6 Surface Facilities Construction Erosion Controls

4.10.6.1 Plant Site

4.10.6.1.1 Site Preparation and Erosion Control

Site preparation will be performed in two stages:

1. Initially, when the plant site will be cleared of shrubs and trees and then rough-graded, and

2. Following clearing, grubbing and rough grading, disturbed areas not required in the early phases of construction development will be seeded to control erosion and runoff.

Erosion control will be developed as necessary with the rough grading. To the extent possible, the sedimentation basins will be used for runoff control. The basin areas will be excavated first with grading work generally progressing outward from the basins. Where portions of the storm drainage system are not installed concurrently with the rough grading, separate provisions for runoff and erosion control will be made. These provisions will consist of temporary siltation basins or hay or straw bale ditch retention checks as previously described.

During construction in the plant site area, as well as at other project facility locations, a silt fence will be installed around the downgradient perimeter of each construction zone. These silt fences will consist of filter fabric and/or interceptor berms leading to a sediment retention structure. Interceptor dikes will be temporary facilities constructed of compacted soil and will be used to divert runoff to a sedimentation basin where sediment will be trapped and stored.

The type of facilities to be installed will be determined by the size of the construction zone, topographic characteristics, and soil erodibility at each construction site. To the extent possible, the silt fence will be installed prior to grading operations.

Graded areas not scheduled for immediate development will be revegetated with a temporary ground cover following the grading work to reduce siltation from runoff erosion. As an area is subsequently developed, any portions of the final storm drainage system not installed with the initial site work would first be installed for the area before beginning other construction. At that point, runoff would be controlled by the final system, although some hay or straw bale ditch checks may still be used to prevent downstream siltation of the system. Development of the site in this manner will reduce the need for short-term temporary erosion control measures. The long-term control will be through the final surface water drainage system. Through application of these procedures the major effects of construction activity will be contained within the construction area boundaries.

4.10.6.1.2 Slope Stabilization

The primary method recommended at the plant site for short-term control and long-term stabilization of slopes is the combination of topsoil application, hydromulching and revegetation.

This combination is recommended because of the site soil types, rainfall rate, existing runoff and erosion rates, and natural vegetation cover in the area. This procedure will best aid the rapid recovery to a naturally stabilized condition.

4.10.6.1.3 Stormwater Detention and Sediment Removal

Stormwater detention and sediment removal will be accomplished with the use of sedimentation basins and diversion berms. The grading of the railroad beds along the north and east sides of the plant site will act as control dikes. These dikes will then divert runoff to the sedimentation basins where peak runoff will be held for slow release and sediment will be removed. Sedimentation basins will be provided to "treat" runoff from all areas of the plant site. These will provide the same function as the other basins for runoff from the entire site.

4.10.6.1.4 Warehouse and Service Apron

Because of the nature of the materials in this area (oil, mud, grease, etc.), the runoff will be collected in a corrugated plate separator to remove foreign materials, with the effluent treated in the wastewater treatment facility. Foreign materials will be placed in the TMA.

4.10.6.1.5 Parking Lots and Service Aprons

This area will drain to a sedimentation pond prior to discharge. Maximum 24-hour storm yield would be 1,751 cubic yards.

4.10.6.1.6 Building Runoff Control

Methods for conveyance and delivery of runoff from roofs or other elevated impermeable structures are needed to prevent erosion and/or water degradation. Runoff will be conveyed to appropriated ditches or grass areas.

4.10.6.2 Plant Site Erosion Control Phases

The following sections are organized by phases for the control of erosion. The first phase is the construction phase which lasts from initiation of construction through the third year of construction. Phase two is approximately years four to twelve of operation. Phase three includes permanent landscape and reclamation after 32 years of operation. Phase four covers the erosion control measures including permanent landscaping at site closure (year 32).

4.10.6.2.1 Phase 1: Construction, Approximately Years 1 to 3

The tasks to be conducted during the first three years of construction at the plant site, as shown in Figure 4-49 are as follows:

1. Construction of stormwater sedimentation basins.

2. Rough grading of site to catch all water runoff with the resulting runoff being conveyed to the appropriate settlement basin water storage. The area behind the core processing and storage area near the coarse ore storage building is the drainage

system dividing line, with all runoff north of this line flowing to the north and all runoff to the south flowing south.

3. Grading of the site along southern drainage dividing line as previously discussed, to direct runoff south to sedimentation basin No. 2. The construction of this drainage system will provide a sedimentation basin for runoff to the south and southeast of the main warehouse complex.

4. Construction of sedimentation basins No. 1 south of the parking lots before grading of the main parking lot and tributary areas to the north will provide sediment removal for construction of the parking facility, part of the entrance roadway and adjoining areas.

With the construction of the above facilities during the first phase of the first year construction, off-site sedimentation from the plant facility will be significantly reduced. Temporary revegetation will include rapidly growing grass and scrub species for quick, effective erosion control. Other control methods include road surfacing and building runoff control.

Long-term vegetation planting will occur during this phase for the areas within the plant site which had only temporary planting late in the first year of construction and will not be disturbed during later construction. Contingency measures will be used as needed.

4.10.6.2.2 Phase II: Approximately Years 4 to 12 of Operation

This phase includes the start of permanent landscape vegetation planting to replace temporary measures in the area of the construction storage area, as shown in Figure 4-50. Additionally, building runoff control for the change house and concentrator buildings will be implemented.

4.10.6.2.3 Phase III: Approximately Year 31 of Operation (Mine Cessation)

This phase covers the erosion control measures at the cessation of mining. The remaining active features of the site include the wastewater treatment plant, discharge lagoons, access road, TMA access road, process water piping from TMA to wastewater treatment plant, leachate collection in TMA, power facilities, and runoff basins. Erosion control measures would protect recently reclaimed areas and ditches along the roadways as shown in Figure 4-51.

4.10.6.2.4 Phase IV: Approximately Year 75

The permanent landscape planting at the end of the long-term care period (year 75), is shown in Figure 4-52. Erosion control features will be maintained whenever erosion is observed during annual inspection.

4.10.6.3 Railroad Spur

Clearing, grubbing and material disposal for the railroad spur will be performed in the same manner as that planned for plant site preparation. Earthwork operations will follow as closely behind the clearing and grubbing operation as is practical with vegetal stabilization immediately following finish grading to reduce exposure of bare ground. Erosion and runoff control techniques, as described below, will be used with permanent culverts and a system of

sedimentation basins built into ditch bottoms to eliminate the unrestricted flow of runoff. Riprap, filter fabric, hay matting and diversion berms in conjunction with settling basins, built as an integral part of the ditch system, will minimize sediment flow into adjacent wetland areas.

Locations of the temporary erosion control facilities to be utilized during construction, such as the straw bale and filter fabric silt traps and the sheet piling at the area of the Swamp Creek crossing structure, will be determined during final engineering and detailed construction planning for the railroad. Once construction is complete, and vegetation has been reestablished in the disturbed areas, the temporary erosion control facilities will be removed.

Wetland material not suitable for roadbed construction will be excavated and organic peat material will be replaced with select material from on-site excavation. Placement of sub-ballast and ballast on the subgrade will complete the railroad bed before ties and rails are installed.

The bridge at Swamp Creek will be provided with concrete abutments and wingwalls. The stream banks will be protected by riprap over geotextile to prevent erosion and resulting runoff of sediments into the stream. Prior to construction of bridge abutments and approaches, sheet piling will be driven into the ground parallel with the stream banks before any grading is done on the approaches. Grading will be performed behind the piling and loosened materials will be contained and prevented from spilling into the stream. The sheet piling will be removed after the banks are fully stabilized. All construction practices adjacent to Swamp Creek will be performed in accordance with the Chapter 30/31 permit approval.

No special vegetation selection and establishment practices are considered necessary along the railroad spur. Species selection, fertilizer use and methods of establishment will follow the requirements described earlier. During the operation of the railroad spur, standard erosion and vegetation control procedures will be used.

4.10.6.4 Access Road

Implementation of runoff and erosion control methods will be completed concurrently with the earthwork activities. These methods include hydroseeding and salvaged topsoil placement where feasible, following final grading to reduce the exposure of bare ground.

Wetland crossings will include temporary berms at the edge of the fill slopes or the equivalent to contain runoff and divert it outside of the wetland for sediment removal before the water enters the wetland. Organic peat removed from wetlands will be replaced with selected cut materials from locations within the road alignment. Materials excavated from wetlands will be used as surface cover.

The bridge at the Swamp Creek crossing will be provided with concrete abutments with wingwalls and the stream banks on the bridge approaches will be protected by riprap over geotextile to minimize erosion and sediment runoff into the stream. Prior to construction of bridge abutments and approaches, sheet piling will be driven into the ground parallel with the stream banks. Grading will be performed behind the piling and loose material will be contained and prevented from spilling into the stream. The sheet piling will be removed after the banks are fully stabilized. All construction practices adjacent to Swamp Creek will be performed in accordance with the Chapter 30/31 permit approval.

Vegetation selection and establishment practices along the access road will be consistent with the reclamation plan. Species selection, fertilizer use and establishment techniques will follow the guidelines described in Section 5.

During use of the access road, standard erosion control and vegetation maintenance procedures will be used. These procedures could include fertilization and mowing of shoulders, brush control along the right-of-way, maintenance of surface water runoff control structures and reseeding of areas disturbed during highway maintenance as appropriate.

4.10.6.5 TMA Access Road/Tailings Transport and Reclaim Water Pipeline Corridor

Typical temporary erosion control techniques will be used during construction and until the new vegetation has been established. Wetland crossings will include temporary berms at the edge of the fill slopes or the equivalent to contain runoff and divert it outside of the wetland for sediment removal before water enters the wetland. Organic peat removed from the wetlands will be replaced with selected cut materials from locations within the access road corridor. Specific details and locations of the temporary erosion control measures used during construction (straw bale silt traps, filter fabric fences or similar measures) would be determined during final engineering.

Following construction, the route will be seeded to provide erosion control and improve aesthetic aspects. During the operation of the plant facilities, landscape maintenance practices will be used to minimize invasion of shrubs and trees which would interrupt normal operating and line maintenance/repair procedures.

4.10.6.6 Pipelines

During construction of pipelines, exposed areas with potential for runoff of sediments will be controlled with straw bale sediment traps. Seeding and reestablishment of vegetation will follow after trench backfilling.

4.10.6.7 Tailings Management Area

Construction of the TMA will be scheduled so that completion of each of the cells occurs at the time at which it is required for placement of tailings. The available construction season in the area requires the concentration of construction effort during the May through November.

During each phase of construction, control of surface water runoff will be accomplished by constructing a series of ditches, berms, and detention ponds, and use of temporary vegetation, soil stabilizers and mulches. Figures 4-53 through 4-56 detail the drainage patterns and location of required control features for each phase of construction for the TMA. Surface water runoff with the potential for high suspended solids content will be diverted through sedimentation basins with overflow structures before being discharged into the drainage system of the surrounding area. These sedimentation basins will allow settling of the suspended solids. As each construction phase is completed, temporary and final vegetative cover will be established where appropriate.

Since these facilities are located in a topographically high area, there are no large quantities of surface flow through the site. Therefore, only minor surface water diversion is required in the

TMA area and there are no major water diversions or other water handling structures proposed. Also, during operation of the facilities with the tailings cell(s) open, total runoff in the area of the TMA will be reduced because all rainfall over the cells will be collected in the cell(s).

Selection of vegetation for use in erosion control during each construction phase of the TMA will be dependent upon the month in which construction is completed and will follow the same criteria as other facilities. Erosion control and maintenance of soil quality on the long-term stockpile will be achieved by seeding with a short-term vegetative cover. Two basic seed mixtures will be used to establish short-term vegetative cover on the TMA area. The composition of these seed mixtures is presented in Section 5.

4.10.7 Erosion Control During Closure and Final Reclamation

The same erosion control techniques used during construction of major project facilities will be employed during the four year closure and final reclamation phase of the project. Use of these techniques will minimize the amount of erosion during the removal of facilities, final grading and reestablishment of vegetation. During the four year reclamation period, erosion control measures will be installed and maintained until the regraded soil surface is stabilized and vegetative cover is established.

4.10.7.1 Tailings Management Area

During each phase of reclamation grading, temporary silt control basins will be constructed to contain surface water runoff from exposed soils. These structures will be similar to those used during construction of the TMA. After final grading and contouring of each tailings cell, a herbaceous cover of grasses and legumes will be established to stabilize the soil surface and minimize erosion on the reclamation cap. Invasion of native woody plant species from adjacent undisturbed areas will be minimized during long-term care of the facility. Permanent vegetative cover on the reclaimed TMA will consist of those species as stated in the reclamation plan. The temporary erosion control structures will be removed after the vegetation has stabilized the soil surface.

The temporary sedimentation basins and straw bale ditch checks proposed for the construction and reclamation phases will be removed after all surface soils disturbed during construction have been stabilized with vegetation and no further need exists for erosion control. With the uniform grades planned for the TMA reclamation cap after final reclamation, surface runoff will be distributed around the TMA perimeter where it will again reenter existing watershed areas and resume runoff patterns similar to those that existed prior to construction.

4.10.7.2 Plant Site

Removal of the buildings and other major structures in the plant site will follow standard demolition and transportation procedures. Upon removal or burial of all in-place concrete and other building materials, reclamation of the plant site will commence.

Final grades will be established per the final reclamation plan. During each phase of reclamation grading, sedimentation basins will be used to contain the surface water runoff from the areas now being reclaimed. A herbaceous cover of grasses and legumes will be established to stabilize the soil surface and minimize erosion on the reclamation cap.

In-place erosion control facilities will be removed after vegetation becomes established and no further need exists for erosion control. Final reclamation grades will distribute surface water runoff to existing watershed areas and reestablish runoff patterns similar to those that existed prior to construction.

4.10.7.3 Railroad, Access Road, TMA Access Road/Pipeline Corridor

At this point in time, it is anticipated that the railroad, access road, and TMA access road, except for the asphalt, rails, ballast and gravel top layers, will remain in place after reclamation of the mine project for future recreational purposes.

The pipeline system will be removed and the route reclaimed following procedures specified herein, where such reclamation does not conflict with the continued use of the TMA access road as a recreational access facility.

4.11 Preblast Survey

In accordance with NR 132.07(5) a project area Preblast Survey Plan will be conducted. The primary goals of the preblast survey is to provide a baseline record and to increase communication between the public and the blaster (CMC). This will help CMC to maintain good community relations which is one of CMC's primary concerns. The survey will be conducted as follows:

- All permanent structures within a 0.85-mile radius of any of the three mine access or ventilation shafts and the lateral extent of the ore body (Figure 4-57) will be inspected. This distance is obtained from the equation for distance to affected buildings in 1LHR7.61 Wis. Adm. Code. This equation is $D = 100(W)^{½}$. The maximum weight per delay of explosives at the mine will be 2,000 pounds. Therefore, $D = 100\sqrt{2{,}000} = 4{,}472' \approx 0.85$ miles.

- Inspections will be documented by qualified professionals just prior to the start of site blasting, with an appropriate allowance of time for submission of survey results to State agencies prior to commencement.

- Property inspection elements will include:

  - foundations;
  - concrete slabs;
  - exterior and interior masonry, including basement walls;
  - structural framing;
  - exterior and interior wall treatments;
  - ceiling and floor treatments;
  - windows and doors (framing and glass);
  - visible plumbing;
  - exterior utility services;
  - exterior structures (antennas, flag poles, etc.); and
  - miscellaneous elements as required.

Inspected elements will be fully documented, including photographs and video tapes where appropriate. Element age and state of general maintenance will be noted.

- Inspections will be made with the consent of property owners.

- Copies of the preblast survey inspection sheets, dated photographs, video tapes, and property condition report will be submitted to each private owner and state agencies. File copies will be retained for use at the site. The proposed blasting is not expected to cause structural damage to structures. Studies to date indicate that project blasting events will fall well below the human response threshold at a 0.5 mile observation distance. Seismic motion from bedrock blasting will be dampened by the overlying glacial sands and gravels (minimum 69 feet thick). Air blasts will be muffled by the length of mine workings and/or shafts coursed to reach the surface.

4.12 Environmental Protection

Development of the proposed mine plan has been accomplished to maximize protection of the physical and human environment of the local area and region. The proposed mining plan is based on the review of project related environmental data obtained over the past two decades. The results and recommendations from the extensive studies were incorporated into the site layout and the development of the design, operation, erosion control and reclamation and monitoring plans. This section summarizes the various environmental protection measures that have been incorporated by CMC to avoid, minimize or mitigate adverse affects on the environment. Details of the environmental protection measures incorporated into the project are provided by this MPA, the EIR, *TMA Feasibility Report/Plan of Operation, Air Pollution Control Permit Application* and various other permit applications submitted for the Crandon Project.

4.12.1 Air Resources

The construction, operation and long-term care phases of the project will be accomplished so as to minimize impacts to the ambient air quality in the surrounding areas. Potential emissions from the proposed Crandon Project have been detailed in the project's *Air Pollution Control Permit Application* which has demonstrated that the proposed mine's air pollution prevention design and emission controls will be highly effective in limiting the emissions from both underground and surface activities. These measures will complement in-plant occupational health, safety and environment programs designed for the protection of all employees working at the mine site. Site layout and operating practices have been incorporated into the design to minimized the overall affected area and reduced emissions. Emission control techniques incorporated into the project design include baghouses, insertable collectors, and water sprays. The ore handling and coarse ore storage area will be covered. Internal roadways and disturbed construction areas will be watered to minimize dust emissions. Watering of graveled roads has been shown to be effective at controlling dust emissions at the Flambeau Mine site in Ladysmith, Wisconsin and at other mining operations. Preventative design techniques include the use of clean burning natural gas, enclosed conveyors and storage bins and paving of the plant access road.

As detailed in the *Air Pollution Control Permit Application* specific emission sampling is proposed for a number of exhaust points to verify compliance with regulatory limits. These include the major mine exhaust at the west raise as well as several surface process emission points. Air

monitoring proposed for the project through operation and long-term care is discussed in Sections 7 and 10 of the MPA, respectively.

During surface construction, areas subject to cut-and-fill operations will be temporarily revegetated after final grading for soil stabilization and dust control. Temporary revegetation will start during the first year and continue through the completion of construction. After final grading of embankment slopes, temporary or permanent vegetation will be planted for soil stabilization and to reduce wind blown dust.

During operation of the mine, generation of dust from drilling will be essentially 100 percent controlled with water injection to the drill bit and through the watering of broken rock (muck) piles prior to handling. Muck pile wetting will be a standard operating procedure. Mobile equipment used for handling rock and transporting personnel, equipment, and material will employ a ceramic filter and recirculation of gas emissions of TSP, nitrogen oxides, hydrocarbons, and carbon monoxide. Dust from blasting will be controlled by use of water sprays and because of gravity settling of particles from the low air velocities and humid underground areas of the mine.

Insertable dust collectors and baghouses will be used to control emissions from the mill and other surface operations. Insertable collectors will generally be used where the captured material is fine and can be returned directly to the process. The insertable collectors will vent inside the buildings.

A vapor balance system will be used during fuel storage tank loading to minimize hydrocarbon emissions. This will consist of a product line and ventilation line connected between tank car or tank truck and the storage tanks. The ventilation lines will exhaust the hydrocarbon vapors from the tank vents to the tank car or tank truck.

Two air pollution management programs will be instituted to provide protection and maintenance of ambient federal and state air quality standards. These programs, which will ultimately be part of the air Monitoring and Quality Assurance Plan, and the APCPA - Malfunction Prevention and Abatement Plan, are ambient air quality monitoring and pollution equipment operation and maintenance. The Malfunction Prevention and Abatement Plan will also include programs to provide consistency with federal regulations such as the New Source Performance Standards (NSPS) for metallic mineral processing plants. Final design of these programs will be reviewed with the WDNR before their initiation.

4.12.2 Surface Water Resources

Surface water management incorporates a number of safety features which serve to protect the site and surrounding surface water. The concentrator facility will use a looped system whereby process water is recirculated and reused. Contact water intended for discharge will be treated to water quality based discharge standards by an on-site wastewater treatment facility. The treated water will be discharged to the Wisconsin River through a 38.3 mile pipeline. The wastewater treatment facility and discharge system are discussed in detail in the project's *Preliminary Engineering Report for Wastewater Treatment Facilities* and the *WPDES Permit Application*.

Surface water management measures have also been incorporated into the Crandon Project which will result in the minimization of erosion and the release of sediment from disturbed areas

throughout the life of the project. As part of project design the amount of disturbance required to safely operate the mine has been kept to a minimum. An erosion control plan for the project is included in Section 4.10 of this report. The project's *Water Regulatory Permit Application* also further discusses surface water protection. Surface water monitoring plans through operation and during long-term care are discussed in Sections 7 and 10 of the MPA.

4.12.3 Skunk Lake Mitigation Plan

Field investigations of geologic, hydrogeologic and hydrologic conditions and extensive groundwater modeling have been used to predict impacts to lakes, springs and streams in the vicinity of the Crandon Project site during construction, operation, closure and reclamation. The results of this work show that, with the exception of Skunk Lake, none of the predicted best engineering judgement impacts will require mitigation. For Skunk Lake, water elevations are estimated to decrease by 1.6 feet for the best engineering judgment predictive simulation due to mine inflow effects. A mitigation plan has been developed by CMC for Skunk Lake. The purpose of the mitigation plan is to establish mitigation measures which avoid "the unreasonable detriment of public rights in the waters of the state", as required by Section 144.855(3)(b), Wis. Stats.

4.12.3.1 Skunk Lake Existing Conditions

The information presented below regarding existing conditions for Skunk Lake is repeated from Section 3.7 of the May 1995 Crandon Project EIR. Also discussed is additional information needed for mitigation system design purposes.

Skunk Lake is located 0.4 mile east of the ore body in the uppermost portion of the Pickerel Creek drainage basin (Figure 4-58). It has a surface area of six acres and a maximum depth of six feet; however, depths in most of the lake are less than three feet. The shoreline of Skunk Lake is predominantly upland hardwoods with the remainder being marsh wetland. The bottom substrate consists primarily of muck. Skunk Lake is located in a topographic depression and appears to have neither a surface water inlet nor outlet.

Staff gage LG-15 was established on Skunk Lake during original project studies completed between 1977 and 1980. Lake levels calculated from data obtained at this location between May 1977 and December 1994 are given in Appendix 3.7-3 of the May 1995 EIR. During this time period a 4.67 foot fluctuation was recorded in the water level in Skunk Lake. Recorded lake levels throughout this time varied from a high of 1,599.85 MSL on June 17, 1991, to a low of 1,595.18 MSL on February 15, 1986. An ordinary high water elevation of 1,598.09 feet MSL was determined by WDNR in July 1983.

A water chemistry sampling station (also designated LG-15) was positioned in the eastern portion of Skunk Lake. Samples were collected from this location monthly from April 1994 through March 1995. Validated water quality data obtained from analyses of samples collected between April and October, 1994 at this site are presented in Appendix 3.7-8 of the May 1995 EIR. Summary statistics including maximum, minimum and mean values for the tested parameters are given in Table 4-15 which compares them to similar statistics derived from samples obtained during the 1977-1980 study.

Table 4-15

Water Quality Data, LG-15 (Skunk Lake)
Summary of Monthly Means and Ranges

		1977-1978			1994[1]		
Station: J/LG-15	Units	Min.	Max.	Mean	Min.	Max.	Mean
Metals							
Aluminum, Total	µg/L	<10	<10	<10	36.90	59.80	45.10
Arsenic, Total	mg/L	<.001	<.001	<.001	<0.005	0.005	Note 1
Cadmium, Total	µg/L	<1	<5	<2	<0.006	0.007	0.003
Copper, Total	µg/L	<1	92	<11	0.250	0.391	0.296
Iron, Total	mg/L	.08	1.30	.45	0.106	0.196	0.150
Lead, Total	µg/L	<10	20	<10	0.120	0.212	0.158
Manganese, Total	mg/L	.018	.724	.221	0.040	0.100	0.082
Mercury, Total	ng/L	<100	<100	<100	1.26	3.15	1.92
Molybdenum, Total	mg/L	<.01	<.01	<.01	<0.020	<0.020	Note 1
Nickel, Total	mg/L	<.01	<.01	<.01	<0.030	<0.030	Note 1
Zinc, Total	µg/L	4	25	9	3.32	5.91	4.64
Phosphorus							
Phosphorus, Total	mg/L	.07	.54	.20	0.009	0.301	0.077
Nitrogen							
Nitrogen, Ammonia	mg/L	.61	3.06	1.57	<0.10	0.34	0.08
Nitrogen, Nitrate	mg/L	<.01	.63	<.17	<0.50	<0.50	Note 1
Sulfur							
Sulfate	mg/L	<1	1	<1	<1.00	10.00	3.92
Solids							
Solids, Dissolved	mg/L	5	310	67	15	59	31
Solids, Suspended	mg/L	1	56	12	<5	<5	Note 1
General Parameters							
Alkalinity, Total	mg/L	4	30	10	<5	6	3
Biological Oxygen Demand	mg/L	2	13	8	<2	9	4
Chemical Oxygen Demand	mg/L	*	*	*	33	50	40
Chloride	mg/L	<1	2	<2	<1	<1	Note 1
Conductivity	µmhos/cm	16	45	27	11	20	14
Cyanide	mg/L	<.001	.006	<.002	<0.020	<0.020	Note 1
Dissolved Oxygen	mg/L	.4	10.5	5.1	1.4	2.7	2.1
Hardness	mg/L	4	32	15	<5	11	5
pH	SU	5.2	6.6	5.8	5.08	5.96	5.36
Temperature	°C	.8	26.0	8.7	9.0	24.1	18.3
Turbidity[a]	NTU	.9	8.7	2.9	1.20	2.10	1.68

[a]Turbidity was measured in FTU during the 1977-1978 study.
[1]April through October, 1994.
SU = Standard Units.
Note 1 = All data reported as less than detection, therefore no mean value is calculated.

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Checked by: GJB

In general, the results reported from analysis of samples collected from LG-15 in 1994 were similar to those obtained during the 1977-1980 effort. Results of water chemistry analysis indicated that Skunk Lake is a soft, slightly acidic pH lake. Data for 1994 indicate that mean hardness, alkalinity and specific conductance values were 5 mg/L as $CaCO_3$, 3 mg/L as $CaCO_3$ and 14 μmhos/cm, respectively. The pH values measured in surface waters at Skunk Lake ranged from 5.08 to 5.96 and averaged 5.36 throughout the duration of the 1994 study.

Dissolved oxygen levels during this sampling period were consistently low throughout the study duration in Skunk Lake. Measurements made at a depth of three feet ranged from 1.4 mg/L to 2.7 mg/L. Dissolved oxygen concentrations made within the top foot of water in Skunk Lake were consistently higher than those made at three feet and ranged from a high of 8.0 mg/L in April 1994 to a low of 3.2 in June of 1994.

All metals analyzed from samples collected at LG-15 during the 1994 study were either below detection limits or were found in low concentrations. During this recent study, low level analyses techniques were used to monitor concentrations of aluminum, cadmium, copper, lead, mercury, zinc and chromium in water samples collected in Skunk Lake. The lower detection limits associated with these techniques allowed for trace level detections of all these metals.

The water chemistry in Skunk Lake is typical of surface water which receives its water from surface runoff. The lake is relatively soft and has a lower pH than is found in local groundwater. The organisms currently inhabiting the lake are not specific to soft water or low pH conditions, however, changes in lake hardness and pH may result in a change in the normal biota found during pre-mining conditions. Because the discharge of groundwater to Skunk Lake has the potential to change the hardness and pH, CMC has developed a plan to soften the water and control the pH prior to introducing the water to the soft, low pH water of the lake.

4.12.3.2 Predicted Skunk Lake Level Changes

The predicted best engineering judgement reduction in stage for Skunk Lake as a result of mine dewatering is approximately 1.6 feet. This is the steady-state, unmitigated stage reduction that would be reached in approximately year eight of mining and remain until mine closure and recovery begins. Thereafter, the reduction would slowly recede until near pre-mining conditions are reached in approximately year eight of recovery. The 1.6 foot reduction is based on a lake stage of 1,596.4 feet which is the modeled best engineering judgement low stage condition that is typical for October. The 1.6 foot elevation is approximately 35 percent of the range of historical Skunk Lake water level changes for the data base collected between 1977 and 1994.

A review of historic lake stage data contained in Appendix 3.7-3 of the May 1995 EIR indicates that the level of Skunk Lake has fallen below 1,596.4 feet during six of the 12 years for which data has been collected. The majority of the readings below 1,596.4 feet MSL were recorded during the late-1980's drought. The data in the appendix also show that the stage of Skunk Lake has been above 1,598.09 feet MSL, the ordinary high water mark, during six of the 12 years for which data has been collected.

These data illustrate that there is a natural wide fluctuation in Skunk Lake water levels and, because the predicted reduction in lake stage due to mine dewatering would represent approximately 35 percent of that fluctuation range, mitigation of Skunk Lake is needed. In response to this need CMC is proposing to add water to the lake during the period between

which mine inflow affects groundwater levels in the vicinity of the lake and post-closure water table recovery has been achieved. Under the plan, CMC will commence the addition of water to Skunk Lake when both water levels in the groundwater monitoring wells in the vicinity of Skunk Lake begin showing documented water level reductions due to dewatering and the lake stage falls below 1,596.4 feet MSL. On a regular operating basis, water addition to the lake will cease whenever the lake stage exceeds 1,598.09 feet MSL, the ordinary high water mark, and would subsequently recommence when it reaches 1,596.4 feet MSL. Due to the shallowness of Skunk Lake and the likelihood the lake freezes through in the winter, water addition will not be performed during the winter months. Water addition will cease in its entirety once water table recovery has occurred following cessation of mining.

4.12.3.3 Mitigation Plan Description

The Skunk Lake mitigation plan developed by CMC consists of monitoring lake water elevations and mine dewatering effects on groundwater elevations near the lake, constructing mitigation facilities, adding water, and the ultimate reclamation of mitigation facilities. The objective of the plan is to replace additional water exfiltrating the lake due to mine induced groundwater level changes in its vicinity, while still allowing typical lake level fluctuations to occur. Allowing the water elevation to fluctuate will help maintain the biological diversity and habitat of the lake.

Mitigation activities will generally consist of monitoring groundwater elevations and lake levels on a quarterly basis until groundwater elevation impacts are observed. Monthly monitoring of both groundwater and lake levels would then be initiated. When mine dewatering activities begin impacting lake levels and groundwater elevations at proposed monitoring well CMC-32 (adjacent to Skunk Lake, see Figure 4-58), water would be added to Skunk Lake. A more detailed discussion of the project's proposed monitoring plan is contained in Section 7 of this report.

Based on the regional groundwater model, a water supplement of 43 gpm is equivalent to the best engineering judgement exfiltration rate of Skunk Lake at the 1,596.4 elevation. The mitigation system will be designed to deliver water to the lake on a constant basis when needed. The maximum delivery rate for the system will be 100 gpm in the unlikely event that practical worst case conditions were encountered. Water supplement to Skunk Lake will be provided by the project's proposed potable well.

The proposed potable well site has been selected so as not to create detrimental impacts to other water bodies in the vicinity of the mine site. As shown on Figure 4-58 the proposed well is located at approximate grid coordinates 114,278 North and 2,275,384 East. The proposed well will be installed consistent with the potable high-capacity well requirements outlined in Chapter NR 812, Wis. Admin. Code. The well design is shown on Figure 4-59. The proposed pipeline route from the proposed potable well to the to wastewater treatment plant and then Skunk Lake will follow existing unimproved roadways present at the site and portions of the TMA access road as shown on Figure 4-58. The approximate pipeline length is 11,900 feet. The pipeline route has been chosen to avoid wetlands and stream crossings. Water will be discharged to Skunk Lake using the discharge structure shown on Figure 4-60.

4.12.3.4 Water Quality Evaluation

Existing Skunk Lake water quality was discussed in Section 4.12.3.1 above. The expected quality of the groundwater proposed for mitigation purposes can be estimated by the quality of water in

groundwater monitoring wells CMC-09 and CMC-10, which are located in proximity to the proposed potable well and in the same hydrostratigraphic unit as the proposed potable well. Table 4-16 contains a summary of water quality recorded for these two groundwater monitoring wells. An estimate of the water quality for the proposed potable well based on the quality of CMC-09 and CMC-10 is also shown in Table 4-16.

The hardness, alkalinity, and pH of Skunk Lake are sufficiently different from the estimated groundwater quality for the proposed potable well that the proposed mitigation plan has been designed to include a treatment system to reduce the hardness, alkalinity, and pH of the mitigation water to levels comparable to those currently in the lake. This action will prevent hardness, alkalinity, or pH based impacts from occurring to the organisms within the lake. Hardness, alkalinity, or pH changes would not be toxic to the organisms, but could result in a shift in the type and diversity of organisms in the lake.

Existing dissolved oxygen is naturally low for Skunk Lake. The use of a planned discharge structure for aeration of the treated groundwater should be sufficient to maintain the dissolved oxygen concentrations in the lake during mitigation.

4.12.3.5 Groundwater Treatment System Description

Groundwater will be treated before it is released to Skunk Lake. The groundwater treatment system will be located within the wastewater treatment plant adjacent to the project's potable water storage tank as shown on Figure 4-61. A pipeline transferring the water to the discharge location would be installed in a trench as shown on Figure 4-62. The discharge structure has been designed to aerate the treated groundwater by discharging onto a riprap lined channel adjacent to the lake.

A well pump with a capacity of 150 gpm would pump groundwater from the proposed potable well to a storage tank located at the plant site. From the storage tank water would be pumped to the Skunk Lake mitigation water treatment unit located adjacent to the storage tank and wastewater treatment building. The unit will be designed to treat the groundwater so that the resulting hardness, alkalinity, and pH would approximate that of Skunk Lake, (i.e., hardness of less than 10 mg/L, alkalinity of less than 10 mg/L and a pH range of 5-6). The system will include ion exchange for removal of hardness and alkalinity, followed by a pH adjustment system. Sulfuric acid will be used for regeneration of the ion exchange system, and sodium hydroxide or other alkali for pH adjustment. Wastewaters from periodic regeneration of the ion exchange system will be routed to the tailings pump box for discharge to the TMA. Thus these wastewaters will ultimately be reused in the mill process water system. At the proposed supplemental flow rate of 43 gpm expected for mitigation, the ion exchange system will require regeneration approximately once every two days. One regeneration of the ion exchange system will generate approximately 3,000 gallons of wastewater which will be discharged to the tailings pump box.

4.12.3.6 Mitigation Adjustment Procedures

CMC may submit requests to adjust this Skunk Lake mitigation plan based on results of ongoing monitoring and would implement such modifications after obtaining WDNR approval of documents submitted with information sufficient to justify requested changes.

Table 4-16

Typical Groundwater Quality in the Vicinity of the Proposed Skunk Lake Mitigation Well

Parameter	Detection Limit of Standard Method	Mean Concentrations (in mg/L, except as otherwise noted) Well CMC-09[1,2]	Well CMC-10[1,2]	Estimated Potable Well
pH (Field), S.U.		7.3	7.0	7.2
Conductivity (Field), umhos/cm		431	812	622
Temperature (Field) °C		9.2	8.4	8.8
Alkalinity		184	187	186
Hardness		188	345	266
Calcium		44	80	62
Total Dissolved Solids		231	478	354
Chemical Oxygen Demand	<10	<10	<10	<10[3]
Nitrate + Nitrite		0.92	0.51	0.7
Nitrogen, Total Kjeldahl		0.08	0.11	0.1
Chloride		1.9	0.6	1.2
Sulfate		12	157	84
Cyanide, total	<0.02	<0.02	<0.02	<0.02[3]
Arsenic, total	<0.005	<0.005	<0.005	<0.005[3]
Iron, total	<0.05	<0.05	<0.05	<0.05[3]
Manganese, total	<0.01	<0.01	<0.01	<0.01[3]
Molybdenum, total	<0.02	<0.02	<0.02	<0.02[3]
Nickel, total	<0.03	<0.03	<0.03	<0.03[3]
Aluminum, total	<0.2	<0.2	<0.2	<0.2[3]
Cadmium, total	<0.01	<0.01	<0.01	<0.01[3]
Copper, total	<0.03	<0.03	<0.03	<0.03[3]
Lead, total	<0.05	<0.05	<0.05	<0.05[3]
Mercury, total	<0.0002	<0.0002	<0.0002	<0.0002[3]
Zinc, total	<0.02	<0.02	<0.02	<0.02[3]

[1]Full data sets are located in the EIR, Appendix 3.6.
[2]Mean concentrations calculated based on non-detects replaced with zero.
[3]Standard detection limit. Estimated concentration is less than standard detection limit.
If no detects for a parameter in any sample, the mean is reported as < detection limit.

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4.12.3.7 Mitigation Structure Removal

Following the completion of mining and the rebound of groundwater elevations as observed in identified wells, mitigation activities will cease. Surface mitigation structures will be removed and disposed of consistent with the procedures outlined in Section 5 for other site facilities. The project's proposed potable well will be abandoned in accordance with state standards current at that time. The buried discharge pipeline will be capped and left in place.

4.12.4 Groundwater

Groundwater impacts associated with the project are discussed in detail in Section 4 of the *EIR*. Estimated groundwater withdrawal rates are discussed in the project's *High Capacity Well Permit Application*. Contact groundwater collected during mining will be treated prior to discharge as discussed in the project's *Preliminary Engineering Report for Wastewater Treatment Facilities.*

Mining and mine backfill procedures have incorporated techniques to minimize groundwater impacts both during and after mining ceases. The TMA has been designed to address long-term care issues including groundwater impacts. These items are also discussed in Section 4 of the *EIR*, in Section 5.6 of this report and Section 6.17 of the *TMA Feasibility Report/Plan of Operation*.

4.12.5 Land Resources

By confining project facilities to the smallest space possible, overall surface disruption will be minimized. As part of construction and reclamation activities, terrestrial habitats will be reclaimed using grasses, shrubs and plants that are native to the area. The project area will be reclaimed in such a way that it will be compatible with long term recreational and forestry land uses, which existed prior to mining. Techniques will be employed to reestablish surface drainage patterns during and after long-term care. Details regarding reclamation activities are included in Section 5 of this report.

4.12.6 Wetlands and Wetland Compensation

Federal and state laws require CMC to design the project for the smallest possible effect on wetlands. To reduce wetlands directly affected from 65.4 acres as expected in the 1980s version of the project to 29.5 acres for the current proposal, the size, shape and location of project facilities were changed. The biggest reduction came from redesigning the tailings management area (TMA) by:

- Reducing the overall size;
- Adjusting the shape;
- Moving the location to the north; and
- Changing the basin slopes and embankments.

These and other changes to the TMA reduced direct wetland impacts by approximately 35.9 compared to earlier designs.

Under a wetland replacement formula used by the Wisconsin Department of Transportation (WisDOT), CMC would need to create 35.29 acres of wetlands, which is a ratio of 1.2 new acres

for each acre directly impacted by the mine project. Current plans are to create 57 acres, a ratio of 1.9 to 1, which is 58 percent more than specified by the formula. The wetland compensation acreage is intended to cover direct, temporary and transient wetland impacts associated with the mine project.

The primary goal of wetland replacement is to create, within the same watershed, wetlands of similar quality to those directly affected by the project. Because there were no lands suitable for wetland restoration in the immediate area of the mine, an extensive search was conducted within a 50-mile radius. After screening 180 parcels of land and giving 35 of these a closer evaluation, a portion of a farm straddling the border between Shawano and Oconto counties was chosen. This parcel was a natural wetland until it was drained years ago for farming. This site was rated as best for wetland restoration because:

- It is large enough.
- It lies in the Fox-Wolf River watershed.
- It has wetland-type soils that readily will support native wetland plants.
- It has groundwater close to the surface and is bordered by drainage ditches that can be dammed to restore wetland conditions.

Project studies show that this land will revert to a high-quality wetland within a few years after it is flooded. Water presently collects on the site in spring, and it is used by migrating and breeding waterfowl such as mallard ducks, wood ducks, and Canada Geese. The site is nearly surrounded by wetlands, and wetland plants grow along drainage ditches and on lands that border it. These plants will naturally reseed the area. The planned restoration will accelerate the process by tilling and reseeding portions of the land.

The site will be developed by regulating water levels to help establish the desired mix of wetland plants. To prove that the restoration project has been successful, the site will be monitored for five to ten years. When restoration is complete, the wetland will consist of a diverse community with three kinds of wetland habitat: 36 acres of shallow marsh, 13 acres of wet meadow, and eight acres of deep marsh. Ultimately, CMC intends to turn the property over to a public entity for permanent use as a natural conservancy area. Details regarding the wetland compensation program are contained in the project's *Section 404 Permit Application - Addendum 1.*

4.12.7 Ambient Noise

The mining operation has been developed to minimize noise impacts. To reduce the impact of noise during operation of the mine facilities the following precautionary measures will be implemented:

- TMA construction will be limited to daytime hours.
- Mine ventilation fans will be selected with the emphasis placed on their low noise emission potential. Fan housing assemblies will be equipped with silencing devices or material to attenuate noise levels.

- Emergency generators will be equipped with both residential grade air intake and exhaust silencers.

- Mobile equipment will be maintained with mufflers.

4.12.8 Public Safety

Vehicular access to the plant site will be controlled by a gate house and fence system at the point of entry. CMC's presence at the site will be full time during the construction, operation, and reclamation periods.

4.12.9 Monitoring and Contingency Plans

Environmental monitoring during the construction, operation and long-term care phases of the project are discussed in Sections 7 and 10 of this report. Contingency plans to address potential deviations from expected monitoring results at the TMA and other site features are addressed in Section 8 of this report.

4.13 Risk Assessment

4.13.1 Introduction

A risk assessment has been conducted to comply with Chapter NR 132.07(3)(i), Wis. Admin. Code, which states:

> "The applicant shall prepare a risk assessment of possible accidental health and environmental hazards potentially associated with the mine operation. Contingency measures with respect to these risks and hazards, and the assumptions in this assessment, shall be explicitly stated."

The following assessment addresses such risks from possible accidents associated with the Crandon Project. Potential environmental effects of normal operations are discussed in the EIR. Operational controls to protect human health and the environment are discussed in Sections 4.8 through 4.12 of this report, in the *TMA Feasibility Report/Plan of Operations*, and in the various other permit applications which have been prepared for the Crandon Project. In addition, the focus of this assessment is on possible off-site health and environmental risks. Possible health risks to on-site workers will be addressed by CMC in safety and environmental and operational mine/mill procedures.

Risk is defined as the possibility of suffering harm from a hazard (Cohrssen and Covello, 1989). For the purpose of this assessment, risk is more precisely defined as the probability of an undesirable consequence resulting from a hazard associated with an accidental event. For those events in which a chemical agent is the hazard, risk is the probability of an adverse health effect to a group or individual, or an adverse ecological effect, resulting from exposure to the chemical agent. Release events that do not have the possibility of resulting in chemical exposure to a human population cannot result in adverse health effects and do not pose a risk. Also, if a particular chemical has little or no toxicity under specific exposure conditions, there is little or no associated risk. Risk is, therefore, a function of the probability that an accident will occur, the

probable concentration, duration, frequency and route of exposure, and the toxicity of the chemical agent.

Chemical reagents which will be used by the Crandon Project are listed in Table 4-17. Most of the reagents present no significant health risk under most exposure conditions. Only those reagents which have the greatest potential to present a health risk are specifically addressed in the appropriate sections of this risk assessment. Other reagents were considered but are not evaluated in this document. Those that were not evaluated present an even lower potential for risk than those reagents that are addressed.

For those events involving a physical hazard, e.g., fire, risk is the probability of an adverse outcome to humans or the environment resulting from an accident. Risk is a function of the probability that an accident will occur, the probability that a resultant physical hazard will impact humans or the environment, and the probable magnitude of that impact.

For this study, the probability of an accidental event is classified semiquantitatively. A probability Class I event is one judged likely to occur at least once every five years. A probability Class II event is one judged to have a probability of occurrence in the range of once every 6 to 50 years. A probability Class III event is one judged to have a probability of occurrence in the range of once every 51 to 500 years. A probability Class IV event is one judged to occur less than once every 500 years. When available, historical accident records were used to derive quantitative probability estimates in support of the semiquantitative probability classification. For many accident scenarios, however, historical records were not available or relevant. In those cases, the best professional judgement of experienced scientific and engineering personnel were used to estimate the probability of an accident event.

There is a possibility for human exposure in accidental events where a complete exposure pathway is present. However, the manifestation of adverse effects, if any, is dependent on the concentration, duration, frequency, and route of exposure and on the toxicity of the agent under probable exposure conditions. Therefore, the risk evaluation for each location or process addressed in this assessment considers not only the probability of release, but the performance of engineering design, administrative controls and response plans intended to minimize the release and resultant exposures.

Risks are classified, in a semiquantitative manner, as negligible, minor, moderate, or significant. A negligible risk describes an event resulting in no adverse exposure, or an event associated with probability Class IV that could potentially result in an adverse exposure. A negligible risk is one that is so small or unimportant that it may safely be disregarded. Another term for a negligible risk is a *de minimus* risk, those risks judged to be too small or remote to be of social concern. A minor risk describes an event associated with probability Class III that could potentially result in an adverse exposure. A moderate risk describes an event associated with probability Class II that could potentially result in an adverse exposure. A significant risk describes an event associated with probability Class I that could potentially result in an adverse exposure or environmental impact.

Each of the locations or processes where possible accidents could occur at the Crandon Project are addressed in turn in this assessment. For each location or process, probable release events are evaluated for different agent classes and the probability class for each event is stated. Agent classes addressed include: chemical reagents, petroleum products, tailings, ore concentrates,

Table 4-17

Chemical Reagents Used On-site

Chemical	CAS #	Physical State	Primary Use
Concentrator Chemicals:			
Calcium Oxide (lime)	1305-78-8	Solid Pellets	pH Modifier
Sulfur Dioxide	7446-09-5	Gas, Stored as Compressed Liquified Gas	Depressant
Zinc Sulfate	7733-02-0	Solid	Depressant
Sodium Cyanide	143-33-9	Solid	Depressant
Sodium Carboxymethyl-cellulose (starch)	9004-32-4	Solid	Depressant
Sodium Dichromate	10588-01-9	Liquid	Depressant
Sodium Silicate	1344-09-8	Liquid	Dispersant
Copper Sulfate	7758-98-7	Solid	Activator
Activated Carbon	7440-44-0	Solid	Absorbent
Xanthate Salts	140-93-2[1]	Solid	Collectors
Sodium Diisobutyldithio-phosphinate	13360-78-6	Liquid	Frother
Thionocarbamate (1-3 percent isopropanol)	067-63-0	Liquid	Frother
Methyl Isobutyl Carbinol (MIBC)	108-11-2	Liquid	Frother
Polypropylene Glycol Methyl Ether (Dowfroth 250)	37286-64-9	Liquid	Frother
Percol 155 (acrylate/acrylamide polymer)	25085-02-3	Solid	Flocculant
Wastewater/Water Treatment Chemicals:[2]			
Sulfuric Acid	8014-95-7	Liquid	pH Modifier/Ion Exchange Regenerant
Sodium Sulfide	1313-82-2	Solid	Metals Precipitation
Hydrated Lime[3]	1305-62-0	Solid	pH Modifier
Sodium Hydroxide	1310-73-2	Liquid	pH Modifier
Coagulant polymer	(type not chosen)	—	Flocculant

[1] Representative of one type of xanthate salt. Other alkyl-xanthate salts will also be used in the process.

[2] Treatment for water added to Skunk Lake as discussed in Section 4.12 of this report will consist of softening and pH adjustment only. Sulfuric acid use is discussed in the wastewater treatment and chemical reagent sections of this assessment. Sodium hydroxide use will be small and is not further addressed in this risk assessment.

[3] Hydrated lime will be used in the wastewater treatment facility (WWTF) during the period before the mill is constructed. After the mill is constructed, the WWTF will use slaked lime produced in the mill.

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process water and wastewaters. Planned contingency measures, which can prevent or contain releases, are described for each probable release event. The resultant risk is then evaluated based on probability of occurrence and the potential, if any, for adverse exposure and environmental impact. Risks from physical hazards and natural disasters are addressed in separate sections of this assessment.

4.13.2 Concentrator

Ore from underground will be hoisted and conveyed to the above-ground concentrator for processing. During the concentration process the ore will be mixed with water and ground to a fine particle size. The particles will be slurried to a flotation process that will selectively separate the zinc, copper, and lead concentrates from other rock particles (tailings).

The concentrator facilities will include the following major processes: ore grinding, flotation, reagent preparation, dewatering and load-out. Lime will be stored in bulk and slaked in a lime storage area. A reagent storage area will contain concentrator reagents not stored in the bulk storage facility. Reagents will be diluted and/or mixed with other reagents in mixing tanks located in a reagent preparation and distribution area and then pumped to storage tanks for holding prior to distribution into the flotation process. This latter process will be located in the flotation area, which will contain the equipment to be used in the actual ore concentration.

4.13.2.1 Ore Concentrates

Concentrate grades of copper, lead and zinc will be produced at approximately 25%, 55% and 50%, respectively. The concentrates will be dewatered to a moisture content of approximately 8-12 percent. They will be normally transported within the mill by conventional conveyor technology, however, occasionally concentrates may be loaded into railcars by a front-end loader. Concentrate will be loaded into covered railcars for out-of-state shipment.

4.13.2.1.1 Probability of Release

In the event of a conveyor malfunction, concentrate might be spilled inside the mill building. Additionally, a spill could occur as a result of an accident involving a front-end loader. Spills of this type are expected to occur during the operational life of the project. Containment or impoundment areas will be designed to recover the material. Proper housekeeping will eliminate the potential release of this material into other areas of the process or the environment. A concentrate spill within the concentrator building is judged to be a probability Class I event.

4.13.2.1.2 Contingency Measures

A spill would be immediately recovered. The mill will contain concrete floors and sumps for washdown and recovery of spillage.

4.13.2.1.3 Risk Analysis

As a result of containment measures, concentrates spilled in the concentrator building are not expected to be released to the environment. Heavy metals and sulfides in the concentrate are not immediately leachable. Since the concentrates are moist, dusting of released material will be minimized. Recovery of spilled concentrates will occur before significant drying could occur.

Exposures to off-site populations are not expected. Events that do not have the possibility of resulting in exposure cannot result in health effects and do not pose a risk. The risk is, therefore, negligible.

4.13.2.2 Chemical Reagents

Chemical reagents which will be used in the mill are listed in Table 4-17. Chemicals stored in the outside bulk storage area will be pumped into the concentrator building for mixing or direct addition to the concentration process. Other concentrator reagents will be stored in bags or drums and will be added to mixing tanks for dilution into aqueous blends. These aqueous blends will be pumped to day tanks for storage and eventual distribution into the concentrator circuit. Most of the reagents will be diluted to concentrations much lower than those contained in the storage and mixing areas.

4.13.2.2.1 Probability of Release

Three potential release events associated with the mill are: reagent spills in the mixing area, dilute reagent blend spills, and mishandling during off-loading to mill storage. Appropriate contingency measures will be taken to mitigate reagent releases in the mill as described in Section 4.13.2.2.2.

Spill of Reagents

Small reagent spills are expected to occur periodically inside the mill building during normal operations. Such spills could result from the mishandling of containers that result in reagent spills by operators during preparation of solutions. Reagent spills in the mill are judged to be a probability Class I event.

Spill of Dilute Reagent Blends

Major spills of dilute reagent blends would occur only as the result of the breakage of pipes in the flotation circuit or a pump failure. Such an occurrence is judged to be a probability Class II event.

Mishandling During Off-Loading to Mill Storage

Chemicals not stored at the bulk storage facility will be off-loaded by forklift from loading areas in the concentrator building and placed in the reagent storage area. A release could occur as a result of a forklift accident. Such a release is judged to be a probability Class II event.

4.13.2.2.2 Contingency Measures

The mill is designed to safely contain spills. The mill design will include concrete floors, curbs, and sumps. The reagent storage and mixing areas will be constructed with corrosion resistant materials and, where required, will be equipped with explosion-proof electrical equipment. The storage area will have sloped floors which drain into sumps. Separate sumps will collect drainage from areas handling chemicals which are incompatible. For example, sodium cyanide storage, mixing, and holding areas will have dedicated sumps and be isolated by berming from other areas. Sodium cyanide will be carefully segregated from acids and from oxidizing agents.

Minor spills will be promptly cleaned up. Liquid spills will be collected by sumps. Spills of solids will be cleaned up and the residuals will be hosed into sumps. In the case of sodium cyanide, spilled briquettes would be recovered and residual dust would be collected. The area would then be flushed with a dilute lime slurry. The sumps will pump into the tailings pump box for transfer to the tailings management area (TMA). Alternatively, reagents collected in the sumps can be pumped back to the process, if appropriate.

Personnel trained in proper emergency response will be on site at all times. Responses to major spills will be in compliance with the spill response contingency plan which will be developed. Components of this plan will include:

- personnel roles and responsibilities;
- emergency response training;
- site security;
- alarm systems;
- emergency recognition and proper reporting;
- specific response procedures;
  - securing the area;
  - personal protective equipment;
  - spill containment and containment materials;
  - recovery of spilled material;
  - decontamination procedures;
  - storage/disposal of wastes;
- emergency medical treatment;
- notification procedures;
- evacuation procedures.

4.13.2.2.3 Risk Analysis

Although a reagent spill in the mill is considered a probability Class I event, exposures to off-site populations are not expected. The facility is designed to safely contain routine spills, and spills will be promptly cleaned up. Events that do not result in exposure cannot result in health effects and do not pose a risk. The risk posed by chemical reagent spills resulting from mishandling or off-loading mishaps in the mill is, therefore, negligible. The risk from dilute reagent blend spills is also considered negligible since exposures to off-site populations are not expected.

4.13.3 Bulk Storage of Reagents

A bulk storage area for some liquid reagents will be located outdoors, immediately adjacent to the east wall of the mill. The bulk storage area will consist of bulk storage tanks on a concrete pad with a containment berm and sump. Reagents stored in the bulk storage area will be pumped to the concentrator for mixing and/or distribution as needed via an aboveground pipeline system.

4.13.3.1 Chemical Reagents

As shown in Table 4-18, the three reagents stored in the bulk storage tanks will be sulfur dioxide, methyl isobutyl carbinol (MIBC), and sodium dichromate. This assessment assumes that sodium

dichromate will be delivered and stored in the liquid physical state, although this reagent can also be supplied in solid form.

Table 4-18

Bulk Storage Reagents

Reagent	30 Day Consumption (lbs)	Bulk Storage Capacity (lbs)
Sulfur Dioxide	124,000	150,000 (two 75,000 tanks)
MIBC	26,000	45,000
Sodium Dichromate	68,000	82,000

Prepared by: JJA1
Checked by: SJL1

4.13.3.1.1 Probability of Release

Three potential release events associated with the bulk storage facility are a bulk storage tank failure, mishandling during off-loading, and a bulk storage pipeline leak. Appropriate contingency measures will be taken to mitigate the impacts of a reagent release from bulk storage as described in Section 4.13.3.1.2.

Bulk Storage Tank Failure

A bulk storage tank failure or breach results from unusual stress from thermal, mechanical, or chemical sources. A tank breach can lead to small releases such as venting through a failed valve. A larger release can result from such causes as tank wall punctures from external mechanical impact or a feeder pipe malfunction. Chemical stresses are not anticipated as the storage tanks will be constructed of materials compatible with the bulk reagents. Mechanical stress is also not anticipated. Since the tanks will be elevated and bermed, they will be protected from vehicular collisions and falling objects. Thermal stress is not expected to result except in the case of an uncontrolled surface fire large enough to affect the bulk storage facility. The probability of such a fire is a probability Class III event as described in Section 4.13.1. Based on engineering judgement, a reagent release resulting from bulk storage tank failure is judged to be a probability Class III event. Tank breaches that might occur would likely result in only small releases.

Mishandling During Off-Loading

A chemical release can also occur during off-loading at the bulk storage facility. In the case of sulfur dioxide and sodium dichromate, the reagents will be transferred by hose from a truck to the bulk storage tanks. Off-loading operations will not proceed without the presence of a trained operator. Based on engineering judgement, such a release is judged to be a probability Class II event. If a release did occur, it is expected to be small. A liquid spill would easily be contained

within the bulk storage containment berm, and a vapor release, as described in Section 4.13.3.1.3, would be so small as not to pose an off-site risk.

Bulk Storage Pipeline Leak

The bulk storage pipeline could develop a leak or break resulting in a reagent release. A pipeline leak could result from a connection failure resulting from wear due to vibratory motion during normal operation. Expansion and contraction due to temperature could also weaken a connection. Based on engineering judgement, however, a pipeline leak or break is considered to be a probability Class II event. Such a release is expected to be small because of early detection resulting from routine inspections.

4.13.3.1.2 Contingency Measures

The storage tanks will be designed using the best available technology and will be inspected regularly. The tanks will be located on a concrete pad and enclosed by a containment berm. A sump located in the bulk storage area will collect rain water. Discharged reagents will also collect in the sump where they would be controlled, contained and recovered. The sump will pump its contents to the tailings pump box whenever the fluid level rises high enough to activate the pump. The tank pipeline will be regularly inspected for leaks or corrosion. The pipeline will be insulated or heat traced to protect it in winter months. The external portion of the line will also be placed in a containment trough that will drain to a sump located either in the bermed area or in the concentrator. The chemicals stored in the bulk storage area are mutually compatible. Acids, caustics, or other reactive reagents will not be stored in the vicinity. Personnel trained in proper emergency response will be on site at all times. Response to a major release will be in compliance with the spill response contingency plan outlined in Section 4.13.2.2.2.

Off-loading operations will not proceed without the presence of a trained operator and an observer. Any liquid spill which occurs is expected to be small and to be easily contained within the bulk storage containment berm. In the event that adjoining soils were impacted as a result of a release, appropriate remedial action would be initiated.

4.13.3.1.3 Risk Analysis

The only stored reagent of concern that could be released from the bulk storage area is sulfur dioxide and even here a large release is unlikely. Sulfur dioxide is stored and shipped as a compressed liquified gas. Sulfur dioxide's behavior on release is dependent on the ambient temperature and the size of the release. A small release of sulfur dioxide would be in the vapor state. In the unlikely event of a significant release resulting from a large bulk storage tank failure, only a fraction of the sulfur dioxide would immediately volatilize. The remaining sulfur dioxide, which did not volatilize, would be released in the liquid state but steadily volatilize. The volatilization rate would, again, be dependent on the ambient temperature.

A small release of sulfur dioxide could form a gaseous plume that would be dispersed to safe levels before leaving the Crandon Project area boundary. Off-site exposures are not likely to occur. Events that do not result in exposure cannot result in health effects and do not pose a risk. The risks from an off-loading mishap or pipeline leak are, therefore, negligible.

In the extremely unlikely event of a large release from a bulk storage tank, a sulfur dioxide plume could remain at significant concentrations beyond the Crandon Project boundary, but even in that case the health effects to off-site populations would be minimal. Air dispersion would cause a plume to spread laterally as it moved away from the source decreasing the concentration of the gas. Release from a single or point source such as a bulk storage tank would produce a narrow plume or corridor of gas. Sulfur dioxide, a respiratory irritant, can be toxic by the inhalation route of exposure. The pronounced irritating effect of sulfur dioxide at relatively low levels (10 ppm) serves to alert people to its presence. Responses to a major release will be in strict compliance to the spill response contingency plan outlined in Section 4.13.2.2.2. Because a release is a probability Class III event and since exposure could occur, the risk is judged to be minor.

A large sulfur dioxide release could result in short-term impacts to plants and animals that are exposed to the gas. However, the magnitude of the impacts would decrease with increasing distance from the release site and long-term adverse ecological impacts are not expected to result from a sulfur dioxide release.

A sodium dichromate spill would be contained in the bermed area where the material could be recovered. Volatilization would not be an important release pathway. Off-site exposures are, therefore, not expected to occur. Events that do not result in exposure cannot result in health effects and do not pose a risk. The resulting risk is, therefore, negligible.

An MIBC spill would be contained in the bermed area, where recovery would occur. MIBC is a flammable liquid, so care would be taken to keep ignition sources away from the spill. Responses to fires are addressed in Section 4.13.13.1. Off-site exposures are not expected from a MIBC release. Events that do not result in exposure cannot result in health effects and do not pose a risk. The resulting risk is, therefore, negligible.

4.13.4 Wastewater Treatment Facility (WWTF)

The WWTF is designed to treat mine drainage water and other wastewaters generated from mining operations. Treatment processes that will be performed in the WWTF include precipitation of dissolved metals, removal of suspended solids, and pH adjustment.

4.13.4.1 Chemical Reagents

Chemical reagents which will be used in the WWTF are listed in Table 4-17. Sulfuric acid and sodium sulfide are the WWTF reagents of potential concern. Sulfuric acid is a corrosive, while sodium sulfide has the potential to generate hydrogen sulfide gas when exposed to low pH aqueous solutions. Low concentrations of hydrogen sulfide gas can be an irritant to eyes and mucous membranes, while exposure to high concentrations can produce headache, dizziness and unconsciousness.

4.13.4.1.1 Probability of Release

Potential release events associated with the WWTF are a chemical spill involving sulfuric acid, and a release of hydrogen sulfide gas generated from sodium sulfide. Contingency measures would be implemented to mitigate a release of these reagents in the WWTF as described in Section 4.13.4.1.2.

Sulfuric Acid Spill

Sulfuric acid will be stored in a bulk storage tank with a capacity of approximately 5,000 gallons. The storage tank may be placed inside the WWTF or alternatively adjacent to the building, with the tank contained in a bermed facility. A fill pipe extending through an outer wall will be used to fill the tank from a tanker truck. Reagent releases associated with off-loading and bulk storage are discussed in Section 4.13.3.1.1. A small sulfuric acid spill associated with mishandling during off-loading and a small pipeline leak are judged to be probability Class II events. A large sulfuric acid release is judged to be a probability Class III event.

Hydrogen Sulfide Release

The wastewater treatment process will contain lime precipitation at pH 9-10 followed by a sulfide precipitation tank for the enhanced removal of metals from the effluent stream. In this process, sulfide is provided by the addition of sodium sulfide. The sulfide precipitation process requires a pH between 7 and 10. Control of pH will be provided by the proper addition of sulfuric acid. If the pH is allowed to fall substantially below 6.5, hydrogen sulfide gas could be generated. A potential cause of a pH drop could be a malfunction in either a pH meter or the sulfuric acid feed system. Both occurrences are judged to be probability Class II events.

4.13.4.1.2 Contingency Measures

Chemical storage and delivery systems will be designed to prevent and to contain spills. The truck off-loading area for sulfuric acid will be curbed with a sloped pad for spill containment. A drain will route spills to either a neutralization area or to a pit filled with crushed limestone. A release in the WWTF from the bulk tank or associated piping would be contained within the bermed area and neutralized. Absorbent materials will be available to contain acid spills. Response to a major spill will be in compliance with the spill response contingency plan.

The sulfide precipitation tank will be covered and vented to the atmosphere. Thus if hydrogen sulfide were generated, exposures within the plant would not be expected. The generation of a significant quantity of hydrogen sulfide gas requires sodium sulfide in large amounts and a sustained low pH. Feed rates of sodium sulfide and sulfuric acid will be regulated to prevent uncontrolled additions.

4.13.4.1.3 Risk Analysis

The design of spill containment measures for sulfuric acid storage and handling will prevent a spill from impacting the environment. Off-site exposures are not expected. Fugitive emissions of hydrogen sulfide gas from the WWTF to the atmosphere are likely to be negligible. Such emissions would be dispersed to safe levels and are not expected to impact plants and animals. Events that do not result in exposure cannot result in health effects and do not pose a risk. The risk posed by WWTF reagents is, therefore, negligible.

4.13.5 Fueling Facilities

Petroleum fuels will be required for the operation of machinery and vehicles. Mining equipment and some surface equipment will require diesel fuel. The surface fleet of trucks and maintenance vehicles will require gasoline. During the operations phase, fuels will be stored in bulk at a central fueling facility.

4.13.5.1 Surface Stored Gasoline and Diesel

The central fueling facility will be an impoundment area containing one 15,000 gallon diesel storage tank, one 12,000 gallon diesel storage tank and one 1,000-gallon gasoline storage tank. The tanks will be above ground, and the area will be bermed and lined. Modern fuel dispensing equipment will be used. A 3,000 gallon diesel measuring tank will be sited adjacent to the two bulk diesel storage tanks. Diesel will be metered from the bulk tanks to the measuring tank. From the measuring tank diesel fuel will be transferred through a pipeline to a storage tank within the mine itself. Surface vehicles will be fueled at the fueling facility. During the construction phase, earth-moving equipment will require diesel fuel which will be supplied from tanker trucks. During the late reclamation phase the central fueling facility will be removed. Fuel required during the closure phase will be provided as needed by a tanker truck as in the early construction phase.

4.13.5.1.1 Probability of Release

Three potential release events associated with the surface-stored fuels are a bulk tank failure, mishandling/leaking hoses, and a construction/reclamation phase release.

Bulk Tank Failure

As described in Section 4.13.3.1.1, bulk storage tank failure is a probability Class III event. A tank failure can result from unusual thermal, mechanical, or chemical stresses. Chemical stresses are not anticipated as the storage tanks will be constructed of materials compatible with the fuels. Mechanical stress is also not anticipated since the tanks will be located within a bermed area offering protection from vehicles. The fueling facility will be located at a distance southeast of the shaft collar, concentrator, and reagent storage areas. A tank breach that might occur would likely result in a small release. Contingency measures would be taken to mitigate a fuel spill as described in Section 4.13.5.1.2.

Mishandling/Leaking Hoses

A release might also result from leaking hoses or valves, or from operator mishandling. This type of release is likely to be small in volume and is judged to be a probability Class I event.

Construction/Reclamation Phase Release

A major fuel spill during the construction or reclamation phases could occur from a mobile storage tank failure or mishandling of fuels. Such a release is considered to be probability Class II event.

4.13.5.1.2 Contingency Measures

A Spill Prevention Counter-Measure and Control (SPCC) plan will be prepared before the mine construction phase begins. The SPCC plan will address fueling operations, fuel spill prevention measures, inspections, training, security, spill reporting, and equipment needs. All responses to a fuel spill, both large or small, will follow the guidelines dictated by the SPCC plan. The tanks will be inspected regularly, and records of spills will be kept and reported to WDNR and other agencies as required.

Absorbent materials, stored at the facility, can be used to mitigate a small spill. Affected areas will be flushed with water and the drainage will be routed to an oil/water separator. Storm water captured in the fuel facility berm area will also be routed to the oil/water separator. Separated fuel will be collected by a vendor while the water would be routed to the wastewater treatment plant. Potentially impacted areas will be contained and impacted soils will be removed as is necessary.

The central fueling facility will be lined to minimize migration of released fuels. In the unlikely event of a massive tank failure, the containment berms, designed with significant capacity to contain the entire contents of the largest single tank plus sufficient freeboard to contain a 25-year rain event, will contain the fuel. The contained fuel would then be removed by pumping to portable tanks.

4.13.5.1.3 Risk Analysis

A large fuel spill from the storage tanks is considered to be a probability Class III event. A spill resulting from mishandling, although more likely, will be small and localized. Due to containment and other contingency measures, migration of released fuels is not expected. Exposure of released fuels to off-site populations is not expected. Significant impacts to plants and animals are not expected. Events that do not result in exposure cannot result in health effects and do not pose a risk. The risk from a fuel spill is judged to be negligible.

4.13.5.2 Diesel Fuel in Mine

Diesel fuel will be used to power some mine equipment. A 4,000-gallon diesel dispensing tank will be located within a concrete berm in the mine, approximately 1,200 feet below surface. The containment area will be designed to hold two times the dispensing tank volume. Diesel fuel will be transferred to the dispensing tank from the diesel measuring tank, located in the central fueling facility at the surface. The fuel will be transferred through a one-inch diameter steel pipeline that will be placed in a six-inch diameter borehole.

4.13.5.2.1 Probability of Release

Two potential release events associated with diesel in the mine are mishandling and pipeline leak/tank failure.

Mishandling

A smaller spill might result from mishandling of fuels, or from small leaks in valves. Such a smaller spill is judged to be a probability Class I event, but is expected to be low in volume and contained within the mine.

Pipeline Leak/Tank Failure

There will not be a constant flow of diesel through the pipeline. Therefore, if a pipeline failure were to occur, it would not be a continual source of leakage. In addition, the borehole is nearly a vertical drop. Any release from the pipeline would run down into the dispensing tank containment area. A spill could also occur from breaches in the diesel dispensing tank. A release of diesel from the pipeline or dispensing tank is judged to be a probability Class III event, and the release is expected to be small.

4.13.5.2.2 Contingency Measures

Flow metering devices will be associated with the diesel pipeline. Because the diesel will be metered from one storage tank to another, losses due to leaks would result in inventory discrepancies which would alert operators to a potential release. A fuel spill in the mine would be collected in mine sumps and pumped to an oil/water separator in the mine. Separated fuel will be collected by a private contractor while the water would be routed to the wastewater treatment plant.

4.13.5.2.3 Risk Analysis

Any spill will be collected in the sumps and disposed of or treated in an appropriate manner. Off-site exposure is not expected. Events that do not result in exposure cannot result in health effects and do not pose a risk. Therefore, even though a diesel spill in the mine is a probability Class I event and a pipeline release is a probability Class III event, the risk for both is judged to be negligible.

4.13.6 Truck Transportation

Reagents used in the mill and WWTF will be shipped to the Crandon Project on a regular basis. The preferred mode of shipment for all reagents will likely be by truck. There is the possibility for accidental release of chemicals during truck transport and related activities. All of the fuels needed for operations at the Crandon Project will also be transported by tanker truck to the fueling facility on a regular basis. There is some potential for accidental release of fuels during transportation and transportation related activities.

4.13.6.1 Chemical Reagents

Chemical reagents that will be used at and shipped to the Crandon Project are listed in Table 4-17. The reagents evaluated in the truck transport assessment are sulfur dioxide, sodium cyanide, sodium dichromate, and sulfuric acid. The U.S. Department of Transportation (DOT) requires that sulfur dioxide shipments be labeled as a poisonous gas. Sulfur dioxide will likely be shipped in tanker trucks as a compressed liquid gas. DOT requires that sodium cyanide shipments be labeled as a poison. Sodium cyanide will likely be shipped by truck as solid

briquettes in bin containers which are used to dispense the material during operation and these bins contain 3,000 pounds each. Although DOT has no labeling requirements for sodium dichromate, it has been included in the transportation risk analysis because it is a possible carcinogen. Sodium dichromate will likely be shipped as a liquid by tanker truck. DOT requires that sulfuric acid shipments be labeled as corrosive. Sulfuric acid will be shipped by tanker truck.

4.13.6.1.1 Probability of Release

Two potential release events associated with the transportation by truck of chemical reagents are vehicular traffic accidents and release in transit from non-traffic accidents. Release from non-traffic accidents can occur, for example, from a leaking valve. Contingency measures to mitigate the impact of any reagent release during truck transport will be taken as described in Section 4.13.6.1.2.

Release from Vehicular Traffic Accident

When a truck carrying a chemical reagent is involved in an accident, stresses imparted by impact or fire can cause a container breach. Depending on the size and location of the breach and the physical state of the reagent, a chemical release could result. The probability of such a release can be estimated by applying historical traffic accident and release rates to the shipping routes and distances that will be used for the Crandon Project.

Reagent suppliers have not yet been selected, so shipping routes and distances can only be estimated. There are five commerce centers of sufficient size to serve as supply centers for the needed reagents. These centers and the approximate mileage for each from the Crandon Project site are:

- Chicago, Illinois — 296 miles (248 Wisconsin miles)
- St. Paul, Minnesota — 278 miles (263 Wisconsin miles)
- Milwaukee, Wisconsin — 211 miles
- Duluth, Minnesota — 210 miles (All Wisconsin miles)
- Green Bay, Wisconsin — 107 miles

Only Wisconsin mileage will be considered in the transportation risk assessment. Addition of out-of-state mileage to the assessment is not included since the reagent suppliers have not yet been identified and the additional miles (e.g., Wisconsin border to Chicago) would not affect the assessment.

Shipments from Chicago to Crandon would pass through both Milwaukee and Green Bay. Thus, the risk from shipments originating in Chicago will always exceed the risks of shipments originating from Milwaukee or Green Bay. To simplify the analysis, the Milwaukee and Green Bay routes will not be further considered since they would pose less risk than the Chicago route. Therefore, only the Chicago, St. Paul and Duluth shipping routes will be evaluated in this assessment.

In deriving accident rates for hazardous material transport, historical data concerning numbers of accidents, numbers of releases, and numbers of miles travelled must be compared. For each of these parameters, several national databases are available. Each of these databases, however, has different reporting requirements, and each collects different data parameters. This leads to some

uncertainty in estimating accident rates. Nevertheless, different studies have generally shown reasonable agreement in estimating accident frequencies. Harwood and Russell (1990) have compiled data on trucking accidents and determined accident rates for different classes of highways. The average values presented in their study have been proposed by the Federal Highway Administration (FHWA) as national default values (Rhyne, 1994). Because of the inherent uncertainty in transportation risk analysis and the lack of specific route information for the Crandon Project, the data compiled by Harwood and Russell were judged to be suitable for estimating truck accident rates in this assessment.

Harwood and Russell (1990) determined that the frequency of a traffic accident for a truck on a rural two lane highway was 0.0000022 truck accidents per mile, expressed in scientific notation as 2.2×10^{-6}. In other words, a truck is expected on average to experience 2.2 accidents for every one million miles travelled. Accident frequencies on a rural freeway, urban freeway, rural two lane highway, urban two lane highway, and rural multilane divided freeway were estimated to be 6.4×10^{-7}, 2.2×10^{-6}, 2.2×10^{-6}, 8.7×10^{-6}, and 2.2×10^{-6} truck accidents per mile, respectively.

The three transportation routes can be broken down by highway class and each class multiplied by the appropriate truck accident rates to calculate the probability of an accident per shipment, as shown in Table 4-19.

Although the estimated frequencies of accidents per shipment do not differ significantly with the routes, the Duluth route is the route with the highest projected accident rate. To simplify the analysis, only the Duluth route and its associated accident frequency of 6.2×10^{-4} accidents per shipment will be used to calculate the probability of release for each of the reagents in the transportation analysis.

Most traffic accidents involving reagent shipments do not result in a release of cargo. Harwood and Russell (1990) have reported the average probability of a release, given an accident, for each highway class. For example, with a rural freeway the probability of a release during an accident is nine percent. Multiplying these factors by the projected number of traffic accidents for each highway class yields an estimate of the annual probability of a release. This information is summarized for the Duluth route in Table 4-20. Using this methodology, the number of releases per shipment for the Chicago and St. Paul routes are lower than that for the Duluth route.

The maximum weight of cargo that can be shipped by truck is approximately 45,000 pounds. It is assumed that most shipments of reagents to the Crandon Project will approximate this size. The number of annual shipments for each of the chemicals of concern can be projected knowing the estimated monthly consumption rate of a reagent and the typical shipment size. This information is summarized in Table 4-21.

Transport of these types of reagents is common within Wisconsin. Although data on the volumes of specific hazardous materials shipped within the state was not available, the WisDOT registered 1,667 individual transporters or suppliers of hazardous materials between July 1, 1993 and June 30, 1994 (Kavulich, 1995). Registrants who ship by truck, rail, water, or air register only once regardless of the number of hazardous materials shipments they actually transport. Transport of hazardous materials is a daily occurrence within the state.

The frequency of reagent releases associated with the transport of each reagent can be estimated by multiplying the probability of a release per shipment by the annual number of shipments for that reagent. This information is summarized in Table 4-22.

Since the expected operational lifetime of the Crandon Project is 28 years, the release per year must be multiplied by 28 to characterize the probability of release. Using the operational definitions presented in the introduction of this risk assessment, a release resulting from a vehicular accident is a probability Class IV event for all four reagents. Additionally, most releases were they to occur would be small, involving only a fraction of the cargo. The Federal Emergency Management Agency (FEMA, undated) has suggested that given a release, a complete cargo loss occurs only 20 percent of the time.

The probability of a traffic accident causing release within the Crandon Project site and boundary areas would be much smaller than off-site release accidents. The access road will be approximately three miles in length. Using the described method for a three mile rural two-lane highway, the annual probability for chemical releases within the Crandon Project border due to traffic accidents were calculated as 1.9×10^{-5} sulfur dioxide releases/year, 5.7×10^{-6} sodium cyanide releases/year, 1.0×10^{-5} sodium dichromate releases/year, and 2.8×10^{-6} sulfuric acid releases/year. Actual release rates on the access road will likely be smaller due to a reduced speed limit, limited traffic, and a predominance of daytime deliveries. Again, given a release, a complete cargo loss would be expected to occur only 20 percent of the time.

Release in Transit from Non-Traffic Accident

Most transportation related chemical releases are associated with non-traffic accidents. Harwood and Russell (1990) compiled a distribution of transportation related hazardous material releases sorted by failure type. Traffic accidents accounted for only 11 percent of releases. The remaining 89 percent of releases were due to non-traffic accident events. Non-traffic accident releases have such causes as: tank failure, valve failure, cargo shifting, venting and operator error, e.g., failure to completely close a valve. Assuming that Harwood and Russell's relationship for traffic and non-traffic release events is applicable to the Crandon Project, the probability of a release in a non-traffic vehicular accident would be 8.09 times the probability of release from a vehicular accident. A release of sodium cyanide would be less likely because this reagent is a solid. The releases per year previously derived for transportation from reagent supply centers and from within the Crandon Project boundary area are multiplied by 8.09 to arrive at the non-traffic accident release projections in Table 4-23.

Table 4-19

Estimated Accidents per Shipment for Specific Routes

Supply Center	Total Wisconsin Miles to Crandon	Highway Class	Mileage	Accident Rate[1] (accidents per million miles)	Accidents per Shipment
Chicago	248	Rural Freeway	124	0.64	7.9×10^{-5}
		Urban Freeway	27	2.2	5.9×10^{-5}
		Rural Two-Lane	70	2.2	1.5×10^{-4}
		Rural Multi-Lane Divided	16	2.2	3.5×10^{-5}
		Urban Two-Lane	11	8.7	9.6×10^{-5}
					4.2×10^{-4}
St. Paul	263	Rural Freeway	85	0.64	5.4×10^{-5}
		Urban Freeway	5	2.2	1.1×10^{-5}
		Rural Two-Lane	167	2.2	3.7×10^{-4}
		Urban Two-Lane	6	8.7	5.2×10^{-5}
					4.8×10^{-4}
Duluth	210	Rural Freeway	5	0.64	3.2×10^{-6}
		Rural Two-Lane	179	2.2	3.9×10^{-4}
		Urban Two-Lane	26	8.7	2.3×10^{-4}
					6.2×10^{-4}

[1]Harwood and Russell, 1990.

Prepared by: JJA1
Checked by: SJL1

Table 4-20

Estimated Releases per Shipment by Truck[1]

Highway Class	Accidents per Shipment	Probability of Release per Accident[2]	Releases per Shipment
Rural Freeway	3.2×10^{-6}	.09	2.9×10^{-7}
Rural Two-Lane	3.9×10^{-4}	.086	3.4×10^{-5}
Urban Two-Lane	2.3×10^{-4}	.069	1.6×10^{-5}
			5.0×10^{-5}

[1]Duluth route.
[2]Harwood and Russell, 1990.

Prepared by: JJA1
Checked by: SJL1

Table 4-21

Estimated Number of Annual Reagent Shipments by Truck

Reagent	30 Day Consumption (lbs)	Shipment Size (lbs)	Estimated Number Annual Shipments
Sulfur Dioxide	124,000	45,000	33
Sodium Cyanide	36,000	45,000	10
Sodium Dichromate	68,000	45,000	18
Sulfuric Acid	20,000	45,000	5

Prepared by: JJA1
Checked by: SJL1

Table 4-22

Estimated Probability of Reagent Release by Truck Transport[1]

Reagent	Releases per Shipment	Shipments per Year	Probability of Release per Year
Sulfur Dioxide	5.0×10^{-5}	33	1.6×10^{-3}
Sodium Cyanide	5.0×10^{-5}	10	5.0×10^{-4}
Sodium Dichromate	5.0×10^{-5}	18	9.0×10^{-4}
Sulfuric Acid	5.0×10^{-5}	5	2.5×10^{-4}

[1]Duluth route

Prepared by: JJA1
Checked by: SJL1

Table 4-23

Estimated Probability of Reagent Release from Non-Traffic Accidents

Reagent	Probability of Release per Year	
	Crandon Project Boundary Area	From Supply Centers
Sulfur Dioxide	$1.5x10^{-4}$	$1.3x10^{-2}$
Sodium Cyanide	$4.6x10^{-5}$	$4.0x10^{-3}$
Sodium Dichromate	$8.1x10^{-5}$	$7.3x10^{-3}$
Sulfuric Acid	$2.3x10^{-5}$	$2.0x10^{-3}$

Prepared by: JJA1
Checked by: SJL1

A release resulting from a non-traffic accident during transport from the reagent supply centers is a probability Class III event for all four reagents. A release from a non-traffic accident within the Crandon Project borders is a probability Class IV event for all four reagents.

4.13.6.1.2 Contingency Measures

DOT regulations published in 49 CFR 177, Subpart D, require that the transporter or common carrier contain and control releases of hazardous materials. The regulation dictates that when a spill or leak occurs the driver will take steps to prevent the leak from spreading, to prevent fires, and to repair the damaged container to the extent that such repair is safe and practical. This regulation also dictates that precautions be taken to protect disabled vehicles, e.g., flat tire from accidents.

DOT regulations published in 49 CFR 172, Subpart G, require that emergency response information be included with shipping papers and be readily available. This information may take the form of Material Safety Data Sheets (MSDS) or some comparable document. The information must include immediate hazards to health, risks of fire or explosion, immediate precautions to be taken in the event of an accident, and initial methods for handling spills in the absence of fire.

Transporters are required by EPA regulations, 40 CFR 263.31, to clean up any hazardous waste that results from a spill during transportation. The remedial action must eliminate any hazards to human health or the environment that resulted from the spill.

In compliance with DOT and EPA regulations and their own corporate health and safety guidelines, CMC will develop appropriate accidental spill response plans. CMC has primary responsibility for a spill within the Crandon Project boundaries. CMC spill response actions will work to minimize the amount of a chemical released during an accidental release event. The project's spill response contingency plan is outlined in Section 4.13.2.2.2.

4.13.6.1.3 Risk Analysis

The behavior of sulfur dioxide released from a storage tank is described in Section 4.13.3.1.3. Most transportation releases are likely to be small and adverse exposure to off-site populations is not expected. A large sulfur dioxide release is less likely to occur. In a large release, a sulfur dioxide plume could remain at high concentrations in a zone directly downwind of the source. The potential for health effects, if any, in populations in this zone are dependent on the concentration of the gas and duration of exposure. Exposure would be short-term and decrease with increasing distance from the source. The gas would be eventually dispersed to background environmental concentrations. Because a sulfur dioxide release associated with the non-traffic accident is considered to be a probability Class III event, the risk is judged to be minor.

The release of sodium cyanide for a non-traffic accident is a Class III event. Sodium cyanide is a solid cyanide salt containing 53 percent cyanide by weight. Sodium cyanide will be supplied to the Crandon Project in briquette form. A transportation related spill can be recovered before the briquettes weather sufficiently to allow cyanide transport in the environment. Therefore, significant exposure to off-site populations, either short- or long-term, is not expected from a sodium cyanide release. Events that do not result in exposure cannot result in health effects and do not pose a risk. The risk from a transportation related sodium cyanide release is, therefore, negligible.

The release of sodium dichromate for a non-traffic accident is a Class III event. A sodium dichromate release during transport could contact soil. In soil, dichromate is typically reduced by organic matter to insoluble chromium (III) oxide (Cr_2O_3). Chromium oxide strongly adsorbs to soil which restricts the migration of chromium and limits exposure. If off-site populations were exposed, the manifestation of health effects, if any, would be dependent on a combination of the concentration, frequency, and duration of exposure. Soils receiving a sodium dichromate spill would be removed in a remedial action. Significant health effects from exposure to sodium dichromate typically require an exposure duration of several years or more. Therefore, even if short-term exposures did occur, adverse health effects are not likely, and the risk is judged to be negligible.

In the event of a sulfuric acid release, the environmental media contacted would experience a reduction in pH. The degree of pH reduction would depend on the size of the release, the volume of affected media, and the buffering capacity of the media. A release, were it to occur, would likely be to soil. The alteration of soil pH would be localized, short-term and reversible either as a result of dilution/flushing or treating the affected area with lime. Significant exposure to off-site populations is not expected. Events that do not result in exposure cannot result in health effects and do not pose a risk. The risk is, therefore, negligible.

A reagent release during truck transport could result in impacts to plants and animals in the vicinity of the release site. Sulfur dioxide impacts would be short-term. Sodium cyanide would be easily recovered. Sodium dichromate and sulfuric acid impacts would be attenuated by soil and impact only a very localized area. In the unlikely event of a release adjacent to a stream, aquatic habitat effects would be short-term, localized and reversible.

4.13.6.2 Petroleum Products

Both diesel and gasoline will be transported to the Crandon Project by truck. The annual fuel transport and consumption for the Crandon Project will represent only a small fraction of the total fuel use within northeast Wisconsin.

4.13.6.2.1 Probability of Release

Fuels will be transported to the Crandon Project by tanker truck from local petroleum distributors. The probability of an accidental release during transportation is difficult to assess because the location of the supplier(s) and the frequency of shipment have not yet been determined. Probabilities for the accidental release of chemical reagents as described in Section 4.13.6.1.1 are low. Fuel shipments are not anticipated to be more frequent than reagent shipments, and the shipping distance will likely be shorter for fuels, thus further decreasing the probability of a release. A fuel release resulting from a vehicular accident during transportation is, therefore, judged to be a probability Class IV event. A fuel release resulting from a non-traffic accident during transportation is judged to be a probability Class III event. It should be noted that transport of fuel in tanker trucks does not pose an unusual risk to the region. Tanker trucks currently visit the region on a regular basis to deliver fuels to gasoline stations located in the communities surrounding the Crandon Project.

Any release on the Crandon Project access road would be a probability Class IV event because of the short length of the road and the small amount of traffic. Contingency measures for responding to a fuel spill during truck transport will be taken to mitigate impacts as described in Section 4.13.6.2.2.

4.13.6.2.2 Contingency Measures

Contingency plans for responding to fuel spills from tanker trucks are required of all mobile transport owners as dictated by DOT regulation 49 CFR 130. These response plans require appropriate personnel training and the development of procedures for a timely response to spills. The plan must identify who will respond to the spill and describe the response actions to potential releases including the complete loss of cargo. The plan must also list the names and addresses of regulatory contacts to be notified in the event of a release.

Absorptive materials may be used initially to contain the spill. After the initial response, soil impacted with residual fuel would be addressed. Remedial efforts could include, if necessary, the removal of soil within a time frame that would preclude significant migration of the fuel to groundwater.

4.13.6.2.3 Risk Analysis

In the event of a release, fuels would be adsorbed by soil, retarding their migration. Although unlikely, off-site populations living in the vicinity of a spill could experience exposure to fuel impacted soil via direct contact exposure. Such an exposure, were it to occur, would likely be minor and short-term and would not result in adverse health effects. Exposures to contaminated groundwater are not expected because of regulatory requirements for timely and effective response actions which will dictate soil or source removal before migration to groundwater takes place. A transportation-related fuel spill resulting from a non-traffic accident is a probability

Class III event, and though unlikely, exposure to residential populations could occur. Therefore, the risk of a fuel spill from a non-traffic accident is judged to be minor.

A transportation-related fuel spill resulting from a vehicular accident is a probability Class IV event and the associated risk is, therefore, judged to be negligible.

A fuel spill during tanker transport could result in impacts to plants and animals in the vicinity of the release site. Impacts would be reversible and short-term because of remedial response actions which would be implemented. Widespread and long-term adverse ecological impacts are not expected.

4.13.7 Rail Transportation

A railroad spur from the mill and bulk storage areas will provide access to the Wisconsin Central Limited Railroad, which currently passes within several miles of the mill. The railroad spur will be approximately 2.7 miles in length. The railroad spur will cross two streams, Swamp Creek and an unnamed creek (#20-8).

There is a possibility that some of the chemical reagents may at times be shipped by rail to the Crandon Project. Sulfur dioxide is the only reagent that could economically be shipped by rail. Rail transport will not be the preferred mode of shipment for sulfur dioxide. Approximately 10 to 15 covered railcars will be loaded with concentrate each day and transported on the Wisconsin Central Limited Railroad to a smelter.

4.13.7.1 Chemical Reagents

Since there is a possibility that sulfur dioxide may at times be shipped to the Crandon Project site by rail, this transportation mode is evaluated in this risk assessment. Although possible rail transportation risks are assessed in this section in a manner similar to truck transportation as described in Section 4.13.6.1, it should be noted that simultaneous transport of a given shipment, by both truck and rail, is not possible. Therefore, potential risks from the two modes of transportation are not cumulative. A railroad spur from the concentrator/bulk storage area will provide access to the Wisconsin Central Limited Railroad, which passes within several miles of the facilities. In the event of rail transport, there is a potential for an accidental release. The DOT labeling requirements for sulfur dioxide are described in Section 4.13.6.1.

4.13.7.1.1 Probability of Release

Two potential release events associated with the transportation by rail of chemical reagents are train accidents and non-accident releases, such as leaking valves. Appropriate contingency measures would be taken in response to reagent release during rail transport as described in Section 4.13.7.1.2.

Release from Train Accident

The probability of a release from a railcar accident can be estimated by applying historical train accident and release rates to the rail routes and distances that will be used for the Crandon Project. Because the locations of reagent suppliers have not yet been determined, routes and distances can only be estimated. Five potential supply centers were described in

Section 4.13.6.1.1. To simplify the analysis, only the farthest supply center, Chicago, will be evaluated. The Chicago route contains approximately 248 miles of track between the Wisconsin border and the Crandon Project site.

The Federal Railroad Administration compiles data on train miles and train accidents. From this data, train accident rates can be calculated. From 1986 to 1991, this rate has been fairly constant at 4.9 accidents per million train miles (Rhyne, 1994). This rate carries an uncertainty factor of about two. The accident rate is higher for lower grade tracks, but it is assumed that high grade tracks will be used to transport reagents.

The distance traveled by rail is multiplied by the train accident rate (4.9×10^{-6} accidents/mile) to estimate the probability of a train accident per shipment. Based on a route distance of 248 miles, the probability of a train accident per shipment is 1.2×10^{-3}.

Sulfur dioxide would be shipped by rail in tank cars holding 120,000 pounds. Were rail the only mode of shipment for sulfur dioxide, there would be 12 shipments per year. By multiplying the rail accident probability (1.2×10^{-3} accidents/shipment) by the annual number of shipments (12 shipments per year), an accident frequency of 1.4×10^{-2} accidents per year is derived. Most train accidents, however, do not result in a release of cargo. Between 1986 and 1991, 11 percent of train accidents involving reagents resulted in a material release (Rhyne, 1994). Multiplying this factor (0.11 releases/accident) by the projected number of annual accidents yields 1.6×10^{-3} releases/year as an estimate of the annual probability of a release. As previously noted, a similar evaluation was conducted for truck transport Section 4.13.6.1.1. Simultaneous transport of a given shipment cannot occur by both truck and rail, therefore, the probability of a transportation release should not be viewed as cumulative. Rail is not the preferred mode of shipment and will not likely be used on a regular basis for the Crandon Project.

Since the expected lifetime of the Crandon Project is 28 years, the release per year must be multiplied by 28 to characterize the probability of release. Using the operational definitions presented in the introduction of this risk assessment, a sulfur dioxide release resulting from a train accident is a probability Class IV event. Additionally, most releases were they to occur would involve only a fraction of the cargo. The Federal Emergency Management Agency (FEMA, undated) has suggested that given a release in a rail accident, a complete cargo loss occurs only 30 percent of the time. Using the described method for a 2.7 mile railroad spur, the annual probability of a sulfur dioxide release within the Crandon Project boundary area due to rail accidents was calculated to be 1.7×10^{-5} releases/year. This is a probability Class IV event. Again, given a release, a complete cargo loss would only be expected to occur 30 percent of the time.

Non-Accident Releases

The Bureau of Explosives (BOE) has compiled statistics on the leakage frequency of rail cars by commodity class (BOE, 1992). These leaks are not associated with train accidents but have such causes as disc rupture, valve failure, fitting failure, and liquid line failure. Between 1986 and 1990, the average frequency of leaking cars per cars shipped for nonflammable gas shipments was 1.1×10^{-3}. Sulfur dioxide is a nonflammable gas. The probability of a leaking rail car associated with sulfur dioxide can be estimated by multiplying the frequency of leaking cars per cars shipped

by the number of shipments, i.e., railcars per year. This yields an estimate of $1.3x10^{-2}$ leaking cars/year.

Using the operational definitions presented in the introduction of this risk assessment, a sulfur dioxide leak during rail transport is a Class III probability event. However, it should be noted that rail is not the preferred mode of shipment and will not likely be used on a regular basis as is assumed in this assessment.

4.13.7.1.2 Contingency Measures

Contingency measures for a reagent release associated with rail transport are similar to those for a release associated with truck transport described in Section 4.13.6.1.2. Regulatory requirements dictate immediate response by a carrier. The railroad spur within the Crandon Project borders will be well maintained.

4.13.7.1.3 Risk Analysis

The behavior of sulfur dioxide released into the environment was described in Section 4.13.3.1.3. A release, if it occurs, is expected to be small, and little exposure to off-site populations is expected. Since a sulfur dioxide train accident release is a probability Class IV event, the associated risk is considered negligible. Non-accident sulfur dioxide leaks during rail transport are probability Class III events. Because a large leak could result in an exposure, the associated risk is judged to be minor. Again, rail will not be the preferred mode of shipment for sulfur dioxide to the Crandon Project.

A reagent release during rail transport could result in short-term impacts to plants and animals in the vicinity of the release site as described in Section 4.13.6.1.3. Aquatic habitats could be affected in the unlikely event of a release adjacent to surface water. Long-term adverse ecological impacts are not expected to result from a reagent release during rail transport.

4.13.7.2 Ore Concentrate

Ore concentrates produced in the mill are described in Section 4.13.2.1.

4.13.7.2.1 Probability of Release

There is a potential for accidental release of concentrates during rail transport. Such a release could result from a railcar accident. It is not expected that there will be a significant release of concentrate in the absence of a railcar accident. Contingency measures that would be taken to mitigate the impacts of a concentrate release are described in Section 4.13.7.2.2. The material is a moist solid and would not be subject to release from pressure valves or drainage valves as is the case with liquids and gases. Because the railcars will be covered, and the concentrates have a moisture content of eight to 12 percent, the possibility for dusting of the concentrates is minimized.

The probability of a release from a railcar accident can be estimated by applying historical train accident and release rates to the rail routes and distances that will be used for the Crandon Project similar to the procedure in Section 4.13.7.1.1. The destination for the concentrate has not yet been determined, but it will not be located in the State of Wisconsin. Because the

destination of the concentrates has not been identified, routes and distances can only be estimated. A destination south of the site will be presumed in order to produce the largest estimate of in-state rail mileage. The distance by rail from the Crandon Project to the southern border of Wisconsin is approximately 250 miles.

The distance travelled by rail is multiplied by the train accident rate ($4.9x10^{-6}$ accidents/mile) to estimate the probability of a train accident per shipment. The probability of a train accident within Wisconsin borders, based on a route distance of 250 miles, is $1.2x10^{-3}$ accidents/shipment. The probability of a train accident within the Crandon Project boundary area, based on the railroad spur distance of 2.7 miles, is $1.3x10^{-5}$ accidents/shipment.

There will be approximately 350 rail shipments per year, each comprising 10 to 15 railcars. The frequency of a rail accident associated with the transport of concentrates can be estimated by multiplying the accident probability (accidents/shipment) by the number of annual shipments (350 shipments/year). The frequency of a rail accident associated with the transport of concentrates within the state of Wisconsin is 0.4 accidents/year. The frequency of a rail accident associated with the transport of concentrates within the Crandon Project boundary area is 0.005 accidents/year.

Most train accidents do not result in a release of the cargo. Between 1986 and 1991, eleven percent of train accidents involving chemicals resulted in a material release (Rhyne, 1994). The majority of these releases involved liquids and gases. Solids are less likely to be released because they are not volatile, not under pressure, and have a low tendency to flow. In order to estimate the number of releases of concentrate, the number of accidents per year can be multiplied by the factor, 0.11 material releases/accident. It is, therefore, estimated that there will be 0.04 concentrate releases/year or 1.2 releases over the 28 year operational life resulting from a rail accident within the state of Wisconsin. Within the Crandon Project borders, it is estimated that there will be $5.5x10^{-4}$ concentrate releases/year or 0.02 releases over the 28-year operational life of the Crandon Project.

Using the operational definitions presented in the introduction of this risk assessment, a concentrate release during rail transport in Wisconsin is a probability Class II event. A concentrate release on the Crandon Project railroad spur, is a probability Class IV event. The Federal Emergency Management Agency (FEMA, undated) has suggested that given a release, a complete cargo loss occurs only 30 percent of the time. The remaining incidents involve a loss of only a fraction of the total cargo.

4.13.7.2.2 Contingency Measures

In the event of a concentrate release, CMC will work closely with the rail carrier to implement cleanup activities. Spills will be recovered to the maximum extent practicable. Recovery operations will commence quickly following a release. The concentrate is amenable to recovery because it is an insoluble solid. Recovery methods will depend on the size of the spill. Small spills will be recovered with shovels, while large spills may require front-end loaders and trucks.

4.13.7.2.3 Risk Analysis

Heavy metals and sulfides in the concentrate are not immediately leachable. Because the concentrates are moist, dusting of released material will be minimized. Recovery of spilled concentrates is expected to occur before significant drying could occur.

Environmental impacts will be minimal, highly localized, short-term and reversible. Although a release is judged to be a probability Class II event, off-site exposure is not expected. Events that do not result in exposure cannot result in health effects and do not pose a risk. Therefore, the risk from a concentrate release during rail shipment is judged to be negligible.

A release of concentrates could result in short-term impacts to plants in the vicinity of the release site. Because of the low mobility of the moist concentrates, such impacts would be confined to the immediate vicinity of the release site. Aquatic biota could be affected in the event of a release adjacent to a stream, but such an occurrence is a probability Class IV event. Impacts would be highly localized and of short duration as a result of clean-up actions. Long-term adverse ecological impacts are not expected to result from a concentrate release.

4.13.8 Tailings Management Area

Tailings, the waste stream generated in the flotation process, will be deposited as a slurry in the tailings management area (TMA) located approximately 4,800 feet east southeast of the mill. The TMA will consist of four tailings cells which will be sequentially constructed and filled throughout the lifetime of the Crandon Project. A tailings delivery pipeline, connected to a tailings distribution system, will deposit tailings through spigots situated around each cell.

Each cell of the TMA will be lined with a composite liner consisting of till overlying coarse stone overlying a thermoplastic geomembrane overlying a natural clay layer. The tailings cells will be designed to hold an approximately 90 foot vertical column of tailings. The bottom of the tailings ponds will be graded and leachate collected in the low points will be pumped through a pipeline to the reclaim pond. There will be two pumps per cell. Less permeable tailings will tend to collect in the center of each tailings cell due to the slope of the beaches towards the center of a cell where surface ponds will form. Water decanted from the surface ponds will be pumped to the reclaim pond by a pump attached to a floating barge. After each tailings cell is full, it will be capped with a cover containing a composite hydraulic barrier. The cap will prevent recharge of water into the tailings.

4.13.8.1 Tailings

Tailings will contain pyrite, a sulfide mineral of iron, along with other minerals and compounds. In the presence of oxygen and water, sulfide minerals oxidize to form sulfate, soluble metal ions, and hydrogen ions. This process can be accelerated by the growth of bacterial species of the genus Thiobacillus, especially at very low pH values. The TMA has been designed, and will be operated, to minimize the oxidation of the sulfide minerals during the filling of the TMA cells, and to prevent oxidation of the sulfide minerals when the TMA cells are closed. The design and operation will significantly limit the long-term potential for acid generation within the TMA cells. In addition to leachable metals derived from the ore, tailings may also contain adsorbed reagent compounds from the process water.

4.13.8.1.1 Probability of Release

A potential tailings release event associated with the tailings ponds is fugitive dusting. Under normal conditions, the tailings will be wet, preventing episodes of dusting. However, when tailings beaches are exposed to freezing conditions for long periods of time with no precipitation or wetting, the frozen tailings surface could dry out and be subjected to wind erosion. High wind episodes under these conditions could result in fugitive dusting of the tailings. The specific meteorological conditions for this phenomenon are not frequent, since precipitation in the winter months will usually keep inactive tailings beach areas under a cover of snow. Operators will inspect the tailings ponds routinely and will be aware of the dry conditions. Should they occur, mitigating measures will be taken. The probability of fugitive tailings dusting in the winter months is judged to be a probability Class I event.

4.13.8.1.2 Contingency Measures

Tailings will be deposited onto the surface of each cell. The tailings delivery pipeline will be connected to a tailings distribution system. This distribution system will deposit tailings through spigots situated all around each cell. These spigots will be closed and opened progressively so that the area where tailings are placed will be continually shifted. This will allow tailings to be deposited in a thin layer and help keep tailing beaches moist throughout the cell.

Conditions in the TMA will be closely monitored year-round. The TMA will be routinely inspected by an operator. If dusting conditions were to arise, preventative measures will be taken. One preventative measure would be the spigotting of a layer of fresh wet tailings. Alternatively, water would be applied and allowed to freeze, forming an ice cap. If necessary, a chemical binder can be applied to prevent fugitive dusting.

4.13.8.1.3 Risk Analysis

Because of the location of the TMA within a buffer zone, transport and exposures beyond the vicinity of the TMA will be minimized. A release event would be an isolated short-term incident, and exposures, if any, would be of insufficient duration to result in health effects. In the event of a tailings dusting condition, significant impacts to plants and animals in the vicinity of the TMA are not expected. The associated risk is considered negligible.

4.13.8.2 Process Water

Process water is that water used in the mill flotation process to slurry the ore and to separate the metal concentrates from tailings. The process water and tailings will be transported from the mill to the TMA where the tailings will settle and the process water will form a pond. From the TMA, the ponded process water will be pumped to the reclaim pond. Process water will be pumped from the reclaim pond back to the mill for reuse in the process. Process water will contain diluted reagents and metals from the ore.

4.13.8.2.1 Probability of Release

Potential process water release events associated with the TMA are migration of degraded groundwater beyond the compliance boundary and overtopping due to either inadequate freeboard or embankment failure. Appropriate contingency measures and contingency plans

which will be implemented to address potential environmental impacts from the TMA are described in Section 4.13.8.2.2.

Migration of Degraded Groundwater Beyond the Compliance Boundary

A very small quantity of water will percolate through the tailings pond liner. Under certain conditions, constituents in the percolating water could be elevated to levels that could result in groundwater degradation. A groundwater quality compliance boundary of 1200 feet has been established around the TMA. Groundwater within the compliance boundary will be monitored. If an exceedance of a groundwater standard at the compliance boundary is anticipated, an appropriate investigation and necessary corrective action would be implemented as described in Section 4.13.8.2.2.

One cause of increased percolation would be a significant breach of the composite liner system. Such a breach could be the result of mechanical damage caused by large differential settlement of the supporting soils or poor construction of the geomembrane layer. The probability of these events is low. The geomembrane liner is designed to be compatible with the waste it is used to contain and to withstand chemical degradation. There is a potential to produce weak acid in the tailings, but the liner is resistant to acid and the TMA is designed to minimize acid formation. Large differential settlement of the supporting soils could occur due to the loading of poor foundation soils or deformation of the embankments. Extensive investigation of the foundation soils and design of the facility to withstand even low probability events such as earthquakes essentially rule out such possibilities. Improper construction of the liner is judged to be a probability Class III event because stringent quality control procedures are required by Wisconsin Administrative Code and will be implemented by CMC.

A second cause of increased constituents percolating through the liner system is an increased concentration of the constituents in the leachate. An increased concentration of constituents in the leachate could be caused by unanticipated oxidation in the tailings. Exposure of tailings to oxygen and water causes acidification, which in turn increases the solubility of metals. Acidification on a large scale is considered to be a probability Class IV event. The process water is alkaline, and the tailings management process is designed to isolate tailings from oxygen during normal operations and after closure, thus minimizing acid formation. In addition, the tailings contain materials which will act to neutralize the small amounts of acid which may form during the operational life of the TMA cells. Significant oxidation of surface tailings during pond operation requires a substantial length of time. In the event of a long-term shutdown, contingency measures will be employed to minimize oxidation of the tailings.

A third cause of an increased rate of percolation would be an unplanned rise in the hydraulic head within the tailings. This condition would be caused by malfunction of the pumps in the leachate control system. There are two pumps per cell. Change in hydraulic head occurs slowly, and a pump failure represents only a short-term condition because the pumps are designed for removal and repair. A significant long-term rise in hydraulic head is, therefore, judged to be a probability Class III event.

A final cause of an increased rate of percolation, which would occur only in the post-closure period, is breach of the composite hydraulic barrier in the cap. This would be a probability Class III event. Such a breach would likely have highly visible and readily correctable causes such as puncture by heavy equipment or significant differential settlement and/or surface erosion.

The degradation of groundwater directly below the TMA is judged to be a probability Class III event. However, in light of contingency measures that would detect and respond to groundwater degradation, the migration of degraded groundwater beyond the TMA compliance boundary is judged to be a probability Class IV event.

Overtopping - TMA

A release of process water from the TMA due to overtopping could be caused by unusually high precipitation. This is judged to be a probability Class IV event. The embankments are designed with sufficient freeboard to contain the 100-year, 24-hour storm taking into account a worst-case wave height. In addition, the greatest potential for overtopping is in the later stages of each cell when the tailings surface approaches its final height. At any time during tailing deposition, when water is stored in a cell, a minimum five foot freeboard will be maintained.

Another potential cause of overtopping would be a breach in the embankment from seismic activity or erosion. The earthquake considered in design at this site is a probability Class IV event, and seismic stability has been verified. An embankment breach resulting from erosion is also judged to be a probability Class IV event because of the erosion control contingency measures that will be used.

4.13.8.2.2 Contingency Measures

Installation of the TMA liner system will follow stringent quality control procedures, including testing of the membrane. The TMA will be operated in stages, one cell at a time. There will be two pumps in the leachate collection system of each cell. Should a pump fail leading to an elevated hydraulic head, the pump will be promptly removed and repaired. In the event of a long-term shutdown, oxidation of the tailings will be prevented by keeping tailings beaches submerged. Oxidation of tailings is accompanied by a change in the color, from dark grey to brownish red. If color changes are observed by operators during routine inspection, appropriate mitigating measures would be immediately initiated. If necessary, lime can be applied to tailings beaches and bactericides can be added to inhibit growth of *Thiobacillus ferrooxidans*, which can accelerate the oxidation of sulfides. The tailings also contain significant amounts of calcite which will act to neutralize acid which may form during the operational life of the TMA cells.

Monitoring wells will be situated around the TMA to evaluate groundwater quality at and within a compliance boundary of 1,200 feet around the TMA. These wells will be sampled regularly and will monitor the quality of groundwater in the vicinity of the TMA. Monitoring plans in compliance with Chapter NR 182, Wis. Admin. Code, are discussed in Sections 7 and 10 of the MPA. If any constituent approaches an exceedance of groundwater standards at the compliance boundary, investigation and corrective action measures will be initiated to mitigate the impact to groundwater and to prevent the off-site migration of contaminated groundwater. Corrective action measures are discussed in the groundwater contingency plan in Section 8 of the MPA.

Each cell will be capped when it is full. The caps will be designed to exclude water and oxygen from the tailings. Any breach in the cap will be repaired.

The cell embankments will be designed to contain solids and liquids during and after a 100-year, 24-hour storm. The outer slopes will be vegetated to minimize erosion. In addition, side slope grades, construction controls and soil characteristics will all be designed to minimize erosion.

The interior of the embankments will be lined and risk of saturation of the embankments is low. If significant erosion is observed by operators, appropriate steps will be taken to repair the embankment before serious damage is realized. In the unlikely event of process water release from the tailings pond by embankment failure, the embankment would be repaired. Overtopping water would spill into perimeter ditching and be routed to runoff basins. The water could be pumped from the basins to the reclaim pond. Affected areas would be investigated for environmental impacts and remedial actions appropriate to the situation would be implemented.

4.13.8.2.3 Risk Analysis

The water table at the TMA lies an average of 43 feet below the composite liner. The intervening soil is glacial till and outwash. Thus, any constituent exiting the TMA must be transported through this till before reaching groundwater. The till has a high absorptive capacity for many constituents, especially metals. Natural flow patterns will transport groundwater away from the TMA, primarily to the north and east with a small component of flow to the south and west.

A regular monitoring program of the groundwater will detect changes to water quality. Contingency measures would be implemented so that water quality standards are met at the compliance boundary. CMC would undertake measures to remediate the aquifer to prevent off-site migration of degraded groundwater. Groundwater modeling results, presented in Section 4 of the EIR and Section 5 of the MPA, project no exceedances of groundwater standards at the compliance boundary. Events that do not result in exposure cannot result in health effects. The migration of degraded groundwater beyond the compliance boundary is, therefore, considered a probability Class IV event, and the risk posed by the TMA to groundwater users is judged to be negligible.

A release of process water from the TMA by overtopping is a probability Class IV event. Discharged water would be directed to runoff basins. Appropriate remedial actions would be initiated as needed. Surface waters would not likely be affected, and exposures to off-site populations are not expected to occur. Events that do not result in exposure cannot result in health effects. Plants and animals are not expected to be affected. The risk from embankment failure is, therefore, considered negligible.

4.13.9 Tailings Delivery Pipeline

Tailings will be transported to the TMA as a slurry through an aboveground pipeline system which will be approximately 4,800 feet in length. The tailings pipeline will be operated as a pressure line with the pump located in the mill. Return water from the reclaim pond to the mill will also be pumped through an aboveground pipe running adjacent to the tailings pipeline.

4.13.9.1 Tailings

Tailings are described in Section 4.13.8.1.1.

4.13.9.1.1 Probability of Release

The tailings delivery pipeline could potentially develop a leak or break resulting in a spill of the tailings slurry. Pipeline leaks could result from a flange connection failure resulting from wear

due to continuous vibratory motion during normal operation. Expansion and contraction from freezing could also weaken connections. Based on engineering judgement, a tailings pipeline leak or break, transporting the slurry, is considered to be a probability Class I event.

4.13.9.1.2 Contingency Measures

The tailings pipeline will rest in a ditch lined along its length with a geomembrane liner. The ditch will be bermed and have a minimum bottom width of six feet and a minimum depth of four feet. The ditch will channel spillage to one of two collection sumps, located in the mill and at the point of lowest grade along the pipeline. In the event of an unplanned flow stoppage, tailings in the pipeline would be intentionally drained to the sumps. The capacity of the ditch exceeds the flow rates of either the tailings or return water pipelines, and thus would contain spills while directing tailings toward the collection sumps. Each sump will be able to contain twice the volume of the pipeline plus the runoff from a 25-year, 24-hour storm. If water overtops the sump it will move into the ditch which will be able to hold the runoff from an additional 25-year, 24-hour storm before the berms are overtopped.

Pipeline sections will be periodically rotated to maintain even wear. Daily visual inspections will be made from an all-weather road running adjacent to the pipeline. The pipeline will be jointed at approximately 400 foot intervals. This will facilitate repairs and preventative maintenance of worn sections. Leaks will be detected by flow meters and hydraulic pressure monitors at the mill and TMA. If the flow rates differ at the two locations, the pump will automatically shut off and valves at the draindown areas will open to drain the tailings slurry into the collection sumps. Solids which remain along the ditch after a spill will be mechanically removed and deposited in the TMA.

The sumps will be regularly inspected by tailings operators. When water levels in the sump located at low grade become high, the water will be pumped directly into the TMA.

4.13.9.1.3 Risk Analysis

Although a tailings pipeline break is considered a probability Class I event, facility design allows for containment and collection of released tailings. Exposures to off-site populations will not occur. Events that do not result in exposure cannot result in health effects and do not pose a risk. If overtopping of the ditch occurred the released material would be limited to rainwater diluted process water as the tailings would settle within the sump and ditch. Overtopping water could potentially spill into a site wetland, however, because the water at this point in time would be process water diluted with rainwater and, taking into account project design, the wetlands are unlikely to experience adverse effects from an overtopping incident. The risk from a tailings pipeline break is judged to be negligible.

4.13.9.2 Process Water

Process water is described in Section 4.13.8.2.

4.13.9.2.1 Probability of Release

A leak or break in the tailings delivery pipeline was addressed in Section 4.13.9.1.1. Such an occurrence was judged to be a probability Class I event.

4.13.9.2.2 Contingency Measures

Contingency measures were described in Section 4.13.9.1.2.

4.13.9.2.3 Risk Analysis

Although a tailings pipeline leak or break is considered a probability Class I event, released process water would be contained in the sumps and would be removed to the TMA. Exposures to off-site populations would not be expected to occur. Events that do not result in exposure cannot result in health effects and do not pose a risk. A water volume equivalent to two 25-year, 24-hour storm events would be required before process water overtopped the berms of the containment ditch. In such an unlikely event, process water would be substantially diluted by rainwater and would not pose a significant ecological risk. The risk from a tailings pipeline break is judged to be negligible.

4.13.10 Reclaim Pond

Water decanted from the TMA as well as leachate from the TMA leachate control system will be pumped to the reclaim pond. From the reclaim pond the water will be pumped back to the mill for re-use in the process.

4.13.10.1 Process Water

Process water is described in Section 4.13.8.2.

4.13.10.1.1 Probability of Release

Two potential process water release events associated with the reclaim pond are a break in decant or leachate water pipelines and overtopping of the embankments. Appropriate contingency measures would be taken in response to a process water release as described in Section 4.13.10.1.2.

Break in Decant or Leachate Water Pipelines

Two pipelines will carry water from the TMA to the reclaim pond. One pipeline will carry decant water, and the other leachate water. Both pipelines will pass outside the TMA containment berms for a short distance. Breaks in this stretch of piping could lead to release of process water onto soils. Based on engineering judgement, breaks in these pipelines are probability Class IV events.

Overtopping

Overtopping is considered a probability Class IV event as described in Section 4.13.8.2.1.

4.13.10.1.2 Contingency Measures

The pipeline carrying leachate from under the TMA will have secondary containment in all areas. In areas outside the TMA containment, the leachate pipeline will be encased within a second

pipe. The pipeline carrying ponded water from the TMA will be placed in a lined ditch. Contingency measures for overtopping are described in Section 4.13.8.2.2.

In the unlikely event that process water were released from the TMA by a pipeline break, the pipeline would be repaired. Similarly, in the event of a release by overtopping, caused by embankment failure, the embankment would be repaired. In either case, affected areas would be investigated for environmental impacts and remedial actions appropriate to the situation would be implemented.

4.13.10.1.3 Risk Analysis

A release of process water from the reclaim pond is a probability Class IV event. Discharged water would be directed to runoff basins. Appropriate remedial actions would be initiated as needed. Surface waters, plants and animals would not likely be affected, and soils would not likely be impacted from a single release event to a degree that would affect groundwater. Exposures to off-site populations are not expected. Events that do not result in exposure cannot result in health effects and do not pose a risk. The risk posed by the process water storage pond is considered to be negligible.

4.13.11 Wastewater Storage Basins

Three wastewater storage basins located in the northwest section of the plant site will hold wastewaters prior to treatment in the WWTF. These basins will be lined with a composite liner. The basins will be designed to equalize large fluctuations in wastewater flow rates and will normally only be filled to a fraction of their storage capacity.

Before the WWTF is constructed, water produced from mine development as well as surface runoff from the preproduction ore storage area will be routed to the wastewater storage basins. These waters will be held in the basins without discharge until construction of the WWTF is completed. When the WWTF is operational, the stored wastewaters will be treated.

4.13.11.1 Project Wastewater

Wastewaters that will be produced by the Crandon Project include mine drainage water, intercepted groundwater, backfill preparation water, and surface runoff water from the preproduction ore storage and ore processing areas. Mine drainage water mixed with backfill preparation water will be pumped from the mine to the storage basins through a pipeline. Intercepted groundwater will be pumped through a separate pipeline. Runoff from the preproduction ore storage and ore processing areas will be routed to the wastewater storage basins. As needed, process water from the reclaim pond will also be treated in the WWTF.

Mine drainage water will contain several metals and sulfate. The metals include: arsenic, cadmium, copper, iron, mercury, selenium, and zinc. Runoff water from the preproduction ore storage area will likely contain some of the same metals.

4.13.11.1.1 Probability of Release

Potential wastewater release events associated with the wastewater storage basins are breach of the composite liner and overtopping of the embankments. Appropriate contingency measures would be taken to mitigate a wastewater release as described in Section 4.13.11.1.2.

Breach of the Wastewater Storage Basin Liner

A significant breach in the composite liner system could result from mechanical damage. Large differential settlement of supporting soils or poor construction could result in mechanical stresses that could cause a liner breach. Stresses large enough to cause a liner breach are very unlikely. Foundation soils will be investigated and the basins will be designed to withstand such events as earthquakes. Construction of the liner will follow appropriate quality control procedures. A significant breach in the composite liner is judged to be a probability Class III event.

Overtopping of Wastewater Storage Basins

Overtopping of the basin embankments could be caused by unusually high precipitation. The embankments will be designed with sufficient freeboard to contain a 25-year, 24-hour storm. Embankment failure from earthquake or erosion might also result in overtopping. Seismic stability has been considered in the design of the basin embankments. Erosion control contingency measures will minimize erosion. The probability of embankment overtopping is judged to be a probability Class IV event.

4.13.11.1.2 Contingency Measures

Installation of the composite liner system during construction will be subject to stringent quality control procedures, including testing of the geomembrane liner during installation. The storage basin embankments will be designed to contain liquids during and after a 25-year, 24-hour storm. Side slope grades, construction controls and soil characteristics will be designed to minimize erosion. To reduce saturation of the embankments, the interior walls will be lined. The outer slopes will be vegetated. If significant erosion is observed by operators, appropriate steps will be taken to repair the embankment before serious damage is realized.

4.13.11.1.3 Risk Analysis

The release of wastewater from the wastewater storage basins could result in saturation of surrounding soils. Metals and other inorganics in the wastewater would adsorb to soil. A release is expected to be an isolated event. From a single release, soils will not likely be impacted to a degree that would affect groundwater. Plants and animals are not expected to be affected. Off-site exposures are not expected. Events that do not result in exposure cannot result in health effects and do not pose a risk. Because off-site exposure to impacted groundwater is not expected, the risk posed by the wastewater storage basins is judged to be negligible.

4.13.12 Discharge Pipeline

A 38.3-mile pipeline, buried below the frostline will carry treated wastewater to the Wisconsin River for discharge. The pipeline will contain pumps along its length to assist water movement toward the discharge point.

Treated wastewater from the WWTF will initially be discharged to lined discharge lagoons for holding pending compliance testing. Each of the two discharge lagoons will be used for this purpose. The discharge lagoons will be filled on an alternating basis. On days when a discharge lagoon is full and no longer accepting WWTF effluent, the stored treated water will be tested to assess whether it meets applicable discharge standards. Water in compliance with discharge standards will be discharged to the Wisconsin River through the underground pipeline. The emptied lagoon will then be able to accept WWTF effluent, during which time the water in the second lagoon will be held, tested, and eventually discharged.

If testing were to indicate that a constituent exceeds a discharge standard, the water will be returned to the wastewater storage basins. The water will be stored in the basins while treatment problems with the wastewater treatment process are diagnosed and corrected, and then it will be retreated. The wastewater storage basins have the capacity to hold seven days' production of wastewater.

4.13.12.1 Treated Wastewater

Water discharged from the discharge lagoons will be of sufficient quality to meet the discharge standards for the Wisconsin River.

4.13.12.1.1 Probability of Release

Potential release events associated with the treated water are a leak in the discharge pipeline and a discharge of insufficiently treated water. Contingency measures which will be implemented for the purpose of preventing the release of insufficiently treated water are described in Section 4.13.12.1.2.

Leak in discharge pipeline

Since the pipeline will be buried, major displacement resulting in a complete break is judged to be a probability Class III event. Unauthorized excavation near the pipeline represents the most likely scenario resulting in a complete break. The pipeline will be designed to operate for the lifetime of the project. Following construction of the pipeline a leak test will be performed. The probability of a significant release of treated water from a leak in the pipeline is judged to be a probability Class III event.

Discharge of improperly treated water

Water stored in the discharge lagoons will be treated water which meets applicable discharge standards. Discharge of insufficiently treated water through the pipeline would require both a WWTF failure and an analytical error allowing discharge of insufficiently treated wastewater through the pipeline.

A potential cause for the WWTF to fail in treating wastewater to standard is equipment malfunctions, such as agitator motors, pH control systems or pumps. Operator errors are also a potential cause of improper water treatment. The probability of a WWTF treatment failure is considered to be a probability Class I event. A concurrent failure of the WWTF and of analytical testing, resulting in an unwarranted discharge is, based on engineering judgement, considered to be a probability Class IV event.

4.13.12.1.2 Contingency Measures

Redundancy will be designed into the wastewater treatment system. In addition, preventive maintenance procedures will be incorporated into system operations. Operators will monitor the automated systems and perform maintenance as needed. Treated water will be discharged to lined discharge lagoons and held there until it is tested to demonstrate it is in compliance with discharge standards. Daily water quality testing of treated water will prevent releasing improperly treated water for discharge.

The discharge pipeline will be designed to withstand normal operating pressures and conditions for the lifetime of the project. The pipeline will be below the frostline. Flow measurement instrumentation placed along the pipeline would aid in the detection of leaks.

4.13.12.1.3 Risk Analysis

Properly treated water will be of sufficient quality to meet discharge standards for the Wisconsin River. If a leak were to occur in the pipeline, adverse effects to humans and the environment are not expected due to the high quality of the treated water carried by the pipeline. Events that do not result in adverse exposure cannot result in health effects and do not pose a risk. Given that a pipeline leak is a probability Class III event and the unlikelihood of adverse exposure, the risk is judged to be negligible.

Discharge of improperly treated wastewater to the Wisconsin River would require the concurrent failure of WWTF processes and of analytical testing procedures. Based on engineering judgement, the discharge of wastewater not meeting discharge standards is a probability Class IV event. Events that do not result in exposure cannot result in health effects and do not pose a risk. The risk is, therefore, judged to be negligible.

4.13.13 Physical Hazards

4.13.13.1 Surface Fire

Surface fires can be started by a variety of causes including vehicular accidents, lab fires, uncontrolled explosions, and the accidental ignition of fuels or flammable chemical reagents. During the period 1984 to 1994, between 36 and 53 underground copper, lead, or zinc mines were in operation in the U.S. (Neason, 1995). During this time period, seven fires, both surface and underground, were reported (Campbell, 1995). This represents 0.7 mine-related fires per year. Making the assumption that all reported fires were surface fires, the probability of a surface fire at a single mine (fires/mine-year) can be calculated by dividing the average number of fires per year by the number of mines in operation. Assuming 36 mines were in operation, the probability of a surface fire is 0.02 fires/mine-year. This represents one fire every 50 years, a probability Class II event. A major fire that cannot be quickly controlled will be even less likely. Fires that do start are expected to be of short duration and to be quickly contained.

Historical data on the specific frequency of ore mill fires is not available. However, data regarding fires at electrical power stations (Hockenbury and Yeater, 1980) indicate that the greatest risk of fire occurs during the construction phase. The mill facility will be constructed from steel and steel cladding.

In the unlikely event that a major fire did burn out of control and spread to reagent storage areas, gases could be formed as combustion products of certain reagents. The combustion products could form plumes which would be dispersed by winds. These plumes would be become increasingly dilute as they migrated away from the fire source. It is unlikely that combustion products would be formed in quantities large enough to produce significant exposures to off-site populations. Events that do not result in exposure cannot result in health effects and do not pose a risk. The risk from toxic combustion products is, therefore, negligible.

4.13.13.1.1 Contingency Measures

In order to minimize the risk of a fire, stringent safety standards will be followed during construction and operation of surface facilities. During the construction phase, a water truck will be stationed on-site and fire extinguishers will be readily available. If controlled burning is required to eliminate wastewood following project clearing activities, a permit will be obtained which will specify measures to be taken for the prevention of fires. In the event that a fire did get out of control, local fire fighting would also be available for assistance.

During the plant operation phase, standard fire safety measures will be exercised. Fire extinguishers and standby water pipelines will be located in high risk areas and personnel will be trained in their use. The surface rescue team will be trained in fire fighting techniques to respond to fires. On-site fire fighting equipment will include a fire control vehicle located at the gate house. Fire hydrants will be located around the site.

As a fire control measure, approved herbicides will be used to keep the ballast section of the railroad spur free of vegetation. Vegetation will also be controlled along the access road. The growth of woody plants in the power line corridor will be controlled. The corridor will also be maintained by periodically trimming back encroaching limbs from adjacent trees. Electrical fires along power line corridors are very low probability events (Eversman, 1983).

The clearing around the mine facilities will form a substantial fire break. In the unlikely event that a fire would spread to the adjoining forest, local forest fighting units would be called for assistance. The access road, railroad spur, and power line corridor would also act as fire breaks to help check the spread of a forest fire.

4.13.13.2 Mine Fire

The Crandon ore body does not contain significant quantities of combustible minerals such as pyrrhotite. There is, therefore, a very low probability of fires associated with the ore or waste materials. This not only reduces the probability of a mine fire, but also limits the size and impact of a mine fire that might develop. Mine fires could be started from ignition of combustible materials used underground. However, other than the mobile equipment, there is little combustible material in this kind of mining operation.

The probability of a fire associated with underground copper, lead, and zinc mines was discussed in Section 4.13.13.1. Assuming that all reported fires occurred underground, a mine fire is a probability Class II event. Over half of the fires reported were started by vehicles (Campbell, 1995).

Mine fires that do develop would be localized, short lived, and would not pose a threat to the environment. Off-site populations would not be exposed to agents resulting in adverse effects. Events that do not result in exposure cannot result in health effects and do not pose a risk. Mine fires, therefore, pose a negligible risk.

4.13.13.2.1 Contingency Measures

Appropriate preventative measures will be exercised as required by the U.S. Mine Safety and Health Administration. These measures include the installation of fire suppression systems, the widespread distribution of fire extinguishers, employee safety programs, and the use of a mine rescue team trained in firefighting techniques.

4.13.13.3 Uncontrolled Explosion

Blasting agents (explosives) will be required for blasting operations in the development and operation of the mine. The most likely explosive to be used is ammonium nitrate/fuel oil (ANFO). Accidental detonation of explosives could result from impact, shock, fire, or electrical discharge. A database maintained by the U.S. Mining Safety and Health Administration (MSHA) for recording mine fires and explosions does not contain a single reported incident of accidental detonation of surface stored explosives between 1984 and 1994 (Campbell, 1995). However, a 1994 Porgea, New Guinea detonation incident has recently been reported. A surface explosion is judged to be a probability Class III event.

The main impacts of an uncontrolled explosion on the surface would be falling debris, fire, and the release of combustion products. Combustion products expected from ANFO are carbon monoxide and nitrogen oxides. Neither of these products is expected to be generated in high enough concentrations for significant off-site exposures to occur. Dust could also be generated but would likely settle to the ground before migrating beyond the CMC boundary area. Because an uncontrolled explosion is a probability Class III event, the risk is judged to be negligible. Uncontrolled underground explosions have not been considered since the environmental effects would not be different from controlled explosions in normal mine operations.

4.13.13.3.1 Contingency Measures

The storage, transportation, and use of explosives will comply with Chapter ILHR 7, Wis. Admin. Code. Ammonium nitrate and fuel oil will be stored separately. Explosives stored on the surface will be in an isolated magazine located approximately 2,500 feet northeast of the main facility. Magazine construction will comply with appropriate codes. Caps, primers, and detonating cord will be stored in a separate magazine. The only access to the magazine area is via a dedicated road from the main facility. Explosives will be transported by a clearly marked truck to the headframe for distribution and use in the mine.

The construction and location of the surface magazine will minimize impacts to facility structures from the debris generated by an explosion. However, it is possible that fires could be set by burning debris. Contingency measures for surface fires have already been addressed in Section 4.13.13.1.1.

4.13.13.4 Significant Mine Subsidence

One potential environmental impact of any underground mine is surface subsidence directly over and/or immediately adjacent to the ore body. The two main causes of subsidence are rock collapse and overburden consolidation. In regard to mine subsidence, evaluations of the proposed mining methods and stope sequences have been conducted, as have studies on bedrock, backfill, and overburden characteristics. Based on these analyses, a maximum subsidence of six inches was estimated (John D. Smith Engineering Associates Limited, 1982).

A six-inch subsidence is within the limits of conventional building design. A six inch subsidence would also have a negligible effect on future land use since the surface topography is quite irregular. In the event of a larger subsidence, off-site impacts would not be realized. Because the probability of a significant mine subsidence is judged to be a probability Class IV event and the impacts are minimal, the risk posed by a mine subsidence is negligible.

4.13.13.4.1 Contingency Measures

The mining method, crown pillar design, and backfill strategy are all designed to prevent subsidence. If ground movement is noted during mining, additional pillars could be left to stabilize the rock mass around the mine.

4.13.14 Natural Disaster Hazards

4.13.14.1 High Precipitation

High precipitation events are considered to be probability Class II events. High precipitation could impact the tailings and the process water storage pond, the tailings pipeline spill collection sump, and the surface water collection basins associated with the WWTF. The effects of unusually high precipitation to each of these locations has previously been addressed. High precipitation could also lead to the failure of erosion control structures. The impacts of such an event would be localized erosion. Long term or off-site impacts would not be expected. Failed erosion control structures would be repaired or rebuilt. Impacts from high precipitation are reversible and off-site impacts are not expected to occur. The risk posed by high precipitation is considered negligible.

4.13.14.2 Power Disruption

A disruption of electrical power to the Crandon Project could occur as a result of a thunderstorm, severe winter weather, or some other severe natural phenomenon. A power disruption is judged to be a probability Class I event. Power disruption is usually of short duration, less than one hour. In the event of a power disruption, emergency power will be provided to the Project by a backup generator. It should be noted that even in the absence of a backup generator, disruption of power would not result in the release of project materials. The risk from power disruption is judged to be negligible.

4.13.14.3 Forest Fire

Because the Crandon Project is situated in a heavily forested region, forest fires started off-site could potentially impact the site. The region has made an investment in both the development

of fire fighting units and the education of the population in forest fire prevention to protect the natural resource of the forest.

The large area of cleared land in the vicinity of the plant will serve to create a fire break, protecting site facilities. In addition, the railroad spur, access road, and electrical power line corridor will also create fire breaks. As described in Section 4.13.13.1.1, on-site fire fighting equipment and personnel will be present to respond to any threat to the facilities from a forest fire. If fire did spread to surface facilities, the release of potentially toxic gases could occur as described in Section 4.13.13.1. Local populations would have already been alerted and/or evacuated because of the forest fire. A forest fire might destroy electrical power lines, causing a shutdown of the mill and WWTF. The mine could continue to power vital services from an on-site electrical generator.

The occurrence of a forest fire spreading to mine facilities is judged to be a probability Class III event. The risk to the environment posed by the Crandon Project as a result of consequences caused by an off-site forest fire are similar to those discussed in Section 4.13.13.1. The associated risk is considered minor.

4.13.14.4 Tornado

Historically, tornados have occurred in northern Wisconsin (Thom, 1963), but the probability is low. In the event that a tornado were to occur in the region, an incident in which it would pass close enough to the mining facilities to cause damage is considered a probability Class IV event. Since the probability of a direct hit by a tornado is very low, the risk from a tornado is judged to be negligible.

4.13.14.5 Earthquake

Northern Wisconsin as a region has a very low seismic risk (Algermission, 1976). Additionally, earth movement will be considered in the design of the mine and of surface facilities. The risk posed by earthquake is therefore negligible.

4.13.15 Risk Summary

Possible hazards and associated risks from accidental release events at the Crandon Project were evaluated in this risk assessment. The results of this evaluation are summarized in Table 4-24. The focus of this assessment was on potential risk to the off-site environment. Risks were expressed in a semi-quantitative manner.

Identified risks possibly associated with the Crandon Project were judged to be negligible or minor. The performance of engineering design, administrative controls and response plans were considered in assessing risks. These measures reduced the probability of release events and the potential for off-site adverse exposures and environmental effects.

Some release events were judged to have a high probability of occurrence but were not associated with off-site exposure and so were of negligible risk. Other release events which have the potential for significant off-site exposures are low probability events and, thus, considered negligible or minor risks. Proper execution of site contingency plans will further reduce the risk from accidental release events at the Crandon Project.

Table 4-24

Risk Summary

Location or Process	Agent	Potential Release Event	Probability Class	Off-Site Exposure	Risk	Contingency Measures
Concentrator	Ore Concentrate	Conveyor Malfunction	I	Insignificant Exposure	Negligible	Mill designed to contain spills; concrete floors, curbs, dust collection system
		Front-End Loader Accident	I			
	Chemical Reagents	Spill of Concentrated Reagent in Mixing Area	I	Insignificant Exposures	Negligible	Mill designed to contain spills; curbs, sumps, sloped floors. Housekeeping of minor spills. Spill response plan will be prepared and personnel will be trained.
		Spill of Dilute Reagent Blends in Flotation Process	II			
		Mishandling During Off-Loading to Mill Storage	II			
Bulk Reagent Storage	Chemical Reagents	Tank Failure	III	i. Sulfur Dioxide - Inhalation Exposure, Respiratory Irritant ii. Other Chemicals - Insignificant Exposure	i. Minor ii. Negligible	Concrete pad, containment berm for tanks, containment ditch for pipeline; emergency response plan will be prepared and personnel will be trained for response.
		Mishandling During Off-Loading	II	Insignificant Exposure	Negligible	
		Bulk Storage Pipeline Leak	II	Insignificant Exposure	Negligible	
WWTF	Chemical Reagents	Sulfuric Acid Tank Failure	III	Insignificant Exposures	Negligible	WWTF designed to contain spills. Spill response plan will be prepared and personnel will be trained. Sulfide precipitation covered; monitor/alarm system.
		Mishandling Sulfuric Acid, Pipeline Leak	II			
		Hydrogen Sulfide Release	II			

Table 4-24 *(Continued)*

Location or Process	Agent	Potential Release Event	Probability Class	Off-Site Exposure	Risk	Contingency Measures
Fueling Facilities	Surface Stored Gasoline and Diesel	Bulk Tank Failure	III	Insignificant Exposure	Negligible	SPCC plan will be prepared and personnel will be trained; fuel area will be bermed and lined.
		Mishandling, Leaking Hoses	I			
		Construction Phase Leaks, Tank Failure	II			
	Diesel in Mine	Mishandling	I	Insignificant Exposure	Negligible	Mine Sumps
		Pipeline Leak or Tank Failure	III	Insignificant Exposure	Negligible	Flow Metering, Mine Sumps
Transportation by Truck	Chemical Reagents	Vehicular Accident	IV	i. Sulfur Dioxide - Inhalation Exposure, Respiratory Irritant ii. Other Reagents - Insignificant Exposure	Negligible	Emergency response plans and information required of transporter. 49 CFR 177 49 CFR 172
		Release in Transit from Non-Traffic Accident	III (off-site) IV (on-site)	i. Sulfur Dioxide - Inhalation Exposure, Respiratory Irritant ii. Other Reagents - Insignificant Exposure	i. Minor ii. Negligible	
	Fuels	Vehicular Accident	IV	Direct Contact Exposure, Irritant	Negligible	Emergency response plans required of transporter, 49 CFR 130; remediation of residual contamination as necessary.
		Release in Transit from Non-Traffic Accident	III (off-site) IV (on-site)	Direct Contact Exposure, Irritant	Minor	
Transportation by Rail	Chemical Reagents	Release from Train Accident	IV	Sulfur Dioxide - Inhalation Exposure, Respiratory Irritant	Negligible	Emergency response plans and information required of transporter. 49 CFR 177 49 CFR 172
		Non-Accident Releases	III	Sulfur Dioxide - Inhalation Exposure, Respiratory Irritant	Minor	

Table 4-24 *(Continued)*

Location or Process	Agent	Potential Release Event	Probability Class	Off-Site Exposure	Risk	Contingency Measures
Transportation by Rail	Ore Concentrate	Release from Train Accident Non-Accident Releases	II (off-site) IV (on-site)	Insignificant Exposure	Negligible	Physical recovery of any spilled concentrate; railroad spur will be maintained for safety.
Tailings Ponds	Tailings	Fugitive Dusting	I	Insignificant Exposure	Negligible	Operator inspection and implementation of response plans when conditions warrant.
	Process Water	Migration of Degraded Groundwater Beyond Compliance Boundary	IV	Insignificant Exposure	Negligible	QC in liner construction, pump maintenance, response measures to prevent oxidation of tailings; monitoring wells and corrective action as necessary.
		Overtopping	IV	Insignificant Exposure	Negligible	Designed for 100-year, 24 hour storm; erosion control measures.
Tailings Delivery Pipeline	Tailings	Pipeline Leak	I	Insignificant Exposure	Negligible	Lined ditch with recovery sump; regular inspection and maintenance.
	Process Water	Pipeline Leak	I	Insignificant Exposure	Negligible	
Reclaim Pond	Process Water	Break in Decant or Leachate Water Pipelines	IV	Insignificant Exposure	Negligible	Leachate pipeline double-cased and buried; decant pipeline in lined ditch.
		Overtopping	IV	Insignificant Exposure	Negligible	Designed for 100-year, 24 hour storm; erosion control measures.
Wastewater Storage Basins	Wastewaters	Breach in Liner	III	Insignificant Exposure	Negligible	QC in liner construction.
		Overtopping	IV	Insignificant Exposure	Negligible	Designed for 25-year, 24 hour storm; erosion control measures.
Discharge Pipeline	Treated Wastewater	Leak in Discharge Pipeline	III	Insignificant Exposure	Negligible	Design, leak testing and flow measurements.

Table 4-24 *(Continued)*

Location or Process	Agent	Potential Release Event	Probability Class	Off-Site Exposure	Risk	Contingency Measures
Discharge Pipeline	Treated Wastewater	Discharge of Improperly Treated Water	IV	Insignificant Exposure	Negligible	WWTF redundancy, testing of treated water prior to discharge.
Physical Hazards	Uncontrolled Surface Fire	NA	II	Combustion Products; Spread of Fire Off-site	Negligible	Standard fire safety measures, trained fire fighting team on-site, fire control vehicle, fire hydrants, fire extinguisher.
	Mine Fire	NA	III	Insignificant	Negligible	MSHA safety compliance, fire suppression systems, mine rescue team trained in fire-fighting, fire extinguisher, employee safety programs
	Uncontrolled Explosion	NA	III	Spread of Fire	Negligible	Compliance with ILHR7, isolated magazine, surface fire contingency measures.
	Significant Mine Subsidence	NA	IV	Insignificant Exposure	Negligible	Reclamation as per NR 132.08.
Natural Disasters	High Precipitation	NA	II	Insignificant Exposure	Negligible	Considered in design.
	Power Disruption	NA	I	Insignificant Exposure	Negligible	Backup Generator
	Forest Fire	NA	III	Insignificant Exposure	Minor	Fire Breaks, Surface Fire Response Measures
	Tornado	NA	IV	Insignificant Exposure	Negligible	Considered in design.
	Earthquake	NA	IV	Insignificant Exposure	Negligible	Considered in design.

NA = Not Applicable

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5 Reclamation Plan

The Crandon Project reclamation plan has been developed to satisfy the requirements of NR 132.08 and to meet the standards set forth in NR 132.08(2).

5.1 Introduction

An extensive investigation of the site and a review of existing data concerning the existing environment at the site has been performed. Pertinent findings and summaries of site climate, physiography, surface soils, unconsolidated deposits, terrestrial and aquatic ecosystems, threatened and endangered species, archaeology and land use are presented in the EIR.

The locations of the proposed project facilities are shown in Figure 4-2. Existing topography of the project site is also shown in Figure 1-1. In general the site consists of rolling terrain which varies in elevation from approximately 1580 feet MSL along Hemlock Creek to approximately 1760 feet MSL between Skunk Lake and Hemlock Creek. The ground surface varies from relatively flat to slopes of approximately 25 percent (1 to 4). Surface vegetation consists mainly of northern hardwood (forest) interspersed with lowland conifer. Generally the existing project area does not contain any unique features or visual qualities. For further discussion on site aesthetics refer to EIR Section 3.13.

5.2 Regulatory Conformance

The reclamation plan is consistent with the requirements for land reclamation of the Wisconsin Administrative Code identified in Chapter NR 132 - Metallic Mineral Mining; and Chapter NR 182 - Regulation of Metallic Mining Wastes. The location within the text of this report of information that addresses specific NR 132 requirements for reclamation is listed in Table 5-1.

During a mining operation, varying degrees of land disturbance occur as part of normal activities. The degree and type of disturbance are dependent upon the mineral being extracted from the land, the mining method, and waste management system used.

The construction and operation of the Crandon Project is described in Section 4 of this submittal. This development will create surface land disturbances which cannot be returned completely to the original site condition after cessation of mining. This will be particularly true of changes in local topography caused by mine site development and the development of the TMA. However, these changes, particularly in view of the Reclamation Plan, are not considered detrimental.

Various reclamation plans were considered in the planning stages of the project to determine the most beneficial land revitalization and final use of the site at the cessation of mining. As a result of these considerations, the project site will be restored to a condition commensurate with the natural landscape, native vegetation, and wildlife. Final land use of the reclaimed project site will be compatible with existing land use on adjacent undisturbed areas at the time of final reclamation.

Table 5-1

NR 132.08 Reclamation Plan Information Key

Code	Description	Location of Information
NR 132.08 Reclamation Plan		
NR 132.08	The reclamation plan for the mining site shall include the following:	See below
NR 132.08(1)	Detailed information and maps on the reclamation procedures including:	MPA, Section 5 (Reclamation Plan) and all Figures, Section 5
NR 132.08(1)(a)	Manner, location, sequence and anticipated duration of reclamation.	MPA, Section 5 (Reclamation Plan)
NR 132.08(1)(b)	Ongoing reclamation procedures during mining operations.	MPA, Section 5 (Reclamation Plan)
NR 132.08(1)(c)	Proposed interim and final topography and slope stabilization.	MPA, Section 4.10 (Erosion Control) MPA, Section 5.0 (Reclamation Plan) MPA, Figures 5-2 thru 5-4 (Plant Site) MPA, Figures 5-5 thru 5-9 (TMA Site)
NR 132.08(1)(d)	Proposed final land use and relationship to surrounding land and land use.	MPA, Section 5-4 (Final Land Use) MPA, Figure 5-1
NR 132.08(1)(e)	Plans for long-term maintenance of mining site including:	See below
NR 132.08(1)(e)(1)	Monitoring of wastes and ground and surface water quality.	MPA, Section 10 (Long-Term Care and Maintenance)
NR 132.08(1)(e)(2)	Names of persons legally and operationally responsible for long-term maintenance.	MPA Section 10.2 (Long-Term Care Responsible Party)
NR 132.08(1)(f)	Projected costs of reclamation, including estimated cost to the state of fulfilling the reclamation plan.	MPA Section 5.12 (Reclamation Costs)
NR 132.08(2)	Evidence satisfactory to the department that the proposed reclamation will conform with the following minimum standards:	See below

Table 5-1, *(Continued)*

Code	Description	Location of Information
NR 132.08(2)(a)	All toxic and hazardous wastes, refuse, tailings and other solid waste shall be disposed of in conformance with applicable state and federal statutes or regulations.	TMA Total Report MPA Total Report
NR 132.08(2)(b)	All tunnels, shafts or other underground openings shall be sealed in a manner which will prevent seepage of water in amounts which may be expected to create a safety, health or environmental hazard, unless the applicant can demonstrate alternative uses which do not endanger public health and safety, and which conform to applicable environmental protection and mine safety laws and rules.	MPA, Section 5.6.1.2 (Mine Closure/Backfilling)
NR 132.08(2)(c)	All underground and surface runoff waters from mining sites shall be managed, impounded or treated so as to prevent soil erosion to the extent practicable, flooding, damage to agricultural lands or livestock, damage to wild animals, pollution of ground or surface waters, damage to public health or threats to public safety.	TMA, Section 6.9 (Surface Water Control System - Tailings Management Area) MPA, Section 4.10 (Erosion Control) MPA, Section 5.0 (Reclamation Plan)
NR 132.08(2)(d)	All surface structures constructed as a part of the mining activities shall be removed, unless they are converted to an acceptable alternate use.	MPA, Section 5.0 (Reclamation Plan)
NR 132.08(2)(e)	Adequate measures shall be taken to prevent significant surface subsidence, but, if such subsidence does not occur, the affected area shall be reclaimed.	MPA, Section 5.6.1.2 (Mine Closure/Backfilling)
NR 132.08(2)(f)	All topsoil from surface areas disturbed by the mining operation shall be removed and stored in an environmentally acceptable manner for use in reclamation.	MPA, Section 4.8.11.6 (Topsoil and Mulch Storage Area) MPA, Section 4.10.5.1 (Topsoil Removal and Preservation)

Table 5-1, *(Continued)*

Code	Description	Location of Information
NR 132.08(2)(g)	All disturbed surface areas shall be revegetated as soon as practicable after the disturbance to stabilize slopes and prevent air and water pollution, with the objective of re-establishing a variety of plants and animals indigenous to the area immediately prior to mining, unless such re-establishment is inconsistent with the provisions of S.144.81(15), Stats. Plant species not indigenous to the area may be used if necessary to provide rapid stabilization of slopes and prevention of erosion, if such species are acceptable to the department, but the ultimate goal of re-establishment of indigenous species shall be maintained.	MPA, Section 5.0 (Reclamation Plan)
NR 132.08(3)	If it is physically or economically impracticable or environmentally or socially undesirable for the reclamation process to return the affected area to its original state, the reasons therefore and a discussion of alternative conditions and uses to which the affected area can be put.	MPA, Section 4.7.3 (Reclamation Plan, General Description) MPA, Section 5.0 (Reclamation Plan)
NR 132.08(4)	If the anticipated life and total area of the mineral deposit are of sufficient magnitude as determined by the department, a comprehensive long-term plan showing, in detail satisfactory to the department, the manner, location and estimated sequential timetable for reclamation of the entire area of contiguous land which will be affected by mining and which is owned, leased or under option for purchase or lease by the operator at the time of application. When a mineral deposit lies on or under the lands of more than one operator, the department shall require the operators to submit mutually consistent comprehensive plans.	MPA, Section 5.0 (Reclamation Plan) MPA, Section 10.0 (Long-Term Care and Maintenance)

MPA = Mine Permit Application
EIR = Environmental Impact Report
TMA = Tailings Management Area-Feasibility Report/Plan of Operation

Prepared by: JBH1
Checked by: PAE

Reclamation planning began with the project's initial site investigation when areas disturbed during exploration and subsequent delineation of the ore body were revegetated. Attention to reclamation continued during the planning phases of the plant surface facilities, TMA, and routing of the access road and railroad spur. Consideration was given to existing site conditions, including soils, vegetation, wildlife, topography, groundwater, drainage, aesthetic characteristics, and climate. Assessments were made of the potential construction impacts on existing site condition. Specific drainage, erosion, grading, landscape, and facility siting plans were prepared to minimize anticipated site disturbance.

These assessments also were utilized in planning reclamation procedures to be used during mine construction, operation, and closure. Many of the concepts discussed below will be subject to refinement as engineering progresses to completion and as operational experience is gained. Accordingly, to the extent it may be required, this reclamation plan will be supplemented to reflect the resulting refinements.

5.3 Reclamation Sequence and Schedule

Reclamation activities related to the proposed project will commence during initial construction activities at the site and will continue until final closure of the site at the end of the long-term care period. The initial construction period will last approximately three years with subsequent construction activities within the TMA area (phased cells) occurring over the operation life of the project. The operation life of the project will be approximately 28 years. The long-term care period will last 40 years after closure. A schedule of construction, operation and long-term care activities is shown in Table 5-2.

Table 5-2

Construction, Operation, Long-Term Care Schedule

Activity	Project Year
Construction	1 - 3
Operation	4 - 31
Closure	32 - 35
Long-Term Care	36 - 75

Prepared by: JBH1
Checked by: PAE

During construction, temporary and long-term erosion control will be accomplished using techniques described in Section 4.10 of this report. Initial reclamation activities that will be used in conjunction with erosion control will be seeding of some disturbed areas with select grass seed mixes to reclaim these areas as well as to provide a source of grass seeds to be used during reclamation activities throughout the project.

Trees will generally be purchased from the nursery trade or transplanted from adjacent areas at various stages of growth to facilitate reforestation of those areas designated for savannah activities. Regrading and topsoiling reclamation activities will take place throughout the project life and at the end of the long-term care period as areas become ready for reclamation.

There are five milestone stages of activities that will dictate when major reclamation activities will occur. These milestones and related reclamation activities are shown in Table 5-3.

5.4 Final Land Use

This section of the reclamation plan contains a description of the proposed final use of the reclaimed mine development area in relation to surrounding land and land use. Specifically, the requirements of NR 132.08(1)(d) are addressed. A discussion of alternative uses is also included.

The proposed plan for revegetating the reclaimed area has been designed to conform with the requirements of NR 132.08(2)(g). The majority of the area to be affected during construction and operation is currently forested and the objective of the reclamation plan is to reestablish the disturbed areas to savannah communities. As described in Section 3.12 of the EIR, the principle existing uses of land in the proposed mine development area and the surrounding site area are forestry, recreation and agriculture. No major changes in these land uses are projected to occur at the time of project closure and final reclamation. The proposed final uses for reclaimed land associated with all major project facilities are presented in Table 5-4 and are designated in Figure 5-1. General use of the reclaimed areas for the proposed final land uses will be at the discretion of the owner at the time of issuance by the WDNR of a certificate of completion for the reclamation plan.

Alternative final land uses that were considered for the project area included an industrial complex using existing project facilities in the plant site and agricultural or intensive forestry (i.e., pine plantation) uses of the TMA area. The industrial and agricultural uses are not considered feasible at this point in the development of the project. If, because of changing conditions later in the life of the project, an alternative use proves to be more beneficial in all or part of the area to be reclaimed than the proposed uses, an amended reclamation plan containing a description of the new proposed use will be submitted to the WDNR in accordance with NR 132.12(3)(a).

The long-term goal of the reclamation plan is to allow ecological succession to occur in all the reclaimed areas. However, to enhance the establishment of a variety of woody plant species in the plant site, selected plantings of mixed hardwoods and coniferous species will be established at various locations in this management area. This will establish a diverse plant community which will enhance the recreational attributes of the reclaimed areas and will provide habitat for a variety of indigenous wildlife species. The plan will not include a specific management scheme that will require maintenance of a certain stage of plant development or succession for the benefit of one or two target game species. Rather, the plant communities will be allowed to develop to be compatible with adjacent undisturbed communities.

Table 5-3

Reclamation Milestones

Time Frame	Milestone	Reclamation Activity
Year 3	• End of construction period.	Plant site: grade, seed vacant disturbed areas TMA: seed and plant exterior slopes of cell 1 TMA Access Road: seed vacant disturbed areas Access Road: seed disturbed areas between shoulder and R.O.W. Railroad Spur: seed disturbed areas between ballast and R.O.W. Water Discharge Pipeline Corridor Structure: seed disturbed vacant areas
Year 12	• Final cover over cell 1 at TMA.	TMA: topsoil and seed cell 1 cover area
Year 23	• Final cover over cell 2 at TMA.	TMA: topsoil and seed cell 2 cover area
Year 32 to 35	• Closure period.	Plant site: - reclaim plant site - remove building except at wastewater treatment plant and discharge location - regrade area - plant and seed reclaimed areas - close mine - plant seed cover TMA: TMA cells 4 - reclaim borrow area Railroad Spur: remove tracks and ballast - topsoil, seed and plant reclaimed area
Year 75	• Cessation of long-term care period. • Removal of rest of facilities.	Plant site: • dismantle WWTF discharge location • seed and plant reclaimed areas Access Road: • dismantle wastewater pipe • dismantle and remove ditch liner • regrade site • topsoil, plant and seed reclaimed area Access Road: If no future use; remove asphalt, topsoil and seed

Prepared by: BFW
Checked by: JBH1

Table 5-4

Proposed Final Use for Reclaimed Project Land

Project Facility	Area Reclaimed Acres	Year Reclamation Complete From Start of Initial Construction	Proposed Final Use*
Access Road Corridor	37	35	Forestry/Recreation
Railroad Spur Corridor	18	35	Forestry/Recreation
Plant Site	128	35(1)	Forestry/Recreation
TMA Access Road/Tailings Transport Corridor	7	35	Forestry/Recreation
TMA/Reclaim Pond(2)	355	35	Open Green Space
Water Discharge Pipeline Corridor	2	75	Forestry/Recreation

* The proposed final uses are typically the same as the existing uses in 1995. The proposed final uses will be established if no other acceptable use is identified for the facilities.

(1) Except wastewater treatment plant, pumphouse, water discharge lagoon, electrical substation and internal access road from the plant to the TMA.

(2) Except reclaim pond; to be removed when no longer required and replace with a tank.

Prepared by: BFW
Checked by: PAE

General use of the reclaimed areas for the access road, railroad spur, plant site, access road/ tailings transport corridor and water discharge pipeline corridor will be dependent, in part, upon when the regraded soil surface is stabilized and vegetative cover is established. A decision to allow use of these reclaimed lands by anyone other than authorized project personnel or WDNR representatives will be made after a certificate of completion regarding the reclaimed land is issued pursuant to NR 132.13(1).

In the TMA area, no recreation or forestry uses will be permitted during the 40-year long-term care period. This will permit the long-term monitoring and maintenance activities associated with this facility to be performed without interference from unauthorized personnel, and will ensure stabilization of the soil surface of the reclamation cap and the establishment of vegetative cover. The access/inspection roads will not be reclaimed following project closure. These roads will be maintained to allow access for inspecting the reclaim facility and for monitoring during the period of long-term care. A decision to allow use of the reclaimed TMA will be reached in conjunction with the WDNR after issuance of the certificate(s) of completion for the reclamation plan and when use of the land will not affect monitoring and other long-term care requirements.

Forestry and recreational uses of reclaimed land associated with the access road and railroad spur and undisturbed land owned by CMC adjacent to these facilities will persist as the final use for the period that CMC maintains control of the property. Should CMC sell or lease to other parties any of the land now under control for the project, subsequent land use will be at the discretion of the new party. A suitable mechanism, such as a deed restriction, will be sought to ensure final land use of the reclaimed TMA will be restricted to those uses that will not adversely affect the function and integrity of this facility.

5.5 Final Grading Plan

Final grading and plantings plans for the project are shown in Figures 5-2 through 5-9. Final grades will be achieved in the areas designated in Figures 5-2 through 5-9 after project structures in each area have been removed using standard demolition and earth-moving techniques. These techniques include using scrapers, bulldozers, earthgraders, dump trucks and backhoes. Areas to be requiring removal of soil to obtain final grades will be cleared and grubbed. The topsoil will be temporarily stockpiled as the underlying soil is removed until base grades are achieved. The subgrade will then be scarified. The topsoil will be replaced on the scarified subbase. Areas requiring fill to obtain final grades will be cleared and grubbed, if necessary. Topsoil, if present, will be removed and temporarily stockpiled. When subgrade elevations have been achieved, topsoil will then be placed to a minimum loose thickness of six inches.

5.6 Reclamation of Plant Site

5.6.1 Environmental Protection Design

5.6.1.1 Plant Site Surface Water Control

During reclamation work stormwater runoff from the plant site and associated disturbed areas will be discharged after passing through appropriate stormwater management facilities. Areas to be disturbed include temporary storage and borrow areas and material stockpile areas as well as the access road.

During construction, runoff from any disturbed landscape will be routed to the sedimentation runoff basins planned for that area. After completion of the reclamation for each area, runoff will continue to be routed to the runoff basins until vegetation is established, at which time the runoff basins may be reclaimed and drainage will follow natural patterns.

The site drainage system has three purposes:

- To collect and treat all stormwater runoff with potential for pollutant contact;
- To collect, route and discharge stormwater runoff while minimizing ponding and nuisance flooding; and
- To control erosion and sediment transport.

The components of the surface water management system include drainage diversion berms, conveyance swales, perimeter drainage ditches, culverts, runoff sedimentation basins and wastewater storage ponds. The surface water management system for the plant site through the life of the project and through long-term care is illustrated on Figures 4-49, 4-50, 4-51 and 4-52 in Section 4 of this MPA.

Design calculations for all components of the surface water management system are provided in Appendix B of this report. The erosion control plan (Section 4.10) discusses erosion control features to be used during various operating phases.

All drainageways and swales will be designed to safely accommodate the runoff from the 25-year, 24-hour precipitation event without scouring or eroding the bottom and sides of the receiving channels. Manning's equation and Soil Conservation Service (SCS) grassed swale design procedures were used to develop ditch dimensions for the design discharge. Factors included in this analysis are channel configuration, type of soil, channel vegetation, peak flow, longitudinal slope, and channel runoff velocity. Various erosion control materials are specified for the swales, berms, and channels to help stabilize the bare ground surface until vegetation is established. Culverts will be designed to pass the peak runoff with no road overtop or erosion at the inlet or outlet points.

Runoff sedimentation basins will discharge into uplands that border the site, ultimately flowing to various wetland areas. Wastewater storage basins will discharge to the wastewater treatment plant. In addition to sediment control, the basins will provide runoff detention which will reduce peak discharges from the site thereby minimizing impacts to the surrounding areas. Table 5-5 shows the available storage area for the basins at the site, along with associated sedimentation particle size and other more specific routing information.

Based on this comparison, the actual storage areas for the sedimentation basins equal or exceed the required storage areas, and adequate sedimentation will be provided. Also, these storage volumes are conservative in that an additional storage volume is available for sediment storage which is considered dead storage for these routing calculations.

Table 5-5

Plant Site Runoff and Wastewater Storage Basin Details

Basin No.	Peak Inflow (CFS)	Peak Discharge (CFS)	Maximum Water Elevation (feet)	Storage Volume (ac. ft)	Actual Surface Area (sq. ft)[1]	Sediment Particle Size (microns)
1	59	2.4	1,652.5	3.40	47,480	3
2	39	2.5	1,617.1	1.76	23,087	5
3	30	2.4	1,634.4	1.50	23,087	5
5	33	2.4	1,646.3	1.46	22,654	5
6[2]	117	5.4	1,642.6	10.10	41,818	3

Prepared by: SRB
Checked by: MDL

[1] Water surface area at maximum water level in pond for 25-year, 24-hour precipitation event.

[2] Analysis based on storage basin No. 6 above. Since basin No. 7 is in series with basin No. 6, the actual surface area and storage volume for the combined set would be double that shown for basin No. 6 above.

The sedimentation facilities are equipped with a bypass outlet (emergency spillway). Storage is available to handle the peak flow of runoff from the 25-year, 24-hour precipitation event without damage to the treatment facility or surrounding structures. Riprap or equivalent erosion protection is provided on the discharge side of the spillway to minimize damage to the receiving areas. All discharge structures are designed to dissipate the flow discharge with perforated header pipe system. This will spread the outflow over a wide area to better match existing conditions.

5.6.1.2 Mine Closure

Mine backfilling will be an ongoing process that will begin with the backfilling of the first mined-out stope. The process will continue until mining ceases. Mine development drifts, crusher area, and other support areas will not be backfilled at the completion of mining. It is estimated that approximately 90 percent of the underground voids will be backfilled. At the completion of mining, any equipment located in the mine will either be removed or the oils and other fluids will be drained and the equipment left in place.

The main production shaft, east shaft and west ventilation shaft will be bulkheaded with reinforced, vented concrete plugs located at the glacial overburden/bedrock interface and will be keyed into the bedrock. Above the concrete plugs the shafts will be backfilled with select, inert materials. Backfill procedures will take settlement into account.

The backfilling of the mine will incorporate procedures and design aspects to minimize potential acidification conditions. The abandoned areas of the mine will be located below the water table after the water table has recovered upon cessation of mine dewatering. It is anticipated that the available oxygen content of the water at these depths will be very low and acidification will not occur.

As part of the project's groundwater modeling work GeoTrans, Inc., CMC's groundwater modeling consultant, completed an analysis to assess the potential for upward movement of solute from the backfilled mine into the glacial system following mine reflooding. The GeoTrans report can be found in Appendix 4.2-3 of the project's EIR. Following is a summary of the results of their work.

The mine reflooding analysis was performed with the project's calibrated groundwater flow model (MODFLOW) and particle tracking using MODPATH. MODPATH is a code developed by Daniel W. Pollack at the U.S. Geological Survey that is an extension of MODFLOW. MODPATH allows the user to input starting particle locations. The code then tracks the particles as they move through the formations. Particle tracking is typically used in solute transport codes that use Method of Characteristic techniques (such as MT3D) to assess the advective transport of the groundwater system. Particle tracking was selected as a scoping analysis to efficiently analyze advection travel paths and travel times in three dimensions. A solute transport model would only be necessary if the particle tracking indicated that advective flow to a compliance boundary set in the till 1200 feet from the ore body was significant.

The particle tracking model assumed that the mine will be backfilled with cemented and uncemented tailings having a bulk hydraulic conductivity of 2.8E-3 ft/day (1.0E-6 cm/s). The particle tracking analysis used the best engineering judgement flow field and a practical worst case flow field to assess the potential range of travel times from the mine to the glacial overburden. The analysis using the best engineering judgement flow field showed that is takes over 2,000 years for the first particle originating in the mine to reach the compliance boundary. This particle traveled upward from the mine into the till and laterally in the till to the compliance boundary. The analysis also showed that only one of the 146 particles used approaches the compliance boundary at 2,000 years. The practical worst case simulations represent a combination of possible, but unlikely factors, that could cause advective transport in excess of the best engineering judgement case. The analysis showed that at 300 years, only one of the 146 particles approaches the compliance boundary.

The particle tracking results showed that advective travel times from the mine to the compliance boundary in the glacial overburden ranged from 300 years for the practical worst case scenario to over 2,000 years for the best engineering judgement scenario. These excessively long travel times represent a low potential for solute to travel from the mine to the glacial overburden. Solute transport modeling of the reflooded mine would indicate an even longer time for the concentration to peak at the compliance boundary. The longer time is due to the inclusion of dispersion and mixing which would further reduce solute concentrations.

Based on the particle tracking analysis, it was determined that solute transport modeling was not necessary for the reflooded mine due to:

- The very low rate of solute movement from the backfilled mine upward through the crown pillar rock and massive saprolite.

- The long travel time for solute particles from the mined areas to the compliance boundary.
- The conservative nature of particle tracking which does not account for mixing and dispersion.
- Neglect of chemical precipitation and absorption which would also increase travel times and reduce concentrations of a number of constituents in the reflooded mine water.

Further details regarding the modeling work completed for the reflooded mine can be found in Appendix 4.2-3 of the project's EIR.

5.6.2 Closure Operations

5.6.2.1 Plant Site

The plant site will remain active throughout the life of the mine. During cessation of mining at approximately year 32 the plant site will begin to be reclaimed. The components of the plant site that will be reclaimed at that time will consist of all mine support facilities, including the concentrator building, services building, storage buildings, hoist houses, ventilation equipment, preproduction ore storage area, construction materials storage area, parking lot, storage tanks, covered coarse ore storage area and the water storage basins. The only remaining structures at this time will be the wastewater treatment plant and associated lime storage facilities, substation facilities, pump house, discharge lagoons, and access road.

5.6.2.2 Lined Facilities

The lined facilities will be removed at closure. Removal will generally occur from the top down. Excavation will be accomplished using standard excavation equipment, including bulldozers, front end loaders, backhoes and dump trucks. After the surface layers have been removed, the underlying clay and top two inches of compacted subgrade will then be excavated concurrently. All excavated material will be placed in the TMA or an approved landfill.

5.6.2.3 Buildings

Buildings will be removed in accordance with the schedule shown in Table 5-3. Building walls will be totally disassembled and removed. Floor slabs and footings will be left in place and covered.

5.6.2.4 Unlined Ponds and Storage Areas

Unlined ponds and storage areas will be regraded and cut/filled as necessary to reach final grade levels as described in Section 5.5.

5.6.3 Plant Site and Wastewater Treatment Facilities

5.6.3.1 End of Construction (Year 3)

The purpose of the landscape plan is to revegetate the plant site in a manner that is functional, aesthetic and self-sustaining. Upon completion of construction at the plant site, areas within the

plant site will either be occupied by plant buildings, graveled, or seeded to provide soil stabilization and wildlife habitat.

The first areas to be permanently revegetated in the plant site during construction will be the public entrance areas that surround the permanent parking area as shown in Figure 5-2. These areas will be graded and topsoiled to a depth of four to six inches and seeded to grasses and forbs. The sites within the plant area that will be seeded to grass are generally on the periphery of the site. The topsoil stockpile and some of the area adjacent to it will also be seeded with a grass mix. Areas seeded to grasses in the early stages of the mine development and operation may serve as a seed bank for subsequent seedings elsewhere on the project.

5.6.3.2 Cessation of Mining (Year 31)

Upon completion of mining, all buildings and supporting materials will be dismantled and removed, except for the electrical substation, wastewater treatment plant, the discharge lagoons, the pump house and the access roads needed to service these facilities through the long-term care period. Soils will be prepared for seeding and planting as described in section 5.11.2. Upon completion of final grading and topsoiling, the entire plant site (excluding the facilities already mentioned), will be revegetated as per the plan shown in Figure 5-3. The final plant community that will inhabit the site will consist of grasses, forbes, and trees to form savannah copses spread across the entire site.

After final grading has been completed the tree copses will be planted in a random pattern. After the trees are planted the grasses and forbs will be drilled and broadcast as needed to completely seed the plant site so as to control erosion, provide vegetative cover and continue the process of reclamation. Typical species lists which will provide the basis for species selected for use at the plant site are shown in Tables 5-6 and 5-7.

5.6.3.3 Cessation of Long-Term Care (Year 75)

At the completion of the long term care period or earlier if it is determined that the facilities are no longer required, the wastewater treatment facility, the pump house, the discharge lagoons and the roads that serviced these facilities will be dismantled and removed from the site. The soils will be prepared as per Section 5.11.2. Upon completion of topsoiling and final grading these last areas will be planted with the same species that will be used for the plant site closure in year 32. The final reclamation plan for the plant site is shown in Figure 5-4.

5.6.4 Reclamation Maintenance

5.6.4.1 Construction

During construction, seeding will begin as soon as portions of the site are brought to final grade and a suitable seedbed has been prepared. No landscape plants will be installed in temporarily disturbed or unfinished areas of the site. Seeding methods and materials are presented in section 5.11.2.2. Maintenance during the construction period should follow the guidelines as put forward in section 5.11.2.4, Short-Term Maintenance.

Table 5-6

Indigenous and Introduced Herbaceous Plant Species For Use in Temporary and Permanent Soil Stabilization

Plant Species		
Seed mixes recommended for dryer soils Native North American Grassland Forbs		Suggested rate/acre*
Yarrow (*Achillea millefolium*)		0.5 oz bulk
Leadplant (*Amorpha canescens*)		2.0 oz bulk
Butterfly weed (*Asclepias tuberosa*)		3.0 oz bulk
Azure aster (*Aster oolentangiensis*)		2.0 oz bulk
Stiff sunflower (*Helianthus rigidus*)		0.5 oz bulk
Bush clover (*Lespedeza capitata*)		2.0 oz bulk
Rough blazing star (*Liatris aspera*)		3.0 oz bulk
Wild lupine (*Lupinus perennis*)		2.0 oz bulk
Wild bergamot (*Monarda fistulosa*)		1.5 oz bulk
White prairie clover (*Petalostemum candidum*)		2.0 oz bulk
Purple prairie clover (*P. Purpureum*)		3.0 oz bulk
Black-eyed susan (*Rudbeckia hirta*)		5.0 oz bulk
Gray goldenrod (*Solidago nemoralis*)		1.0 oz bulk
Stiff goldenrod (*Solidago rigida*)		1.0 oz bulk
Total		32.0 oz/acre
Native North American Grassland Grasses	Drilled Rate	Broadcast Rate
Big Bluestem (*Andropogon gerardi*)	1.0 lbs PLS	2.0 lbs PLS
Oatgrass (*Danthonia spicata*)	2.0 lbs PLS	4.0 lbs PLS
Canada wild rye (*Elymus canadensis*)	1.0 lbs PLS	2.0 lbs PLS
June grass (*Koeleria macrantha*)	1.0 lbs bulk	2.0 lbs bulk
Little bluestem (*Schizachyrium scoparium*)	5.0 lbs PLS	7.0 lbs PLS
Totals	10 lbs/acre	17 lbs/acre

Note: This is a typical list of plants for use in site reclamation and is subject to modification.
* Flower seed is broadcast only.
Introduced species used as a cover crop:
Oats (spring planting) 40 lbs. per acre.
Winter wheat (fall planting) 40 lbs. per acre.
PLS = Pure live seed.

Table 5-6 *(Continued)*

Plant Species		
Seed mixes recommended for mesic soils Native North American Grassland Forbs		Suggested rate/acre*
Yarrow (*Achillea millefolium*)		0.5 oz bulk
Fragrant giant hyssop (*Agastache foeniculum*)		1.0 oz bulk
Butterfly weed (*Asclepias tuberosa*)		3.0 oz bulk
Canada tick-trefoil (*Desmodium canadense*)		1.5 oz bulk
Northern bedstraw (*Galium boreale*)		1.0 oz bulk
Common ox-eye (*Heliopsis helianthoides*)		2.0 oz bulk
Rough blazing star (*Liatris pycnostachya*)		3.0 oz bulk
Wild bergamot (*Monarda fistulosa*)		1.5 oz bulk
White prairie clover (*Petalostemum candidum*)		3.0 oz bulk
Purple p. clover (*petalostemum purpureum*)		3.0 oz bulk
Black-eyed susan (*Rudbeckia hirta*)		5.0 oz bulk
Stiff goldenrod (*Solidago rigida*)		1.0 oz bulk
Culvers root (*Veronicastrum virginicum*)		0.5 oz bulk
Golden alexander (*Zizia aurea*)		2.0 oz bulk
Total		27.50 oz/acre
Native North American Grassland Grasses	Drilled rate	Broadcast rate
Big bluestem (*Andropogon gerardi*)	4.0 lbs PLS	6.0 lbs PLS
Oatgrass (*Danthonia spicata*)	1.0 lbs PLS	2.0 lbs PLS
Canada wild rye (*Elymus canadensis*)	1.5 lbs PLS	2.0 lbs PLS
Switch grass (*Panicum virgatum*)	0.5 lbs PLS	2.0 lbs PLS
Little bluestem (*Schizachyrium scoparium*)	1.5 lbs PLS	3.0 lbs PLS
Indian grass (*Sorghastrum nutans*)	2.0 lbs PLS	4.0 lbs PLS
Totals	10.5 lbs/acre	18.0 lbs/acre

Note: This is a typical list of plants for use in site reclamation and is subject to modification.
* Flower seed is broadcast only.
Introduced species used as a cover crop:
Oats (spring planting) 40 lbs. per acre.
Winter wheat (fall planting) 40 lbs. per acre.
PLS = Pure live seed.

Table 5-6 *(Continued)*

Plant Species		
Seed mixes recommended for hydric soils Native North American Grassland Forbs		Suggested rate/acre*
Swamp milkweed (*Asclepias incarnate*)		2.0 oz bulk
New England aster (*Aster novae-angliae*)		1.0 oz bulk
Joe-pye week (*Eupatorium maculatum*)		1.5 oz bulk
Boneset (*Eupatorium perfoliatum*)		1.5 oz bulk
Common ox-eye (*Heliopsis helianthoides*)		2.0 oz bulk
Tall blazing star (*Liatris pycnostachya*)		3.0 oz bulk
Black-eyed susan (*Rudbeckia hirta*)		5.0 oz bulk
Arrow-head (*Sagittarian Iatifolia*)		0.5 oz bulk
Blue vervain (*Verbena hastata*)		1.0 oz bulk
Culvers root (*Veronicastrum virginicum*)		0.5 oz bulk
Golden alexander (*Zizia aurea*)		2.0 oz bulk
Total		24.0 oz/acre
Native North American Grassland Grasses	Drilled rate	Broadcast rate
Big bluestem (*Andropogon gerardi*)	2.0 lbs PLS	3.0 lbs PLS
Canada wild rye (*Elymus canadensis*)	2.0 lbs PLS	4.0 lbs PLS
Switch grass (*Panicum virgatum*)	0.5 lbs PLS	0.5 lbs PLS
Fringed brome (*Bromus ciliatus*)	1.0 lbs PLS	2.0 lbs PLS
Tussock sedge (*Carex atricta*)	1.0 lbs bulk	2.0 lbs bulk
Cord grass (*Spartina pectinata*)	1.0 lb bulk	2.0 lb bulk
Wool grass (*Scirpus cyperinus*)	0.5 lb bulk	1.0 lb bulk
Totals	9.0 lbs/acre	16.5 lbs/acre

Note: Blue joint (*Calamagrostis canadensis*) would be excellent to add to, or be the major component of the above grass mix. However, Blue joint is very expensive at this time and difficult to find.

* Flower seed is broadcast only.

Introduced species used as a cover crop:

Oats (spring planting) 40 lbs. per acre.
Winter wheat (fall planting) 40 lbs. per acre.
PLS = Pure live seed.

Table 5-6 *(Continued)*

Plant Species	
Seed mixes recommended for tall grass woods edge savanna Native North American Grassland Forbs	Suggested rate/acre*
Yellow (*Achillea millefolium*)	0.5 oz bulk
Columbine (*Aquilegia canadensis*)	1.0 oz bulk
Calico Aster (*Aster lateriflorus*)	0.5 oz bulk
Joe-pye weed (*Eupatorium purpureum*)	1.0 oz bulk
White Snakeroot (*Eupatorium rugosum*)	1.0 oz bulk
Northern bedstraw (*Galium boreale*)	0.5 oz bulk
Common ox-eye (*Heliopsis helianthoides*)	1.0 oz bulk
Rough blazing star (*Liatris aspera*)	1.0 oz bulk
Wild lupine (*Lupinus perennis*)	3.0 oz bulk
Wild bergamot (*Monarda fistulosa*)	1.0 oz bulk
White prairie clover (*Petalostemum candidum*)	2.0 oz bulk
Purple prairie clover (*Petalostemum purpureum*)	4.0 oz bulk
Lion's foot (*Prenanthes alba*)	0.5 oz bulk
Black-eyed Susan (*Rudbeckia hirta*)	3.0 oz bulk
Early Meadow Rue (*Thalictrum dioicum*)	2.0 oz bulk
	20.5 oz bulk
Native North American Grassland Grasses	
Big Bluestem (*Andropogon gerardi*)	2.0 lbs PLS
Hairy Wood Chess (*Bromus purgans*)	1.0 lbs bulk
Oatgrass (*Danthonia spicata*)	1.0 lbs bulk
Canada Wild Rye (*Elymus canadensis*)	1.0 lbs bulk
Virginia Wild Rye (*Elymus virginious*)	1.0 lbs bulk
False melic (*Schizachne purpurascens*)	0.5 lbs bulk
Bottlebrush Grass (*Hystix patula*)	1 lb bulk
Little Bluestem (*Schizachrium scoparium*)	3 lbs PLS
	10.5 lbs

Note: This is a typical list of plants for use in site reclamation and is subject to modification.
* Flower seed is broadcast only.
Introduced species used as a cover crop:
Oats (spring planting) 40 lbs. per acre.
Winter wheat (fall planting) 40 lbs. per acre.

Table 5-6 *(Continued)*

Plant Species		
Introduced species for turf area Fine fescue/perennial rye grass mixture Variety		Percent
SR 3000 Hard Fescue		15.0
Scaldis Hard Fescue		15.0
Hector Red Fescue		10.0
Dawson Red Fescue		10.0
Mary Chewings Fescue		20.0
Azay Sheep Fescue		20.0
SR4200 Dwarf Rye grass		10.0
Rate of seeding (lbs per 1,000 sq. ft.) = 5 lbs	Total	100.0

Prepared by: BFW
Checked by: JBH1

Table 5-7

Indigenous Hardwood and Evergreen Trees for Use in Planting Savannah Copses and Woodland Areas

Plant Species
Trees
Northern Hardwoods - MESIC
Sugar Maple *(Acer saachararum)*
Basswood *(Tilia americana)*
Quaking Aspen *(Populus tremuloides)*
Yellow Birch *(Betula allegheniensis)*
White Birch *(Betula papyrifera)*
Red Oak *(Quercus rubra)*
Red Maple *(Acer rubrum)*
Ironwood *(Ostrya virginiana)*
Hemlock *(Tsuga canadensis)*
White Pine *(Pinus strobus)*
Lowland Hardwoods
Red Maple *(Acer rubrum)*
Black Ash *(Fraxinus nigra)*
Yellow Birch *(Betula alleghaniensis)*
White Birch *(Betula papyrifera)*
Quaking Aspen *(Populus tremuloides)*
Green Ash *(Fraxinus pennsylvanica)*
Iron Wood *(Ostuga virginiana)*
White Cedar *(Thuja occidentalis)*
Balsam Fir *(Ables balsomea)*
Tamarack *(Larix laricina)*
Black Spruce *(Picea mariana)*
White Pine *(Pinus strobus)*

Woody plant species for use in landscaping and reclamation will consist of a mixture of the above indigenous species suitable to meet long-term management objectives for each management unit. Species will be selected by soil type and soil moisture.

Note: The above lists identify typical plant species that could be used in landscaping/reclamation of project facilities. These species lists may be modified in consultation with the WDNR.

Prepared by: BFW
Checked by: JBH1

5.6.4.2 During Operation

The restored native plant communities will be maintained on an as needed basis to allow development in a manner consistent with similar naturally occurring plant communities. Volunteer native species will be left to develop. Guidelines as put forth in section 5.11.2.4, Short-Term Maintenance, will be followed during the period of operation as well.

Grassland vegetation will initially be managed by mowing or controlled burning on an as needed basis. Burning only the grassland helps to stimulate seed production. Since the plant site may be used as a seed source for other areas of the mine site, burning may be used when seed will be harvested in the same year.

5.6.4.3 Long-Term Care

During the long-term care period (year 35-75), the restored native plant communities will be maintained on an as needed basis to allow development in a manner consistent with similar naturally occurring plant communities. Volunteer native species will be left to develop.

If during the annual monitoring of the project area, it is determined that the plant community is under stress, CMC will evaluate the need to add additional plant materials, or any other action deemed necessary to correct the condition.

5.7 Reclamation of TMA and Borrow Area

5.7.1 Environmental Protection Design

5.7.1.1 Surface Water Control

Stormwater from the top of the active TMA cell berm will be directed into the TMA cell. Stormwater runoff from the external slopes and other noncontact areas will be managed with the surface water control system. Stormwater runoff for the various phases of operation and associated disturbed areas will be collected and routed through the required stormwater management facilities. Areas disturbed include temporary borrow and material stockpile areas as well as the access road. Runoff from these areas will also be properly managed before being discharged.

During operation activities in any area, runoff from the disturbed landscape will be routed to the runoff basin planned for that area. After completion of construction for each area, runoff will continue to be routed to the basins until vegetation is established, at which time the basins may be reclaimed after which drainage will follow natural patterns.

The site drainage system has three purposes:

- To collect and treat contact stormwater runoff.
- To collect, route and discharge stormwater runoff while minimizing ponding and subsequent infiltration into the TMA.
- To control erosion and sediment transport.

The components of the surface water management system include drainage diversion berms, downslope swales, perimeter drainage ditches, culverts, and runoff basins. The TMA surface water management system is discussed in Section 4 of the MPA.

To control surface runoff over the final cover of the reclaimed TMA, a series of surface water diversion berms may be provided. The diversion berms may be used as needed to help reduce erosion by dividing the drainage flow lengths into shorter segments and allows direction of flow to match existing condition hydrology to the various wetlands. Each diversion berm collects and conveys runoff to a downslope drainageway which in turn discharges the collected runoff to a perimeter drainage ditch. The perimeter drainage ditches convey the surface water runoff to runoff basins, provided at various points around the facility. The runoff basins will be in place for construction and may be removed after the areas have ben seeded and vegetation established. The runoff basins located around the site are shown on Figures 4-53 through 4-56. The runoff basins will discharge into uplands that border the site, ultimately flowing to various wetland areas. In addition to sediment control, the basins will provide runoff detention which will reduce peak discharges from the site thereby minimizing any impact to the surrounding areas.

The storage and outlet capabilities of the basins will be such that peak runoff from the 100-year, 24-hour precipitation event will be stored without reaching the emergency spillway elevation of the basin, meeting the requirements of NR 182.11. Appendices to the project's TMA Feasibility Report/Plan of Operation contain design calculations and the TR-55 hydrology and POND2 (Haestad Methods routing program) documentation showing the adequacy of the design. Table 5-8 shows the available storage area for the basins at the site, along with associated sedimentation particle sizes and other more specific routing information.

Table 5-8

TMA Runoff Basin Details

Runoff Basin No.	Peak Inflow (CFS)	Peak Discharge (CFS)	Maximum Water Elevation (ft)	Storage Volume (Ac-Ft)	Water Surface Area (sq. ft)[1]	Sediment Particle Size (microns)
4[2]	15	1.6	1,596.8	0.79	19,602	5
8	52	9.8	1,628.7	3.14	42,690	3
9	45	7.8	1,694.3	2.47	82,764	2
10	42	9.2	1,650.9	2.12	35,284	3
11	60	10.5	1,656.7	3.60	39,204	3
12	31	8.5	1,701.0	1.42	32,234	4

[1] Water surface area at maximum water level in pond for 100 year, 24 hour precipitation event.
[2] Runoff basin is part of the tailings pipeline draindown sump.

Prepared by: SRB
Checked by: MDL

All drainageways and swales in the TMA will be designed to accommodate the runoff from the 100-year, 24-hour precipitation event without scouring or eroding the bottom and sides of the receiving channels. Manning's equation and Soil Conservation Service (SCS) grassed swale design procedures will be used to develop ditch dimensions adequate for the design discharge. Factors included in this analysis include channel configuration, type of soil, channel vegetation, peak flow, longitudinal slope, and channel runoff velocity. Velocities will be checked for erosion and sediment deposition problems. Various erosion control materials are specified for the swales, berms, and channels to help stabilize the bare ground surface until vegetation is established. Culverts will be designed to pass the peak runoff with no road overtop or erosion at the inlet or outlet points.

The required storage areas for adequate sedimentation have been provided in the design of these runoff basins. These storage volumes are conservative in that an additional storage volume is available for sediment storage which is considered dead storage for these routing calculations.

The runoff facilities are equipped with a bypass outlet or emergency spillway. Storage is available to handle the peak flow of runoff from the 100-year, 24-hour precipitation event without damage to the treatment facility or surrounding structures. Riprap or equivalent erosion protection is provided on the discharge side of the spillway to minimize damage to the receiving areas.

All discharge structures are designed to dissipate the flow discharge with perforated header pipe system. This will spread the outflow over a wide area to better match existing conditions.

5.7.1.2 Liner

Specific design information concerning the TMA liner is contained in Feasibility Report/Plan of Operation. Generally, the primary goal of the TMA liner design is to provide an effective hydraulic barrier beneath the tailings to contain the tailings pore water (leachate) and to allow for the effective removal of the leachate during operations and for a period of time after closure.

The composite liner and leachate collection system components consist of seven distinct layers for which the design rationale and function is explained in the subsections which follow. Two types of liner systems are proposed, one for the cell bottoms and the second for the interior slopes of the cell. The liner on the cell bottoms (and partially up the interior side-slopes) is overlain by leachate drainage layers. The two types of liner system have components from top to bottom as follows:

- Base liner system configuration

  - 18 inches riprap
  - 6 inches fines from the till processing (filter layer)
  - 18 inches glacial till (filter layer)
  - geotextile (filtering)
  - 24 inches gravel (drainage layer)
  - geotextile (cushioning)
  - 60 mil thermoplastic geomembrane
  - 12 inches of low permeability soils
  - prepared subgrade consisting of compacted till or native till soils

- Interior sloped configuration of composite liner

  - 18 inches riprap (only on interior slopes where required during final deposition)
  - 18 inches of glacial till (protective layer)
  - geotextile (cushioning)
  - 60 mil textured thermoplastic geomembrane
  - 12 inches of low permeability soil
  - prepared subgrade consisting of compacted till fill or native till soils

5.7.1.3 Leachate Collection System

The TMA Leachate Collection System (LCS) is designed to meet the following performance goals:

- provide efficient collection and limit the head on the liner during operation and the post-closure period;

- provide a LCS which, along with the liner, will meet the overall allowable leakage rates during the design period;

- provide a LCS which will effectively function given the operating conditions, operating loads and tailings characteristics;

- provide a LCS which can be cleaned during the operating and closure period; and

- provide a LCS with an effective liquids removal system.

The primary design function of the LCS is to convey tailings pore water (leachate) to the collection points in the most efficient manner possible. The primary design function is accomplished by the four main components of the LCS which are the leachate drainage layer, the leachate collection system piping, the leachate removal system, and the leachate transfer system. The design of these four components is addressed in the TMA Feasibility Report/Plan of Operation.

5.7.1.4 Final Cover

The TMA has been designed to limit tailings oxidation and solute release from the tailings mass through:

- the placement of tailings at a high pH, with excess alkalinity to minimize the potential for acid generation during operation;

- limiting oxygen entry into tailings during the operating and post-closure period;

- the design of a composite base liner system to limit percolation rates; and

- the design of a final cover which meets the following objectives:
  - limits oxygen entry into the tailings mass,
  - limits infiltration of precipitation into the tailings mass using a hydraulic barrier of equal or less permeability compared to the TMA base liner,
  - provides a stable surface which can meet reclamation requirements, and
  - provides an erosion-resistant surface.

The selected final cover which meets the stated design criteria consists of a multi-layered cover system, including the following components from top to bottom:

- topsoil and vegetative layer
- rooting layer
- drainage layer
- thermoplastic geomembrane
- low permeability soil layer
- grading layers and support layers where required

5.7.1.5 Potential Impacts to Groundwater

A concerted effort has been put forth in the design and planning of the TMA to contain and control releases to the groundwater that would be environmentally detrimental. The results of the evaluation of the TMA design as it relates to groundwater quality standards is contained in Section 4 of the EIR and Section 6.17 of the *TMA Feasibility Report/Plan of Operation.*

5.7.2 Reclamation of TMA Site - Phased Reclamation Activities

5.7.2.1 End of Construction (Year 3)

The plant community selected to revegetate the TMA site for final reclamation is a grassland community. This community will add wildlife cover and year round color and interest to the TMA.

The revegetation of the TMA site will be performed using a combination of seed mixes listed in Table 5-6. Areas that will not be disturbed for the duration of the mining operation will be seeded to the proper seed mix based on soil composition, moisture and aspect. These areas will be seeded with a cover crop to help control erosion as the native plants develop. In the areas that will be disturbed by subsequent construction, a standard WDOT seed mix No. 30, or equivalent, 1989 Edition, will be placed to control erosion, and provide a vegetative cover. The phased landscape reclamation plan for year 3 is shown in Figure 5-5.

5.7.2.2 Closure of Cell 1 (Year 12)

Upon closure of Cell 1, with final grading and topsoiling the vegetation for final reclamation will be grass species selected from Table 5-6 that will meet soil conditions on site. The vegetation shall be placed as described in Section 5.11.2.2, Seeding and Planting Methods. Figure 5-6 shows the areas and associated seed mix.

5.7.2.3 Closure of Cell 2 (Year 23)

Upon closure of Cell 2, with final grading and topsoiling the vegetation for final reclamation will be grass species selected from Table 5-6 that will meet soil conditions on site. The vegetation shall be placed as described in Section 5.11.2.2, Seeding and Planting Methods. The seeds needed to plant grasses on the Cell 2 cover could be able to be collected from Cell 1 and other areas within the project that have established grass areas. Figure 5-7 shows the areas of seeding and associated seed mix.

5.7.2.4 Closure of Cell 3 and 4 (Year 28 and 34)

Upon closure of Cell 3 and 4, with final grading and topsoiling the vegetation for final reclamation will be prairie species selected from Table 5-6 that will meet soil conditions on site. The vegetation shall be placed as shown in Figures 5-8 and 5-9, as described in Section 5.11.2.2, Seeding and Planting Methods. The seeds needed to plant grass on Cell 3 and 4 should be able to be collected from Cells 1, 2 and other areas within the project that have established grass areas.

The borrow area will be reclaimed at this time and will be planted to a savannah community. Trees will be planted in random groups and placed to blend and soften the edge of the existing forest. Trees will be planted and grass species selected to match soil conditions on site.

5.7.2.5 Cessation of Long-Term Care (Year 75)

At the cessation of long-term care all access roads will be removed and reclaimed. Vegetation or soils that are disturbed at this time will be repaired.

Between year 55 and year 75, the process water storage tank as well as the access roads will be reclaimed when the facilities are no longer needed. These areas will be planted to a savannah community. Trees will be planted in random groups and placed to blend and soften the edge of the existing forest. Trees will be planted and grass species selected to match soil conditions on site.

Table 5-9 contains a summary of the expected functional characteristics of vegetation in the reclaimed TMA and borrow area, 15 years after reclamation. The final plan for revegetating the TMA and borrow area is shown in Figure 5-9.

5.7.3 Reclamation Maintenance

5.7.3.1 Construction

During construction of the TMA area, revegetation will begin as soon as portions of the site are brought to final grade and a suitable seedbed has been prepared. No revegetation will be done in temporarily disturbed or unfinished areas of the site. The seeding methods and materials are presented in Section 5.11.2.2, Seeding and Planting Methods. Maintenance during the construction period should follow the guidelines as put forward in Section 5.11.2.4, Short-Term Maintenance. Species selection will be from Table 5-6.

Table 5-9

Expected Vegetation Characteristics (Structure, Function and Aesthetics) of Reclaimed Project Areas 15 Years After Final Closure

Area	Structure		Function	Aesthetics
	Vertical	Horizontal		
Access Road				
Recreation	Ground layer of forbs and grasses; clumps of planted conifers/hardwoods; random distribution of shrubs and trees.	Mixture of forbs and grasses with random distribution of shrubs and trees; occasional clumps of planted trees; irregular edge along original cleared zone.	Erosion control; wildlife habitat/travel lanes; recreational use.	Visual diversity and enhancement; year-round color.
Railroad Spur				
Recreation	Ground layer of forbs and grasses; shrubs and trees.	Mixture of forbs and grasses with random distribution of shrubs and trees; irregular edge along original cleared zone.	Erosion control; wildlife habitat/travel lanes; recreational use.	Visual diversity and enhancement. Year-round color
Plant Site				
Recreation	Ground layer of forbs and grasses; scattered clumps and planted conifers/hardwoods; random distribution of shrubs and trees. A Savannah community.	Clumps of conifer/hardwood plantings from original landscaping; mixture of forbs and grasses with random distribution of shrubs and trees; irregular edge along original cleared zone.	Erosion control; wildlife habitat; recreational use.	Visual diversity and enhancement; year-round color; continuity with undisturbed areas. Enhancement of recreational use by providing plant diversity and large open areas.
Discharge Pipeline Corridor				

Table 5-9 *(Continued)*

Area	Structure		Function	Aesthetics
	Vertical	Horizontal		
Recreation	Ground layer of forbs and grasses; mixture of trees and shrubs from invasion.	Mixture of forbs and grasses in uplands; closed canopy n upland forested segments; wetland species in lowland areas.	Erosion control; wildlife habitat/travel lanes; recreational use.	Visual diversity and enhancement.
TMA Access Road/Tailings Transport Pipeline Corridor				
Recreation	Ground layer of forbs and grasses; random distribution of shrubs and trees.	Mixture of forbs and grasses with random distribution of shrubs and trees; irregular edge along original cleared zone.	Erosion control; wildlife habitat/travel lanes; recreational use.	Visual diversity.
TMA				
Open Green Space	Ground layer of forbs and grasses.	Mixture of forbs and grasses over entire area; early successional shrubs.	Erosion control; wildlife habitat/travel lanes.	Visual diversity and enhancement; year-round color.

Prepared by: BFW
Checked by: JBH1

5.7.3.2 During Operation

The restored native plant communities will be maintained on an as needed basis to allow development in a manner consistent with similar naturally occurring plant communities. Volunteer native species will be left to develop. Alien plant species that invade the restored areas will be eradicated and removed if deemed not desirable and invasive or damaging to the ongoing reclamation process. Guidelines as put forth in Section 5.11.2.4, Short-Term Maintenance and will be followed during the period of operation as well.

Grassland vegetation may be managed by mowing as necessary. Mowing the grassland helps to stimulate seed production in prairie plants.

5.7.3.3 Long-Term Care

During the long-term care period (years 35-75), the restored native plant communities will be maintained on an as needed basis to allow development in a manner consistent with similar naturally occurring plant communities. Volunteer non-woody native species will be left to develop along with the planted herbaceous species. Tree species that invade the restored areas on top of the capped TMA site will be eradicated and removed if root growth is deemed a hazard to the integrity of the cap. Trees that volunteer on the side slopes that do not pose a possible hazard to the capped TMA will be allowed to grow and develop. Guidelines as put forth in Section 5.11.2.4, Short-Term Maintenance will be followed during the period of long-term care as well.

If during the monitoring of the project area, it is determined that the plant community is under stress, CMC will add additional plant materials, or take other action it deems necessary to correct the condition.

5.8 Reclamation of Access Road/Tailings Transport System

The access road and tailings transport system between the plant site and the TMA have been designed to minimize contact water. They have also been designed to provide longer term access to the TMA site during the long term care period and to provide a containment system for the post-closure transport of leachate from the TMA to the wastewater treatment plant at the plant site.

Once these facilities are no longer required, the piping, trench and sump will be reclaimed. The pipelines will be dismantled and removed from the site and properly disposed of pursuant to pertinent regulations. The trench and sump liner system will be excavated with standard equipment and disposed of pursuant to pertinent regulations. During the post-closure period TMA leachate will be transported by truck from the reclaim pond to the wastewater treatment plant.

5.8.1 Access Road/Tailings Transport System: Phased Reclamation Activities

5.8.1.1 End of Construction (Year 3)

Upon completion of construction of the TMA Access Road, the right-of-way will be graded, topsoiled and seeded. The areas of the right-of-way that will have the pipeline on it will be planted to a grass seed mix appropriate to the site. The species that will be used in the reclamation can be found in Table 5-6.

5.8.1.2 Cessation of Mining (Year 31)

At the cessation of mining the tailings transport pipeline will be dismantled and removed from the site. The TMA access road and water reclaim pipeline will remain in place for monitoring of the TMA during the long-term care period.

5.8.1.3 Cessation of Long-Term Care (Year 75)

The water reclaim pipeline will be dismantled and removed from the site when it is no longer required. The road base will be left in place and covered with a topsoil layer sufficient to allow vegetation to establish. The ditches will be filled in and regraded to blend the old road bed with adjacent grades. The TMA access road corridor will be reclaimed with prairie vegetation. Appropriate vegetation from the species listed in Table 5-6 will be seeded following guidelines in Section 5.11.2.2.

5.8.2 Reclamation Maintenance

5.8.2.1 Construction

During construction of the TMA access road/tailings transport system, seeding will begin as soon as portions of the site are brought to final grade and a suitable seedbed has been prepared. The seeding and planting methods and materials are presented in Section 5.11.2.2. Maintenance during the construction period should follow the guidelines as put forward in Section 5.11.2.4, Short-Term Maintenance. Species selection will be from Table 5-6.

5.8.2.2 During Operation

The restored native plant communities will be maintained on an as needed basis to allow development in a manner consistent with similar naturally occurring plant communities. Volunteer native species will be left to develop. Guidelines as put forth in Section 5.11.2.4, Short-Term Maintenance and should be followed during the period of operation as well.

5.8.2.3 Long-Term Care

During the long-term care period (Year 35-75), the restored native plant communities will be maintained on an as needed basis to allow development in a manner consistent with similar naturally occurring plant communities. Volunteer non-woody native species will be left to develop along with the planted herbaceous species. Woody species that encroach on the road and pose a safety hazard will be removed. Guidelines as put forth in Section 5.11.2.4, Short-Term Maintenance should be followed during the period of long-term care as well.

If during the monitoring of the project area, it is determined that the plant community is under stress, CMC will add additional plant materials, or take other action it deems necessary to correct the condition.

5.9 Reclamation of Site Access Road

5.9.1 Access Road Phased Reclamation Activities

5.9.1.1 End of Construction (Year 3)

Upon completion of construction of the site access road, the right-of-way will be graded and topsoiled and seeded. A typical cross section of the access road is shown on Figure 5-10. The areas of the right-of-way that will have utilities on it will be planted to a grass seed mix appropriate to the site. The species that can be used in the reclamation can be found in Table 5-6.

5.9.1.2 Cessation of Mining (Year 31)

The access road will remain active through the long-term care period (Year 75) for access to the wastewater treatment plant and the TMA for monitoring purposes. Maintenance of the right-of-way will take place on an as needed basis.

5.9.1.3 Cessation of Long Term-Care (Year 75)

Upon cessation of the long-term care period, the asphalt will be removed and disposed of properly. The road base will be left in place and covered with a topsoil layer sufficient to allow vegetation to establish. The ditches will be filled in and regraded to blend with the old road bed and surrounding lands. The Access Road will be reclaimed with grass vegetation.

At the main entrance off of STH 55 the open area left by the removal of the road will be planted with grasses and a grove of trees (large enough to block the entrance) indigenous to the site to discourage vehicular traffic from using the revegetated roadbed. Species will be chosen from Tables 5-6 and 5-7.

All utilities will be dismantled and removed from the site. Buried pipelines will be capped, and left in-place. Disturbance to soil and vegetation by the removal of the utilities and road will be graded and topsoiled to proper levels. Appropriate vegetation from the species listed in Table 5-6 will be seeded following guidelines in Section 5.11.2.2.

5.9.2 Reclamation Maintenance

5.9.2.1 Construction

During construction of the access road, seeding will begin as soon as portions of the site are brought to final grade and a suitable seedbed has been prepared. The seeding methods and materials are presented in Section 5.11.2.2. Maintenance during the construction period should follow the guidelines as put forward in Section 5.11.2.4, Short-Term Maintenance. Species selection will be from Tables 5-6 and 5-7.

5.9.2.2 During Operation

The restored native plant communities will be maintained on an as needed basis to allow development in a manner consistent with similar naturally occurring plant communities. Volunteer native species will be left to develop. Woody species that encroach on the road and pose a safety hazard will be removed. Guidelines as put forth in Section 5.11.2.4, Short-Term Maintenance should be followed during the period of operation as well.

Grassland vegetation will be managed by mowing and controlled burns as required. Burning helps to stimulate seed production in prairie plants. The access road may be used as a seed source for other areas to be planted to grassland vegetation in the mine site.

5.9.2.3 Long-Term Care

During the long-term care period (Year 35-75), the restored native plant communities will be maintained on an as needed basis to allow development in a manner consistent with similar naturally occurring plant communities. Volunteer non-woody native species will be left to develop along with the planted herbaceous species. Woody species that encroach on the road and pose a safety hazard will be removed. Guidelines as put forth in Section 5.11.2.4, Short-Term Maintenance should be followed during the period of long-term care as well.

If during the monitoring of the project area, it is determined that the plant community is under stress, CMC will add additional plant materials, or take other action it deems necessary to correct the condition.

5.10 Reclamation of Railroad Spur

5.10.1 Railroad Spur Phased Reclamation Activities

5.10.1.1 End of Construction (Year 3)

Upon completion of construction of the railroad spur, the right-of-way will be graded and topsoiled and planted as shown in Figure 5-11. The species that will be used in the reclamation can be found in Table 5-6 and 5-7.

5.10.1.2 Cessation of Mining (Year 31)

At the cessation of mining, the railroad spur will no longer be used. After removal of the rails, ties and ballast, final topsoiling and grading will take place. Grassland vegetation will be established in the reclaimed areas. Seedbed and plant area preparation, seeding methods, mulching and fertilizing will be completed in accordance with the procedures described in Section 5.11.

At the main entrance of the railroad spur to the Crandon Project property, the open area left by the removal of the railroad spur will be planted with a grove of trees (large enough to block the entrance) indigenous to the site to discourage vehicular traffic from using the revegetated roadbed. Species will be chosen from Table 5-6 and Table 5-7.

5.10.2 Reclamation Maintenance

5.10.2.1 Construction

During construction of the railroad, seeding will begin as soon as portions of the site are brought to final grade and a suitable seedbed has been prepared. No landscape plants will be installed in temporarily disturbed or unfinished areas of the site. The seeding and planting methods and materials are presented in Section 5.11.2.2, Seeding and Planting Methods. Maintenance during the construction period should follow the guidelines as put forward in Section 5.11.2.4, Short-Term Maintenance. Species selection will be from Table 5-6 and 5-7.

5.10.2.2 During Operation

The restored native plant communities will be maintained on an as needed basis to allow development in a manner consistent with similar naturally occurring plant communities. Volunteer native species will be left to develop. Guidelines as put forth in Section 5.11.2.4, Short-Term Maintenance and should be followed during the period of operation as well. Grassland vegetation may initially be managed by mowing as required.

5.10.2.3 Long-Term Care

During the long-term care period (Year 35-75), the restored native plant communities will be maintained on an as needed basis to allow development in a manner consistent with similar naturally occurring plant communities. Volunteer non-woody native species will be left to develop along with the planted herbaceous species. Guidelines as put forth in Section 5.11.2.4, Short-Term Maintenance should be followed during the period of long-term care as well.

If during the monitoring of the project area, it is determined that the plant community is under stress, CMC will add additional plant materials, or take other action it deems necessary to correct the condition.

5.11 Revegetation

5.11.1 Planting Plans

5.11.1.1 General Site Revegetation

Table 5-9 and Figures 5-1, 5-4 and 5-9 depict the overall site plan for the revegetation of the mine site. The plans identify the location and sizes of the various elements for the proposed revegetation.

The plans support the intent of the final land use described in Section 5.4. Table 5-10 describes the reclamation procedures, timetable, plant communities and planting methods for the project. The overall intent of revegetation is to provide nesting and feeding opportunities for wildlife, and to provide non-consumptive passive recreation opportunities. The grassland and savannah planting concept was selected because it provides a wide variety of feeding and nesting opportunities for wildlife. The grassland on the TMA was selected to avoid the possibility of woody invasion and habitat that could cause damage to the soil cover and liner by the uprooting of vegetation caused by high winds. The layout of the savannah will provide an extensive plant community "edge" area that is ideal for wildlife feeding. The grassland areas will provide good opportunities for hiking, nature

Table 5-10

Plant Communities, Planting Methods, Materials, Maintenance Practices and Schedule for Reclaiming Project Facilities

Area	Species Composition		Planting Methods[a]		Materials	Maintenance Practices	Implementation Schedule Project Years			
	Grass/Forbs	Trees/Shrubs	Grass/Forbs	Trees/Shrubs			Construction Phase	Operation Phase	Final closure	Long-Term Care
Access Road	____b	Random groups of mixed conifers and hardwoods	Soil contact seeding/broadcast	Hand plant	Trees - bare root, 4-6 ft. Topsoil, fertilizer, mulch	Annual inspections, regrade, reseed and replant as needed.	1 - 3	--	--	69 - 70
Railroad Spur	____b	Random groups of mixed conifer & hardwoods	Soil contact seeding/broadcast	Hand plant	Topsoil, fertilizer, mulch Trees - bare root 4 - 6 ft.	Annual inspections, regrade replant and reseed as needed.	1 - 3	--	31	--
Plant Site	____b	Selected plantings of hardwoods and conifers	Soil contact seeding/broadcast	Hand plant	Topsoil, fertilizer, mulch; Trees in maple/basswood type 6-8 feet in height; Trees in aspen/birch type 3 - 4 ft. in height Trees in random groups	Annual inspections, regrade, reseed and replant as needed. In maintained areas, mow and fertilize.	1 - 3	3 - 8	31 - 35	69 - 70
	____c	None	Soil contact seeding/broadcast	N/A	Topsoil, fertilizer, mulch, binding (optional)	In maintained areas, mow and fertilize.	1 - 3	--	--	35 - 70
Effluent Pipeline Corridor and Discharge Structure	____b	None	Broadcast and soil contact seeding	N/A	Mulch, fertilizer	Annual inspections, regrade and reseed as needed.	1 - 3	--	--	35 - 70
TMA Access Road/Tailings Transport Pipeline Corridor	____b	Random groups of mixed conifer and hardwoods	Broadcast and soil contact seeding	Head plant	Topsoil, fertilizer, mulch, binding (optional) bare root and B + B trees	Annual inspection, regrade and reseed as needed; annual mowing of pipeline ROW.	1 - 3	--	31	70
TMA & Borrow Area	____b	None	Broadcast, soil contact seeding	N/A	Topsoil; fertilizer, mulch, binding (optional).	Annual inspections, regrade, reseed and replant as needed.	1 - 3	9, 16, 27	34	--
	____d	None	Broadcast, soil contact seeding							

[a] In addition to the actual seeding/planting methods, the following steps will be taken, as necessary, to ensure a suitable seed bed is prepared for each area being reclaimed: final grading, chiseling, topsoil application, disc/harrowing, and slope scarification. These mechanical operations will be followed by seeding, fertilizer application and mulching.

[b] The herbaceous seed mixtures will consist of the native species in Table 5.6, in proportions suitable for the soil, slope and moisture conditions present at the site being reclaimed.

[c] Turf grass seed mix.

[d] WisDOT seed mix #30.

Prepared by: BFW
Checked by: JBH1

study and bird watching while providing a sense of security to the wildlife population. A summary of project area final reclamation is described in Table 5-11. Finally, locally indigenous plant species were selected to revegetate disturbed portions of the mine site. These plants will provide forage for wildlife, will promote natural plant community development.

5.11.1.2 Species Selection

The plant species selected for the proposed plan reflect the ultimate goal of creating self sustaining natural plant communities on appropriate land forms. Two major plant community types have been identified for the project area as follows: savannah copses and grasslands. Each of the plant communities are represented on the final planting plan, Figures 5-4 and 5-9.

The plant lists in Tables 5-6 and 5-7 contain a variety of plant materials typical to each community and are grouped into standard categories of trees, grasses and understory. These trees, grasses, and understory plants are native to Wisconsin and some are indigenous to the area. The plant list also contains a summary of the quantity of seeds per acre for each soil type. Prior to installing the trees and grass species, the disturbed area will be prepared as described in Section 5.11.2.1.

5.11.1.3 Typical Planting Plans & Sections

Typical plan and elevations for the savannah copses at initial planting are shown in Figures 5-12 and 5-13. Typical plan and elevations are shown for years six and 15 revegetation in Figures 5-14, 5-15, 5-16 and 5-17. These planting plans include individual plant names (for initial planning only), locations, typical spacing and relative crown size for a 100-foot x 100-foot typical plant community area. Additionally, typical planting plans and elevations have been prepared for two other conditions (Figures 5-18 through 5-21) to depict various edge conditions. These edge conditions are, savannah copses/existing woodland edge & savannah copses grassland edge. These typical plans are not to be used as a planting plan since each savannah copses should have its own individual look and feel. Each set of plantings will be based on field experience at the time of installation.

These plans represent a typical distribution of woody plant species. Grassland species and seeded understory species are not depicted on the typical plans. Actual plant distribution on the site will depend on site conditions such as slope, aspect, soil moisture, micro climate, etc. Individual plant species will be located in areas that they are best suited to.

Table 5-11

Summary of Project Area Final Reclamation

Facility	Proposed Action*	Proposed End Status
Plant Site	Dismantle and regrade. Purge buried pipelines, cap and leave in-place. Slabs and footings, leave in-place.	Enhancement with a savannah community with 75 percent grassland and 25 percent hardwood forest.
Railroad Spur	Remove rails, ties, ballast and sub-ballast. Replace topsoil and final grade.	Return to pre-mining vegetative conditions through use of forest/grassland vegetation, enrichment with indigenous species, and invasion of herbaceous and woody species. Leave enough room for an eight to ten foot path for recreational use.
Access Road	Remove pavement and base. Replace topsoil and final grade.	Return to pre-mining vegetative conditions through use of short-term vegetation, enrichment with indigenous species, and invasion of herbaceous and woody species. Leave enough room for an eight to ten foot path for recreational use.
Access Road and Tailings Transport Corridor	Cover base with soil layer.	Return to pre-mining vegetative conditions through use of forest vegetation, enrichment with indigenous species, and invasion of herbaceous and woody species. Leave enough room for an eight to ten foot path for recreational use.
TMA	Remain in place, covered and capped.	Revegetation with grasses and forbs, and shrub plantings.
Reclaim Pond	Remove liner system and embankments. Replace topsoil and final grade.	Return to pre-mining vegetative conditions through use of forest vegetation, enrichment with indigenous species, and invasion of herbaceous and woody species.
Discharge Pipeline	Purge, plug and leave in-place.	Revegetation established with initial construction to remain.

* Action will be taken if no other acceptable use or requirement exists for the facility.

Prepared by: BFW
Checked by: JBH1

5.11.2 Implementation Plans

5.11.2.1 Seedbed and Plant Area Preparation

Seedbed and plant area preparation will primarily consist of the grading and topsoiling of the project area, and the analysis, augmentation, and stabilization of that topsoil layer. After construction is complete and after mining has ceased and the facilities have been removed, the subsoil in the savannah areas will be tilled with a disc harrow or ripped to break up compaction caused by the mining operation. The topsoil that has been stripped and stored, will be spread evenly over the site as needed so as to provide a four- to six-inch topsoil layer over the areas that are to be reclaimed within the project site. The top soiled areas will be analyzed for fertility and nutrients. Based on this analysis, the topsoil layer will be fertilized and stabilized to facilitate adequate growth of the appropriate plant community in that area. Time of year for this operation will depend on the proper sequence for planting and establishing cover layer species as well as grassland species and cover crops. The procedures used will be appropriate for controlling erosion on the site.

5.11.2.2 Seeding and Planting Methods

The installation of plant materials will be performed in accordance with professionally accepted standards. Specifically, the range of methods of installation for the appropriate vegetation includes:

1. Trees (deciduous and evergreen)

   a. Tree spade (for trees on site that may be able to be moved and are 2-inch in diameter or greater).

   b. Hand planting (for all bare root and balled and burlapped stock).

2. Ground cover (grasses and forbs, cover crops and other selected understory vegetation).

   a. Mechanical seeding (ground contact)
   b. Broadcast seeding
   c. Hydro-seeding

Seeding rates are listed with each specific type of seed mix as shown in Table 5-6.

5.11.2.3 Mulching and Fertilizing

Organic mulches will be used, as needed, to reduce erosion, provide a source of organic matter, and conserve soil moisture, thereby enhancing the establishment of vegetation. The range of methods include:

1. Mulching

   a. Hydro mulching
      (1) Material (cellulose based product)
      (2) Tack coat (only where needed on slopes)

b. Mechanical (blowing)
   (1) Material (weed free straw)
   (2) Tack coat (only where needed on slopes)
c. Mechanical and hand placement
   (1) Material (shredded bark, wood chips, gravel or other materials).

2. Fertilizing

a. Trees
   (1) Material (granular or time release packets) as required for each plant type according to the soil analysis.
   (2) Application (manual)
b. Grasses and forbs and other designated ground covers
   (1) Material (liquid or granular) as required for each plant community type according to the soil analysis.
   (2) Application (mechanical, spray or rotary spreader)

5.11.2.4 Short-Term Maintenance

The objective of short-term maintenance operations is the establishment of the permanent landscape. Short-term operations will be in effect for the first two growing seasons following installation of trees and herbaceous ground layers. These maintenance practices as listed below include relatively common techniques and will occur in the revegetated areas.

- Remove dead trees.
- Replace subsoil and topsoil, overseed, and mulch in washed out areas to reduce erosion and maintain stable vegetative growth.
- Overseed grass areas as necessary to ensure a viable stand.
- Water trees and other plants as necessary during the first two growing seasons after planting.
- Fertilize and maintain mulch where necessary during the first two growing seasons after planting.
- Mow vegetation to a height of six to eight inches in the grassland areas as needed during the first two growing seasons.

5.12 Reclamation Costs

An estimate of the costs associated with reclamation are shown in Table 5-12. The estimate has been developed for each year during which reclamation activities will be accomplished. The estimate is itemized by feature or area to be reclaimed.

Table 5-12 Reclamation Cost Estimate

Year 3 Reclamation (1995 $)

ITEM	UNIT	NO.	COST/UNIT	EXTENSION
1. Plant site: grade, seed and plant vacant disturbed areas.				
a. Replace topsoil (6")	cubic yard (cy)	53,250	$2.00	$106,500
b. Seed, fertilize & mulch	acre (ac)	66	$2,000	$132,000
			subtotal =	$238,500
2. TMA: grade, seed and plant exterior slopes of TMA 1. Final and intermediate slopes to be planted with grass seed.				
a. Replace topsoil (6")	cy	34,700	$2.00	$69,400
b. Seed, fertilize & mulch (grass and forbs)	ac	43	$2,000	$86,000
			subtotal =	$155,400
3. TMA access road: topsoil, seed, fertilize and mulch exterior slopes of haul road with grass.				
a. Replace topsoil (6")	cy	1,700	$2.00	$3,400
b. Seed, fertilize & mulch	ac	2.1	$2,000	$4,200
			subtotal =	$7,600
4. Access Road: topsoil, seed, fertilize and mulch access road between shoulder and R.O.W. with grass and forbs.				
a. Replace topsoil (6")	cy	12,100	$2.00	$24,200
b. Seed, fertilize & mulch	ac	15.0	$2,000	$30,000
			subtotal =	$54,200
5. Railroad spur: topsoil, seed, fertilize and mulch between ballast and R.O.W. with grass.				
a. Replace topsoil (6")	cy	6,200	$2.00	$12,400
b. Seed, fertilize & mulch	ac	7.7	$2,000	$15,400
			subtotal =	$27,800
6. Effluent pipeline: topsoil, seed, fertilize and mulch disturbed areas (30' wide by 37.5 miles long).				
a. Replace topsoil (6")	cy	30,250	$2.00	$60,500
b. Seed, fertilize & mulch	ac	136.0	$2,000	$272,000
			subtotal =	$332,500
			Total Year 3 Reclamation Cost =	**$816,000**

Prepared by: MRS
Checked by: JBH1

Table 5-12 Reclamation Cost Estimate (cont.)

Year 12 Reclamation (1995 $)

ITEM	UNIT	NO.	COST/UNIT	EXTENSION
1. TMA: Install final cover on TMA 1.				
a. Soil grading layer (thickness varies)	cy	632,400	$2	$1,264,800
b. 12" native clay	cy	87,500	$14	$1,225,000
c. 60 mil geomembrane	square feet (sf)	2,662,500	$0.40	$1,065,000
d. 12" drainage layer	cy	88,500	$6	$531,000
e. 36" rooting layer (till soils)	cy	258,000	$2	$516,000
f. 6" topsoil	cy	44,300	$2	$88,600
g. Seed, fertilize and mulch	acre (ac)	55.6	$2,000	$111,200
h. Misc. erosion control (berms, riprap, etc)	lump sum	1	$50,000	$50,000
			Total Year 9 Reclamation Cost =	**$4,851,600**

Prepared by: MRS
Checked by: JBH1

Table 5-12 Reclamation Cost Estimate (cont.)

Year 23 Reclamation (1995 $)

ITEM	UNIT	NO.	COST/UNIT	EXTENSION
1. TMA: Install final cover on TMA 2.				
a. Soil grading layer (thickness varies)	cy	927,700	$2	$1,855,400
b. 12" native clay	cy	115,400	$14	$1,615,600
c. 60 mil geomembrane	square feet (sf)	3,497,500	$0.40	$1,399,000
d. 12" drainage layer	cy	116,500	$6	$699,000
e. 36" rooting layer (till soils)	cy	341,100	$2	$682,200
f. 6" topsoil	cy	58,300	$2	$116,600
g. Seed, fertilize and mulch	acre (ac)	73	$2,000	$146,000
h. Misc. erosion control (berms, riprap, etc)	lump sum	1	$50,000	$50,000

Table 5-12 Reclamation Cost Estimate (cont.)

Year 28 Reclamation (1995 $)

ITEM	UNIT	NO.	COST/UNIT	EXTENSION
1. TMA: Install final cover on TMA 3.				
a. Soil grading layer (thickness varies)	cy	529,700	$2	$1,059,400
b. 12" native clay	cy	75,000	$14	$1,050,000
c. 60 mil geomembrane	square feet (sf)	2,284,000	$0.40	$913,600
d. 12" drainage layer	cy	75,900	$6	$455,400
e. 36" rooting layer (till soils)	cy	220,200	$2	$440,400
f. 6" topsoil	cy	38,000	$2	$76,000
g. Seed, fertilize and mulch	acre (ac)	47.7	$2,000	$95,400
h. Misc. erosion control (berms, riprap, etc)	lump sum	1	$50,000	$50,000
			Total Year 26 Reclamation Cost =	**$4,140,200**

Prepared by: MRS
Checked by: JBH1

Table 5-12 Reclamation Cost Estimate (cont.)

Year 35 Reclamation (1995 $)

ITEM	UNIT	NO.	COST/UNIT	EXTENSION
1a. Plant site - Building demolition including removal of all plant buildings except the wastewater treatment plant, pump house, discharge lagoons, substation and access road.				
a. Demolition	cubic feet (cf)	16,590,000	$0.21	$3,483,900
b. Remove foundations	lineal feet (lf)	3,900	$63.00	$245,700
c. Remove slabs	square feet (sf)	291,000	$4.10	$1,193,100
d. Remove stone base	cubic yards (cy)	43,000	$2.30	$98,900
e. Dispose of steel (on-site)	cy	1,000	$6.00	$6,000
f. Dispose of concrete (on-site)	cy	11,400	$6.00	$68,400
			subtotal =	$5,096,000
1b. Plant site - Remove utility roads and rail spur within plant site, remove and dispose lined basins, regrade areas to final grades and plant as grassland or savannah.				
a. Removal and diposal of lined areas	cy	52,000	$6.00	$312,000
b. Remove & disposal of railroad tracks & ties	lineal feet (lf)	5,900	$20.00	$118,000
c. Remove railroad ballast & subballast	cubic yards (cy)	6,600	$2	$13,200
d. Remove gravel base course	cy	7,500	$2	$15,000
e. Regrading	cy	214,000	$2	$428,000
f. Replace topsoil (6")	cy	107,000	$2	$214,000
g. Seed, fertilize & mulch (grass and forbs)	acre (ac)	85	$2,000	$170,000
h. Seed, fertilize & mulch (savannah)	ac	48	$2,500	$120,000
i. Remove fencing	lf	10,000	$2.50	$25,000
			subtotal =	$1,415,200
2. Tailings pipeline: Reclaim 5,800 lineal feet of tailings pipeline (2 pipes) and lined ditch.				
a. Remove and dispose of piping (on-site)	lf	11,600	$20.00	$232,000
b. Remove and dispose lined ditch (on-site)	cy	8,600	$6.00	$51,600
c. Regrading	cy	3,500	$2.00	$7,000
d. Replace topsoil (6")	cy	1,700	$2.00	$3,400
e. Seed, fertilize & mulch (grass and forbs)	ac	2	$2,000.00	$4,000
			subtotal =	$298,000

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Checked by: JBH1

Table 5-12 Reclamation Cost Estimate (cont.)

Year 35 Reclamation Continued (1995 $)

ITEM	UNIT	NO.	COST/UNIT	EXTENSION
3. Railroad Spur - Reclaim 2.7 miles of railroad track including a 1000' siding. Track consists of a 20' wide by 1.5' thick bed of crushed rock. Also, remove 66' long x 20' wide bridge over Swamp Creek.				
a. Remove track and ties	lf	14,400	$10.50	$151,200
b. Disposal of track & ties	lf	14,400	$4.25	$61,200
c. Remove ballast and subballast	cy	16,000	$2.30	$36,800
d. Remove Swamp Creek Bridge				
d.1. Concrete demolition	cy	300	$90	$27,000
d.2. Steel demolition	lineal feet (lf)	300	$6.00	$1,800
d.3. Dispose of concrete/steel (on-site)	cy	500	$4.20	$2,100
e. Replace topsoil (6")	cy	5,300	$2.00	$10,600
f. Seed, fertilize and mulch	acre (ac)	6.6	$2,000.00	$13,200
			subtotal =	$303,900
4. TMA: Install final cover on TMA 4, remove lined reclaim pond, regrade and seed borrow areas.				
a. Soil grading layer (thickness varies)	cy	567,200	$2	$1,134,400
b. 12" native clay	cy	80,800	$14	$1,131,200
c. 60 mil geomembrane	square feet (sf)	2,457,500	$0.40	$983,000
d. 12" drainage layer	cy	81,600	$6	$489,600
e. 36" rooting layer (till soils)	cy	238,200	$2	$476,400
f. 6" topsoil	cy	40,900	$2	$81,800
g. Seed, fertilize and mulch	ac	85.8	$2,000	$171,600
h. Misc. erosion control (berms, riprap, etc)	lump sum	1.0	$50,000	$50,000
			subtotal =	$4,518,000
5. Mine shafts: Recover salvageable materials from mine and seal shafts with concrete plugs. Install concrete water barriers.				
a. Concrete shaft plugs	cy	500	$500	$250,000
b. Backfill shafts to surface	cy	5,400	$2	$10,800
c. Concrete water barriers	cy	600	$500	$300,000
d. Recovery of salvageable materials	lump sum	1	$20,000	$20,000
e. Remove top 10' of shaft collars	lump sum	1	$20,000	$20,000
			subtotal =	$600,800
		Total Year 32 Reclamation Cost =		**$12,231,900**

Prepared by: MRS
Checked by: JBH1

Table 5-12 Reclamation Cost Estimate (cont.)

Year 75 Reclamation (1995 $)

ITEM	UNIT	NO.	COST/UNIT	EXTENSION
1. Plant site - Building demolition including removal of remaining plant buildings. Remove and dispose lined lagoons. Abandon underground piping. Regrade and seed disturbed areas.				
a. Demolition	cubic feet (cf)	1,050,000	$0.21	$220,500
b. Remove foundations	lineal feet (lf)	1,200	$63.00	$75,600
c. Remove slabs	square feet (sf)	32,000	$4.10	$131,200
d. Remove stone base	cubic yards (cy)	5,000	$2.30	$11,500
e. Dispose of steel (off-site)	cy	200	$50	$10,000
f. Dispose of concrete (off-site)	cy	1,400	$40	$56,000
g. Regrading	cy	9,000	$2	$18,000
h. Removal and diposal of lined areas	cy	7,400	$40	$296,000
i. Abandon underground piping in place	lf	4,000	$5	$20,000
j. Replace topsoil (6")	cy	4,400	$2	$8,800
k. Seed, fertilize & mulch (grass and forbs)	acre (ac)	4	$1,500	$6,000
l. Seed, fertilize & mulch (savannah)	ac	1.5	$2,000	$3,000
m. remove fencing	lf	1,500	$3.00	$4,500
			subtotal =	$861,100
2. Access road: Reclaim 3.1 miles of access road consisting of a 22' wide, 3" thick paved surface with a 30' wide, 12" thick gravel base course. Also, remove 129' long bridge over Swamp Creek.				
a. Remove bitmunimous pavement	square yard (sy)	40,000	$3.90	$156,000
b. Disposal of bituminous concrete (off-site)	cubic yard (cy)	3,300	$40.00	$132,000
c. Regrade aggregate base course	cy	18,000	$2	$36,000
d. Remove Swamp Creek Bridge				
d.1. Concrete demolition	cy	400	$90	$36,000
d.2. Steel demolition	lineal feet (lf)	600	$6.00	$3,600
d.3. Dispose of concrete/steel (on-site)	cy	500	$4.20	$2,100
e. Replace topsoil (6")	cy	24,000	$2	$48,000
f. Revegetate (hydroseeding-100' R.O.W.)	acre (ac)	37	$2,000	$74,000
			subtotal =	$487,700

Prepared by: MRS
Checked by: JBH1

Table 5-12 Reclamation Cost Estimate (cont.)

Year 75 Reclamation Continued (1995 Dollars)

ITEM	UNIT	NO.	COST/UNIT	EXTENSION
3. TMA access road: Reclaim 4,700 lineal feet of access road consisting of a 24' wide, 12" thick gravel base course.				
a. Regrade corridor	cy	6,700	$2	$13,400
b. Replace topsoil (6")	cy	3,500	$2	$7,000
c. Seed, fertilize & mulch (grass and forbs)	ac	4.0	$2,000	$8,000
			subtotal =	$28,400
4. TMA: Remove reclaim water pond and associated items.				
a. Remove and dispose offsite (including liner)	cy	15,000	$40.00	$600,000
b. Regrade corridor	square yard (sy)	26,600	$1.00	$26,600
c. Replace topsoil (6")	sy	26,600	$1.00	$26,600
d. Seed, fertilize & mulch (grass and forbs)	acre (ac)	5.5	$2,000	$11,000
			subtotal =	$664,200
5. Effluent pipeline: Remove and dispose structures (manholes, pump buildings, etc.). Abandon pipeline in place.				
a. Remove and dispose structures	lump sum	1	$100,000.00	$100,000
b. Abandon pipeline in place	lf	198,000	$1.00	$198,000
c. Replace topsoil (6" at structure locations)	cy	1,000	$10.00	$10,000
d. Seed, fertilize & mulch (grass and forbs)	acre (ac)	2	$2,000	$4,000
			subtotal =	$312,000

6 Preliminary Water Budget

6.1 Introduction

Three detailed water balances have been developed for the project. An "average" or best engineering judgement water balance was developed to identify flow rates on an annual average basis, assuming long-term annual average weather conditions, the best engineering judgement concerning expected groundwater inflows to the mine, expected annual average mine/mill operating conditions, and long-term average operating conditions at the TMA.

An expected "maximum" water balance was developed to identify the maximum flow rates on an annual average basis assuming weather conditions which would occur for an extreme wet year, the maximum expected groundwater inflows to the mine, expected annual average mine/mill operating conditions, and long-term average operating conditions at the TMA. A "minimum" water balance was developed to identify the minimum flow rates on an annual average basis assuming weather conditions which would occur during an extreme drought year, the minimum expected groundwater inflows to the mine, expected annual average mine/mill operating conditions, and long-term average operating conditions at the TMA.

6.2 Site Water Flows

The water balances were developed based on the following equation:

$$\Sigma Q_i = \Sigma Q_o + \Sigma Q_a$$

where: ΣQ_i = annual average flow of water into the site from all sources
ΣQ_o = annual average flow of water out of the site from all sources
ΣQ_a = annual average flow of water which accumulates on the site from all sources

Water flows into the site, Q_i, include the following:

- groundwater infiltration into the mine, including intercepted groundwater and contact mine water;
- well water used as a supply of potable water and for other purposes;
- precipitation; and
- water vapor contained in the ventilation air entering the mine.

Water flows out of the site, Q_o, include the following:

- treated water discharged from the site to the Wisconsin River;
- residual water in the ore concentrates shipped from the site;
- evaporation from site ponds, basins and lagoons;
- water vapor contained in the ventilation air exiting the mine; and
- seepage from the TMA, reclaim pond and other basins and lagoons at the site.

Water flows which accumulate on the site, Q_a, include the following:

- retained moisture in the tailings at the TMA and
- retained moisture in the backfill tailings underground.

Water flows associated with precipitation and runoff from non-contact areas of the site and the small amounts of evapotranspiration from the site have been excluded from the water balance calculations. These flows are minor compared to the other water flows described previously, and would not significantly affect the site water balances. Non-contact runoff will pass through site sedimentation ponds and be released to natural drainageways.

6.3 Site Water Balances

The three site water balances showing the water flows under annual average flow rates during normal operation of the mine and mill are shown on Figures 6-1, 6-2, and 6-3. The flow rates in the water balances are based on the mine and mill operating normally under an average ore production rate of two million tons/year, having the largest tailing cell in service, and the assumptions shown in Table 6-1.

Table 6-1

Assumptions for Site Water Balance

Factor	Water Balance Assumptions[1]		
	Minimum Condition	Average Condition	Maximum Condition
• Precipitation rate (inches/year)	17.4	30.4	45
• Evaporation rate (inches/year)	39	26	15
• Groundwater inflow to the mine:			
- intercepted groundwater (gallons/minute)	175	300	575
- contact mine water (gallons/minute)	175	300	575
- total inflow (gallons/minute)	350	600	1,150

[1]Precipitation and evaporation rates pertain to open water areas such as the TMA, reclaim pond, water storage basins, etc.

Prepared by: RJC1
Checked by: JWS

Based on these inputs, the water balance for average conditions, Figure 6.1, shows an annual average of 25 gpm of well water would be used for potable and other purposes, 461 gpm of treated wastewater would be discharged to the Wisconsin River, 97 gpm of moisture would be retained with the tailings in the tailings cells, a total of 93 gpm of moisture would be retained in the cemented and uncemented tailings in the mine backfill stopes, and a net 41 gpm would be evaporated by the mine ventilation system.

The water balance for the maximum condition, Figure 6-2, shows an annual average of 25 gpm of well water would be used for potable and other purposes, 1207 gpm of treated wastewater would be discharged to the Wisconsin River, 101 gpm of moisture would be retained with the tailings in the tailings cells, a total of 93 gpm would be retained in the cemented and uncemented tailings in the mine backfill stopes, and a net 34 gpm would be condensed in the mine by the mine ventilation system.

The water balance for the minimum condition, Figure 6-3, shows an annual average of 25 gpm of well water would be used for potable and other purposes, 77 gpm of treated wastewater would be discharged to the Wisconsin River, 95 gpm would be retained with the tailings in the tailings cell, a total of 93 gpm of moisture would be retained in the cemented and uncemented tailings in the mine backfill stopes, and a net 47 gpm would be evaporated by the mine ventilation system.

7 Monitoring Plan Through Operation

A monitoring and quality assurance plan has been developed for the construction and operation phase of the Crandon Project in response to the requirements of Chapters NR 132.06(3)(d), NR 132.11, NR 182.075, NR 182.08(2)(e)8, NR 182.09(2)(a)7 and NR 182.13, Wis. Admin. Code. Monitoring under this plan will cease, and the long-term care and maintenance program discussed in Section 10 of this report will begin, when site closure has been completed. Closure is deemed completed when final site grading and initial revegetation of the site is complete. If at any time, during which the monitoring program is in effect, collected data show that certain aspects of the plan do not warrant continuation, CMC will request to discontinue those parts of the program. CMC also will from time to time make suggested changes to the monitoring plan to address site conditions current at the time. Any recommended plan modifications will be discussed with the WDNR before they are implemented.

Construction and operation phase monitoring includes individual programs for groundwater, mine inflows, TMA leachate, surface water, terrestrial ecology, wetlands and air/meteorology. Each of these programs is discussed below. An item not discussed in this section is the monitoring requirement for effluent discharges to surface water. That requirement will be prescribed in the discharge permit issued for the project and applicable Wisconsin Administrative Code provisions.

Typical sample collection procedures, analytical methods, target practical quantification limits, precision targets, etc., will be similar to those outlined in the Quality Assurance Plan included in the project's February 1994 *Notice of Intent to Collect Data and Detailed Scope of Study* and in plan updates contained in Appendix 3-1 of the project's EIR. An updated Quality Assurance Plan will be prepared and submitted to the WDNR prior to commencement of groundwater sampling.

7.1 Groundwater

The groundwater monitoring program discussed below relates to the construction and operations phase of the project. The groundwater monitoring program satisfies three objectives. The first objective is to gather groundwater level data to be used to monitor drawdown of the water table and potential impacts on pertinent surface water bodies such as lakes, streams and wetlands in the vicinity of the plant site and TMA. The second objective is to monitor groundwater quality in the vicinity of the TMA and plant site to assess compliance with applicable groundwater quality standards. The third objective of the program is to collect baseline data from wells to be installed in the overburden in the vicinity of the mine, which will be used following closure to assess compliance with applicable groundwater quality standards.

As discussed in the project's EIR, regional baseline groundwater level monitoring for regional groundwater levels has been ongoing since the late 1970's. Thus, no additional regional baseline groundwater level monitoring is proposed prior to construction and operations. As required in Chapter NR 182.075 (1)(d)5, Wis. Admin. Code, twelve consecutive months of baseline groundwater quality monitoring is planned for the TMA. As presented in this plan, eight consecutive months of baseline groundwater quality monitoring are also proposed for the plant site and wells in the vicinity of the mine prior to construction which will result in more than 12 months of data prior to start of operations. Details regarding baseline groundwater monitoring and subsequent operations monitoring frequency and parameters are presented below.

7.1.1 Monitoring Locations

Monitoring locations for each component of the operations and construction groundwater monitoring program are discussed separately. Section 7.1.1.1 discusses monitoring locations for regional groundwater level measurements. Section 7.1.1.2 discusses monitoring locations for groundwater quality sampling at the TMA. Sections 7.1.1.3 and 7.1.1.4 discuss groundwater quality monitoring locations for the plant site and in the vicinity of the mine, respectively.

7.1.1.1 Regional Groundwater Level Monitoring

The regional groundwater modeling studies described in Section 4 of the project's EIR indicate that the best engineering judgement scenario groundwater level changes could extend for a radius of up to one to two miles around the mine. Thus, the objective in selecting wells for monitoring the regional water table changes was to cover an area that extends roughly three miles radially from the mine. An additional objective was to select wells that will provide information regarding the hydraulic relationship between pertinent lakes, wetlands and streams against which estimated potential drawdown related impacts can be evaluated.

Figure 7-1 shows the location of existing and proposed wells to be used for the principal purpose of monitoring water level changes to the regional groundwater table. Table 7-1 provides a summary of these wells with respect to formation monitored and whether the well is a water table well, piezometer or well for monitoring perched conditions. Note that, given the lack of significant vertical gradients in upland areas away from head dependant recharge lakes and wetlands, some existing piezometers will be used in lieu of new water table wells. In the vicinity of the mine site, piezometers will be monitored because many of the existing groundwater monitoring water table wells are projected to go dry due to mine dewatering.

7.1.1.2 TMA Groundwater Quality Monitoring

Because the TMA is located over a local groundwater divide, groundwater flows radially from beneath the TMA, in all directions. Thus it is necessary to monitor groundwater quality around the entire perimeter of the TMA. Figure 7-2 shows the location of the proposed monitoring wells that will be used for groundwater quality monitoring at the TMA in relation to the location of the proposed 1,200 foot compliance boundary around the facility. Each monitoring location consists of a nested pair of two wells. The first well at each nest is proposed to be a water table well that will monitor groundwater quality at the water table. The second well at each location is proposed to be a piezometer that will monitor groundwater quality below the groundwater table in outwash units of relatively high permeability. Table 7-2 summarizes proposed well type, the formation to be monitored, and the anticipated screened interval for each well in the TMA monitoring program.

7.1.1.3 Plant Site Groundwater Quality Monitoring

Figure 7-3 shows the location of the proposed plant site groundwater monitoring wells and the location of the proposed 100 foot compliance boundary around the plant site. Wells CMC-15P, -16 and 16P, and -17 and 17P will be used to monitor groundwater quality around the plant site. Note that during operations, groundwater beneath the plant site will be directed to the south toward the mine due to mine inflow. Thus, the north side of the facility will be the upgradient side of the plant site. Wells CMC-16 and 16P will be a nested water table well

Table 7-1

Proposed Regional Groundwater Elevation Monitoring Wells[1]

Well	Well Type	Formation Monitored	Well Status	Intended Purpose
Regional Wells				
EX-4BU	P	LWT	E	Monitor drawdown of the water table north of the orebody.
DMB-15	WT	CO	E	Monitor drawdown of the water table near Oak Lake.
CMC-09P	P	EWT	E	Monitor drawdown of the water table immediately south of the ore body.
DMP-3	P	CO	E	Monitor drawdown of the water table south of the ore body between Little Sand and Oak Lakes.
CMC-OWA4	P	EWT	E	Monitor drawdown of the water table immediately north of the ore body.
CMC-OWA1	P	SS	E	Monitor hydraulic head in the structured saprolite over the ore body.
CMC-OWA3	P	EWT	E	Monitor drawdown of the water table over the ore body.
CMC-OWA5	P	EWT	E	Monitor drawdown of the water table immediately south of the ore body.
CMC-14P	P	MS	E	Monitor drawdown of the water table over eastern part of the ore body.
CMC-10P	P	EWT	E	Monitor drawdown of the water table over the ore body.
EX-15BL	WT	FO	E	Monitor drawdown of the water table west of Duck Lake.
EX-16BL	P	LWT/FO	E	Monitor changes in hydraulic head within the outwash beneath and adjacent to Duck Lake.
CMC-05	WT	LWT	E	Monitor drawdown of the water table south of the TMA.
EX-14BU	WT	CO	E	Monitor drawdown of the water table south of the TMA.
DMB-10	P	FO/LWT	E	Monitor drawdown of the water table between the mine and Hoffman Springs.
DMB-23	P	FO	E	Monitor drawdown of the water table east of Mole Lake.
DMA-18	WT	CO	E	Monitor drawdown of the water table southwest of Oak Lake.
CMC-18	WT	LWT/CO	N	Monitor drawdown of water table in vicinity of TMA.
CMC-18P	P	CO	N	Monitor drawdown in outwash in vicinity of TMA
CMC-19	WT	LWT/CO	N	Monitor drawdown of water table in vicinity of TMA.

Table 7-1 *(Continued)*

Well	Well Type	Formation Monitored	Well Status	Intended Purpose
CMC-19P	P	CO	N	Monitor drawdown in outwash in vicinity of TMA.
CMC-20	WT	LWT/CO	N	Monitor drawdown of water table in vicinity of TMA.
CMC-20P	P	CO	N	Monitor drawdown in outwash in vicinity of TMA.
CMC-21	WT	LWT/CO	N	Monitor drawdown of water table in vicinity of TMA.
CMC-21P	P	CO	N	Monitor drawdown in outwash in vicinity of TMA.
CMC-22	WT	LWT/CO	N	Monitor drawdown of water table in vicinity of TMA.
CMC-22P	P	CO	N	Monitor drawdown in outwash in vicinity of TMA.
CMC-23	WT	LWT/CO	N	Monitor drawdown of water table in vicinity of TMA.
CMC-23P	P	CO	N	Monitor drawdown in outwash in vicinity of TMA.
CMC-24	WT	LWT/CO	N	Monitor drawdown of water table in vicinity of TMA.
CMC-24P	P	CO	N	Monitor drawdown in outwash in vicinity of TMA.
CMC-25	WT	LWT/CO	N	Monitor drawdown of water table in vicinity of TMA.
CMC-25P	P	CO	N	Monitor drawdown in outwash in vicinity of TMA.
CMC-26	WT	LWT/CO	N	Monitor drawdown of water table in vicinity of TMA.
CMC-26P	P	CO	N	Monitor drawdown in outwash in vicinity of TMA.
CMC-27	WT	LWT/CO	N	Monitor drawdown of water table in vicinity of TMA.
CMC-27P	P	CO	N	Monitor drawdown in outwash in vicinity of TMA.
CMC-28P	P	EWT	N	Monitor drawdown in Pre- to Early Wisconsinan Till in vicinity of mine.
CMC-29P	P	EWT	N	Monitor drawdown in Pre- to Early Wisconsinan Till in vicinity of ore body.
CMC-30P	P	EWT	N	Monitor drawdown in Pre- to Early Wisconsinan Till in vicinity of mine.
CMC-31	WT	LWT/CO	N	Monitor drawdown of water table south of Little Sand Lake.
CMC-32	WT	LWT/CO	N	Monitor drawdown of water table between ore body and Skunk Lake.
CMC-15P	P	EWT	N	Monitor drawdown in Pre- to Early Wisconsinan Till in vicinity of plant site.

Table 7-1 *(Continued)*

Well	Well Type	Formation Monitored	Well Status	Intended Purpose
CMC-16	WT	LWT/CO	N	Monitor drawdown of water table in vicinity of plant site.
CMC-16P	P	EWT	N	Monitor drawdown in Pre- to Early Wisconsinan Till in vicinity of plant site.
CMC-17	WT	LWT/CO	N	Monitor drawdown of water table in vicinity of plant site.
CMC-17P	P	EWT	N	Monitor drawdown in Pre- to Early Wisconsinan Till in vicinity of plant site.
Wells in the Vicinity of Discharging Streams				
WP-4U	WT	CO	E	Monitor water table near Swamp Creek, assess changes in vertical gradients near discharge area.
WP-4L	P	CO	E	Along with WP-4U assess changes in vertical gradients near Swamp Creek.
WP-5L	P	LWT/CO	E	Along with WP-5U assess changes in vertical gradients south of Swamp Creek near discharge boundary.
WP-5U	WT	CO	E	Monitor water table and assess changes in vertical gradients near discharge boundary.
EX-8AL	P	EWT	E	Monitor changes in vertical gradients near Hemlock Creek.
EX-8BU	WT	CO	E	Monitor changes in vertical gradients and the water table near Hemlock Creek.
Wells in the Vicinity of Head Dependant Recharge Lakes and Wetlands				
CDM-16	P	FO	E	Monitor change in head in glacial outwash beneath lake bed of Little Sand Lake.
G40-S17	P	EWT/FO	E	Monitor change in hydraulic head in outwash beneath Little Sand Lake.
CMC-SP-06	WT	LWT	E	Monitor water table elevation along the north side of Little Sand Lake.
CMC-SP-05A	WT	LWT	E	Monitor water table elevation along the north side of Little Sand Lake.
CMC-SP-05B	P	LA	E	Monitor change in hydraulic head in lake bed of Little Sand Lake.
CMC-SP-03A	WT	LWT	E	Monitor water table elevation along the north side of Little Sand Lake in wetland F10.
CMC-SP-03B	P	LA	E	Monitor change in hydraulic head within lake bed of Little Sand Lake beneath the F10 wetland.
DMA-19	P	CO/LWT	E	Monitor change in hydraulic head in outwash north of Little Sand Lake.

Table 7-1 *(Continued)*

Well	Well Type	Formation Monitored	Well Status	Intended Purpose
CMC-SP-09	WT	LWT	E	Monitor water table elevation north of Little Sand Lake and along with DMA-19 measure changes in vertical gradients.
G40-Y15	P	CO	E	Monitor changes in hydraulic head in outwash beneath the lake bed of Little Sand Lake.
G40-Y15A	WT	LA	E	Monitor the water table along the east side of Little Sand Lake and measure changes in vertical gradients.
CMC-SCC-102B	P	CO	E	Monitor drawdown of the water table in the Swamp Creek Cedars wetland.
CMC-SL-103A	P	IM	E	Monitor changes in vertical gradients in the Skunk Lake wetland.
CMC-SL-103B	P	CO	E	Monitor changes in vertical gradients in the Skunk Lake wetland.
CMC-DL-103A	PERCHED	LWT	E	Monitor perched water levels adjacent to the Duck Lake wetland.
CMC-DL-103B	WT	LWT/CO	E	Monitor drawdown of the water table beneath the Duck Lake wetland.
G41-E22	P	FO	E	Monitor changes in hydraulic head beneath the lake bed of Deep Hole Lake.
G41-A23	P	LWT	E	Monitor changes in hydraulic head beneath the lake bed of Deep Hole Lake.
DMA-48	WT	CO	E	Monitor drawdown of the water table near Hoffman Springs.

[1] Well construction information such as screen length and interval are available in Table 3.6-1 of the project's EIR for those wells already installed. See Tables 7-2 and 7-3 for screen intervals for proposed wells identified on Figure 7-1.

LWT = Late Wisconsinan Till
CO = Coarse Outwash
FO = Fine Outwash
EWT = Pre- to Early Wisconsinan Till
MS = Massive Saprolite
SS = Structured Saprolite
LA = Lacustrine Silts and Clays
IM = Ice Marginal Deposits

WT = Water Table Well
P = Piezometer
PERCHED = Well Monitoring Perched Conditions

E = Existing Well
N = New Proposed Well

Prepared by: SVD1
Checked by: SGL

Table 7-2

Proposed TMA Groundwater Quality Monitoring Wells

Well	Well Type	Formation Monitored	Anticipated Screened Interval (ft-MSL)[1]
CMC-18	WT	LWT/CO	1580-1595
CMC-18P	P	CO	1545-1550
CMC-19	WT	LWT/CO	1580-1595
CMC-19P	P	CO	1545-1550
CMC-20	WT	LWT/CO	1580-1595
CMC-20P	P	CO	1550-1555
CMC-21	WT	LWT/CO	1585-1600
CMC-21P	P	CO	1550-1555
CMC-22	WT	LWT/CO	1585-1600
CMC-22P	P	CO	1560-1565
CMC-23	WT	LWT/CO	1585-1600
CMC-23P	P	CO	1550-1555
CMC-24	WT	LWT/CO	1585-1600
CMC-24P	P	CO	1530-1535
CMC-25	WT	LWT/CO	1585-1600
CMC-25P	P	CO	1545-1550
CMC-26	WT	LWT/CO	1585-1600
CMC-26P	P	CO	1550-1555
CMC-27	WT	LWT/CO	1585-1600
CMC-27P	P	CO	1550-1555

[1]Actual screened intervals to be determined based on field conditions.

WT = Water Table Well
P = Piezometer
LWT = Late Wisconsinan Till
CO = Coarse Outwash

Prepared by: SVD1
Checked by: SGL

and piezometer that reside upgradient of the plant site to provide background data. Well CMC-15P will be constructed as a piezometer to measure groundwater quality on the downgradient side of the plant site south of a site runoff basin. Note that a separate water table well is not included at the CMC-15P location given the projected extent of drawdown in this area. Wells CMC-17 and 17P will be a nested water table well and piezometer that will measure groundwater quality along the western side of the plant site, just south of the wastewater storage basins.

Table 7-3 provides a summary, with respect to well type, formation monitored, anticipated screened interval, and intended use of the wells proposed for use in the groundwater monitoring program for the plant site.

7.1.1.4 Post Mine Closure Groundwater Monitoring

Monitoring wells shown in Figure 7-4 are proposed to serve as groundwater quality monitoring points around the reflooded mine within the proposed 1,200 foot compliance boundary. The compliance boundary around the mine extends vertically to the top of bedrock. During operations, groundwater flow in the glacial overburden will be directed toward the mine, thus eliminating the potential for constituent migration toward the compliance boundary for the mine. After closure of the mine, groundwater flow will resume a generally east to west flow across the ore body subcrop. It is only after closure that constituents from the mine could potentially migrate toward the compliance boundary. Thus, the location of the wells for monitoring groundwater quality around the mine were selected to monitor water quality after closure of the mine. Well CMC-30P will serve as the background groundwater monitoring point upgradient and east of the ore body subcrop. Wells CMC-09P and CMC-29P will serve as sidegradient groundwater monitoring points south and north of the ore body. Well CMC-28P will serve as a downgradient groundwater monitoring well west of the ore body.

The wells proposed for use in monitoring groundwater quality around the mine will be piezometers screened in the Pre- to Early Wisconsinan Till. The Pre- to Early Wisconsinan till was selected for monitoring since this formation would be impacted first in the unlikely event of constituent migration from the reflooded mine into the glacial overburden. Table 7-3 provides a summary, with respect to well type, formation to be monitored, anticipated screen elevation and intended use of the wells proposed for use in the groundwater monitoring program for the reflooded mine.

7.1.2 Monitoring Well Construction

All proposed new groundwater monitoring wells will be constructed in accordance with Chapter NR 141, Wis. Admin. Code. Water table wells will be constructed with 15 foot screens. Piezometers will be constructed with five foot screens. The materials and dimensions for gravel packs, filter pack seals, annular space seals, and ground surface seals will be in accordance with NR 141 requirements. Anticipated screen elevations were discussed above.

7.1.3 Existing Monitoring Well Abandonment

Prior to or during the construction period, monitoring wells and piezometers not on the monitoring plan will be abandoned in accordance with Chapter NR 141, Wis. Admin. Code. Figure 7-5 shows the location of the wells that are proposed to be abandoned.

Table 7-3

Proposed Plant Site and Mine Vicinity Groundwater Quality Monitoring Wells

Well	Well Type	Formation Monitored	Anticipated Screened Interval[1] (ft-MSL)	Intended Purpose
Plant Site				
CMC-15P	P	EWT	1570-1575	Monitor groundwater quality downgradient of plant site runoff basin. During operations the water table will likely reside in EWT.
CMC-16	WT	LWT/CO	1580-1595	Monitor groundwater quality at the water table upgradient of the plant site during operations.
CMC-16P	P	EWT	1500-1505	Monitor groundwater quality in the EWT upgradient of the plant site during operations.
CMC-17	WT	LWT/CO	1580-1595	Monitor groundwater quality at the water table downgradient of the plant site wastewater storage basins.
CMC-17P	P	EWT	1500-1505	Monitor groundwater quality in the EWT downgradient of the plant site wastewater storage basins.
Mine				
CMC-09P	P	EWT	1511-1516	Monitor groundwater quality in the EWT side gradient of the mine after closure.
CMC-28P	P	EWT	1500-1505	Monitor groundwater quality in the EWT downgradient of the mine after closure.
CMC-29P	P	EWT	1540-1545	Monitor groundwater quality in the EWT sidegradient of the mine after closure.
CMC-30P	P	EWT	1510-1515	Monitor groundwater quality in the EWT upgradient of the mine after closure.

[1]Actual screened interval to be determined based on field conditions.

P = Piezometer
WT = Water Table Well
LWT = Late Wisconsinan Till
EWT = Pre- to Early Wisconsinan Till
CO = Coarse Outwash

Prepared by: SVD1
Checked by: SGL

Monitoring wells located outside of the plant site and TMA footprint and constructed with an impermeable annular space seal will be abandoned in accordance with NR 141.25(2)(b). The procedure involves removing the protective cover, filling the well casing with neat cement grout, bentonite-cement grout, concrete, or bentonite-sand slurry and then cutting the well casing off 30 inches below the ground surface.

For all wells located within the TMA footprint and plant site or those constructed without an annular space seal, the well will be abandoned in accordance with NR 141.25(2)(c). This procedure involves removing the protective cover and completely removing the well casing by overdrilling or pulling the well casing. The well hole will be filled with neat cement, bentonite-cement grout, concrete, or bentonite after the well is overdrilled or as the well casing is being removed.

7.1.4 Monitoring Frequency and Parameters

Sections 7.1.4.1 through 7.1.4.4 discuss the monitoring frequencies, parameters and methods for each component of the groundwater monitoring program.

7.1.4.1 Regional Groundwater Level Monitoring

Figure 7-1 and Table 7-1 show and describe the location of groundwater monitoring wells that will be used to measure regional groundwater table elevation changes. Groundwater levels at these wells will be monitored on a quarterly basis during the construction and operation phase of the monitoring program. Groundwater levels will be monitored with an electronic water level indicator capable of measuring depth to water to one hundredth of a foot.

7.1.4.2 TMA Groundwater Monitoring

Chapter NR 182.075(1)(d)5, Wis. Admin. Code, requires that groundwater be monitored in the vicinity of the TMA on a monthly basis for at least 12 consecutive months prior to placement of tailings to determine baseline water quality. CMC proposes to complete this program for the groundwater monitoring wells listed in Table 7-2 and shown on Figure 7-2. Parameters proposed to be analyzed include those listed in Table 7-4. Parameters listed include state and national primary and secondary drinking water standards, selected indicator parameters, and parameters identified as likely to be contained in the tailings as a result of waste characterization work.

A review of Table 7-4 indicates that selected primary and secondary drinking water standard parameters are not included. Primary parameters not included are organic substances, turbidity, radioactivity, asbestos, fluoride and bacteria. Secondary parameters not included are color, corrosivity, foaming agents (MBAS), and odor. Examples of the logic for excluding these parameters from the baseline parameter list follows.

Organic compounds are not proposed for testing because there is no reason to believe, based on past land use, that any organic contamination is present on the site. Furthermore, there is no reason to believe that the mining operation will lead to any organic contamination. Therefore, there will be no need to characterize the TMA background groundwater quality with respect to organics.

Table 7-4

Baseline TMA Groundwater Monitoring Analytical Parameters

Parameter
A) Primary Drinking Water Standards
Arsenic
Antimony
Barium
Beryllium
Cadmium
Chromium, Total
Copper
Cyanide
Lead
Mercury
Nickel
Nitrogen, Nitrate/Nitrite
Selenium
Thallium
B) Secondary Drinking Water Standards
Aluminum
Chloride
Iron
Manganese
Silver
Sulfate
Solids, Total Dissolved
Zinc
C) Indicator Parameters
Alkalinity, Total
Calcium
Hardness, Total
Spec. Cond. (Field)
Magnesium
Temperature (Field)
pH (Field)
D. Other Parameters
Cobalt
Molybdenum
Sodium

Prepared by: JWS
Checked by: RTJ

Turbidity is not proposed for monitoring because it is a meaningless parameter with respect to groundwater. Groundwater, unlike surface water, has no inherent turbidity. The velocities at which groundwater moves are too slow to provide the energy needed to keep small particles in suspension. Any turbidity which shows up in groundwater samples is an artifact of the well development process, and has nothing to do with turbidity in the groundwater itself. Therefore, turbidity is never tested in programs that are aimed at characterizing groundwater quality.

Radionuclides are not proposed for testing because there is no historical evidence of quality problems related to them, either in the groundwater at the site specifically, or in the Crandon area groundwater in general. More importantly, no mining activity will take place which could cause radionuclide contamination of groundwater to occur. Therefore, there is no need to characterize the background groundwater with respect to radionuclides.

Similar logic applies to asbestos, fluoride, bacteria and the secondary parameters not included on the baseline list. As discussed in Section 2.3 above, CMC has specifically requested an exemption under Chapter NR 182.19 to address the exclusion of the above referenced primary and secondary drinking water standards from its TMA baseline monitoring program.

NR 182.13 (2)(e)1 requires quarterly analysis of groundwater samples for water levels, specific conductance (field), pH (field and laboratory), total dissolved solids (TDS), and other parameters based on the results of the waste characterization studies during TMA site operation. For the Crandon Project, quarterly monitoring is proposed to be conducted typically in January, April, July, and October of each calendar year for those wells listed in Table 7-2. The waste characterization and transport modeling studies completed for the project have identified calcium, copper, lead, manganese, sulfate, and zinc as the principal constituents that may be generated at the site. These six parameters and temperature (field) are included in the quarterly monitoring plan. Total alkalinity and total hardness, as indicators of overall water quality, will also be quarterly parameters.

A comprehensive analysis program as referenced in NR 182.13(2)(e)2 will be performed annually during operations as part of the July sampling round. Parameters included in the comprehensive program will be those included in the quarterly monitoring program and those listed below. The additional selected parameters are those that, based on waste characterization work, could reasonably be expected in the leachate from the TMA.

Aluminum	Iron
Antimony	Magnesium
Arsenic	Mercury
Barium	Nickel
Cadmium	Selenium
Cobalt	Silver
Cyanide	Sodium

7.1.4.3 Plant Site Groundwater Monitoring

Figure 7-3 and Table 7-3 summarize the wells that will be sampled as part of the plant site groundwater monitoring program. Once operations begin, wells in the plant site groundwater

monitoring program will be sampled on the same schedule and for the same parameters included in the TMA quarterly monitoring program. Volatile organic compounds will be sampled and analyzed annually during the second quarter. The parameters selected are based on waste characterization studies and materials that will be used at the plant site. Baseline monitoring to establish existing conditions around the plant site will be conducted monthly for eight consecutive months prior to commencement of construction. The parameters listed in Table 7-4 will be analyzed during each monthly sampling event. During baseline monitoring, the plant site groundwater monitoring wells will be sampled for VOCs during the first and fifth sampling round.

7.1.4.4 Post Mine Closure Groundwater Monitoring

Figure 7-4 and Table 7-3 summarize the wells that will be used in the groundwater monitoring program for the mine. Prior to commencement of mine operations, baseline monitoring of the wells to establish existing conditions will be conducted for eight consecutive months. The parameters listed in Table 7-4 will be analyzed during each monthly sampling event. Since groundwater flow will be directed toward the mine during operations, there will be no possibility for constituent migration out of the mine. Thus quarterly monitoring of these wells is not proposed during operations. However, to maintain a valid baseline against which future groundwater quality can be compared, the mine groundwater monitoring wells that do not go dry will be monitored annually for the same parameters included in the TMA annual program.

7.1.5 System Maintenance

CMC will immediately notify the WDNR if for any reason a monitoring well or device is destroyed or fails to function properly. Unless notified otherwise in writing by the WDNR, CMC will restore, or properly abandon and replace the destroyed or failed monitoring devices within 60 days of the written notification referred to above.

7.2 Mine Inflow

Mine inflow will consist of groundwater flow into the mine and mine workings and will vary in volume during the different stages of mine construction and operation. The amount of groundwater collected from mine dewatering will be determined annually using the following procedures.

The total estimated amount of water pumped from the mine will be recorded through the use of either flow measurement equipment or by calculating flow using recorded pump running time and the specific discharge rate-versus-head relationship for the pumps used to remove water from the mine. Groundwater inflow will be calculated by subtracting the estimated amount of potable water delivered to the mine and the estimated difference of moisture in the ventilation inflow from the total amount of water pumped and adding the estimated amount of water hoisted in the ore to the difference.

7.3 TMA Leachate

The TMA leachate monitoring program will consist of the following:

- Recording the volume of leachate pumped from each active TMA cell annually.

- Documentation of annual maintenance and cleaning of all leachate conveyance lines.
- Obtaining leachate samples semi-annually (April and October) for each cell in which tailings have been placed.
- Analysis of leachate samples for the same parameters included in the annual comprehensive TMA groundwater monitoring program outlined in Section 7.1.4.2 above.

Each TMA cell is designed with two side slope risers (SSR) which provide the mechanical means of removing leachate from the base collection point of the tailings cell. Each cell has two SSRs, each equipped with a pump, which will be activated by a submersible liquid level transducer which responds to water levels in the SSR sumps.

Each SSR will be equipped with a sampling port or spigot from which the operator will collect leachate samples either during normal SSR pump operation or by manually activating the pump. Samples will be obtained by placing the sample container below the spigot and opening the valve until the required sample quantity is obtained. Table 7-5 contains a list of the SSR's and their locations.

Table 7-5

TMA Leachate Sampling Locations

Cell	Location	Sideslope Riser Number
TMA 1	North Sump	SSR-1
TMA 1	South Sump	SSR-2
TMA 2	North Sump	SSR-3
TMA 2	South Sump	SSR-4
TMA 3	North Sump	SSR-5
TMA 3	South Sump	SSR-6
TMA 4	North Sump	SSR-7
TMA 4	South Sump	SSR-8

Prepared by: REM
Checked by: JWS

7.4 Surface Water

A description of the proposed monitoring activities for surface waters is provided below. The program is directed at specific surface water resources including surface water quality and lake levels and stream flows. Monitoring activities are intended to provide information that will allow

an assessment of whether changes occur in these systems due to construction and operation of the mine.

7.4.1 Surface Water Quality

Surface water sampling has been conducted for waters in the vicinity of the Crandon Project site since the late 1970s. Upon the commencement of construction, surface water monitoring will be reinitiated at the 13 locations listed in Table 7-6. Figure 7-6 shows the surface water monitoring locations. Table 7-7 provides a list of the parameters which will be included in the surface water monitoring program. Streams and creeks included on the program will be sampled semi-annually (April and August). Lakes will be sampled annually in July.

Table 7-6

Proposed Surface Water Monitoring Locations

Surface Water	Site ID
Swamp Creek	SG-2
Swamp Creek	SG-5A
Swamp Creek	SG-AA
Pickerel Creek	SG-19
Hemlock Creek	SG-6
Creek 11-4	SG-30
Hoffman Creek	SG-E
Creek 12-9	SG-23[1]
Skunk Lake	LG-15
Duck Lake	LG-12
Deep Hole Lake	LG-13
Little Sand Lake	LG-7
Oak Lake	LG-11

[1] Access to monitoring site SG-23 for Creek 12-9 has been restricted by local property owners. Attempts will continue to obtain permission to access this site.

Prepared by: GJB1
Checked by: CAE

Table 7-7

Proposed Surface Water Monitoring Parameters

Parameter	Parameter
Alkalinity	Aluminum
Boron	Antimony
Chemical Oxygen Demand	Arsenic
Cyanide	Barium
Fluoride	Cadmium
Hardness	Calcium
Nitrogen, Kjeldahl	Copper
Nitrogen-Ammonia	Iron
Nitrogen-Nitrate	Lead
Ph	Magnesium
Sulfate	Manganese
Total Dissolved Solids	Mercury
	Nickel
	Selenium
	Silver
	Zinc

Prepared by: GJB1
Checked by: JWS

7.4.2 Lakes Levels and Stream Flows

Lake levels will be monitored monthly for the lakes listed in Table 7-6 and shown on Figure 7-6 during open water periods commencing at the initiation of construction and continuing until year eight of mining, which is the estimated time that steady state mine inflow and the maximum extent of groundwater level changes will have occurred. At this time lake level monitoring will be reduced to once per year for those lakes that have reached steady state conditions. Lake levels will be measured using staff gauges.

Stream flow monitoring for those streams listed in Table 7-6 and shown on Figure 7-6 will be conducted quarterly (April, July, October and January, ice conditions permitting) commencing at the start of construction. Quarterly monitoring will continue for eight years. At that time for those streams unaffected by the project or for which steady state conditions have been achieved annual monitoring will be performed. Stream flows will be measured using a stream flow measuring gauge.

7.5 Terrestrial Ecology

The objective of the terrestrial ecology monitoring program is to provide an evaluation of environmental quality while the Crandon Project is in operation. This program will focus on vegetational stress.

The terrestrial ecology monitoring program will assess the general conditions of site area ecosystems, including wetlands, within a radius of approximately three miles of the project site. This will be accomplished by color infrared (CIR) aerial photography at a scale of one inch equals 660 feet. The initial aerial photography will be completed prior to the start of construction phase activities and will continue on a schedule of every five years until the final cell of the TMA is reclaimed.

Photographs will be obtained during July to coincide with sensitive growth phases of the potentially affected ecosystems. If possible, the preconstruction photography will also be completed in July. A copy of the CIR photos will be provided to the WDNR with the project's annual monitoring report for the year in which the photograph was taken. An analysis of the photography will be provided to the WDNR with the annual report.

7.6 Wetlands

The purpose of the wetland monitoring program is to characterize the existing hydrologic regime in each wetland included in the program, to establish a baseline before construction begins, and to monitor the wetlands during the construction and operation phases of the mine to detect potential changes in their hydrology and/or vegetation.

As described in Section 4 of the EIR, potential increases or decreases in the available water to the wetlands could result in a change in their plant community structure. Increased water could result in mortality to the existing woody species and a shift in plant community. Decreased water would likely result in a slow invasion of plants better adapted to drier conditions. To regularly assess both the potential hydrologic and vegetative community effects, water level and vegetation monitoring are proposed.

Wetlands immediately adjacent to the proposed TMA, that are either directly impacted by filling or indirectly affected by potential increases or decreases in surface or subsurface flows, have been included in the proposed wetland monitoring program. These wetlands include F66, F29, and F15 (Figure 7-7). The Swamp Creek Cedars (wetland O1) is also included in the program due to the potential for groundwater drawdown effects to the state threatened Calypso Orchid.

Prior to construction, piezometers will be installed in the wetlands listed above. Water level readings will be taken quarterly for the first eight years after commencement of mining. Monitoring will terminate for those wetlands for which no impacts are observed or for which steady state conditions have been reached. For wetlands not falling into either category, monitoring will be continued.

Vegetation sampling transects will also be established in each wetland. For those wetlands adjacent to the TMA, the transect will begin at the point closest to the proposed TMA and extend to the opposite end of the wetland. Two transects are proposed for wetland O1. One extending for approximately 500 feet to the northeast from the southwest tip of the wetland and

one traversing the wetland from the uplands on the east to the uplands on the west. This effort will be performed in accordance with steps 7 through 20 (Field Procedures) in Part IV, Section E of the 1987 *Corps of Engineers Wetland Delineation Manual.* A photo log will be prepared using the termini of the transect lines as photo points. Vegetation sampling will be conducted annually in late summer or early autumn, beginning at the initiation of construction and continuing through year eight after the mine starts operations. Decisions regarding the direction of the transect portion of the wetland monitoring program will be made using the same criteria established for the wetland water level monitoring program.

Given that an unsaturated zone exists beneath wetlands F15 and F66, and that impacts to these wetlands can, therefore, only be attributable to surface hydrology changes, the outlined monitoring program for these two wetlands is proposed to commence when TMA construction commences in the TMA cell adjacent to them.

A separate monitoring plan has been prepared for the project's proposed wetland compensation site. This plan is contained within the project's *Section 404 Permit Application - Addendum 1.*

7.7 Air/Meteorology

In order to demonstrate compliance with the National Ambient Air Quality Standards (NAAQS), CMC is proposing to conduct ambient air monitoring during the construction and operation phases of the project for particulate matter (PM). Other parameter emissions that are exhausted from stationary stacks will be tested to verify compliance with the limits specified in the project's *Air Pollution Control Permit Application* (APCPA). These limits have been used to demonstrate compliance with the NAAQS through dispersion modeling results contained in the application.

This section of the MPA outlines the proposed air and meteorological monitoring program to be used for the Crandon Project during construction and operation. The monitoring will include sampling for total suspended particulate (TSP) and particulate matter less than 10 microns (PM10). Metal analyses will also be performed on collected particulate matter. Data pertaining to meteorological conditions, e.g., wind speed and direction, temperature, and precipitation, will be collected continuously.

A site specific Quality Assurance/Quality Control (QA/QC) Plan for the ambient air monitoring program will be developed by CMC for WDNR approval prior to implementation of data collection. The plan will include:

- Project Description.
- Organization and Responsibility.
- QA Targets for Accuracy and Method Detection Limits.
- Sampling Procedures.
- Sample Custody.
- Analytical Methods.
- Calibration Procedures and Frequency.
- QC Checks.
- Data Reduction and Reporting.
- Corrective Actions.
- System and Performance Audits.
- QA Records.

Following is a description of the proposed ambient air monitoring program.

7.7.1 Sampling Locations

Based upon the air dispersion modeling results included in the APCPA, it is proposed that CMC will operate two high volume total suspended particulate (TSP) ambient air monitors, two high volume particulate matter less than 10 micron (PM10) ambient air monitors, and a meteorological station. The proposed monitoring site locations generally represent areas where the dispersion model predicted the highest ambient impacts are likely to occur. Significant population areas, predominant wind directions, and potential sensitive receptors were also considered in the site selection evaluation process.

Specific site selection will be based on United States Environmental Protection Agency (USEPA) siting criteria as described in *Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD)* EPA-450/4-87-007, as well as WDNR requirements. Specific monitoring sites will be selected from several potential locations with the following criteria employed:

- Relatively flat terrain;
- Accessibility for installation and servicing of equipment;
- Availability of electric power;
- More than 100 feet from unpaved roads; and
- Lack of vertical obstructions.

The general location of the proposed sites are detailed below and shown on Figure 7-8. The approximate Universal Transverse Mercator (UTM) coordinates for these sites are provided in Table 7-8.

- Site No. 1 will be located directly west of the mine on Little Sand Lake Road. This site will have one TSP sampler, one PM10 sampler, and the meteorological station. Both samplers will be located on platforms.

- Site No. 2 will be located to the east of the Tailings Management Area (TMA). This site will be further south than the predicted maximum ambient impact due to the inaccessibility of that area. The expected general location will be near Berry Lane. This site will have one TSP sampler and one PM10 sampler, both on platforms.

It is anticipated that the final site selection will be decided based on a joint on-site review with the WDNR and CMC prior to the actual submittal of the QA/QC Plan.

Table 7-8

Proposed Ambient Air Monitoring Site Locations

Site Number	Monitoring Equipment	UTM x (m)	UTM y (m)
AM-1	TSP PM10 Meteorological Station	348,963.4	5,037,926.8
AM-2	TSP PM10	353,292.7	5,037,664.6

UTM = Universal Transverse Mercator
m = meter
TSP = total suspended particulate
PM10 = particulate matter less than 10 microns

Prepared by: MAD1
Checked by: JWS

7.7.2 Operating Schedule

The TSP and PM10 samplers will operate every sixth day (24 hours on, commencing at midnight central standard time [CST], 120 hours off). The sampling schedule will correspond to the same schedule the WDNR uses for PM sampling. The filters will be removed the day after sampling and installed the day prior to sampling. To avoid non-representative particulate loading, the exchange of filters will occur within 24 hours of completion of the sampling.

The meteorological sensors will operate continuously for the entire monitoring period. Data will be reviewed (real-time measurements) weekly to verify proper operation and downloaded monthly (minimum).

It is anticipated that the TSP and PM10 samplers and meteorological station will commence operation when construction activities are initiated and continue through the reclamation phase of the project.

7.7.3 Sampling Equipment

The ambient air monitoring for TSP and PM10 will be conducted with volumetric flow samplers. With these high volume samplers, the air flow through the system is maintained at a constant rate via a volumetric flow controller which utilizes the principal of choked (critical) flow. The flow will be within the required USEPA guidelines (1.10 cubic meters per minute (m^3/min) to 1.7 m^3/min for TSP samplers, and 1.02 m^3/min to 1.24 m^3/min for PM10 samplers).

The meteorological data collection will be conducted with a datalogger at a meteorological station and will include the following sensors: wind speed, wind direction, temperature, and precipitation.

The equipment that will be used for the TSP and PM10 samplers and meteorological station will be the same or similar to that used during the baseline monitoring activities. Specific equipment information (manufacturer, model number, serial number, etc.) will be included in the QA/QC Plan.

7.7.4 Calibrations and Audits

Specific calibration procedures will be detailed in the QA/QC Plan for the project. The TSP and PM10 samplers will be calibrated using a variable resistance calibration kit. The sensors on the meteorological tower will be calibrated as follows:

- Wind Speed: Synchronous motor fixture
- Wind Direction: Linearity test fixture
- Temperature: NIST traceable thermometer
- Precipitation: Graduated cylinder

Calibration of all the sensors will take place on-site prior to start-up, before and after any maintenance, and at such time that the field technician observes conditions that warrant a recalibration. At a minimum, all equipment and sensors will be calibrated every six months.

It is anticipated that the WDNR will audit the samplers and meteorological station at the start of the monitoring program.

7.7.5 Sampling Parameters

The filters from the high volume TSP and PM10 ambient air monitors will be analyzed for the ambient PM concentration. Specific laboratory procedures for the filters will be detailed in the QA/QC Plan. Once every four months, all of the filters from each TSP monitor will be composited. A metal analysis will be conducted for the following metals:

- Arsenic
- Beryllium
- Cadmium
- Chromium (total)
- Mercury
- Nickel
- Lead

Particle characterization will only be conducted for those filters which exceed 75 micrograms per cubic meter ($\mu g/m^3$) at standard conditions of temperature and pressure.

7.7.6 Preventative Maintenance

The result of equipment and instrument readings depends on the inherent accuracy and proper operation, use, and function of the instrument. It is important that the equipment and instrument operate under optimum conditions at all times. Preventative maintenance procedures and frequencies to be used for the ambient air monitoring equipment will be described in the QA/QC Plan.

7.8 Reporting

7.8.1 Groundwater

The results for the baseline groundwater monitoring program will be summarized and submitted 30 days after final verification of the last round of results has been received. The summary will include groundwater elevations, field parameter measurements and groundwater analytical data. Based on the review of the baseline data it may be necessary to establish alternate concentration limits for those groundwater parameters where baseline conditions exceed standards. In this event, CMC will include a statistical analysis of the data and propose appropriate alternate concentration limits.

The results of quarterly groundwater monitoring will be submitted to the WDNR 30 days after final verification of analytical groundwater results on forms supplied by the WDNR.

7.8.2 Mine Inflow, TMA Leachates, Surface Water, Terrestrial Ecology, and Wetlands

In February of each year following the collection of monitoring data for the previous year, an annual monitoring report will be prepared and submitted to the WDNR. The report will include data collected from the previous year's activities as outlined in Sections 7.2 through 7.6.

7.8.3 Air and Meteorological Data Recordkeeping and Reporting

CMC will submit data consisting of 24-hour average TSP and PM10 concentrations and the results from the metals analysis to the WDNR quarterly, within one month of receiving the results from the laboratory. In addition, calibration data will be submitted when it is conducted.

Should the 24-hour concentrations at either monitoring site exceed 150 $\mu g/m^3$ at standard conditions of temperature and pressure, CMC will investigate the occurrence and send a letter to the WDNR within 15 days after receiving the original laboratory analysis. The letter will include information pertaining to the operating conditions and any related data on sampling conditions.

In addition, a microscopic analysis of the filter sample(s) will also be conducted with the results reported to the WDNR as soon as possible.

For the meteorological station, CMC will submit data consisting of hourly averages for wind speed and direction, temperature, and rainfall to the WDNR. Results will be submitted with the TSP and PM10 results.

All of the data will be submitted in accordance with guidelines provided by the Air Monitoring Section of the WDNR's Bureau of Air Management. An explanation of any missing data will be included.

8 Contingency Plan

Pursuant to Chapter NR 182.09(2)(d), Wis. Admin. Code, a detailed Contingency Plan has been developed "to prevent or minimize human health or environmental damage in the event of an accidental or emergency discharge or other condition not anticipated in the [project's *TMA Feasibility Report/Plan of Operation*] which does not comply with license conditions or other applicable standards." The contingency plan contained herein will address the following two potential general occurrences as relates to the TMA and will only address environmental problems that likely could be detected by the monitoring program.

- Accidental or emergency discharges or other unplanned events.
- Environmental problems detected by the monitoring program.

Accidental or emergency discharges or other unplanned events for other aspects of the project are fully addressed in the project's Risk Assessment (Section 4.13 of the *Mine Permit Application*), and are not covered here. A spill prevention, control, and countermeasures plan pursuant to the Clean Water Act will be available prior to the commencement of site operations.

This Contingency Plan will also address measures that will be employed to determine if and when mitigation may be required for private wells, the Swamp Creek Cedars (Wetland O1), Hoffman Springs/Hoffman Creek, and Creek 12-9. Hoffman Springs/Hoffman Creek and Creek 12-9 were identified in Sections 4 and 5 of the project's EIR as potentially being exposed to impacts under practical worst case conditions that may require mitigation. Given the unlikely occurrence of practical worst case conditions, it is not appropriate to design a detailed mitigation program for these areas at this time. As described in Section 4 and 5 of the EIR, it is not possible to predict if the estimated groundwater drawdown under the Swamp Creek Cedars, for either the best engineering judgement or practical worst case scenarios, will result in significant impacts to this wetland ecosystem. Also, any potential effects may not occur until after the groundwater drawdown has reached steady-state conditions. As impacts to this wetland are not a certainty at this time, it is not appropriate to define a detailed mitigation program for this wetland. It is prudent, though, to establish the monitoring program to be used for the three areas, to define the encountered conditions under which mitigation would be initiated, and to define a conceptual mitigation plan in the event mitigation were deemed necessary. In the event that mitigation is determined to be necessary, CMC will develop a detailed design for the mitigation system given site conditions that were encountered at that time. That plan would be submitted to WDNR for review and comment prior to its implementation.

An assessment of the extent of regional drawdown as relates to the location and construction of existing private wells in the vicinity of the site as discussed in the project's *High Capacity Well Permit Application* and EIR indicates that a total of 12 private wells may see a reduction in water levels greater than four feet if the regional best engineering judgement groundwater model predicted water level changes were to occur. A section of the project's contingency plan addresses actions to be taken by CMC in the event these impacts become imminent.

Numerous conservative assumptions have been incorporated into the project's regional groundwater modeling work. Based on these assumptions, the project's water balance for minimum conditions, Figure 6-3, shows it is possible that very little discharge (<80 gpm) of treated project wastewaters could occur. It is also possible that actual mining conditions could result in less inflow than the conservative modeling has predicted, even under minimum

conditions. In this event, it is possible that the mine inflow rate could be insufficient to meet the water makeup needs for the project's mill. If this condition were to occur, CMC would install a single well or a series of wells screened in the overburden over the ore body to provide the needed water. The capacity of this system would be approximately 200 gpm. Impacts associated with this water development plan, if needed, would be less than those projected for the best engineering judgement mine inflow case as discussed in Section 4 of the project's EIR.

Section 7 of this report includes a program for monitoring during the construction and operation phases of the project. Long-term care and maintenance is discussed in Section 10. The purpose of the monitoring programs is to provide appropriate data to be used to evaluate the performance of the project's environmental protection components. This Contingency Plan will define the contingency measures to be implemented should a statistically significant increase in a monitoring parameter occur at the TMA or should unanticipated impacts occur.

8.1 TMA Contingency Plan

This section addresses TMA related specific contingency procedures regarding groundwater, surface waters and wetlands. The surface water plan relates to the fact that reclaim water at times will be treated at the project's wastewater treatment facility and discharged at the Wisconsin River. Also, the wetland plan relates to larger wetlands on the perimeter of the TMA where surface water flows will be changed as a result of TMA construction.

As described in detail in the project's *Tailings Management Area Feasibility Report/Plan of Operation*, the TMA is designed with multiple safeguards for groundwater and surface waters. Among these are:

- Composite bottom and final cover liner systems, each including a geomembrane and a layer of low-permeability soil.
- Geomembrane materials chosen for compatibility with the tailings.
- A leachate drain and collection system.
- A top rooting zone sufficiently deep to prevent freeze/thaw damage to the final cover liner.
- Surface grading and landscaping designed to minimize erosion.
- Embankments able to withstand a major earthquake.
- Stormwater storage capacity adequate for a 100-year storm event with ample margin for safety.

Leakance through the bottom liner system has been simulated using the EPA HELP model. Groundwater solute transport modeling predicts no exceedance of groundwater quality standards at the compliance boundary.

Although the above and other safeguards make a major failure in the tailings management system implausible, the possibility of an unexpected small-scale event must be considered. Such events would be slow to evolve.

The monitoring plan described in Section 7 would detect any unexpected groundwater conditions at an early stage, allowing ample time for investigation, evaluation and, if necessary, corrective action. In the event corrective action were necessary, a number of remedial measures are available that are being used successfully worldwide.

8.1.1 Groundwater

Various groundwater quality parameters and groundwater elevations will be monitored and analyzed as part of the TMA groundwater monitoring program. The results of the analyses will be subjected to statistical analysis to test for significant changes in the measured levels. If a statistically significant increase in groundwater parameters is detected, the contingency measures listed below will be implemented.

If groundwater quality is determined to be statistically significantly different from background or different from modeled or forecast, CMC will notify the WDNR within 45 days of making the determination. Any alteration of the approved monitoring program, investigation of the differences or selection and implementation of remedial actions will be conducted in consultation with the WDNR.

Step No. 1: Review all sampling, sample handling, and analytical procedures used during the monitoring period to determine if the proper procedures were used when the samples were taken.

Step No. 2: Determine what the elevated parameters represent by:

- Determining the regional variations in groundwater quality for individual parameters based on available information.
- Determining the historical site-specific variations in groundwater quality based on monitoring data.
- Determining if all monitoring wells are showing elevated levels or if the occurrence is localized.

Step No. 3: Resample to verify the analytical results that are in question.

Step No. 4: If similar results occur from the resampling, then determine the significance of the elevated parameter(s) and their potential impact on the environment.

Step No. 5: Based on the relative significance of the elevated parameter(s), determine if immediate action is required or if continued monitoring is sufficient.

Step No. 6: Determine, if possible, what the source of the occurrence is.

During the initial evaluation period, groundwater monitoring will continue according to the normal schedule. Once the evaluation is complete and if it has been concluded that a problem may exist, the next level of investigation will be to determine the extent of the problem. This could require the monitoring of existing wells or piezometers downgradient of the TMA or the installation of additional groundwater monitoring wells in the affected area to determine the vertical and horizontal extent of the concern. This exercise could also consist of a numerical or analytical analysis to determine the impact of the elevated parameters, and to assist in determining what can be done to correct the situation. The information gathered during this period of investigation will be submitted to the WDNR.

The results of the investigation will determine the nature and extent of the remedial action needed to correct the problem. Remedial action could consist of any or all of the following:

- Additional groundwater monitoring of the aquifer systems located downgradient from the problem area. This could include monitoring on a more frequent basis, but with a limited number of key indicator parameters. It might also include the use of specialized groundwater monitoring wells.
- Repair of the source of the problem.
- Installation of a series of flow barrier-type groundwater pumping wells.

8.1.2 Surface Water Discharge

Discharge standards and contingency plans related to the wastewater discharges from the project's wastewater treatment facilities are covered under the WPDES permitting process. Any exceedance of the discharge permit limits will be addressed pursuant to applicable WPDES permit conditions.

8.2 Private Wells, Swamp Creek Cedars, Hoffman Springs/Hoffman Creek and Creek 12-9

CMC's contingency plan to address potential impacts to private wells, the Swamp Creek Cedars, Hoffman Springs/Hoffman Creek, and Creek 12-9 is outlined below.

8.2.1 Private Wells

CMC is negotiating local agreements with the Towns of Lincoln and Nashville where the project facilities are located. Under Section 144.855, Wis. Stats., the Towns have certain obligations which guarantee property owners a replacement water supply should their normal water supply be adversely affected by mining. It has been proposed that the Towns' obligations under Section 144.855, Wis. Stats., be transferred to CMC in the local agreements.

CMC will have an extensive groundwater monitoring system in place prior to any site development. This will monitor changes in groundwater elevation and, as groundwater elevations change relatively slowly, will give advance notice of any possible impacts on private wells. This will enable CMC to implement any mitigation measures to ensure a continuous supply of water for affected well owners.

8.2.2 Swamp Creek Cedars

Based on the regional groundwater modeling work completed for the project, groundwater levels at wetland O1, Swamp Creek Cedars, may be lowered as mining progresses. The model predicts a greater reduction in groundwater levels at the southern limits of the wetland versus the northern limits. Based on the analysis of impacts to wetlands such as the Swamp Creek Cedars as discussed in Section 4 of the project's EIR, the general character of wetland O1 should not change significantly even if groundwater levels in its vicinity are reduced. Wetland O1 will still receive significant amounts of surface water runoff in the spring, which will provide moisture during the growing season. The dominant tree species in the wetland will likely tolerate the reduction in moisture levels. The wetland vegetation in the understory and herbaceous layers, however, could slowly be replaced by species better adapted to drier soil conditions. Any effects would likely be most prominent along the upland periphery of the wetland. Such effects would also reverse once pre-mining conditions return after mine closure.

Soil moisture conditions in wetland O1 may be important due to the presence of two populations of the state threatened Calypso Orchid. As a result, as described in Section 7 of the MPA, both water levels and vegetation will be monitored in wetland O1 to identify potential changes in this wetland system during mining. If as a result of monitoring, reductions in water levels or significant changes in wetland hydrology or vegetation are noted that are not the result of normal seasonal variations or are outside estimated ranges, the contingency measures listed below will be implemented. If wetland monitoring indicates an adverse impact is occurring, CMC will notify the WDNR within 45 days of making the determination. Any alteration of the approved monitoring program, investigation of suspect impacts or selection and implementation of remedial actions will be conducted in consultation with the WDNR.

Step No. 1: Verify that the water level reading procedures and reporting are correct and in accordance with the approved monitoring plan; and/or correlate, if necessary, vegetation trends with meteorological records and evaluate the area for other potential natural occurrences such as beaver activity that may have resulted in the observed change.

Step No. 2: Determine what the collected data represent by:

- Determining the regional variations in wetland water levels based on a survey of area wetlands.
- Determining if the occurrence is due to abnormal climatic conditions such as drought.
- If applicable, determining what the extent of drawdown is in relation to the wetland.

Step No. 3: If the results do not indicate a cause for the occurrence other than the project, determine the significance of the occurrence and its potential impact on the environment.

Step No. 4: Based on the relative significance of the occurrence, determine if immediate action is required or if continued monitoring is sufficient.

Step No. 5: Determine, if possible, what the source of the occurrence is.

During the initial evaluation period, wetland monitoring will continue according to the normal schedule. Once the evaluation is complete and if it has been concluded that a problem may exist, the next level of investigation will be to determine the extent of the problem. This could include the installation of groundwater piezometers in the affected area to further characterize the groundwater level in the vicinity of the wetland. The information gathered during this period of investigation will be submitted to the WDNR.

The results of the investigation will determine if remedial action is required and what actions are needed to correct the problem. Remedial actions could consist of, but may not be limited to:

- Providing a supplemental source of water to the wetland.
- Increasing the size of the wetlands to be constructed to offset the area of wetland adversely impacted.

If it is determined as part of the implementation of the contingency measures outlined above that a supplemental source of water for wetland O1 is needed, one or more well(s) and a water discharge system in the vicinity of the wetland would be installed. Each such well would be installed as a dedicated source and be screened in the coarse outwash unit. The discharge system would consist of a discharge pipeline from each well to a discharge structure installed immediately adjacent to the wetland. No water treatment would be needed, since the mitigation plan would involve replacing the reduced groundwater contribution to the wetland with groundwater. Plans and specifications for mitigation facilities would be developed and forwarded to the WDNR for review and comment at the point that monitoring results indicated that mitigation was, in fact, necessary. Since the groundwater drawdown impacts will be slow to develop, there will be ample time to develop mitigation plans and implement corrective action if required.

8.2.3 Hoffman Springs/Hoffman Creek and Creek 12-9

Based on the regional groundwater modeling work completed for the project, a reduction in groundwater flow to Hoffman Springs and subsequently Hoffman Creek and also to Creek 12-9 may occur as mining progresses. The level of Hoffman Springs is controlled by an outlet structure, therefore decreases in water elevation in Hoffman Springs are not expected to be significant. While a water elevation change is not expected, a reduction in flow in the spring and creek could result in impacts to organisms in the water system, including brook trout. As a result, monitoring of water quality and flow has been proposed in Section 7 of the MPA for Hoffman Creek.

Based on the groundwater modeling and surface water lake and wetland water budget modeling completed for this project, a reduction in flow to Creek 12-9 may also occur as mining progresses. Creek 12-9 is an intermittent stream in its upper reach and a groundwater fed stream in its lower reach. A reduction in flow to the intermittent section of the stream is not expected to have an effect on aquatic organisms. A reduction in flow to the groundwater fed section could have an effect on aquatic organisms. As a result, monitoring of water quality and flow has also been proposed for Creek 12-9 in Section 7 of the MPA.

In the event that the monitoring of Hoffman Creek or Creek 12-9 were to identify significant changes in water quality or flows, the following contingency measures will be implemented.

If surface water level monitoring indicates an adverse impact, CMC will notify the WDNR immediately after making the determination. Any alteration of the approved monitoring program, investigation of the suspected impact or selection and implementation of remedial actions will be conducted in consultation with the WDNR.

Step No. 1: Review all flow monitoring, sampling, sample handling, and analytical procedures used over the monitoring period to determine if the proper procedures were used for monitoring.

Step No. 2: Determine what the collected data represent by:

- Determining the regional variations in the creek's water characteristics for individual parameters, based on available information.

- Determining the historical site-specific variations in the creek's water quality and flow characteristics, based on monitoring data.

Step No. 3: Resample or remonitor to verify the results that are in question. Also conduct a review of aquatic biota in the stream to determine if a change in population has occurred.

Step No. 4: If similar results occur from the resampling or remonitoring, or if a change in biota has occurred or is occurring, determine the significance of the results and their potential impact on the creek.

Step No. 5: Based on the relative significance determined in Step No. 4, determine if immediate action is required or if continued monitoring is sufficient.

During the initial evaluation period, creek monitoring will continue according to the normal schedule. Once the evaluation is complete and if it has been concluded that a problem may exist, the next level of investigation will be to determine the extent of the problem. This could require an increase in the type and frequency of monitoring in the affected area to determine the extent of the concern. The information gathered during this period of investigation will be submitted to the WDNR. Since the groundwater drawdown impacts will be slow to develop, there will be ample time to develop mitigation plans and implement corrective action if required.

The results of the investigation will determine the remedial action needed, if any, to correct the problem. Remedial actions could consist of, but may not be limited to:

- Additional monitoring of the creek's surface water quality and flows and/or its aquatic life. This could include monitoring on a more frequent basis, but with a limited number of key indicator parameters. It might also include the use of specialized monitoring equipment or techniques.

- Providing a supplemental source of water to the spring.

- Stocking of brook trout.

Providing a supplemental source of water to the spring or creek would involve the installation of a well and water discharge system in their vicinity. The well would be installed as a dedicated source and be screened in the coarse outwash unit. The discharge system would consist of a

discharge pipeline from the well to a discharge structure installed immediately adjacent to the spring or creek. No water treatment would be needed, since the mitigation plan would involve replacing the reduced groundwater contribution to the spring and creek with groundwater. Plans and specifications for mitigation facilities would be developed and forwarded to the WDNR for review and comment at the point that monitoring results indicated that mitigation was, in fact, necessary.

9 Emergency Notification Procedures

Accidents and major incidents will be reported to the designated CMC employee who will maintain a record of these incidents. An internal notification procedure will be established and the designated employee will evaluate the extent of the incident and will initiate notification of the appropriate regulatory agency. The employee will report the information to the appropriate individuals in the CMC management who will direct corrective action to be taken.

Following is a listing of potential emergencies, accidents or unplanned events that could occur during the life of the Crandon Project. The agencies, entities, and/or authorities which may be contacted, when appropriate, in the event of an occurrence are also provided.

Major Environmental or Fuel Spill or Release to the Environment

- WDNR Spill Team Coordinator - Area Warden (715) 528-4400
- U.S. EPA, Region V - Permits and Technical Support Branch (312) 353-2000
- Forest County (715) 674-7020
- Langlade County (715) 627-4317
- Wisconsin Division of Emergency Government (608) 266-3232
- National Response Center (800) 424-8802
- Crandon Fire Department (715) 478-3311
- Forest County Sheriff (715) 478-3331
- Sokaogon Chippewa Community (715) 478-2604
- Forest County Potawatomi Community (715) 478-2903
- Menominee Indian Tribe of Wisconsin (715) 799-5114

Accidental Detonation of Explosives

- MSHA-Marquette Michigan Field Office (906) 228-6805
- Forest County Sheriff (715) 478-3331
- DILHR (608) 266-1340

Fire

- Crandon Fire Department (715) 478-3311
- Forest County USDA Forest Service (800) 537-3473
- Langlade County Ranger Station (715) 627-4317

Sabotage/Vandalism

- Forest County Sheriff (715) 478-3331
- If explosives are stolen: Bureau of Alcohol, Tobacco & Firearms (312) 353-3834
- FBI (Wausau, WI) (715) 842-2666

10 Long-Term Care and Maintenance

Long-term care for the site will commence at the completion of closure for both the plant site and TMA (approximately year 35). This will be the point in time when general final plant site and TMA grading (except for the wastewater treatment plant, access road, and TMA access road) and revegetation as defined in the site reclamation plan have been completed.

The discussion in Section 10.1 addresses specific long-term care and maintenance requirements as per Chapters NR 132.08, NR 182.09, NR 182.16, and NR 182.19, Wis. Admin. Code. These requirements relate to the procedures to be used, the estimated costs, and financial responsibility for the project's 40-year long-term care period (years 36 to 75). As part of the long-term care and maintenance plan, all programs will be reviewed annually to assess the need for adjustment or modification. Any recommended plan modifications will be discussed with the WDNR before they are implemented.

The discussion in Section 10.2 addresses the post long-term care responsibility which (assuming a 35-year project life) is from year 75 forward.

10.1 Monitoring and Maintenance Procedures

Long-term care and maintenance for the project will include periodic inspection of the site; maintenance of land forms, vegetation and monitoring devices; and monitoring of groundwater, TMA leachates, surface water, wetlands and terrestrial ecology. Each of these topics is discussed in detail in the following sections. Typical sample collection procedures, analytical methods, target practical quantification limits, precision targets, etc., will be similar to those outlined in the Quality Assurance Plan included in the project's February 1994 *Notice of Intent to Collect Data and Detailed Scope of Study* and in plan updates contained in Appendix 3-1 of the project's EIR. An updated Quality Assurance Plan will be prepared and submitted to the WDNR prior to commencement of groundwater sampling.

Chapter NR 182.09(2)(a)7 references the presentation of a long-term care plan sheet for the project which includes a table indicating terms and anticipated schedule for long-term care monitoring and maintenance. Due to the number of monitoring programs and monitoring sites for the Crandon Project, it is more appropriate to provide the desired information in tabular and multiple figure formats. Table 10-1 provides a summary of the project's 40 year long-term care and maintenance plan. Figures 10-1 through 10-4 graphically display proposed monitoring.

10.1.1 Inspections

CMC will inspect reclaimed areas semi-annually for the first four years after reclamation and once per year thereafter for 36 years. The semi-annual inspections will occur in the spring and fall. The annual inspections will occur in the late summer. The inspections will be conducted by a person qualified to evaluate conditions associated with erosion, vegetation growth, settling, and monitoring device integrity. Also, an annual inspection of the TMA berms will be conducted to assess their structural integrity.

10.1.2 Maintenance

Maintenance activities will consist of landform, vegetative and monitoring device maintenance.

Table 10-1

40 Year Long-Term Care and Maintenance Plan

	Frequency Per Year	Duration
1. Inspections		
Inspect reclaimed site for erosion, vegetation growth, settling, and monitoring device integrity		
Phase I	Spring & Fall	4 Years
Phase II	Late Summer	36 Years
2. Maintenance		
A. Landform	As Needed	40 Years
B. Vegetation	As Needed	40 Years
C. Monitoring Devices	As Needed	40 Years
3. Groundwater Monitoring		
A. Water Levels		
Category I	Quarterly[1]	4 Years
Category II	Quarterly[1]	8 Years
Category III	Quarterly[1]	Until Water Levels Stabilize
B. TMA[2]	Quarterly[3] Annually[4]	40 Years[5]
C. Reflooded Mine[6]	Quarterly[3]	40 Years[5]
4. TMA Leachate	Semi-Annually[7]	40 Years[5]
5. Surface Water[8]		
A. Water Quality		
Phase I		
Streams/Creeks	Semi-Annually	1 Year
Lakes	Annually	1 Year
Phase II		
Streams/Creeks/Lakes	Annually	5 Years
B. Levels/Flows		
Phase I		
Streams/Creeks	See Note 9	1 Year
Lakes	See Note 10	1 Year
Phase II		
Streams/Creeks	Annually	5 Years
Lakes	Annually	5 Years

Table 10-1 *(Continued)*

	Frequency Per Year	Duration
6. Terrestrial Ecology[11]	Annually (Summer)	4 Years
7. Wetlands[12]		

[1] Locations: See Figure 10-1.
Frequency: January, April, July, and October.

[2] Locations: See Figure 10-2.

[3] Frequency: Quarterly - January, April, July, and October.
Parameters: Temperature (Field), Specific Conductance (Field), pH (Field and Lab), Total Dissolved Solids, Total Alkalinity, Total Hardness, Calcium, Copper, Lead, Manganese, Sulfate, and Zinc.

[4] Frequency: Annually - July.
Parameters: Add Aluminum, Antimony, Arsenic, Barium, Cadmium, Cobalt, Cyanide, Iron, Magnesium, Mercury, Nickel, Selenium, Silver, and Sodium to the July quarterly round.

[5] After five years of long-term care monitoring, CMC will request a reduction in monitoring frequency and/or parameters that would remain in effect for the duration of the 40 year long-term care period.

[6] Locations: See Figure 10-3.

[7] Frequency: April and October.
Parameters: All parameters listed in footnotes 3 and 4.

[8] See Section 10.1.5 of report for sampling locations and analytical parameters.
Frequency: Semi-Annually = April and August.
Annually = July.

[9] Frequency will either be annually or quarterly depending upon the stream or creek.

[10] Annually for those lakes that have reached steady state conditions. Monthly for all others.

[11] Color infrared aerial photography.

[12] If wetland water level measurements or vegetation surveys conducted during the construction and operation monitoring program indicate significant effects on a monitored wetland which are attributable to the project, then wetland monitoring at that location during the long-term care and maintenance period will be conducted three times per year (spring, summer, and autumn) until water levels in monitored groundwater monitoring wells stabilize. At this point in time, monitoring will cease.

Prepared by: JWS
Checked by: SVD1

10.1.2.1 Landform

The method of backfilling the stopes and capping the mine should result in little to no settling at the plant site. Engineering analyses have shown that maximum settling would be no more than six inches due to mine subsidence even under conservative assumptions. The shaft will be designed to provide adequate structural stability over the life of the project and beyond. A reinforced concrete plug in the mine shafts, at the bedrock/overburden interface, will minimize overburden subsidence. The upper portion of the lined shafts, through the overburden, will be filled and will provide additional structural support for the shaft concrete.

The settlement in the cells in the TMA is expected to be approximately three to five feet in the center of each cell. Most of this settlement will take place within the first year after filling the cell and prior to installation of the final cover system. Cell cover installation will take place after most of this initial settlement has occurred. Design final grades for the cell cover system have taken into account settlements of the tailings after cover installation so that adequate overland water flow drainage off the cell areas occurs throughout the long-term care period.

Current plans are to revegetate the site and allow the land to settle to a final form. No additional grading of the project area will be done except for erosion control or vegetation maintenance after reclamation is completed. Erosion control will consist of regrading and revegetating eroded areas.

10.1.2.2 Vegetation

After reclamation has been certified complete, additional revegetation of eroded areas will occur as required through the long-term care period. Revegetation techniques are described in Section 5 of the MPA.

10.1.2.3 Monitoring Devices

CMC will notify the WDNR if a groundwater monitoring well or device is destroyed or fails to function properly. Whenever possible, CMC will initiate restoration or proper abandonment and replacement of destroyed or failed monitoring devices within 60 days of the written notification referred to above. Groundwater monitoring wells will be properly abandoned in accordance with the provisions of Chapter NR 141, Wis. Admin. Code, if they are no longer a necessary part of a monitoring program.

10.1.3 Groundwater Monitoring

The long-term care groundwater monitoring program is proposed to consist of three components. The first component will involve monitoring of the rebound of regional groundwater levels. The second component will involve monitoring of groundwater quality within the compliance boundary of the TMA. The third component will involve monitoring of groundwater quality within the compliance boundary of the mine workings. Given that the plant site will have been removed and the area revegetated by that time, no additional monitoring around the former plant site is required during the long-term care period. Therefore, the plant site wells CMC-15P, -16, -16P, -17 and -17P will be abandoned at this time using the procedures outlined in Section 7.1.3. The long-term care monitoring programs for regional groundwater levels, the TMA and the backfilled and reflooded mine are discussed below.

10.1.3.1 Regional Groundwater Level Monitoring

Figure 10-1 shows the locations of groundwater monitoring wells that will be used to measure groundwater levels on a quarterly basis after the mine ceases operations. The wells included are the same as those that will have been monitored for water elevations during the construction and operations phase of the project. The regional water table is projected to be nearly recovered eight years after mine reflooding starts. Within this time, many of the wells that are a mile or more from the site will have recovered. Thus the wells that will be monitored for regional groundwater levels have been grouped into three categories that coincide with the recovery of the regional groundwater table.

As shown on Figure 10-1, farfield wells which are those wells located more than approximately a mile from the site, and shallow wells around Little Sand Lake will be monitored for water levels for four years after closure. They will then be removed from the monitoring program provided the last year of monitoring shows stable water levels in comparison to pre-operation conditions. Midfield wells, defined as those that are about a mile from the site, will be monitored for water levels for eight years after closure and then removed from the monitoring program provided the last year of monitoring shows stable water levels in comparison to pre-operation conditions. Wells in the immediate vicinity of the mine site would be monitored for groundwater levels until the groundwater system over the mine is nearly recovered, which is projected to occur at approximately 15 years after mine reflooding begins.

Table 10-2 summarizes the phased use of monitoring wells for regional groundwater levels during the long-term care period. Note that monitoring wells used in the long-term care groundwater quality monitoring program will have water level measurements as part of those respective programs (see Section 10.1.3.2 and 10.1.3.3 below) regardless of their inclusion in or deletion from the regional water level monitoring program.

10.1.3.2 TMA Groundwater Quality Monitoring

Figure 10-2 shows the location of groundwater monitoring points that will be included in the TMA long-term care groundwater monitoring program. The wells included are the same wells as those that will have been used during the construction and operations phase of the project. Upon completion of site revegetation, each well will be monitored quarterly during the months of January, April, July and October of each calendar year for the parameters listed below.

pH (Field and Laboratory)	Calcium
Specific Conductance (Field)	Copper
Temperature (Field)	Lead
Total Hardness	Manganese
Total Dissolved Solids	Sulfate
Total Alkalinity	Zinc
Water levels	

Table 10-2

Proposed Long-Term Care Regional Groundwater Elevation Monitoring Wells

A) Wells to be monitored for regional groundwater levels for four years.

DMA-48
DMB-10
DMB-23
DMA-18
CMC-31
G41-A23
G41-E22
EX-14BU
EX-8AL & AU
WP-4U & L
WP-5U & L
CMC-SP-06
CMC-SP-05 A & B
CMC-SP-03 A & B
G40-Y15A

B) Wells to be monitored for regional groundwater levels for eight years.

DMB-15
DMP-3
G40-S17
CDM-16
DMA-19
CMC-SP-09
G40-Y15
EX-15BL
CMC-05
EX-16BL
CMC-SL-103 A & B
CMC-32
CMC-SCC-102B
CMC-SL-103 A & B
EX-4BU

C) Wells to be monitored for regional groundwater levels until water table is nearly recovered over the mine (approximately 15 years).

CMC-10D
CMC-14D
CMC-OWA1, 3, 4 & 5

[1] Wells CMC-09P, -18, -18P, -19, -19P, -20, -20P, -21, -21P, -22, -22P, -23, -23P, -24, -24P, -25, -25P, -26, -26P, -27, -27P, -28P, -29P and -30P included in a long-term care groundwater quality monitoring program. Water levels will continue to be measured in these wells as part of the water quality monitoring programs as described in Section 10.1.3.2 and 10.1.3.3.

Prepared by: SVD1
Checked by: JWS

A comprehensive analysis program as referenced in NR 182.13(2)(e)2 will be performed annually as part of the July sampling round. Parameters included in the comprehensive program will be those included in the quarterly monitoring program and those listed below. The additional selected parameters are those that, based on waste characterization work, could be expected in the leachate from the TMA.

Aluminum	Iron
Antimony	Magnesium
Arsenic	Mercury
Barium	Nickel
Cadmium	Selenium
Cobalt	Silver
Cyanide	Sodium

10.1.3.3 Reflooded Mine Groundwater Quality Monitoring

Figure 10-3 shows the location of groundwater monitoring wells that will be included in the long-term care monitoring program for the reflooded mine. The wells included in the long-term care monitoring plan are the same as those used during the construction and operations phase of the project. These wells will be sampled for parameters included in the TMA long-term care quarterly monitoring program. The wells will be sampled quarterly for a period of five years during the months of January, April, July, and October. After five years of quarterly monitoring, CMC will request a reduction in monitoring parameters and frequency that will remain in effect for the duration of the 40 year long-term care period.

10.1.3.4 System Maintenance

CMC will immediately notify the WDNR if for any reason a monitoring well or device is destroyed or fails to function properly. Unless notified otherwise in writing by the WDNR, CMC will restore, or properly abandon and replace, destroyed or failed monitoring devices within 60 days of written notification referred to above.

10.1.4 TMA Leachate

The TMA leachate monitoring program described in Section 7.3 is proposed to be continued during the long-term care and maintenance period.

10.1.5 Surface Water

The long-term care and maintenance monitoring of the surface waters in the project area will be completed in a diminishing fashion. Water quality and stream flows will be monitored for the first year following closure of the facilities in accordance with the frequency outlined in Section 7.4 above. Lake level monitoring will be conducted annually (August) during the first year for lakes that have reached steady state condition and monthly during ice free conditions for other lakes. Monitoring frequency will then be reduced to one monitoring event annually for a period of five years. Provided no adverse impacts are identified in this time period, all surface water monitoring will be discontinued. Long term care and maintenance surface water

monitoring will be completed at the sites listed in Table 10-3 and shown on Figure 10-4. The analytical parameters that will be monitored at these sampling sites are listed in Table 7-7.

Table 10-3

Proposed Surface Water Long-Term Care Monitoring Locations

Surface Water	Site ID
Swamp Creek	SG-5A
Swamp Creek	SG-2
Swamp Creek	SG-AA
Hemlock Creek	SG-6
Skunk Lake	LG-15
Duck Lake	LG-12
Deep Hole Lake	LG-13
Little Sand Lake	LG-7

Prepared by: GJB1
Checked by: JWS

10.1.6 Terrestrial Ecology

The aerial photographic review of the area surrounding the Crandon Project site, described in Section 7.5, will be performed during the long-term care period for four consecutive years following the mine's closure. The purpose of this review will be to evaluate the success of revegetation during reclamation. The area to be surveyed will be the same as described in Section 7.5.

10.1.7 Wetlands

If wetland water level measurements or vegetation surveys conducted during the construction and operation monitoring program indicate significant effects on a monitored wetland that are attributable to the project, then wetland monitoring at that location during the long-term care and maintenance period will be conducted three times per year (spring, summer, and autumn) until water levels in monitored groundwater monitoring wells stabilize. At this point in time, monitoring will cease.

10.1.8 Reporting

The results of quarterly groundwater monitoring will be submitted to the WDNR 30 days after final verification of analytical groundwater results on forms supplied by the WDNR. In February

of each year following the collection of monitoring data for the previous year, an annual monitoring report will be prepared and submitted to the WDNR. The report will include data collected from the previous year's activities.

10.1.9 Long-Term Care and Maintenance Costs

Tables 10-4 and 10-5 contain itemized estimates of long-term care and maintenance costs for the project. Table 10-4 contains an itemization of the estimated annual costs for the first six years of long-term care and maintenance. Table 10-5 contains an itemization of these costs for years 7 through 40 of the long-term care and maintenance period.

Table 10-4 reflects the greater incidence of long-term care and maintenance activities during the earlier years of the period. The six-year period was selected since it represents the projected point after closure at which a certificate of completion of reclamation would be issued by WDNR for the project. The six-year period includes two years to monitor the revegetated site after closure, and four years in which CMC's notice of the completion of reclamation is processed by WDNR.

10.2 Post Long-Term Care Responsibility Party

Per Sections 144.43(3) and 144.441(2)(c), Wis. Stats., CMC will be perpetually responsible for the long-term care of the tailings management area (TMA) following its closure, defined as "the routine care, maintenance and monitoring." In addition, during the operation of the TMA and for at least 40 years following its closure, CMC will need to maintain proof of financial responsibility "ensuring the availability of funds for compliance with the closure and long-term care requirements" of Wisconsin law [Sections 144.441(2)(b) and 144.443(3), Wis. Stats.]. The DNR may extend this 40-year period for proof of financial responsibility if it "determines that it is necessary to protect human health or the environment" [Section 144.441(2)(f), Wis. Stats.].

In addition, CMC will be perpetually liable for any violations of law that results in "mining-related injuries," defined to include "death or injury to person or property caused by . . . [e]nvironmental pollution from emissions, seepages, leakages or other discharges from mine excavations . . . or from mining waste . . ." Sections 107.30(13) and 107.32, Wis. Stats. Based on the foregoing mandate, it is clear that CMC will not walk away or burden the State of Wisconsin or its citizens with any costs associated with the Crandon Project.

Table 10-4

Annual Long-Term Care and Maintenance Costs
Years 1 Through 6

Item Description	Basis of Costs	Units	Unit Cost	Estimated Quantity	Cost
Site Inspections	Site Inspection and Report	Inspections per Year	$5,000	1.67 (Ave.)[1]	$8,350
Maintenance					
• Landform-Erosion Damage Repair	Repair Erosion Loss at 0.0625 Tons/Yr./Acre	Tons	$300	34.4	$10,320
• Vegetation and Soil Amendments	Replace Plantings, Seed, Fertilize, Mulch	Acres	$4,520	5 (Ave.)[2]	$22,600
• Monitoring Device Replacement[3]	Replace and Abandon Wells, Documentation, Service Other Wells	Lump Sum	$5,000	0.2 (Ave.)[1]	$1,000
Groundwater Monitoring[4]					
• Regional Groundwater Level Monitoring	Water Level Monitoring of wells as Groundwater Table Recovers	Level Readings per Year	$50	119 (Ave.)[1]	$5,950
• TMA Groundwater Quality	Sample Analysis and Reporting	Samplings per Year	$310	80 Samples	$24,800
• Mine Groundwater Quality	Sample Analysis and Reporting	Samplings per Year	$310	16	$4,960
TMA Leachate[4]	Sample Analysis and Reporting	Samplings per Year	$310	16 Samples	$4,960

Table 10-4 *(Continued)*

Item Description	Basis of Costs	Units	Unit Cost	Estimated Quantity	Cost
Surface Water[4]					
• Lake and Stream Quality	Collection, Prep and Analysis Yearly Ave.	Samplings per Year	$255	8.7 (Ave.)[1]	$2,220
• Lake and Stream Levels/Flows	Lakes Annually;Streams Spring/Fall	Level/Flow Readings per Year	$100	8.7 (Ave.)[1]	$870
Terrestrial Ecology	Aerial Photo Documentation	Per Flight	$3,000	0.67 (Ave.)[1]	$2,010
Wetland Monitoring	Piezometers and Plant Communities	Monitorings per year	$3,000	0.4 (Ave.)[1]	$1,200
Leachate Treatment	Treatment with Lime/ Sulfide/Filtration	Gallons	$0.003	9,946,000[5]	$29,840
Treatment Plant and Pipeline Maintenance	Ongoing Maintenance for Existing Treatment System and Pipeline	Lump Sum	$45,000	1	$45,000
			Subtotal		$164,080
Administration/Reporting	General Estimate	Lump Sum		15 Percent	$24,620
			Total		$188,700

[1]These figures are used to average the cost of a particular task so that a yearly average can be estimated.
[2]Average prorated as follows: Year 1 = 10 acres; Year 2 = 8 acres; Year 3 = 6 acres; Year 4 = 4 acres; Year 5 = 2 acres; Year 6 = 0 acres.
[3]Assumes one well is abandoned and replaced every five years and other wells are serviced annually.
[4]Assumes CMC labor to be used. Cost for this labor is included in sample collection and/or water flow or water level measurement unit costs.
[5]Average leachate generation rate in gallons per year based on HELP model for post-closure years 1 through 6.

Prepared by: PAE
Checked by: JWS

Table 10-5

Annual Long-Term Care and Maintenance Costs
Years 7 Through 40

Item Description	Basis of Costs	Units	Unit Cost	Estimated Quantity	Cost
Site Inspections	Site Inspection and Report	Inspections per Year	$5,000	One/Year	$5,000
Maintenance					
• Landform Erosion Damage Repair	Repair Erosion Loss at 0.0625 Tons/Year/Acre	Tons	$300	34.4	$10,320
• Vegetation and Soil Amendments	None Required after 6th Year	–	–	–	–
• Monitoring Device Replacement	Replace and Abandon Wells, Documentation, Service Other Wells[1]	Lump Sum	$5,000	0.2	$1,000
Groundwater Monitoring[2]					
• Regional Groundwater Level Monitoring	Water Level Monitoring of wells as Groundwater Table Recovers	Level Readings per Year	$50	16 (Ave.)[3]	$800
• TMA Groundwater Quality	Sample Analysis and Lab Testing	Samplings per Year	$310	80 Samples	$24,800
• Mine Groundwater Quality	Sample Analysis and Reporting	Samplings per Year	$310	16	$4,960
TMA Leachate[2]	Sample Analysis and Lab Testing	Samplings per Year	$310	16	$4,960

Table 10-5 *(Continued)*

Item Description	Basis of Costs	Units	Unit Cost	Estimated Quantity	Cost
Leachate Treatment	Treatment with Lime/ Sulfide/Filtration	Gallons	$0.003	2,993,000[4]	$9,000
Treatment Plant and Pipeline Maintenance	Ongoing Maintenance for Existing Treatment System and Pipeline	Lump Sum	$45,000	1	$45,000
			Subtotal		$105,840
Administration/Reporting	General Estimate	Lump Sum		15 Percent	$15,860
			Total		$121,700

[1]Assumes one well is abandoned and replaced every five years and other wells serviced annually.
[2]Assumes CMC labor to be used. Cost for this labor is included in sample collection and/or water flow or water level measurement unit costs.
[3]These figures are used to average the cost of a particular task so that a yearly average can be estimated.
[4]Average leachate generation rate in gallons per year based on HELP model for post-closure years 7 through 40.

Prepared by: PAE
Checked by: JWS

11 References

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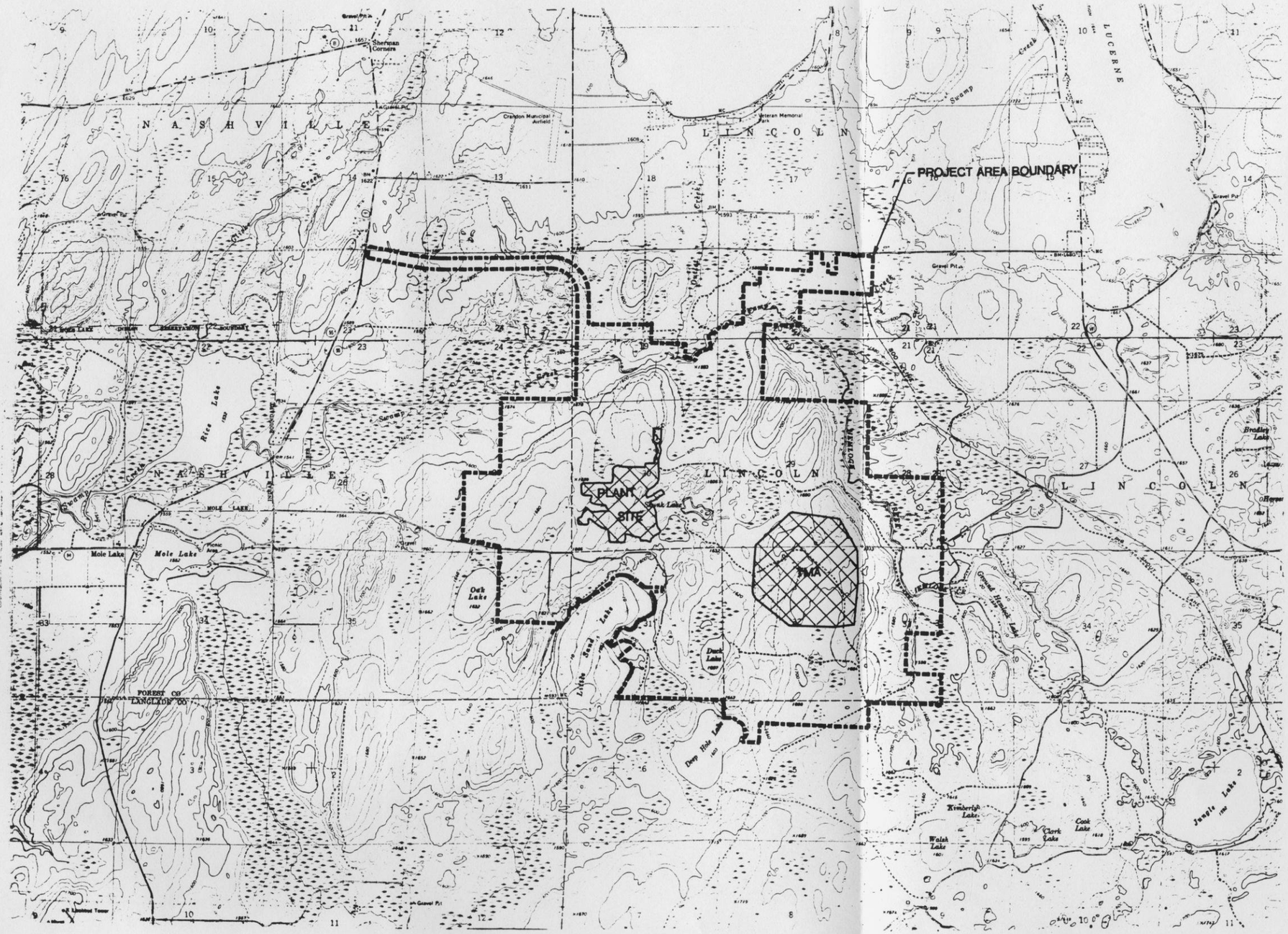
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N

ROAD CLASSIFICATION

Primary highway, hard surface
Secondary highway, hard surface
Light-duty road, hard or improved surface
Unimproved road
Interstate Route
U. S. Route
State Route

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

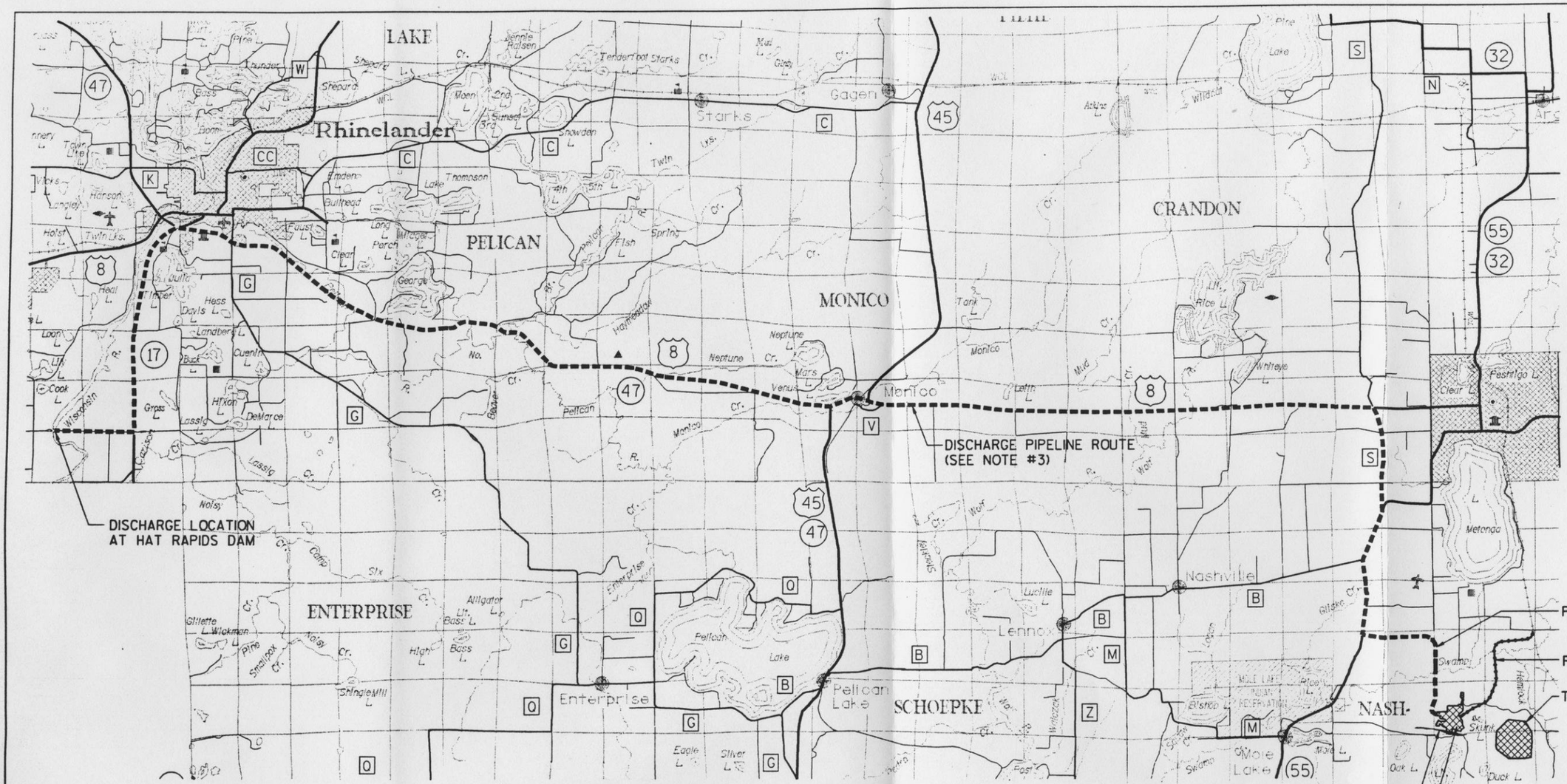
Crandon Mining Company

FIGURE 1-1
PROJECT SITE TOPOGRAPHIC MAP

Scale: 0 2000' 4000'
Date: MAY, 1995
Prepared By: Foth & Van Dyke
By: BSH

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93C049



LEGEND

- LAKES
- U.S. OR STATE HWY
- COUNTY TRUNK ROAD
- TOWN ROAD
- SECTION LINE
- CORPORATE LIMITS
- (8) U.S. HWY NO.
- (47) STATE HWY NO.
- [W] COUNTY HIGHWAY LETTER
- PROPOSED WASTEWATER PIPELINE

NOTES:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION.
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.
3. THE DISCHARGE PIPELINE ROUTE BEGINS AT THE CRANDON PROJECT SITE, FOLLOWS THE PROPOSED PLANT SITE ACCESS ROAD TOWARD THE NORTHWEST TO STATE TRUNK HIGHWAY (STH) 55, APPROXIMATELY 1/2 MILE SOUTH OF AIRPORT ROAD, THEN NORTH ON STH 55 TO COUNTY TRUNK HIGHWAY (CTH) S, THEN NORTH ON CTH S TO U.S. ROUTE (USR) 8, THEN WEST ON USR 8 TO STH 17. FROM THE INTERSECTION OF USR 8 AND STH 17, THE ROUTE FOLLOWS STH 17 SOUTH TO HAT RAPIDS ROAD AND THEN WEST ON HAT RAPIDS ROAD TO THE HAT RAPIDS DAM.

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE:	MAY'95
APPROVED BY:	JBH	DATE:	MAY'95
APPROVED BY:	PAE	DATE:	MAY'95

Crandon Mining Company

FIGURE 1-2

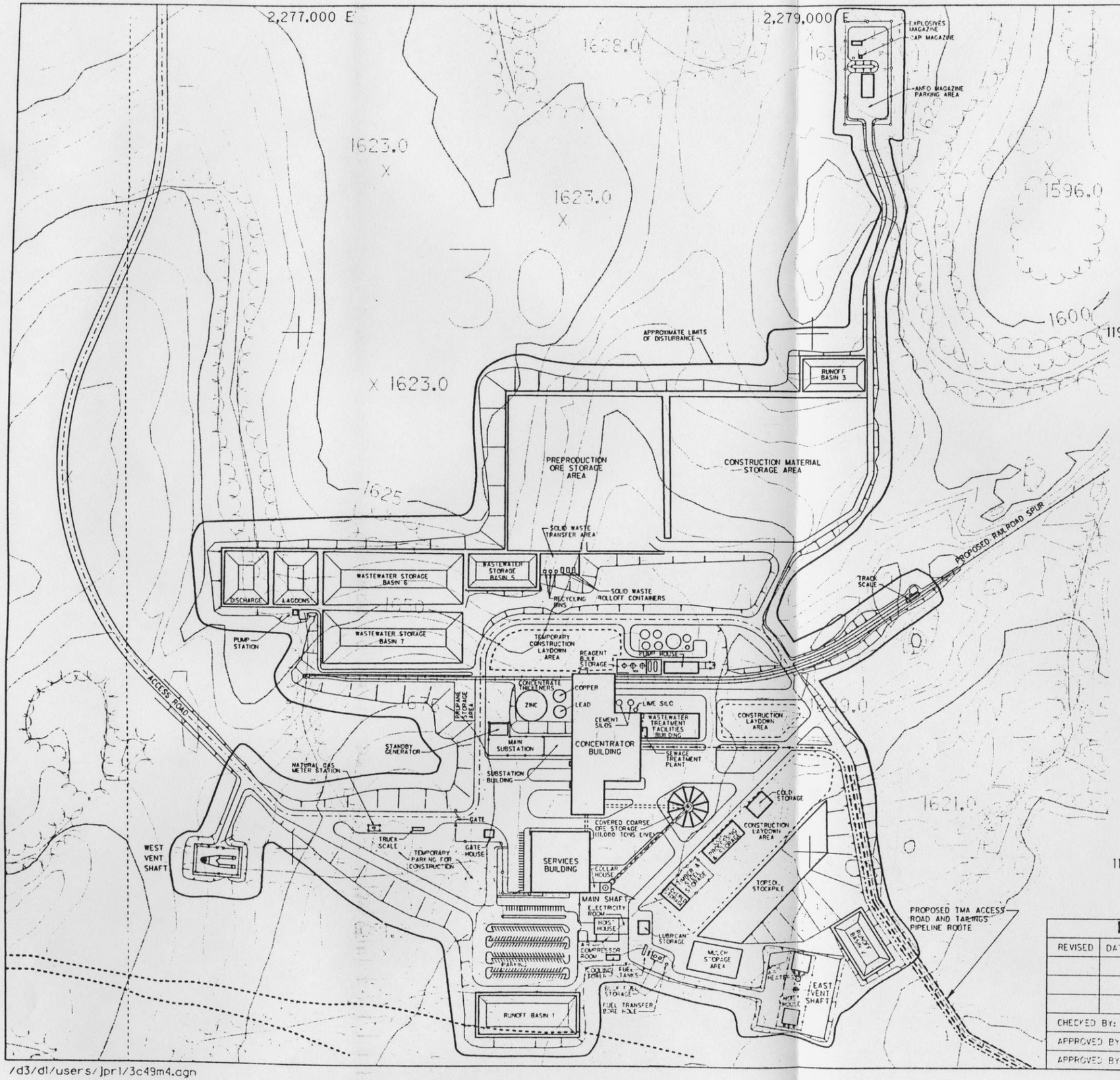
PROPOSED PIPELINE ROUTE FOR WISCONSIN RIVER DISCHARGE

Scale: 0 6000' 12,000' | Date: MAY, 1995

Prepared By: Foth & Van Dyke | By: GAM

/d3/dl/users/jprl/4c65f4.dgn

93C049



N

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- —1675— EXISTING CONTOUR
- x 1692.0 SPOT ELEVATION
- SECTION LINE
- ORE BODY
- APPROXIMATE LIMITS OF PLANT SITE DISTURBANCE
- TAILINGS PIPELINE DITCH ALIGNMENT

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1"=1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS FIVE FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
5. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

SCALE
0 200' 400'

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE:	MAY'95
APPROVED BY:	JBH	DATE:	MAY'95
APPROVED BY:	PAE	DATE:	MAY'95

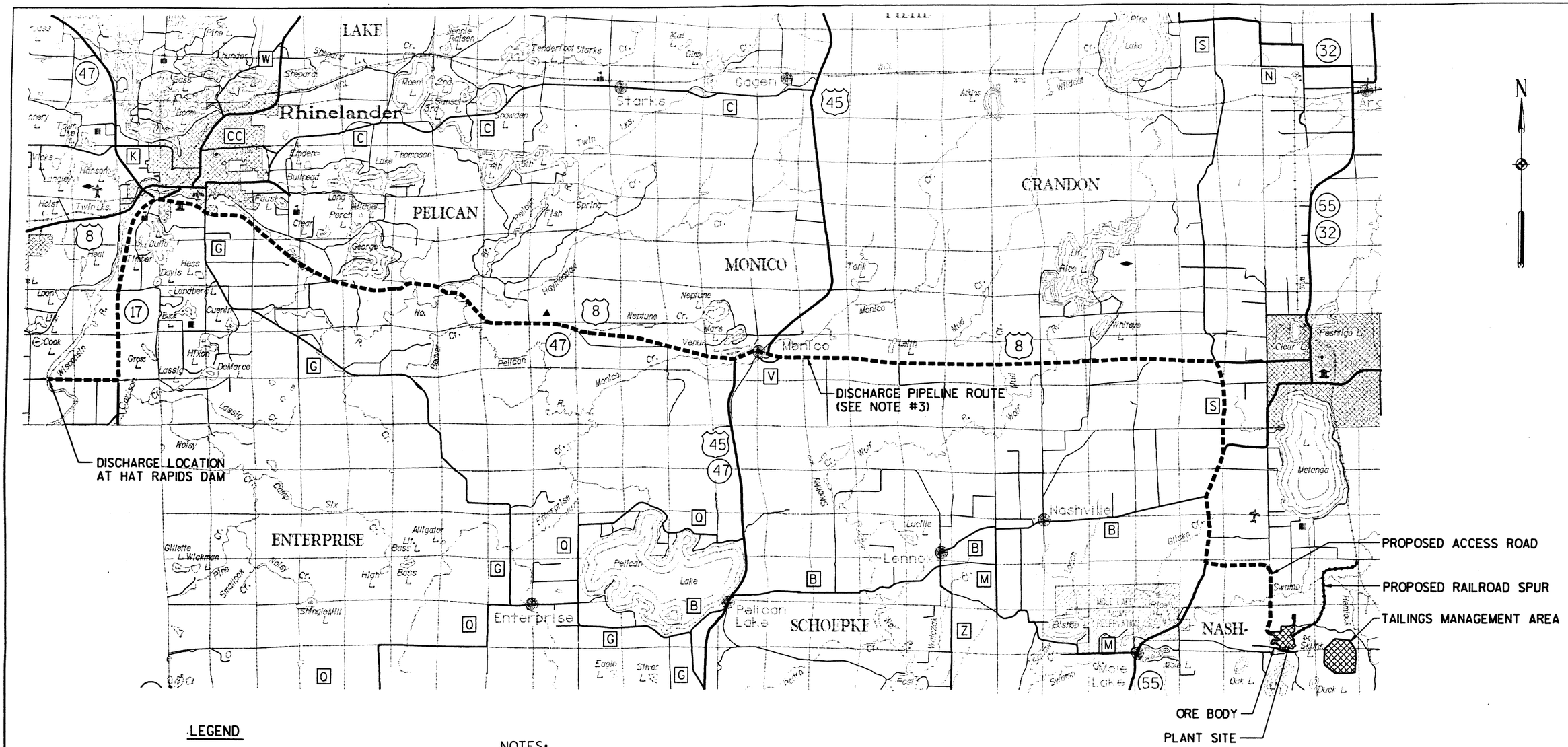
Crandon Mining Company

FIGURE 2-1
PLANT SITE LAYOUT

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	JRB2

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93C049



LEGEND

- LAKES
- U.S. OR STATE HWY
- COUNTY TRUNK ROAD
- TOWN ROAD
- SECTION LINE
- CORPORATE LIMITS
- (8) U.S. HWY NO.
- (47) STATE HWY NO.
- [W] COUNTY HIGHWAY LETTER
- PROPOSED WASTEWATER PIPELINE

NOTES:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION.
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TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS	DATE:	MAY '95
APPROVED BY:	JBH	DATE:	MAY '95
APPROVED BY:	PAE	DATE:	MAY '95

Crandon Mining Company

FIGURE 1-2

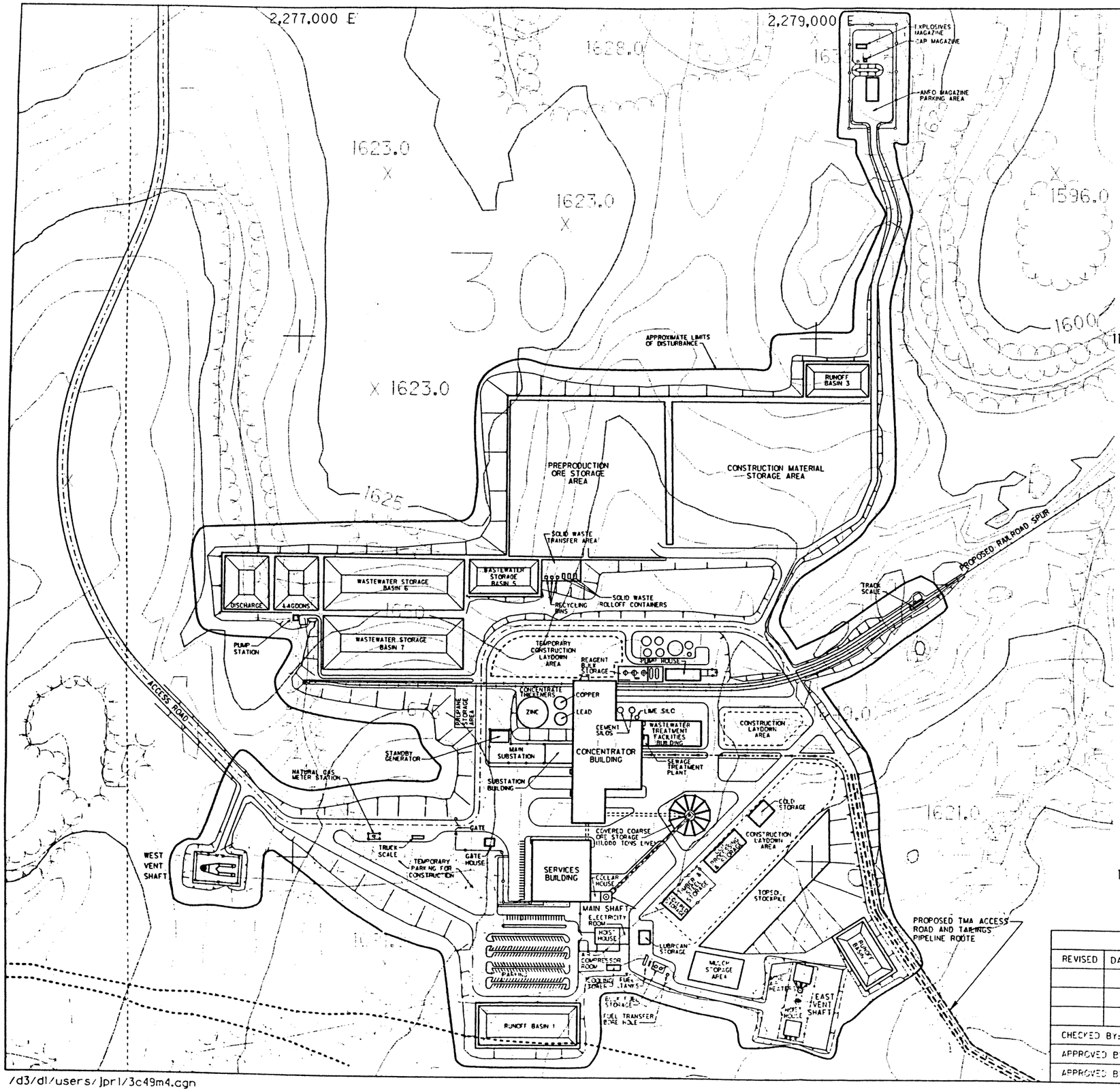
PROPOSED PIPELINE ROUTE FOR WISCONSIN RIVER DISCHARGE

Scale: 0 6000' 12,000' | Date: MAY, 1995

Prepared By: Foth & Van Dyke | By: GAM

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LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- —1675— EXISTING CONTOUR
- x 1692.0 SPOT ELEVATION
- SECTION LINE
- ORE BODY
- APPROXIMATE LIMITS OF PLANT SITE DISTURBANCE
- TAILINGS PIPELINE DITCH ALIGNMENT

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1"=1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS FIVE FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
5. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

SCALE
0 200' 400'

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE:	MAY'95
APPROVED BY:	JBH	DATE:	MAY'95
APPROVED BY:	PAE	DATE:	MAY'95

Crandon Mining Company

FIGURE 2-1
PLANT SITE LAYOUT

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	JRB2

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2,260,000 E 2,265,000 E 2,270,000 E 2,275,000 E 2,280,000 E 2,285,000 E 2,290,000 E

130,000 N

125,000 N

120,000 N

115,000 N

110,000 N

105,000 N

LAKE METONGA

LAKE RD

SHERMAN LK

RICE LAKE

WOLF LAKE INDIAN RESERVATION

NASH-

PLANT SITE

LINCOLN

MA

VILLE

AINSWORTH

FOREST COUNTY
LANGLADE COUNTY

MOLE LAKE

SAND LAKE RD

OAK LAKE

LITTLE SAND LAKE

DUCK LAKE

DEEP HOLE LAKE

GROUND HEMLOCK LAKE

KIMBERLY LAKE

WALSH LAKE

CLARK LAKE

ST JOHNS LAKE

ROLLING STONE LAKE

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- COUNTY BOUNDARY
- CIVIL TOWN BOUNDARY
- SECTION LINE
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- WETLAND AREA
- WETLAND DIVIDER
- WETLAND STUDY BOUNDARY

WETLANDS WITHIN THIS BOUNDARY BASED ON NORMANDEAU ASSOCIATES, INC., AND INTERDISCIPLINARY ENVIRONMENTAL PLANNING, INC. 1983. WETLANDS OUTSIDE THIS BOUNDARY BASED ON AERIAL PHOTOGRAPHIC INTERPRETATION BY FOTH & VAN DYKE IN 1995.

- PROJECT AREA BOUNDARY

N

NOTES:

1. BASE MAP DIGITIZED FROM 1"=1000' SCALE, MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
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3. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

Crandon Mining Company

FIGURE 2-4
WETLAND MAP

Scale: 0 1750' 3500' Date: MAY, 1995

Prepared By: Foth & Van Dyke By: BSH

93C049

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	WETLAND DESIGNATION	ACRES	SUBTOTAL	TOTAL ACRES
PROPOSED ACCESS ROAD	Z7	.33		
	Z6	.44		
	Z9	.58		
	W2	.16		
	W1	2.40		
			3.91	
PLANT SITE	5	.28	.28	
TMA ACCESS ROAD	F11	.40		
	13	.07		
			.47	
RECLAIM POND	14	.06		
	15	.14		
			.20	
TMA	F30	.02		
	F31	6.45		
	F32	.68		
	F81	.33		
	16	.10		
	F33	1.82		
	17	.54		
	M4	.73		
	M3	3.16		
		6.76		
	UNNAMED (3)	1.0		
			21.59	
PROPOSED R.R. SPUR	T4	2.99		
	T1	.06		
			3.05	

29.50

2,270,000 E 2,275,000 E 2,280,000 E 2,285,000 E

125,000 N 120,000 N 115,000 N

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- COUNTY BOUNDARY
- CIVIL TOWN BOUNDARY
- SECTION LINE
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- F35 WETLAND IDENTIFICATION

NOTES:

1. BASE MAP DIGITIZED FROM 1"=1000' SCALE, MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
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3. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY: JKS1 DATE: MAY '95
APPROVED BY: JBH DATE: MAY '95
APPROVED BY: PAE DATE: MAY '95

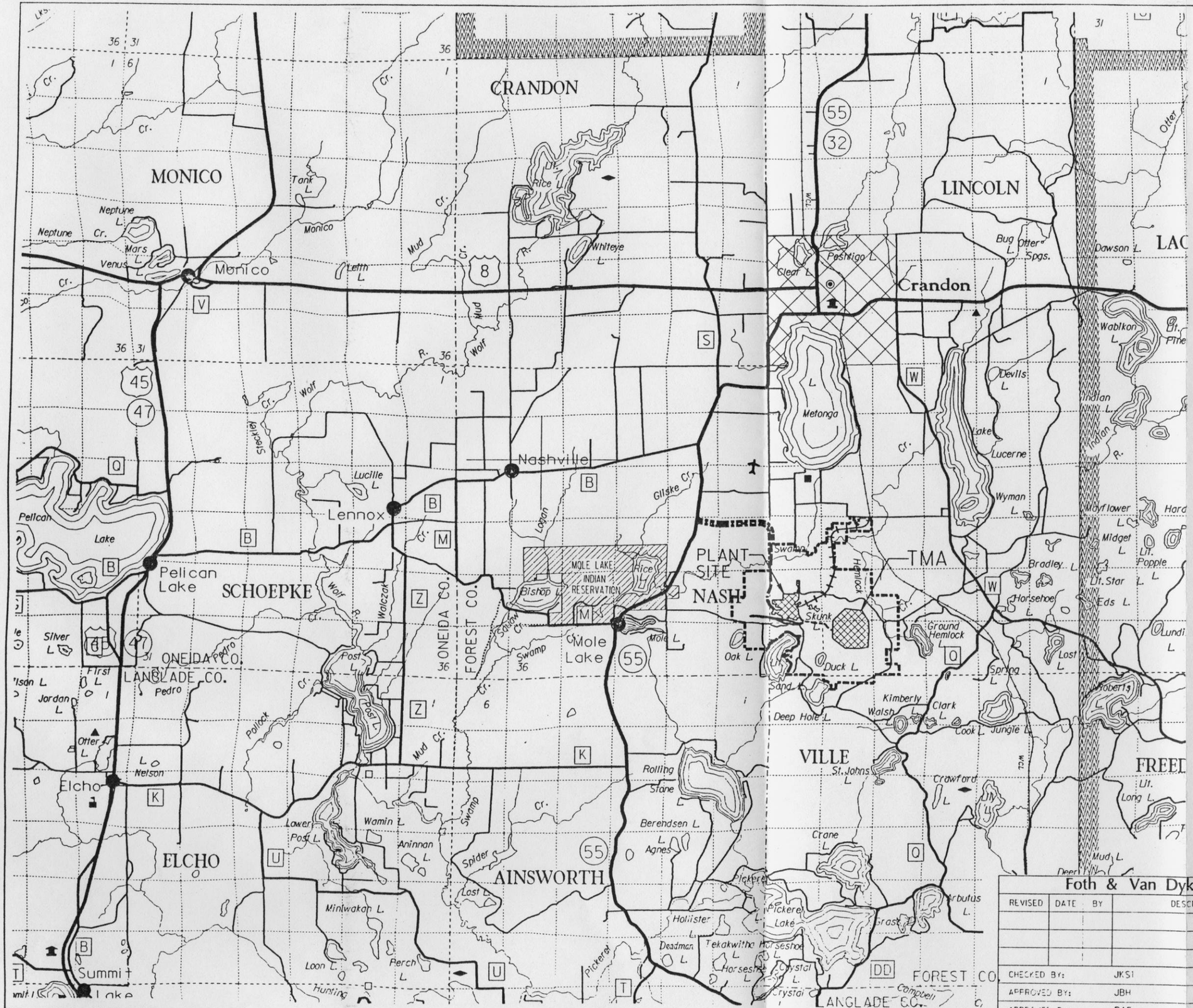
Crandon Mining Company

FIGURE 2-5
WETLAND ACREAGE MAP

Scale: 0 800' 1600' Date: MAY, 1995
Prepared By: Foth & Van Dyke By: BSH

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LEGEND

- U.S. OR STATE HWY
- COUNTY TRUNK ROAD
- TOWN ROAD
- COUNTY BOUNDARY
- CIVIL TOWN BOUNDARY
- SECTION LINE
- (8) U.S. HWY NO.
- (47) STATE HWY NO.
- [W] COUNTY HIGHWAY LETTER
- NATIONAL & STATE FOREST BOUNDARY
- CORPORATE LIMITS
- UNINCORPORATED VILLAGE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- PROJECT BOUNDARY LINE

NOTES:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION.
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

Crandon Mining Company

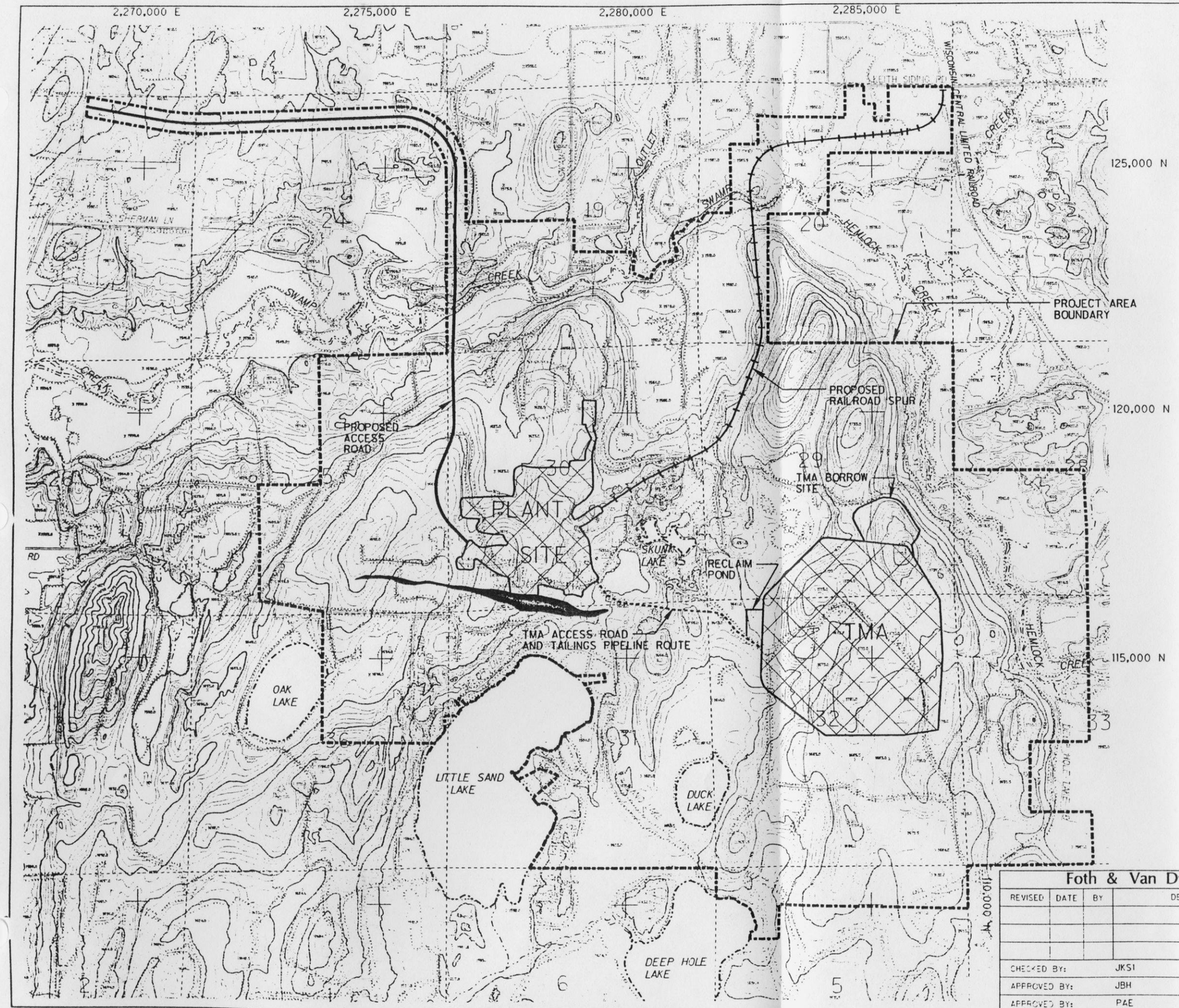
FIGURE 4-1
SITE LOCATION

Scale: 0 5000' 10,000' Date: MAY, 1995

Prepared By: Foth & Van Dyke By: BSH

/d3/dl/users/jpri/3c49ml.dgn

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LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- 1675 — EXISTING CONTOUR
- 1692.0 EXISTING SPOT ELEVATION
- SECTION LINE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES

N

NOTES:

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3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS 25 FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
5. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

0 1000' 2000'
SCALE

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

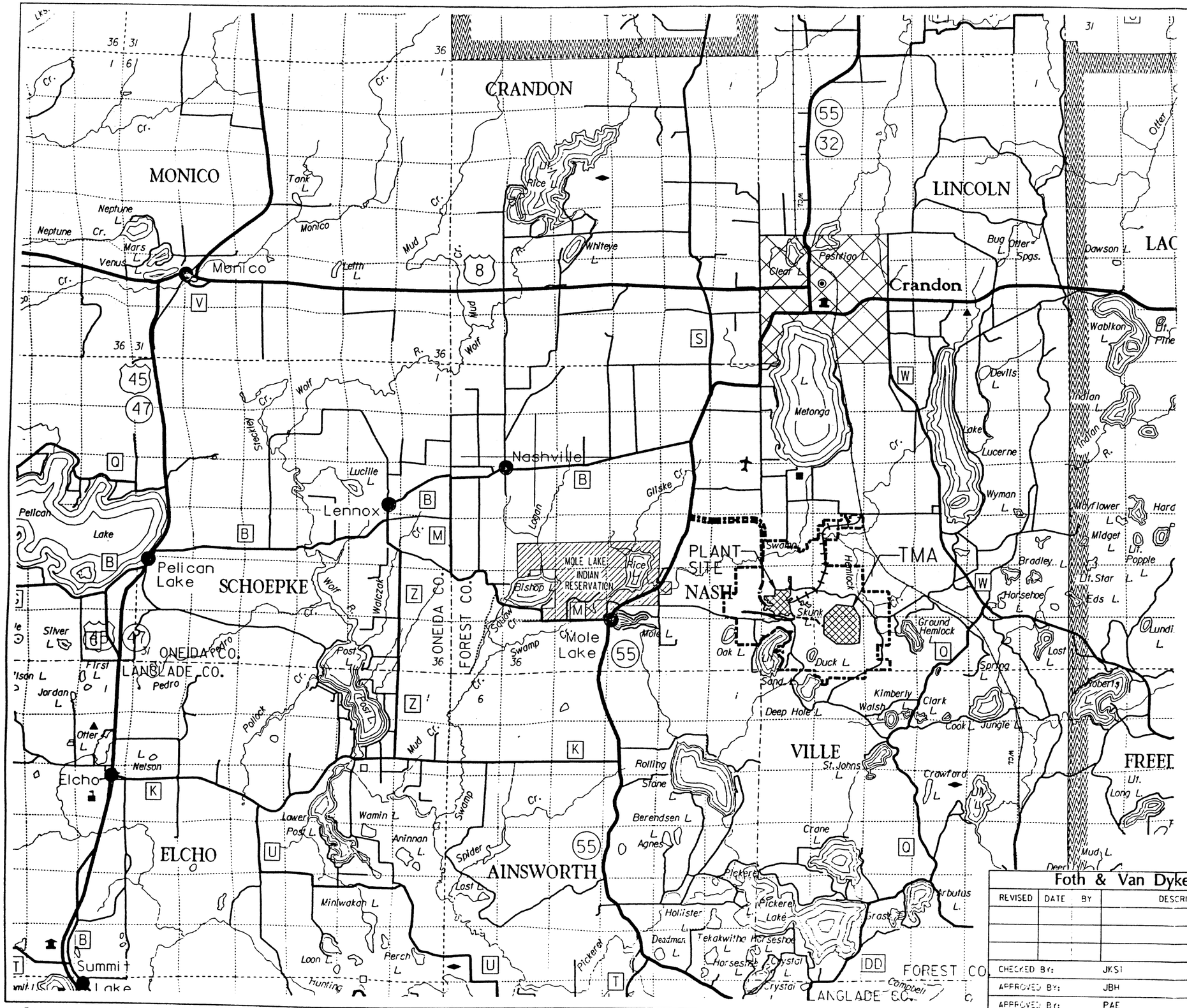
Crandon Mining Company

FIGURE 4-2
PROJECT AREA

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	JRB

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LEGEND

- U.S. OR STATE HWY
- COUNTY TRUNK ROAD
- TOWN ROAD
- COUNTY BOUNDARY
- CIVIL TOWN BOUNDARY
- SECTION LINE
- (8) U.S. HWY NO.
- (47) STATE HWY NO.
- [W] COUNTY HIGHWAY LETTER
- NATIONAL & STATE FOREST BOUNDARY
- CORPORATE LIMITS
- UNINCORPORATED VILLAGE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- PROJECT BOUNDARY LINE

N

NOTES:

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2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95	
APPROVED BY:	JBH	DATE: MAY '95	
APPROVED BY:	PAE	DATE: MAY '95	

Crandon Mining Company

FIGURE 4-1
SITE LOCATION

Scale: 0 5000 10,000 Date: MAY, 1995

Prepared By: Foth & Van Dyke By: BSH

/d3/d1/users/jpri/3c49ml.dgn

93C049

2,270,000 E
2,275,000 E
2,280,000 E
2,285,000 E
125,000 N
120,000 N
115,000 N
110,000 N

PROJECT AREA BOUNDARY
PROPOSED ACCESS ROAD
PROPOSED RAILROAD SPUR
TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
PLANT SITE
TMA
TMA BORROW SITE
RECLAIM POND
SKUNK LAKE
OAK LAKE
LITTLE SAND LAKE
DUCK LAKE
DEEP HOLE LAKE
CATTLE CREEK
SWAMP CREEK
HEMLOCK CREEK
WISCONSIN CENTRAL LIMITED RAILROAD
SHERMAN LN
RD

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- EXISTING CONTOUR (1675)
- EXISTING SPOT ELEVATION (1692.0)
- SECTION LINE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1" = 1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS 25 FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
5. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

0 1000' 2000'
SCALE

Foth & Van Dyke

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CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

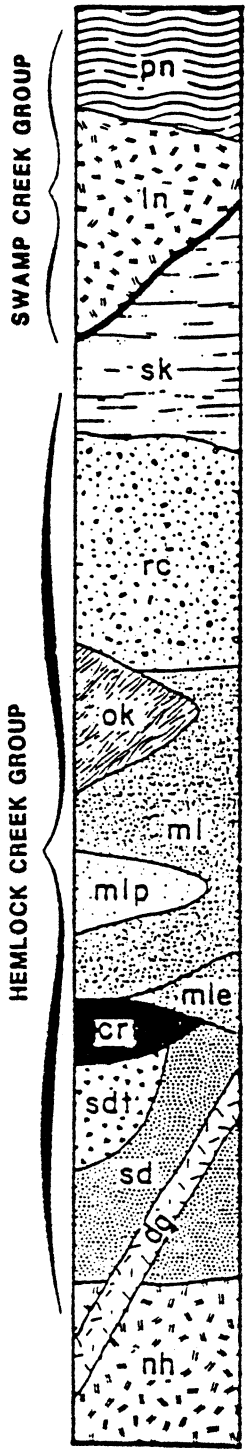
Crandon Mining Company

FIGURE 4-2
PROJECT AREA

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	JRB

/d3/d:/users/jpr1/4c62z1.dgn

93C049



PINE FORMATION (pn)
Cherty tuff and argillite.

LINCOLN FORMATION (ln)
Quartz porphyritic rhyolite flows with minor interflow tuff, chert and argillite.

SKUNK LAKE FORMATION (sk)
Predominantly fine to coarse ash chert tuff, some cherty and very minor argillite.

RICE LAKE FORMATION (rc)
Volcanic debris flows (blocky chloritic and minor siliceous lapilli and breccia size debris) and eutaxitic ash flows, some chert.

OAK LAKE FORMATION (ok)
Sequence of cherty tuff and sericitic tuff.

MOLE LAKE FORMATION (ml)
Predominantly mafic ash tuff.

PROSPECT MEMBER (mlp)
Volcanic debris flow consisting of siliceous, lapilli size debris.

EAGLE MEMBER (mle)
Volcanic greywacke.

CRANDON FORMATION (cr)
Laminated, bedded & replacement sulfides (zinc ore) interbedded with pyritic argillite, pyritic felsic tuff and chert.

SAND LAKE FORMATION (sd)
Sequence of fine felsic tuffs and minor felsic debris & lava flows.

TOWNSHIP MEMBER (sdt)
Volcanic vent breccia affected by multiple stage hydrothermal alteration and sulfide enrichment.

NASHVILLE FORMATION (nh)
Feldspar porphyritic mafic flows.

DUCK LAKE GABBRO (dg)
Fresh, 2 pyroxene gabbro.
Cross cuts nh and sd.

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CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBHI	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

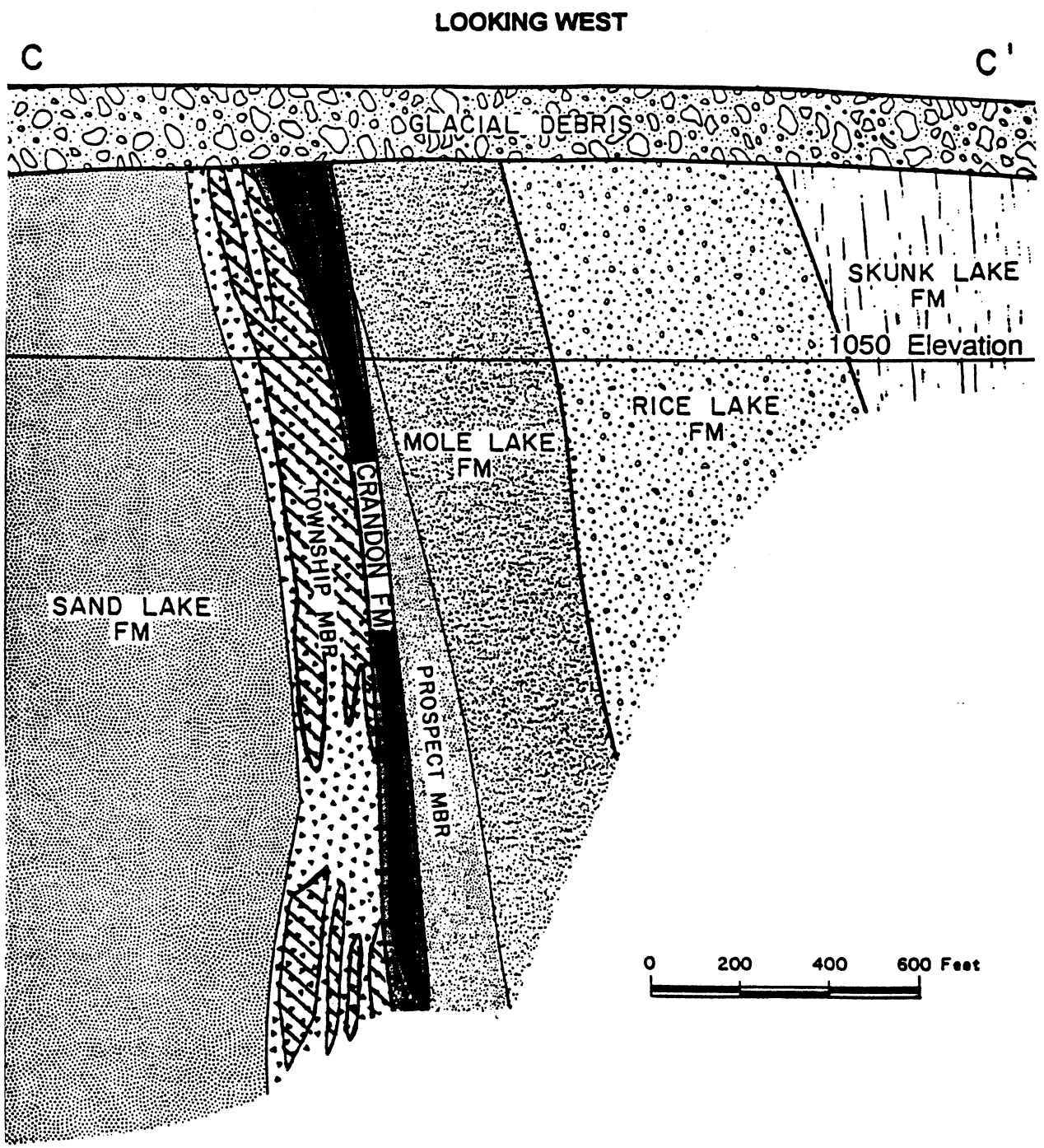
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FIGURE 4-3
STRATIGRAPHIC COLUMN

Scale:	NOT TO SCALE	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	BSH

c:\cadwork\3c49m5.dgn

93C049



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CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBHI	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

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FIGURE 4-4

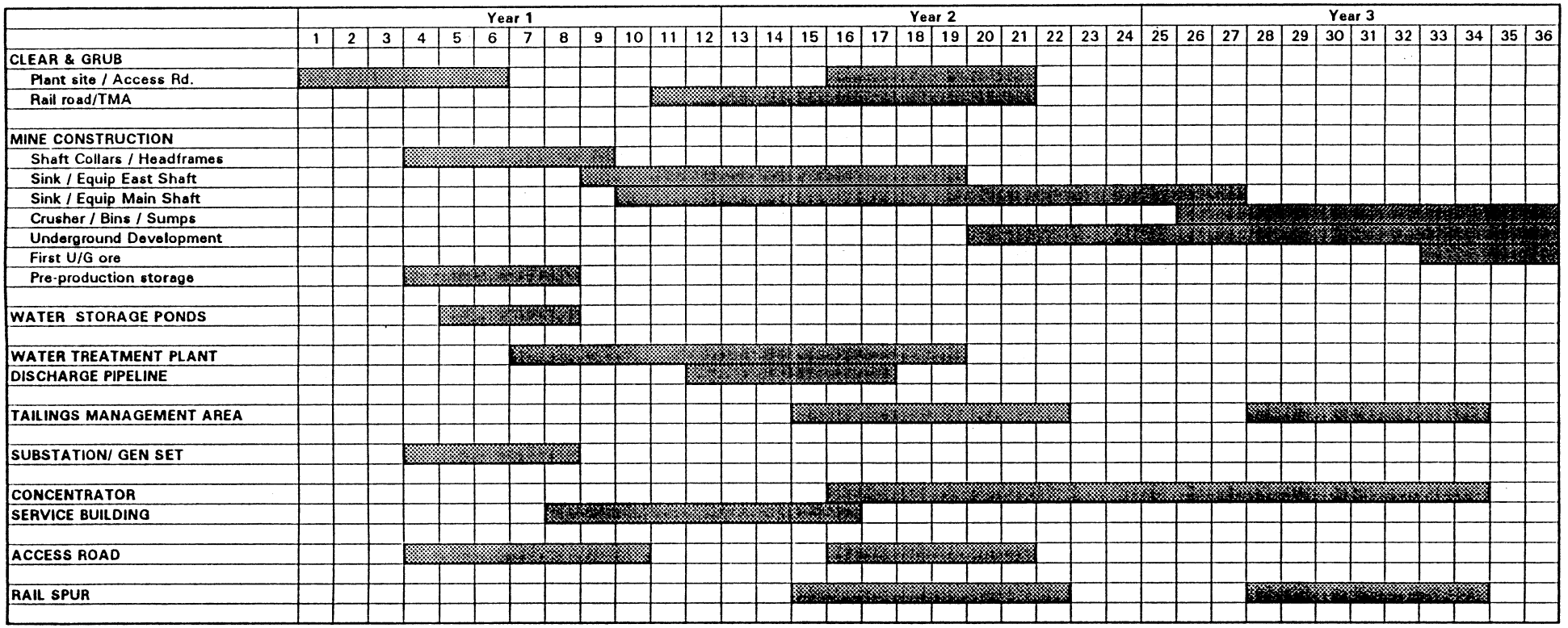
GENERALIZED GEOLOGIC CROSS SECTION C-C'

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	BSH

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93C049

c:\cadwork\3c49figs.dgn



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CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

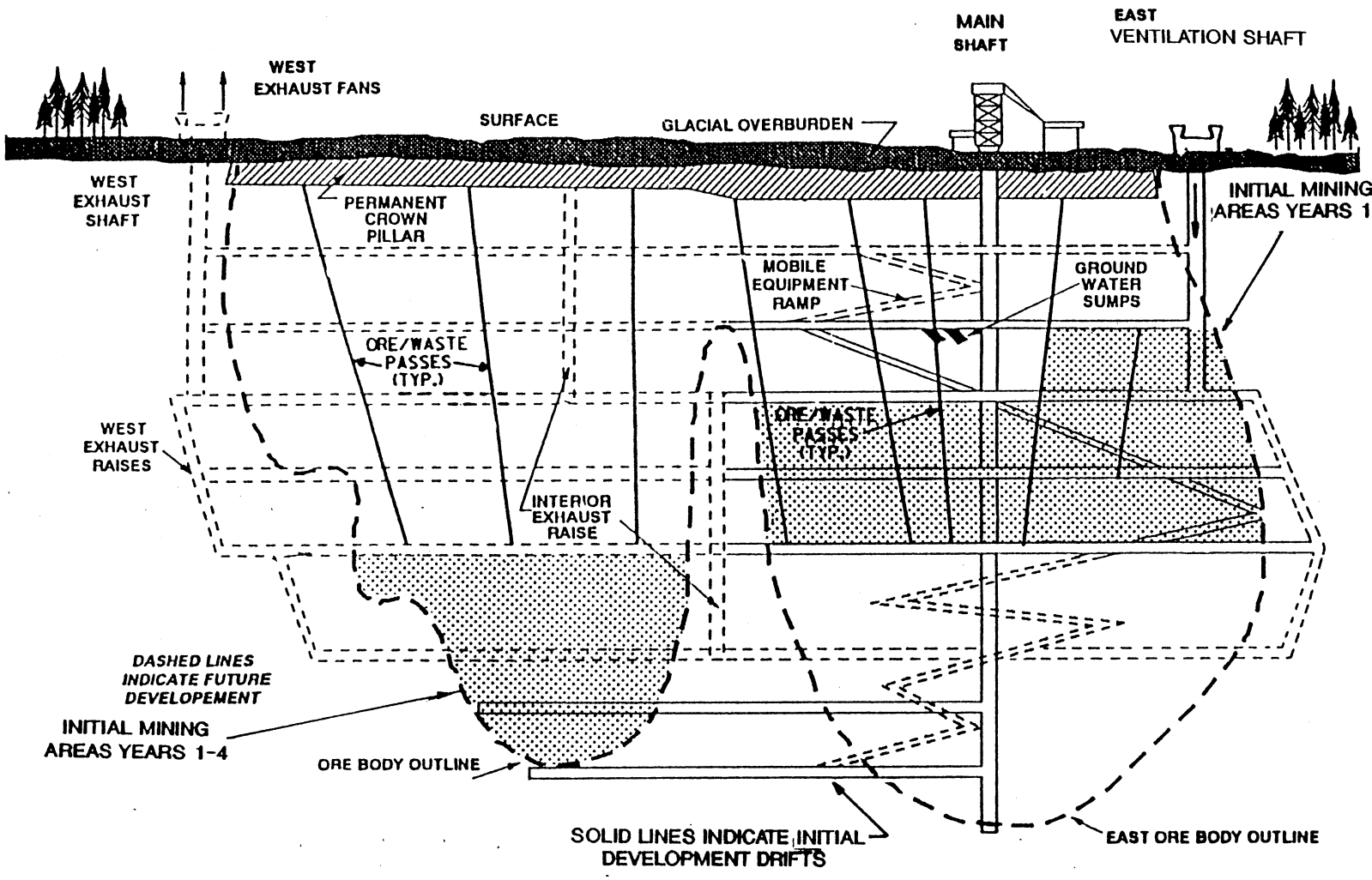
Crandon Mining Company

FIGURE 4-5

CONSTRUCTION SCHEDULE

Scale:	NOT TO SCALE	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	JRB2

93C049



Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBHI	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

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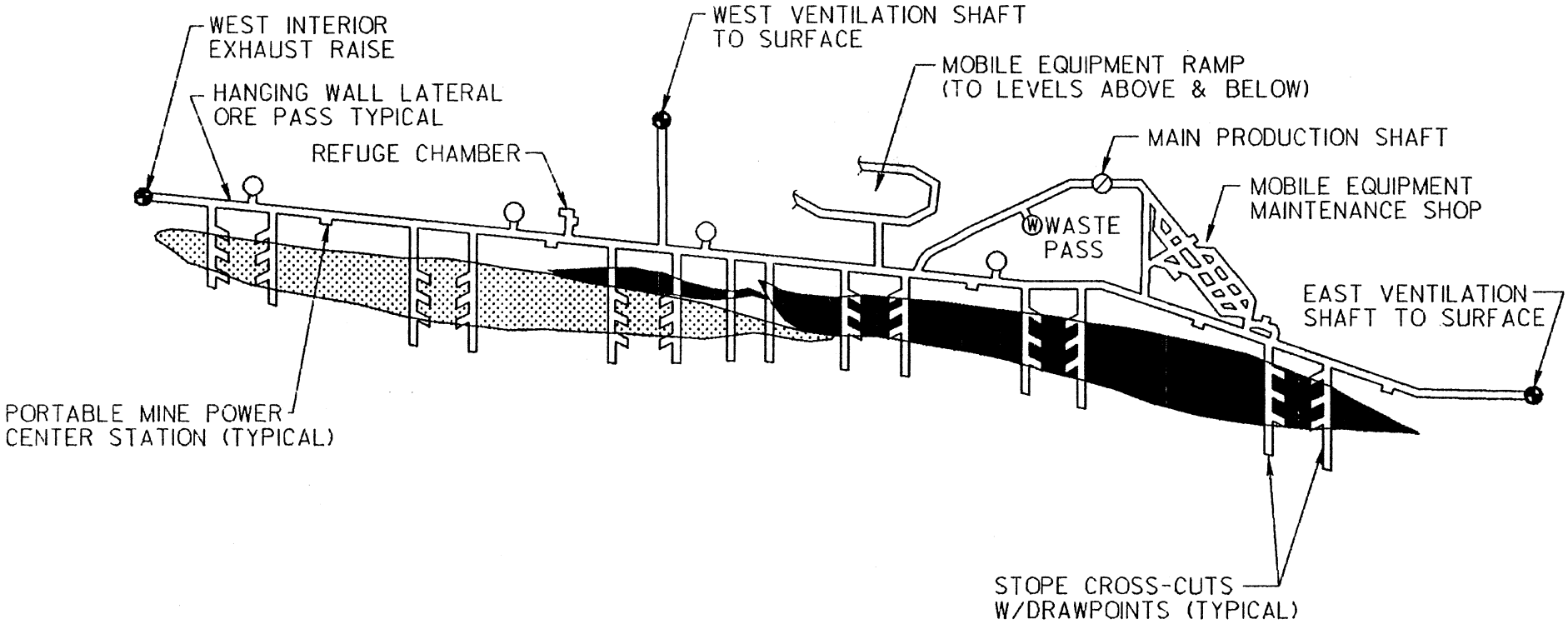
FIGURE 4-6

SCHEMATIC LONGITUDINAL SECTON (LOOKING NORTH)

Scale:	NOT TO SCALE	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	BSH

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93C049



Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBHI	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

Crandon Mining Company

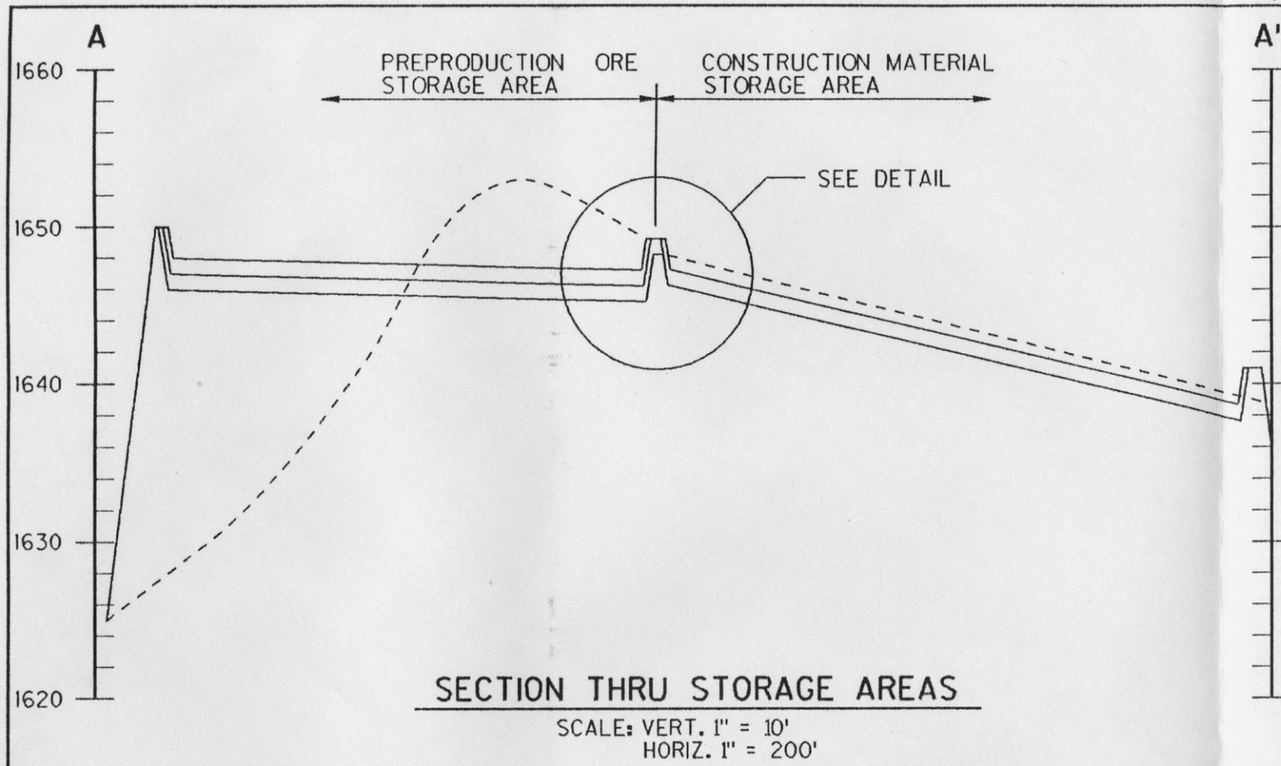
FIGURE 4-7

MAIN MINE LEVEL (350)
CONCEPTUAL PLAN

Scale:	NOT TO SCALE	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	BSH

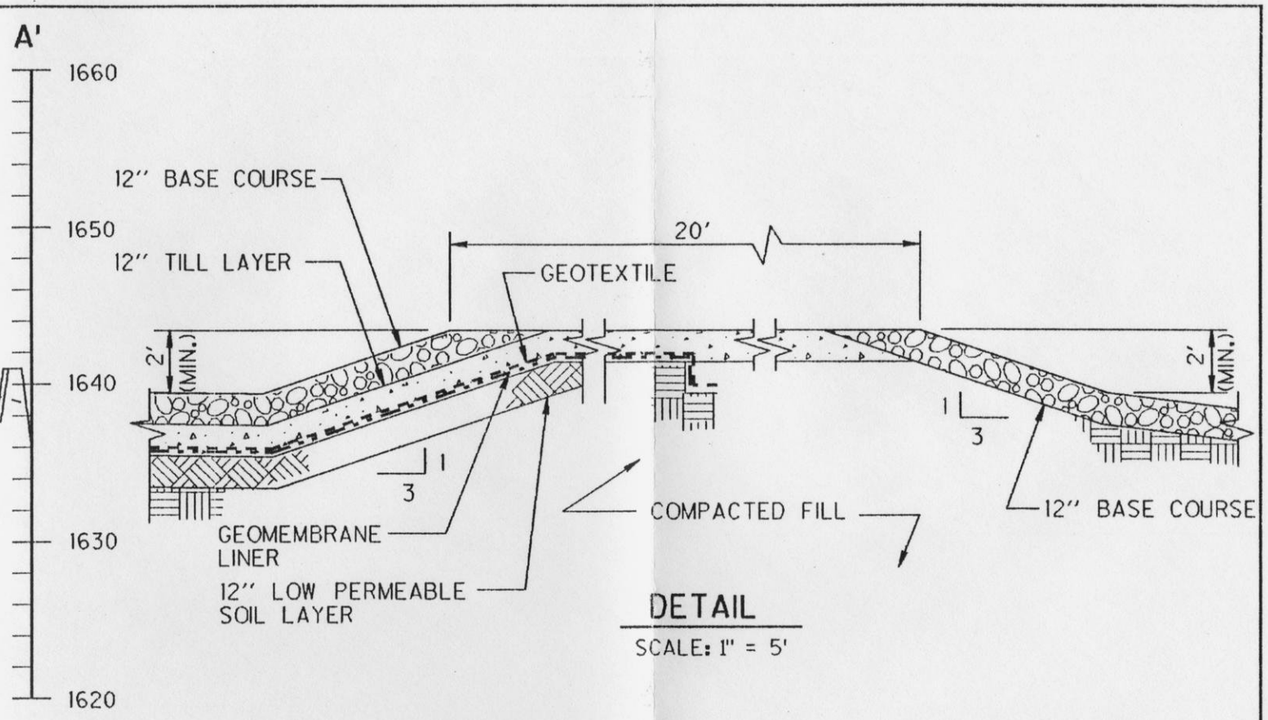
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93C049



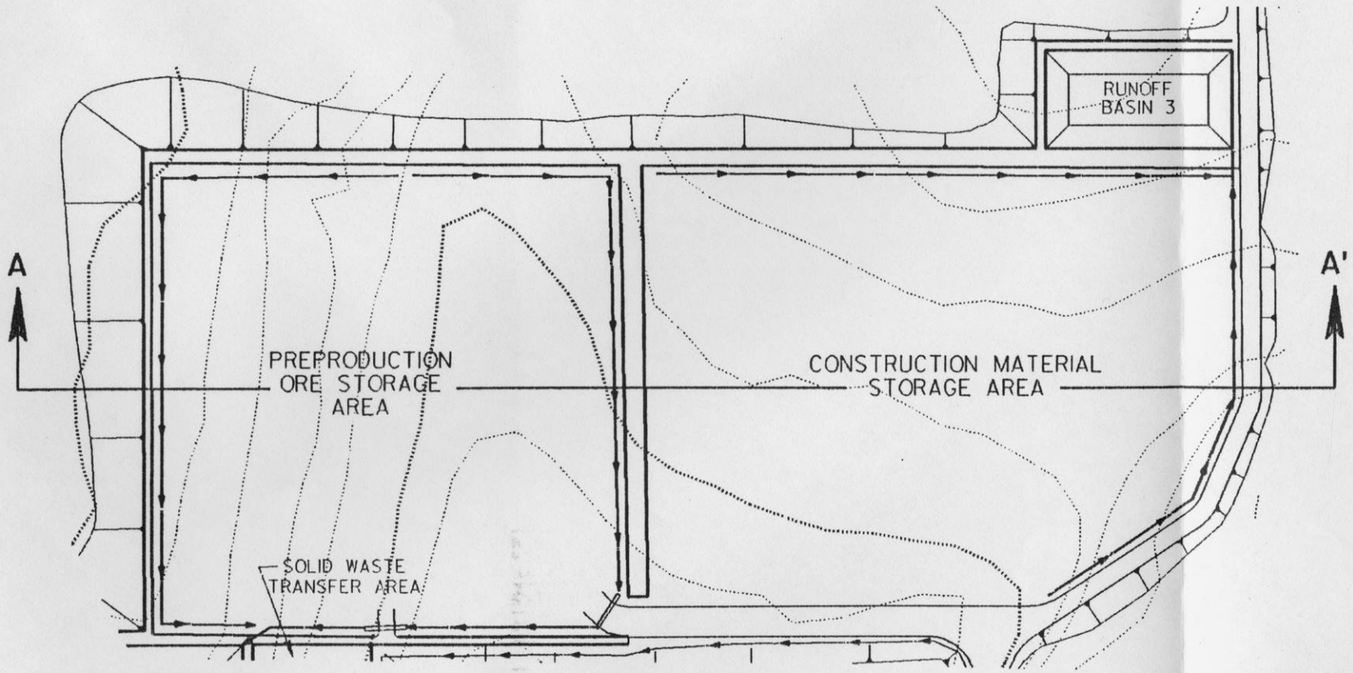
SECTION THRU STORAGE AREAS

SCALE: VERT. 1" = 10'
HORIZ. 1" = 200'



DETAIL

SCALE: 1" = 5'



PLAN VIEW - STORAGE AREAS

SCALE: 1" = 200'

TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

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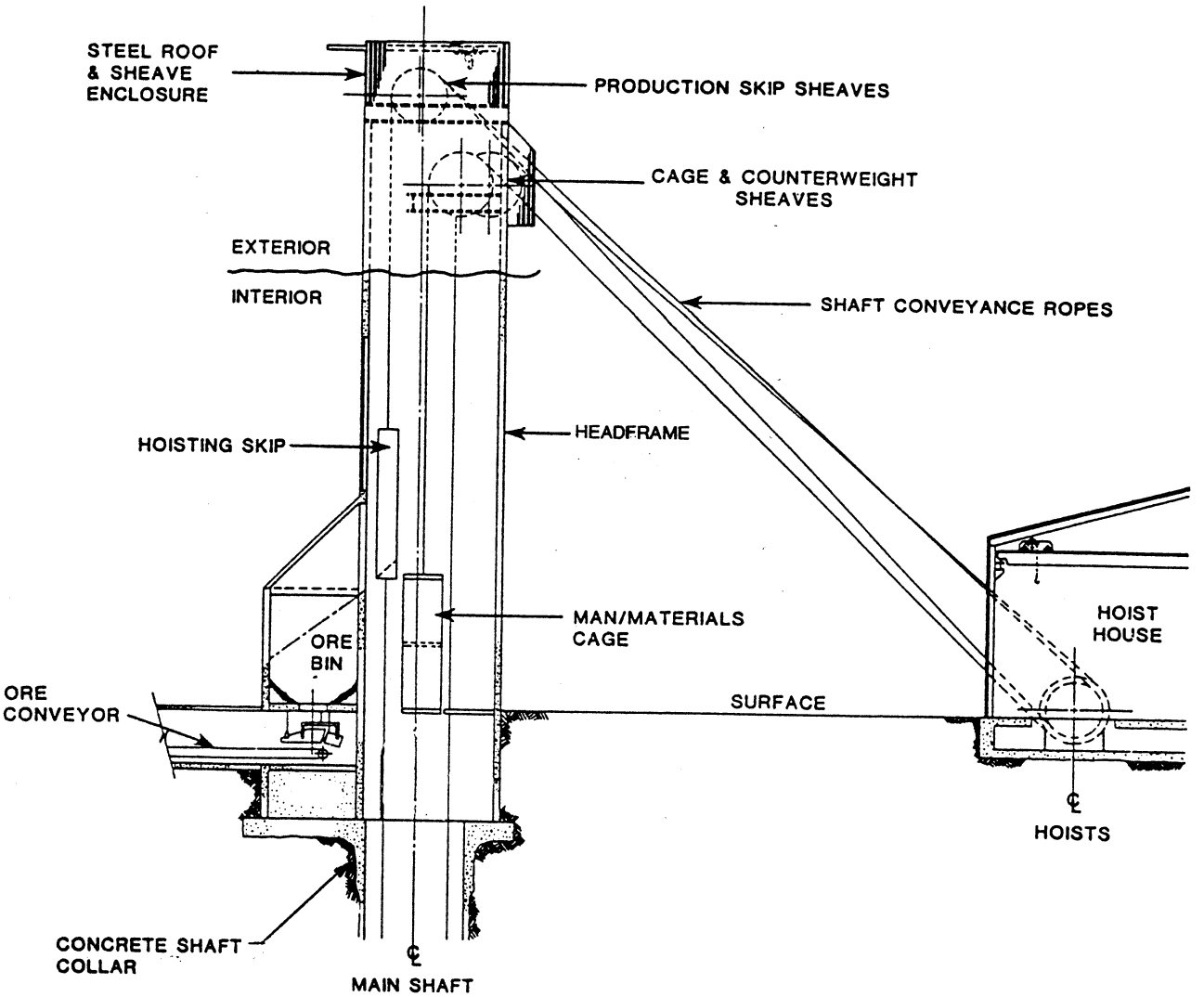
FIGURE 4-10

STORAGE AREAS PLAN & SECTION

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	JPR

93C049

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LOOKING EAST

Foth & Van Dyke			
REVISED	DATE	BY	DESCRIPTION

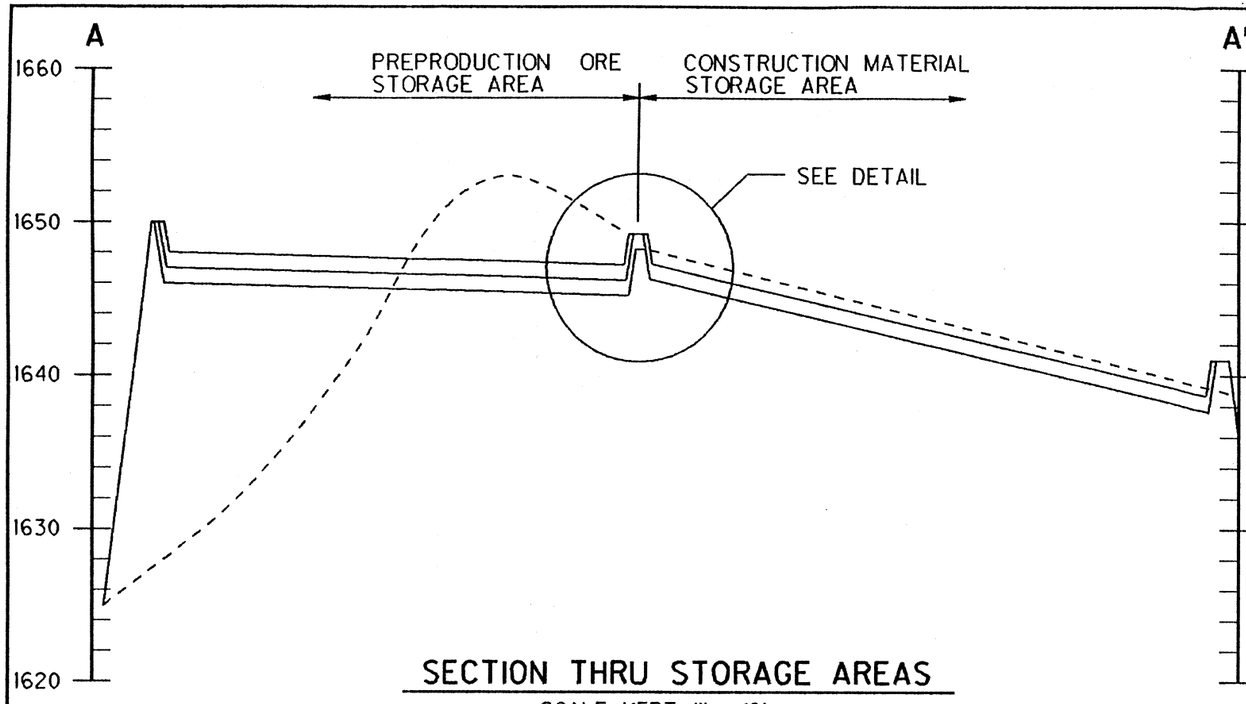
CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBHI	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

Crandon Mining Company

FIGURE 4-9

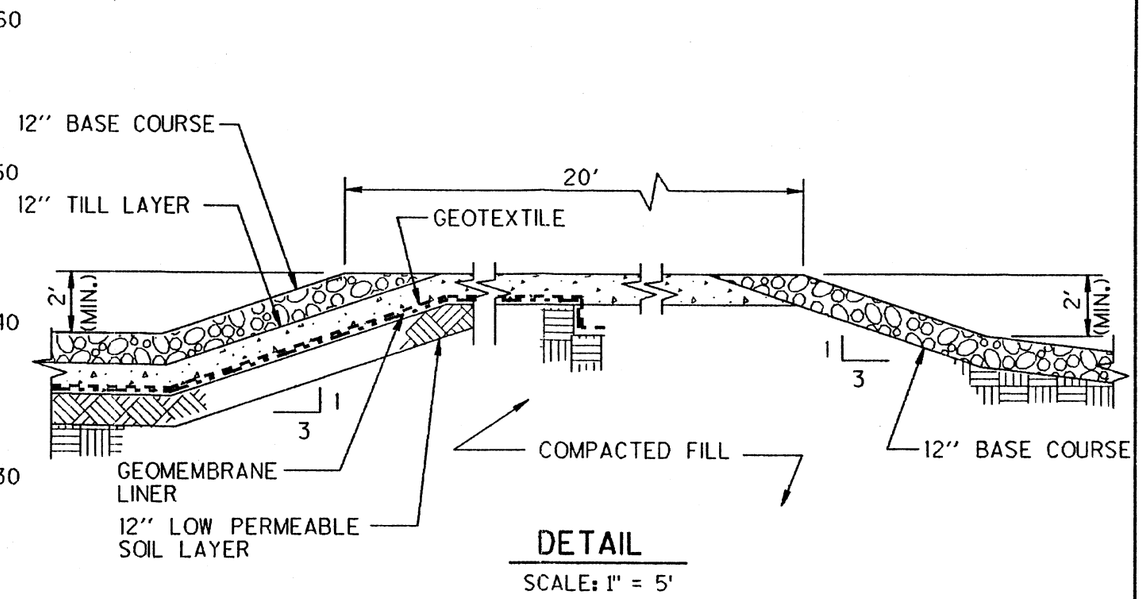
MAIN SHAFT HEADFRAME HOISTS

Scale:	NOT TO SCALE	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	JPRI



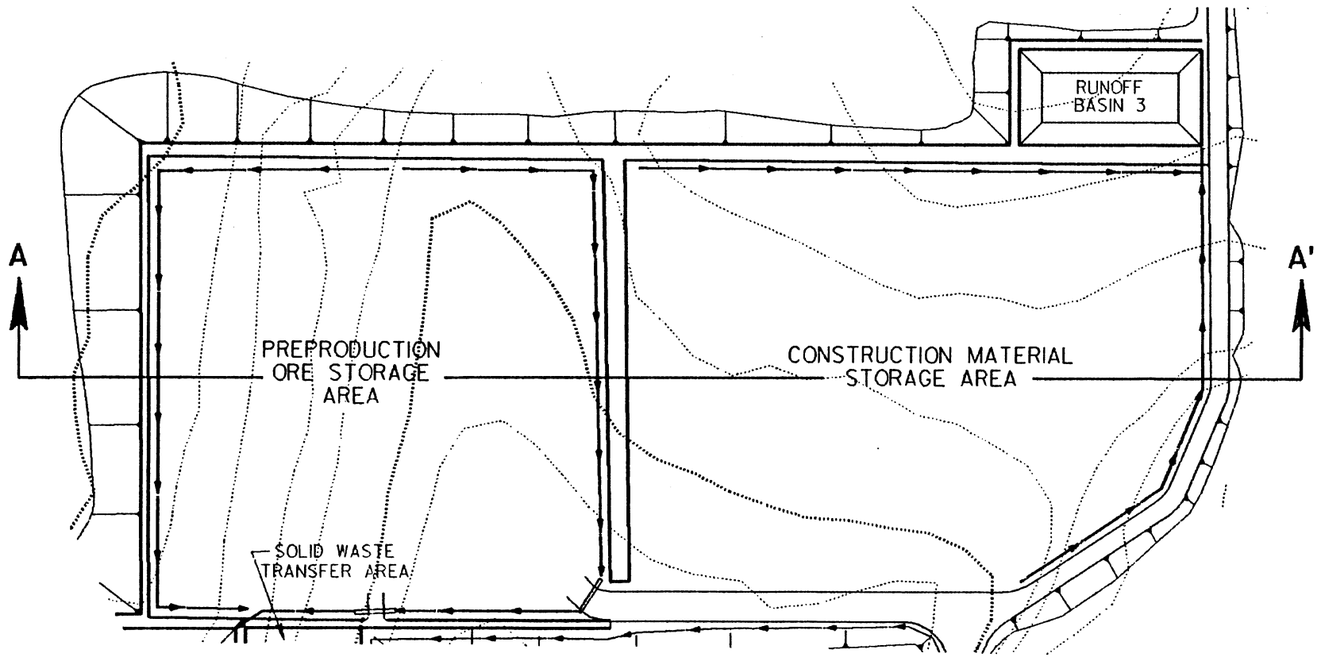
SECTION THRU STORAGE AREAS

SCALE: VERT. 1" = 10'
HORIZ. 1" = 200'



DETAIL

SCALE: 1" = 5'



PLAN VIEW - STORAGE AREAS

SCALE: 1" = 200'

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

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CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

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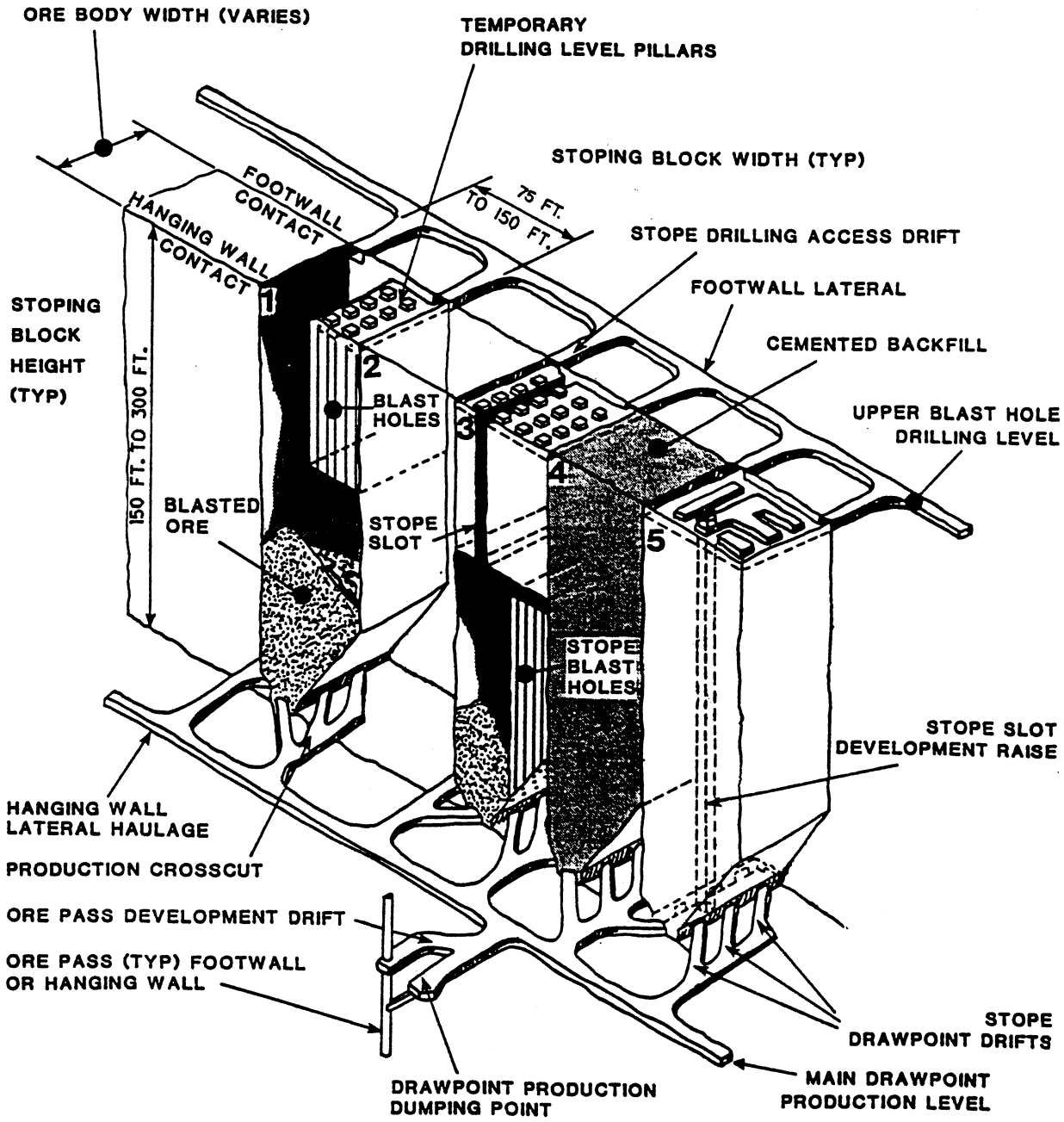
FIGURE 4-10

STORAGE AREAS PLAN & SECTION

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	JPR

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STOPING BLOCK NO. 1–ACTIVE PRODUCTION–STOPE BLASTING NEARING COMPLETION

STOPING BLOCK NO. 2–ALTERNATE STOPING BLOCK/PILLAR–TO BE MINED AFTER BACKFILLING ADJACENT STOPES

STOPING BLOCK NO. 3–ACTIVE PRODUCTION–INITIAL STAGES OF STOPE BLASTING

STOPING BLOCK NO. 4–DEPLETED STOPE BLOCK–CEMENTED BACKFILL IN PLACE

STOPING BLOCK NO. 5–STOPE BLOCK PARTIALLY DEVELOPED

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REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY'95
APPROVED BY:	JBHI	DATE: MAY'95
APPROVED BY:	PAE	DATE: MAY'95

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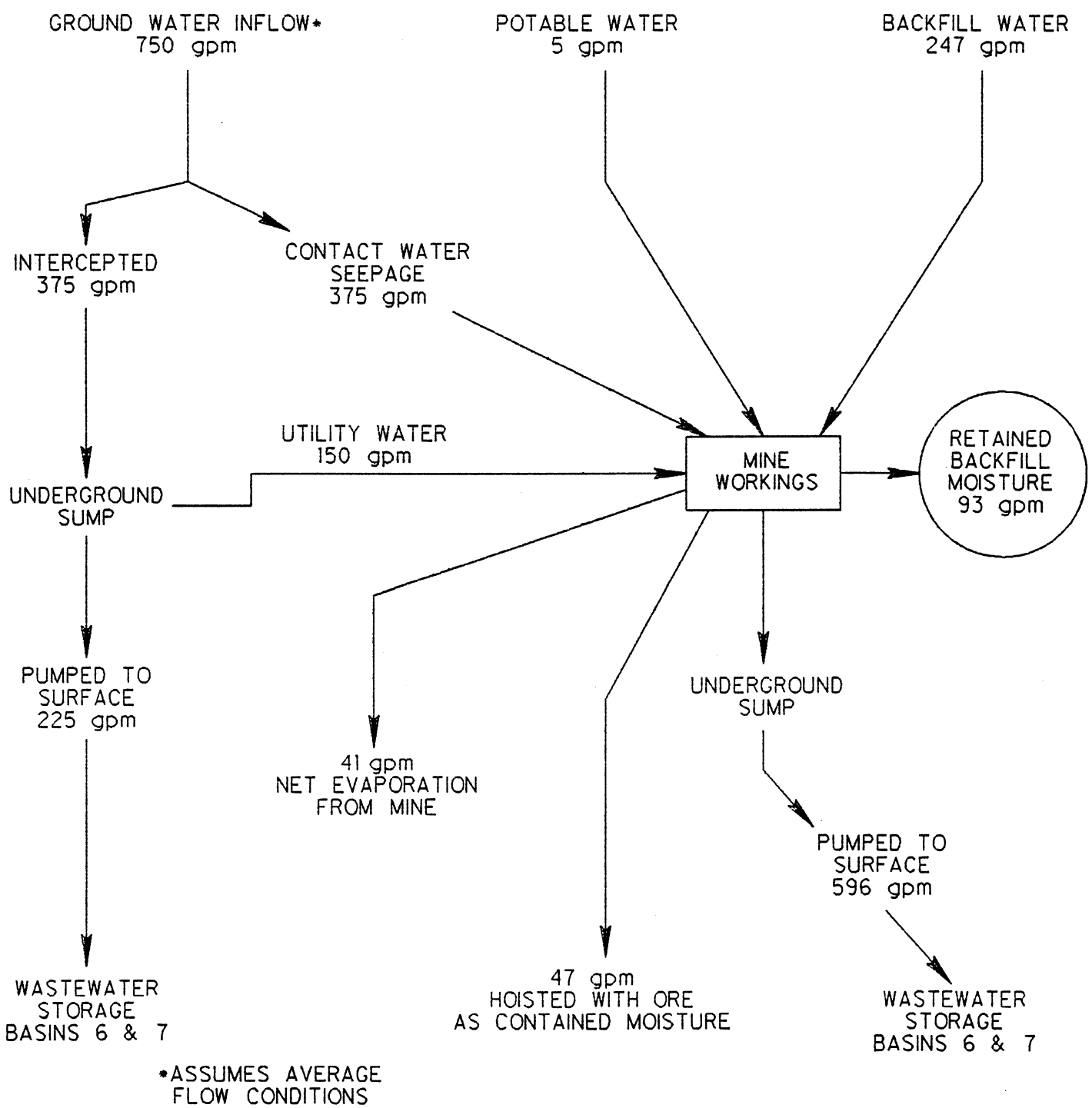
FIGURE 4-11

CONCEPTUAL STOPING SEQUENCE

Scale:	NOT TO SCALE	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	BSH

/d3/dl/users/jprl/3c49m5.dgn

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CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

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FIGURE 4-12

MINE DRAINAGE SCHEMATIC & WATER BALANCE

Scale:	NOT TO SCALE	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	JPRI

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93C049

/d3/dl/users/jprl/3c49m5.dgn

REVISED	DATE	BY	DESCRIPTION

Foth & Van Dyke

APPROVED BY: PAE	CHECKED BY: JKSI	DATE: MAY '95
APPROVED BY: JBHI	DATE: MAY '95	
DATE: MAY '95		

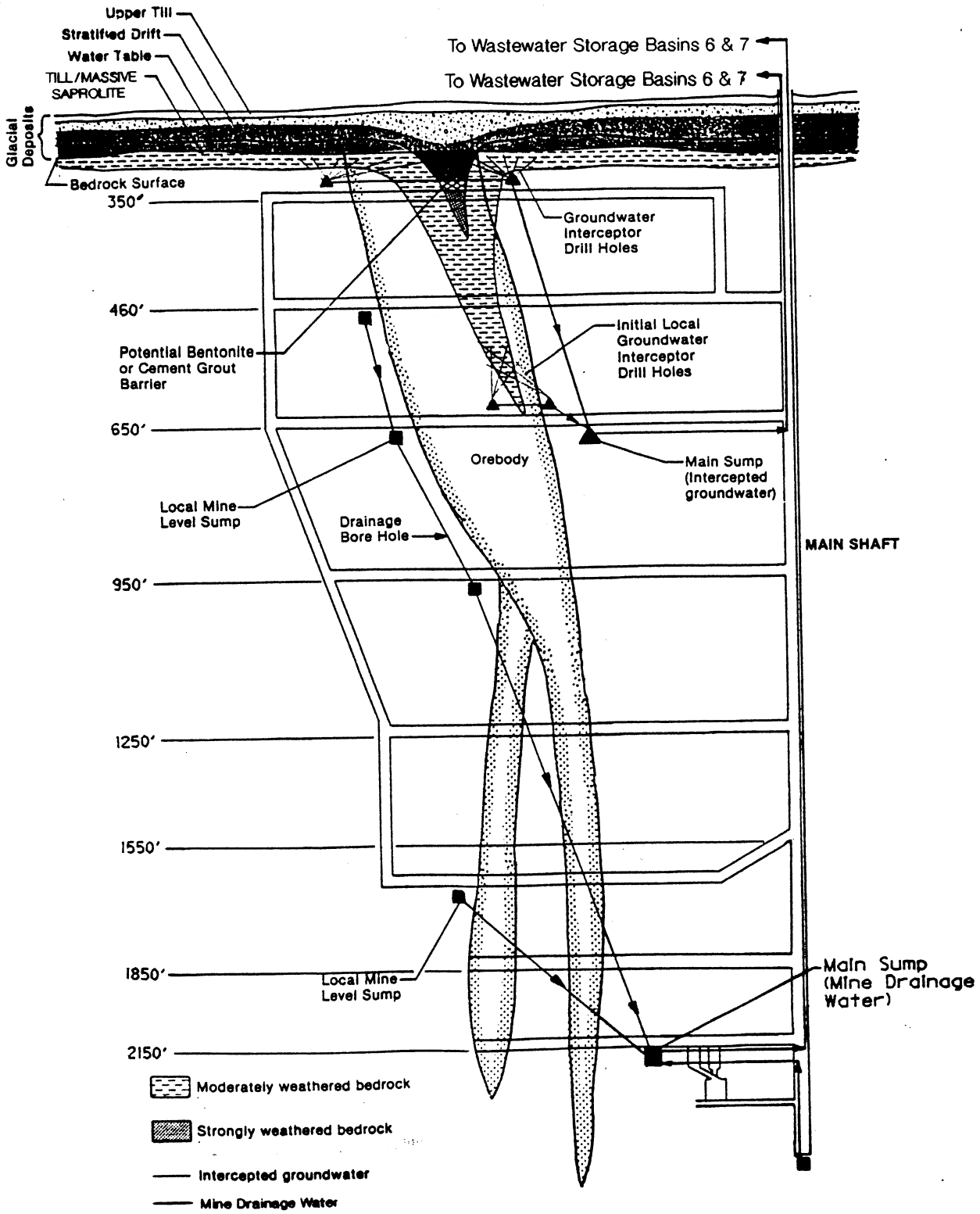
Crandon Mining Company

FIGURE 4-13

GROUNDWATER INTERCEPTOR SYSTEM
(CONCEPTUAL CROSS SECTION)

Prepared By: Foth & Van Dyke	Scale: AS SHOWN	Date: MAY, 1995	By: BSH

93C049



Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBHI	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

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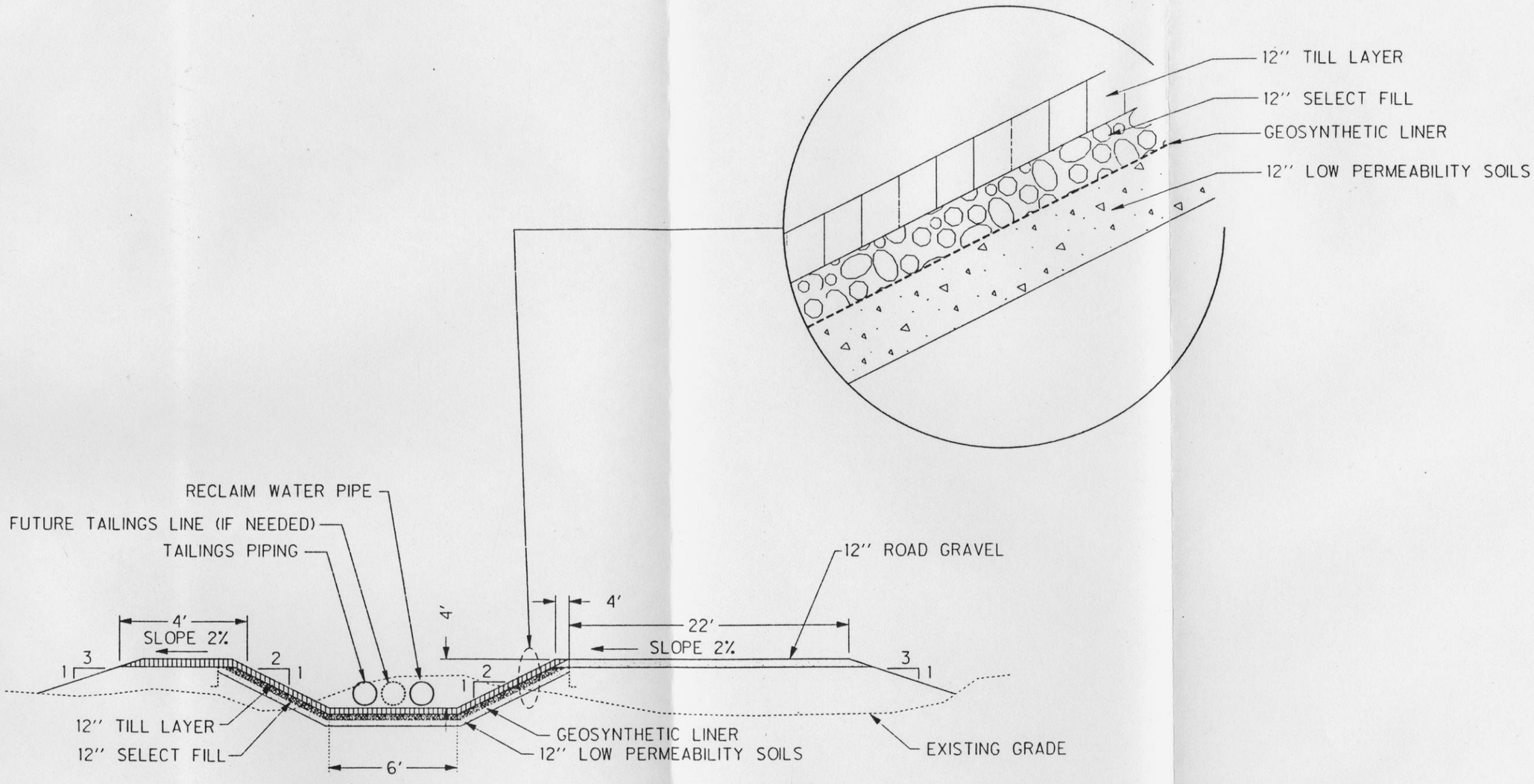
FIGURE 4-14

MINE DRAINAGE SCHEMATIC
(TYPICAL LEVEL DESIGNATIONS)

Scale:	NOT TO SCALE	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	BSH

/d3/dl/users/jprl/3c49m5.dgn

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TYPICAL SECTION

NOT TO SCALE

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

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CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

Crandon Mining Company

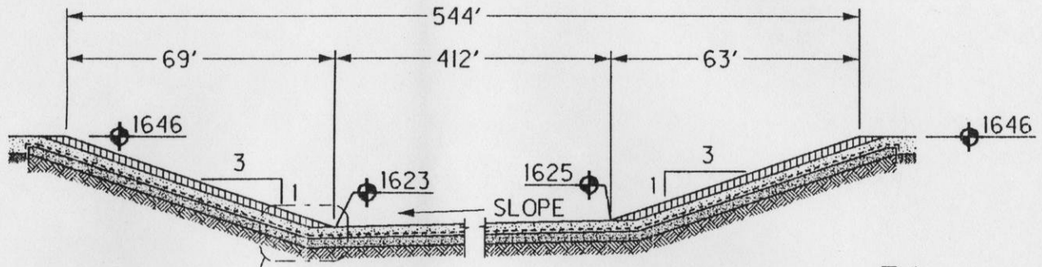
FIGURE 4-17

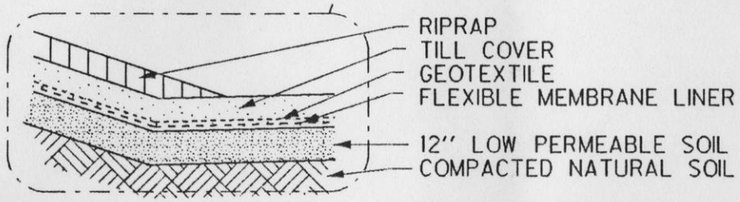
TYPICAL SECTION THROUGH
TMA ACCESS ROAD / PIPELINE CORRIDOR

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	JOW

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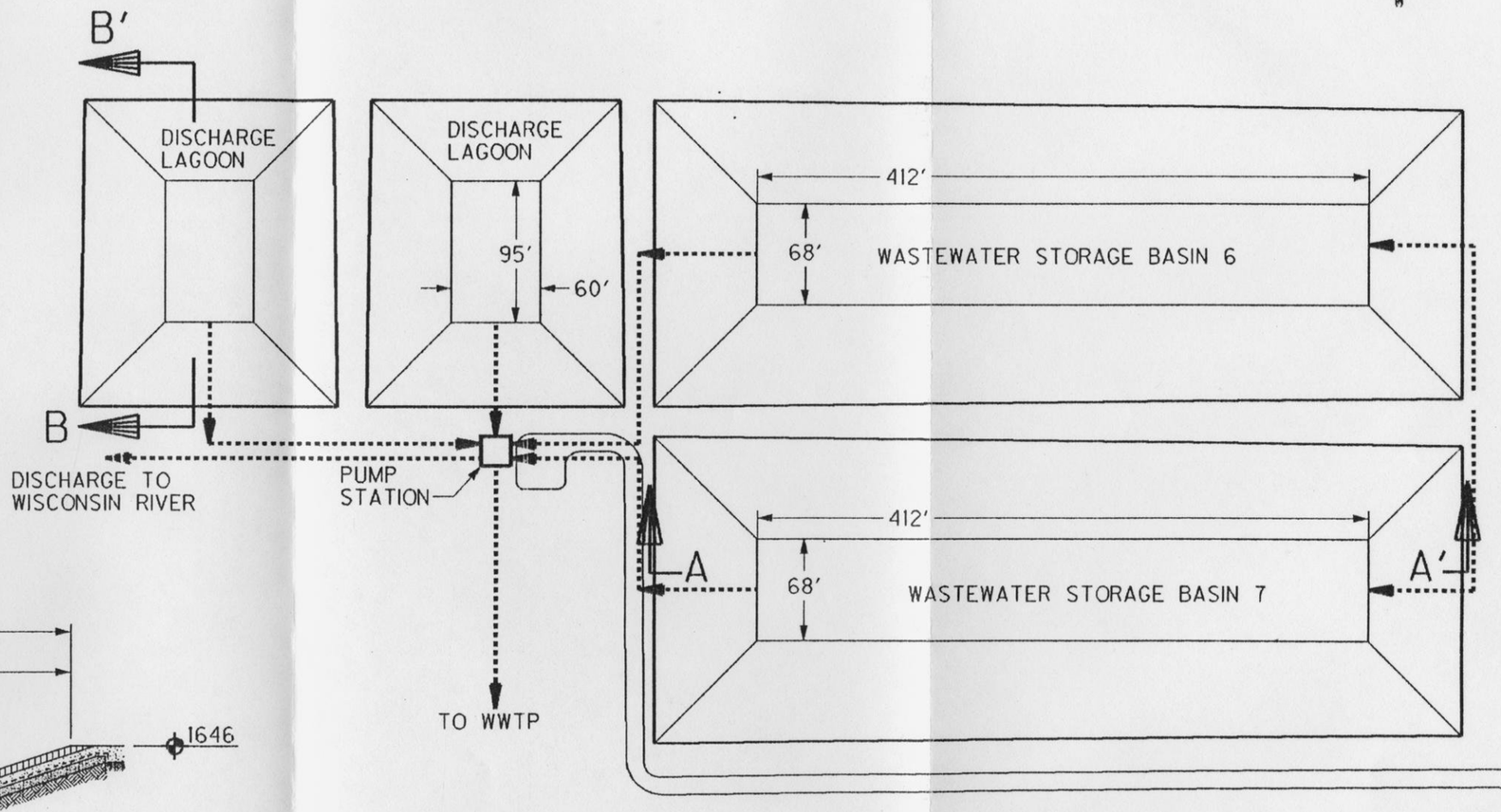
93C049





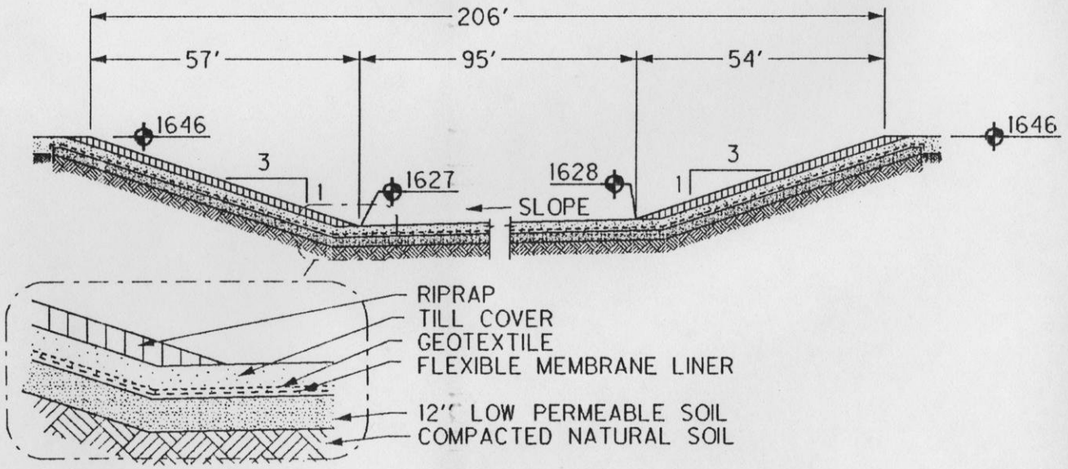
SECTION A - A'

NOT TO SCALE



PLAN

SCALE: 1" = 100'



SECTION B - B'

NOT TO SCALE

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
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APPROVED BY:	PAE	DATE: MAY '95

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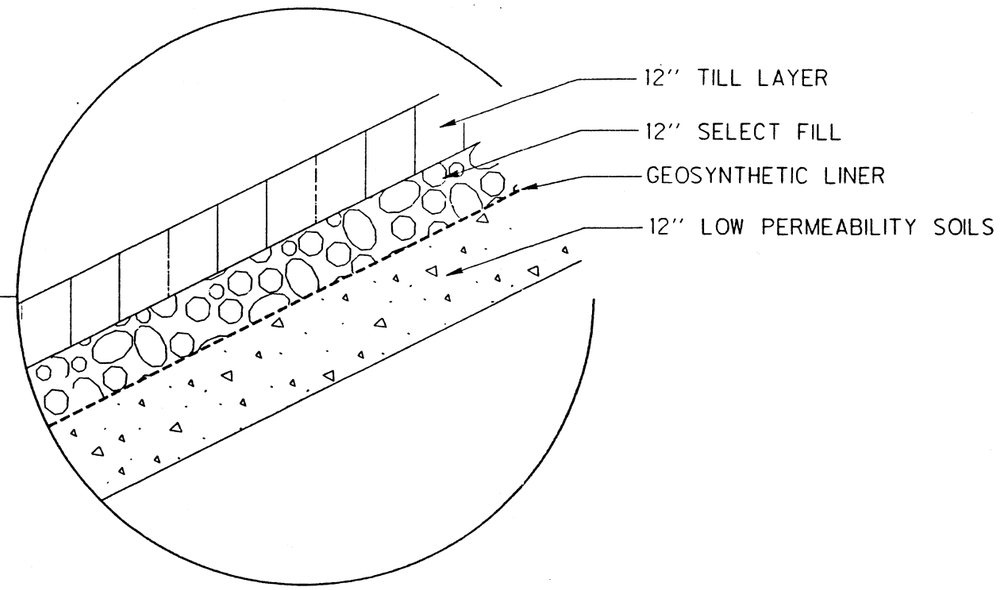
FIGURE 4-18

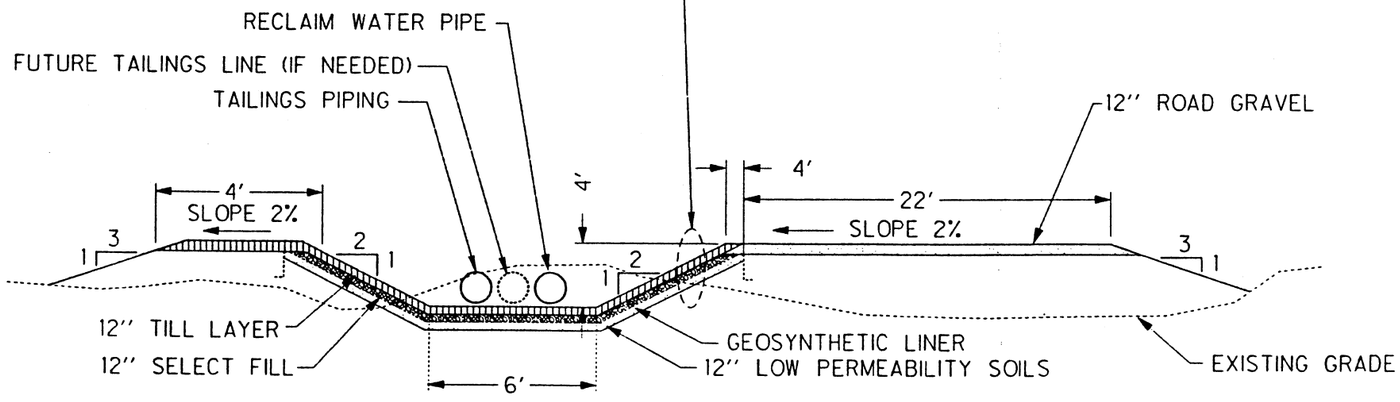
WASTEWATER STORAGE BASINS 6 AND 7 AND DISCHARGE LAGOONS

Scale:	AS SHOWN	Date:	MAY '95
Prepared By:	Foth & Van Dyke	By:	ARJ

c:\cadwork\4c56f71.dgn

93C049





TYPICAL SECTION

NOT TO SCALE

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
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Crandon Mining Company

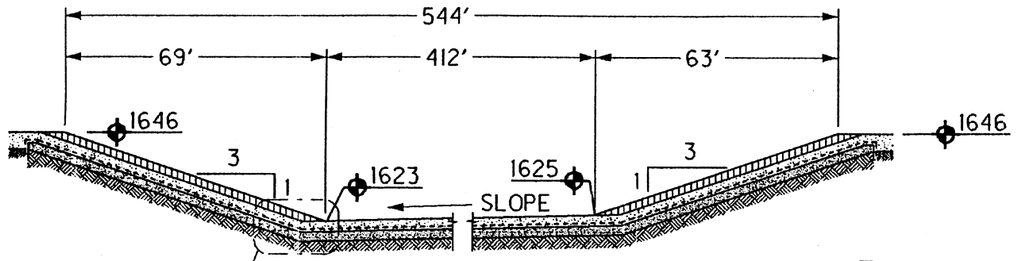
FIGURE 4-17

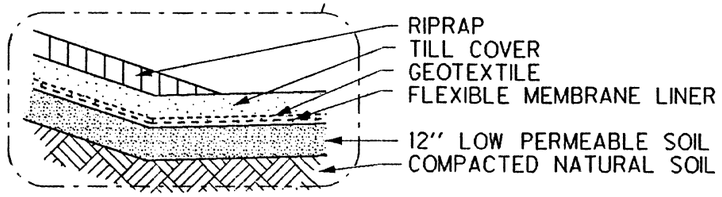
TYPICAL SECTION THROUGH TMA ACCESS ROAD / PIPELINE CORRIDOR

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	JOW

c:\cadwork\4c56f51.dgn

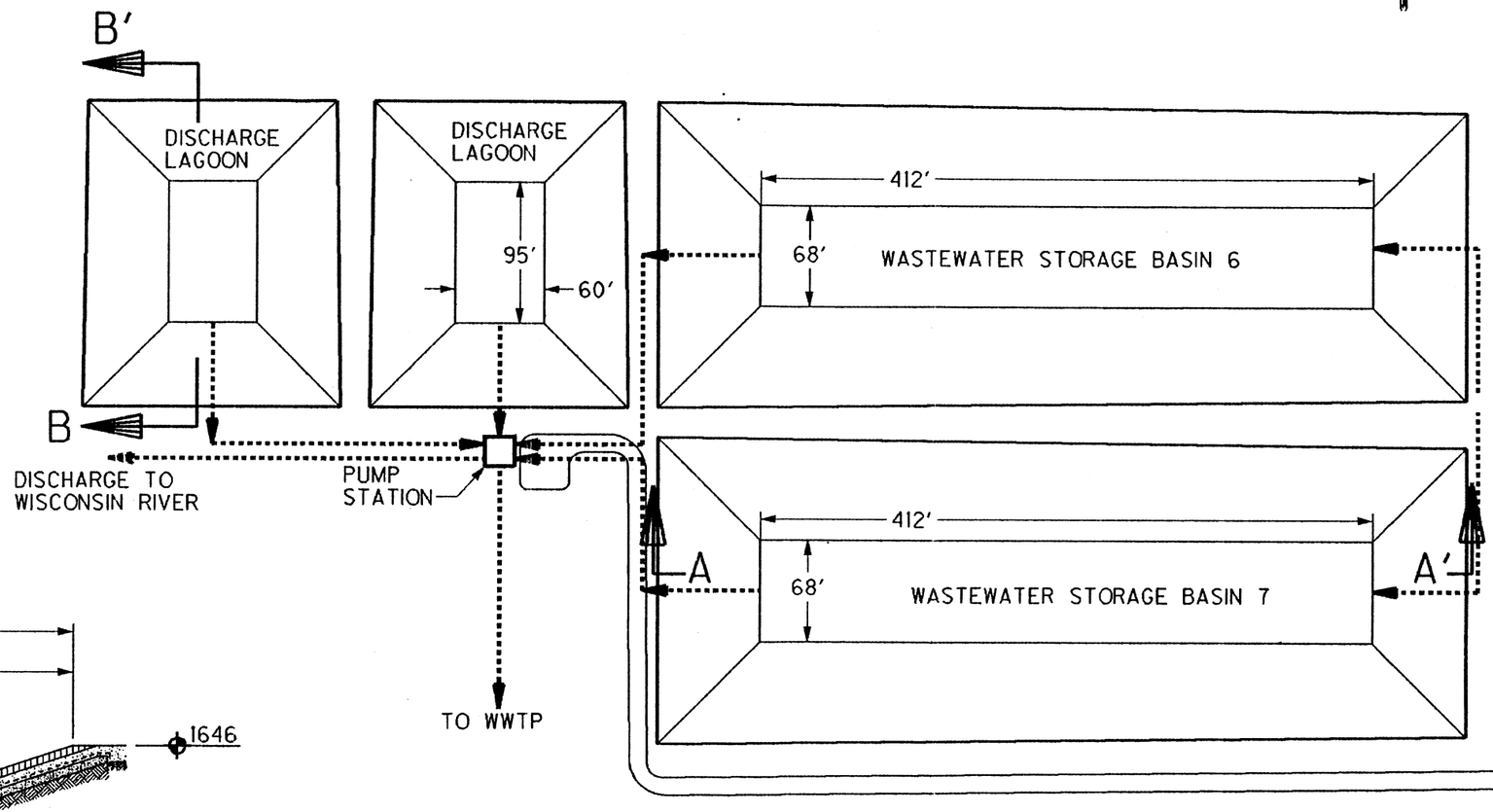
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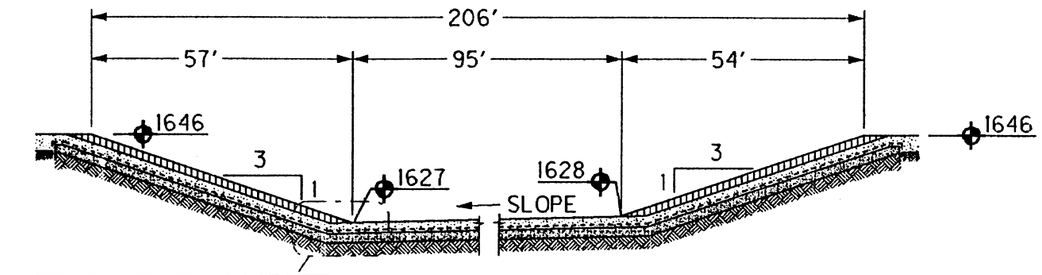
SECTION A - A'

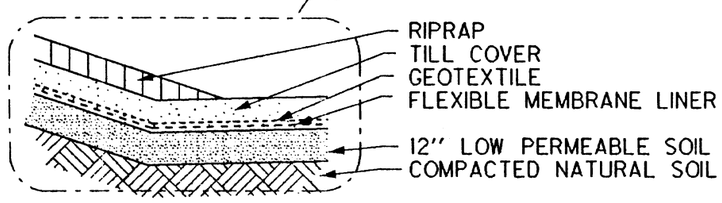
NOT TO SCALE



PLAN

SCALE: 1" = 100'





SECTION B - B'

NOT TO SCALE

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
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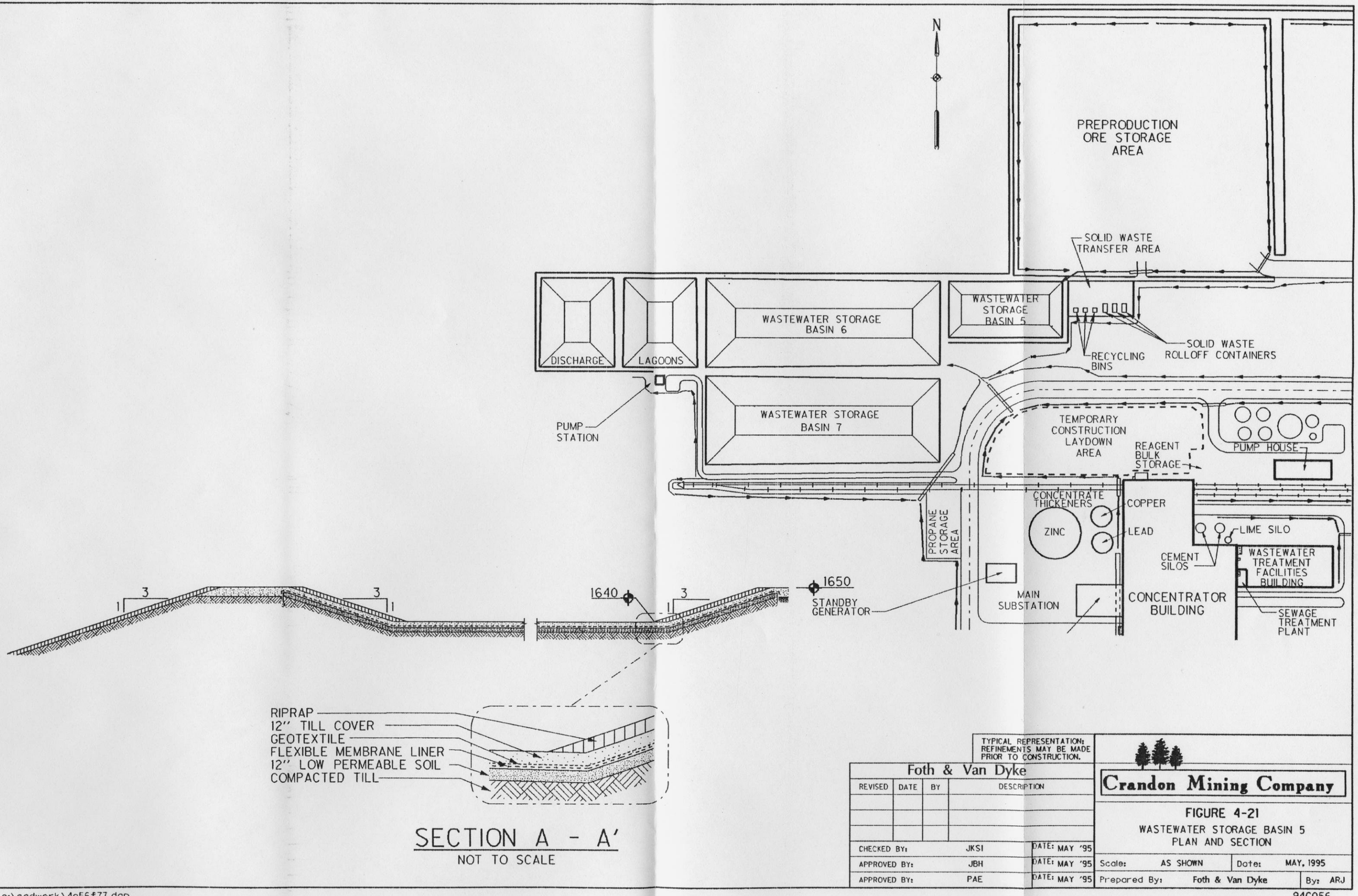
FIGURE 4-18

WASTEWATER STORAGE BASINS 6 AND 7 AND DISCHARGE LAGOONS

Scale:	AS SHOWN	Date:	MAY '95
Prepared By:	Foth & Van Dyke	By:	ARJ

c:\cadwork\4c56f71.dgn

93C049



SECTION A - A'

NOT TO SCALE

TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

Crandon Mining Company

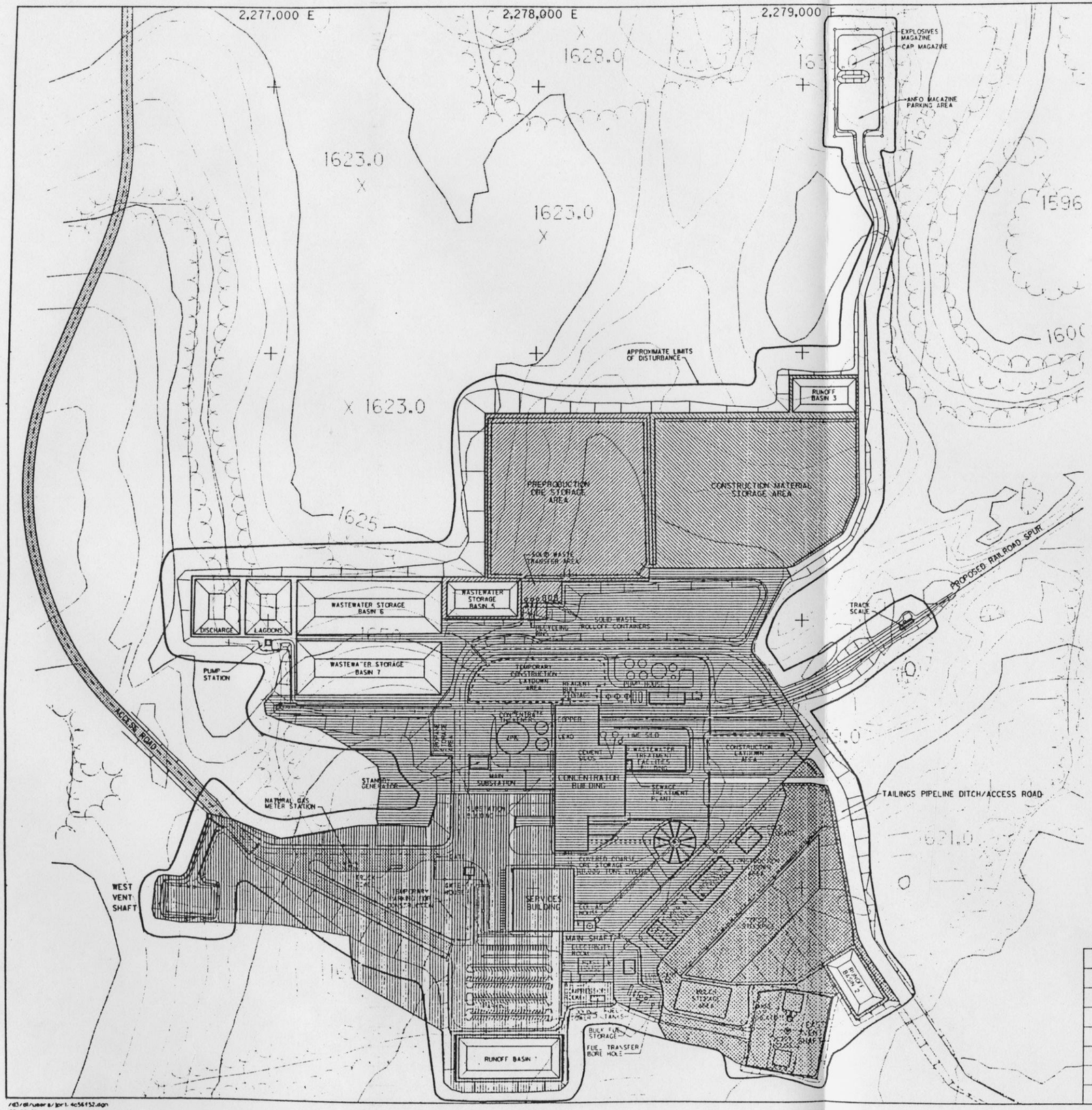
FIGURE 4-21

WASTEWATER STORAGE BASIN 5
PLAN AND SECTION

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	ARJ

c:\cadwork\4c56f77.dgn

94C056



LEGEND

- EXISTING CONTOUR
- EXISTING SPOT ELEVATION
- EXISTING TRAIL
- EXISTING TREELINE
- PROPOSED LIMITS OF PLANT SITE DISTURBANCE
- PROPOSED STRUCTURE OR BUILDING
- PROPOSED RAILROAD SPUR
- PROPOSED CHAIN LINK FENCE
- PROPOSED WELDED WIRE FENCE
- PROPOSED DRAINAGE DITCH
- PROPOSED TAILINGS PIPELINE DITCH
- PROPOSED ASPHALT ACCESS ROAD
- PROPOSED CULVERT
- PROPOSED SLOPE DIRECTION
- RUNOFF DRAINAGE AREA - TO WASTEWATER BASIN NO. 1
- RUNOFF DRAINAGE AREA - TO WASTEWATER BASIN NO. 2
- RUNOFF DRAINAGE AREA - TO WASTEWATER BASIN NO. 3
- RUNOFF DRAINAGE AREA - TO WASTEWATER BASIN NO. 5
- RUNOFF DRAINAGE AREA - TO WASTEWATER BASINS NO. 6 & 7

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1" = 1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS FIVE FEET.
4. PLANT SITE BASED ON REFINEMENTS TO THE APRIL 1986 PLOT PLAN DEVELOPED BY RAYMOND KAISER ENGINEERS, INC.

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

Crandon Mining Company

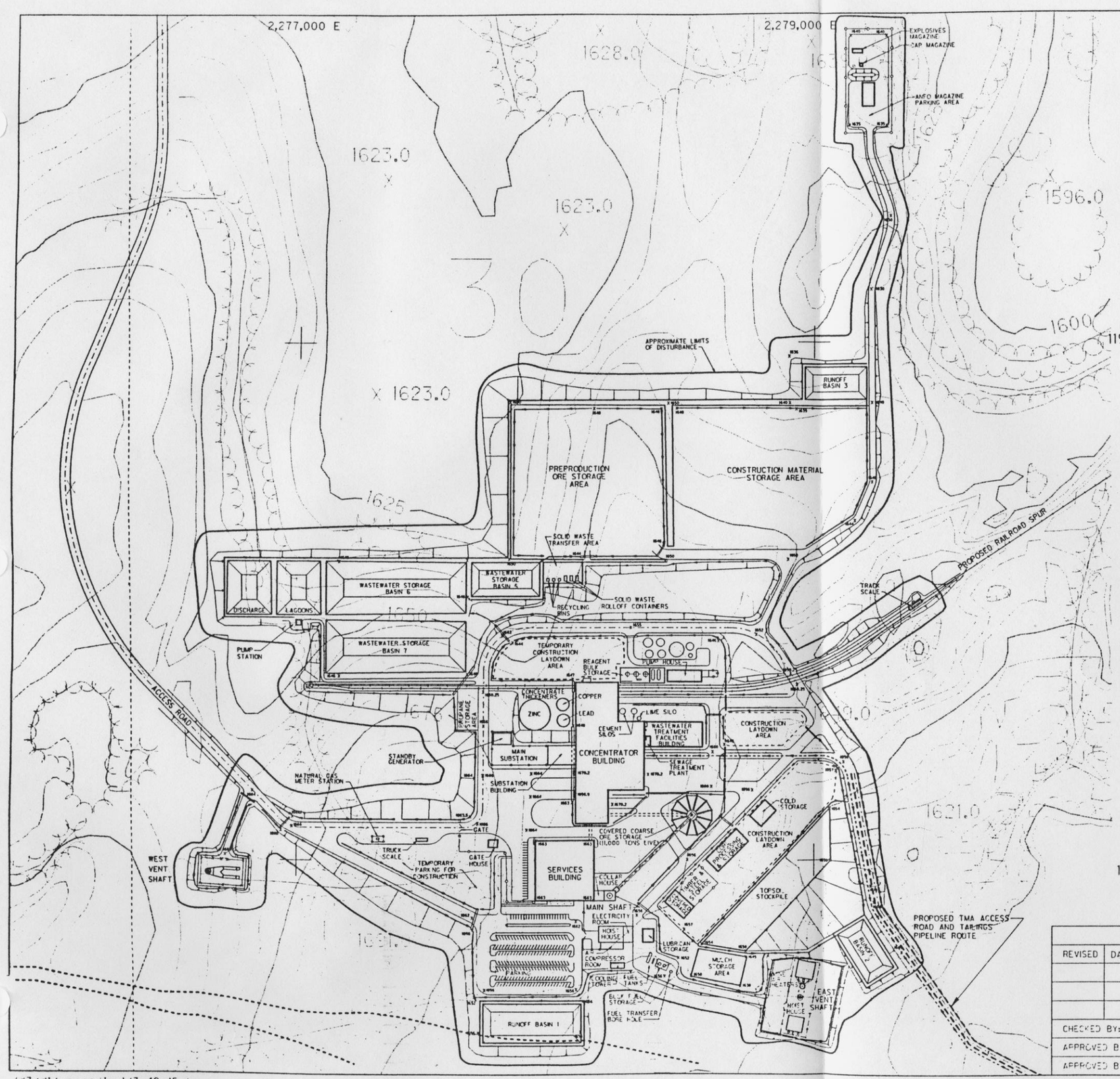
FIGURE 4-22
PLANT SITE
RUNOFF DRAINAGE AREAS

Scale: 0 200 400' | Date: MAY, 1995

Prepared By: Foth & Van Dyke | By: ARJ

94C056

/d3/dl/users/jpr1.4c56f52.dgn
05/26/95



N

LEGEND

- STREAMS
- EXISTING ROAD
- —1675— EXISTING CONTOUR
- x 1692.0 EXISTING SPOT ELEVATION
- SECTION LINE
- ORE BODY
- x 1650 SPOT ELEVATION
- DRAINAGE DITCH
- CULVERT
- PROPOSED LIMITS OF PLANT SITE DISTURBANCE
- TAILINGS PIPELINE DITCH ALIGNMENT

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1" = 1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS 25 FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
5. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

SCALE
0 200' 400'

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

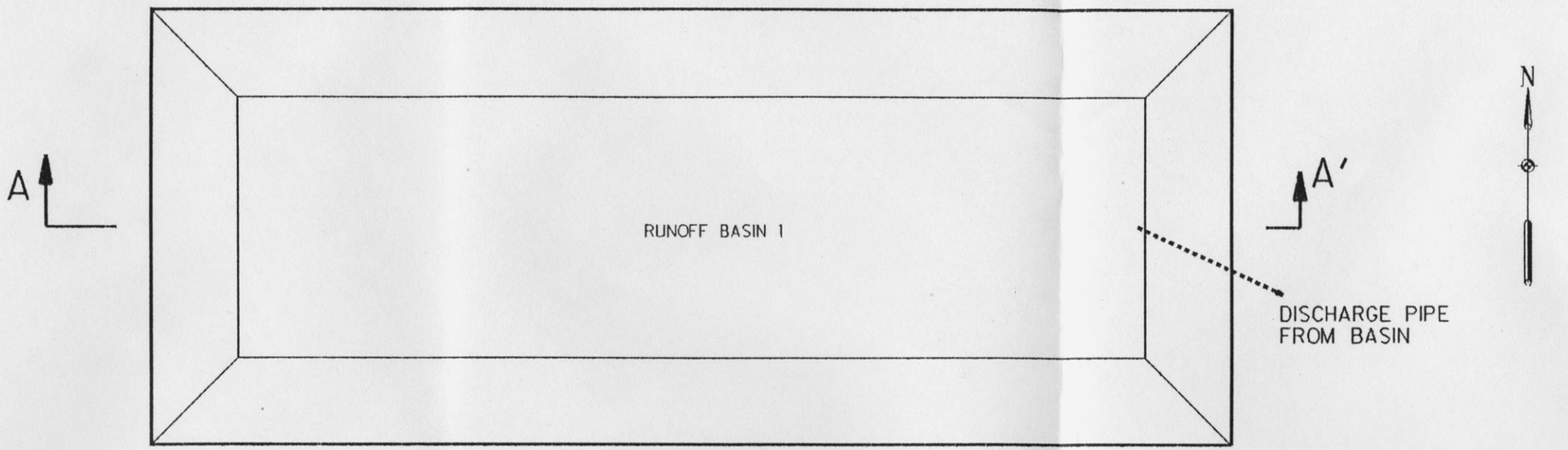
Crandon Mining Company

FIGURE 4-23
PLANT SITE DRAINAGE

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	JRB2

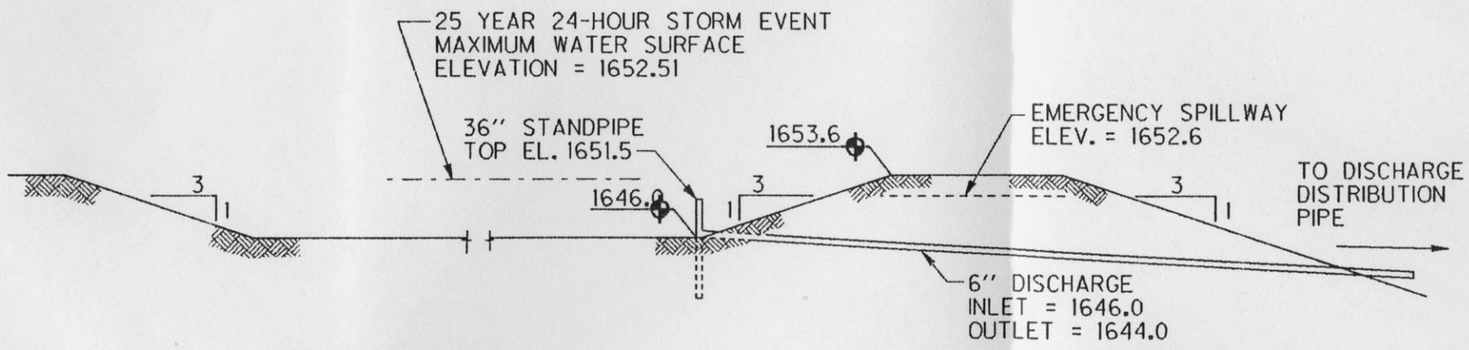
/d3/d1/users/jpr1/3c49ml5.dgn

93C049



PLAN

SCALE: 1" = 50'



SECTION A - A'

NOT TO SCALE

TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE:	MAY'95
APPROVED BY:	JBH	DATE:	MAY'95
APPROVED BY:	PAE	DATE:	MAY'95

Crandon Mining Company

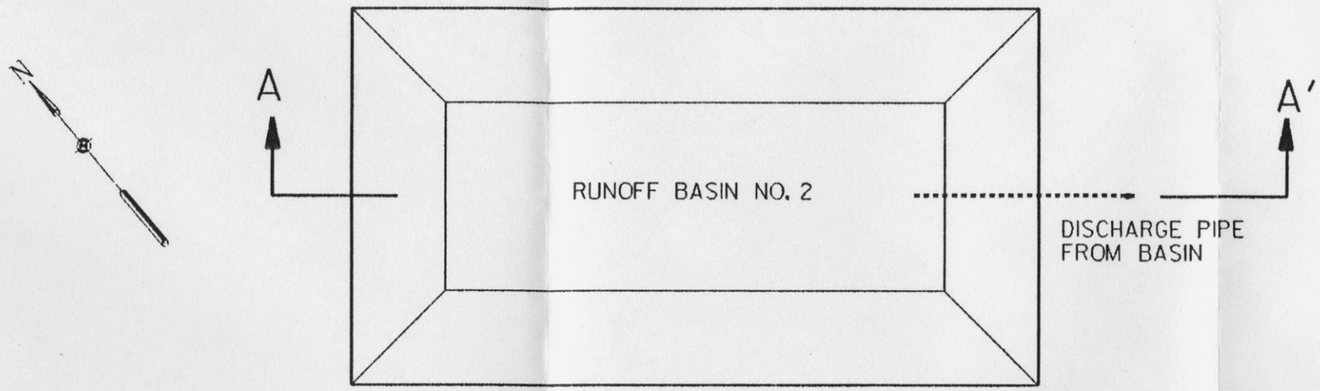
FIGURE 4-24

RUNOFF BASIN 1
PLAN AND SECTION

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	ARJ

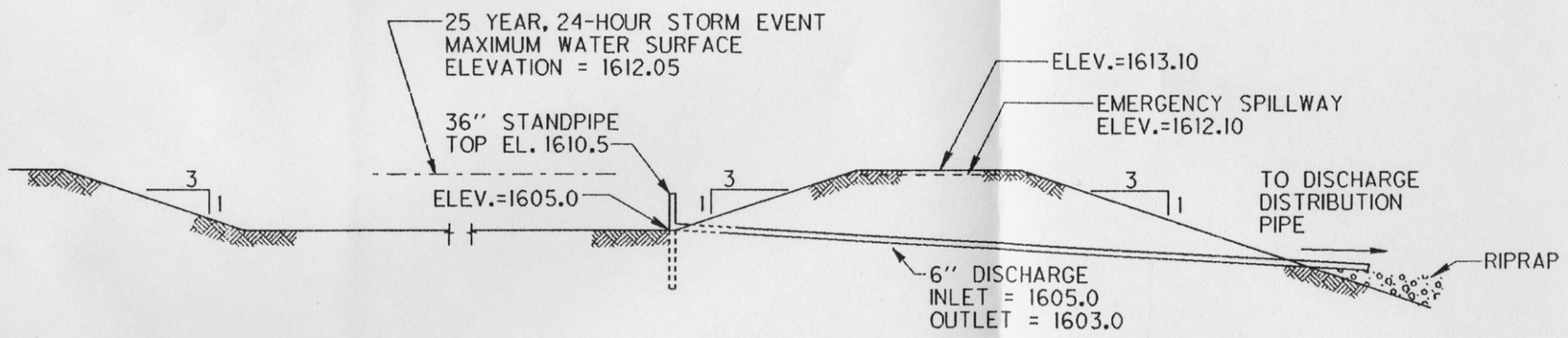
c:\cadwork\4c56f78.dgn

94C056



PLAN

SCALE: 1" = 50'



SECTION A - A'

NOT TO SCALE

TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

Crandon Mining Company

FIGURE 4-25

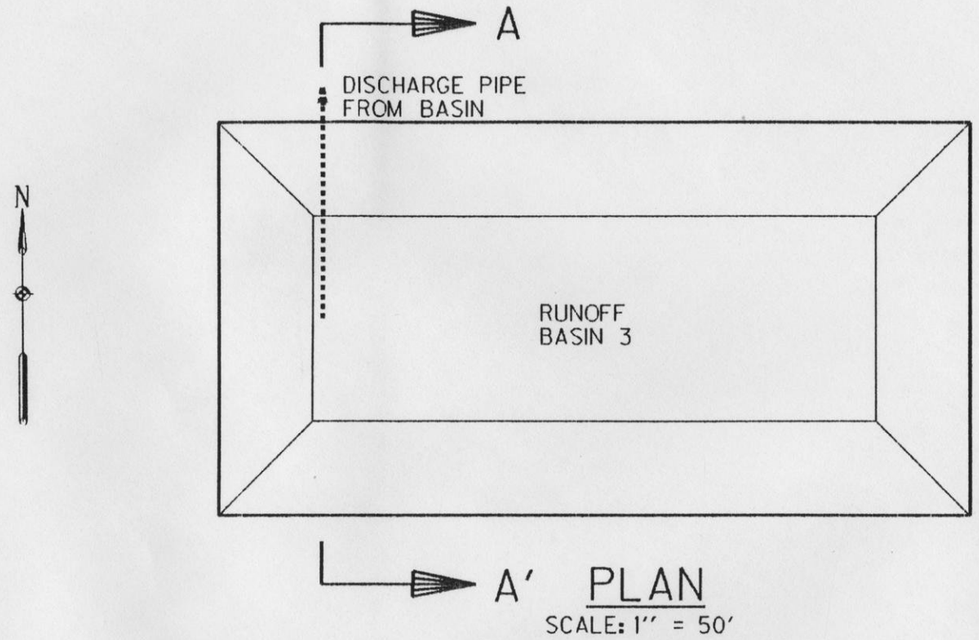
RUNOFF BASIN 2

PLAN AND SECTION

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	ARJ

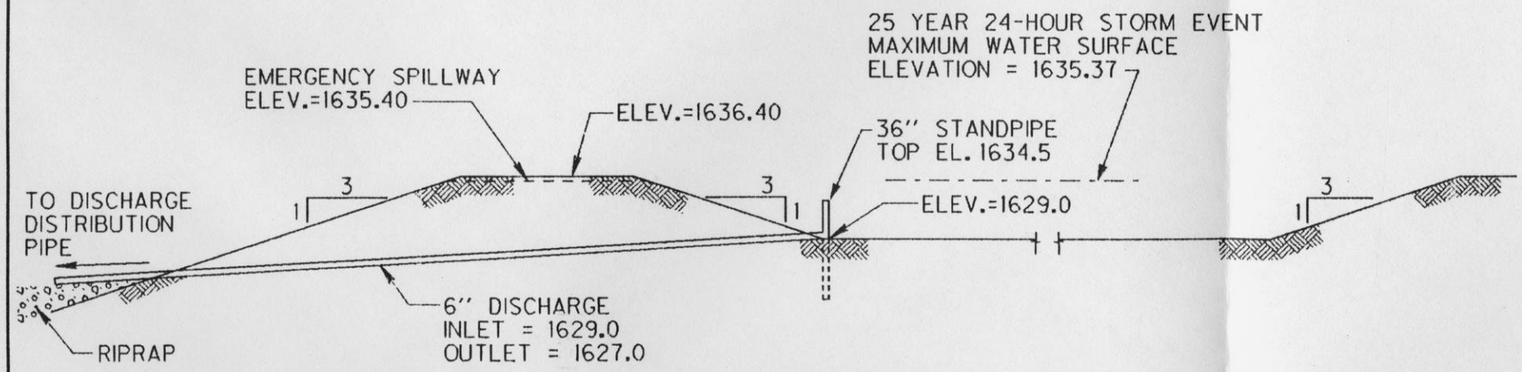
c:\cadwork\4c56f79.dgn

94C056



PLAN

SCALE: 1'' = 50'



SECTION A - A'

NOT TO SCALE

TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

Crandon Mining Company

FIGURE 4-26

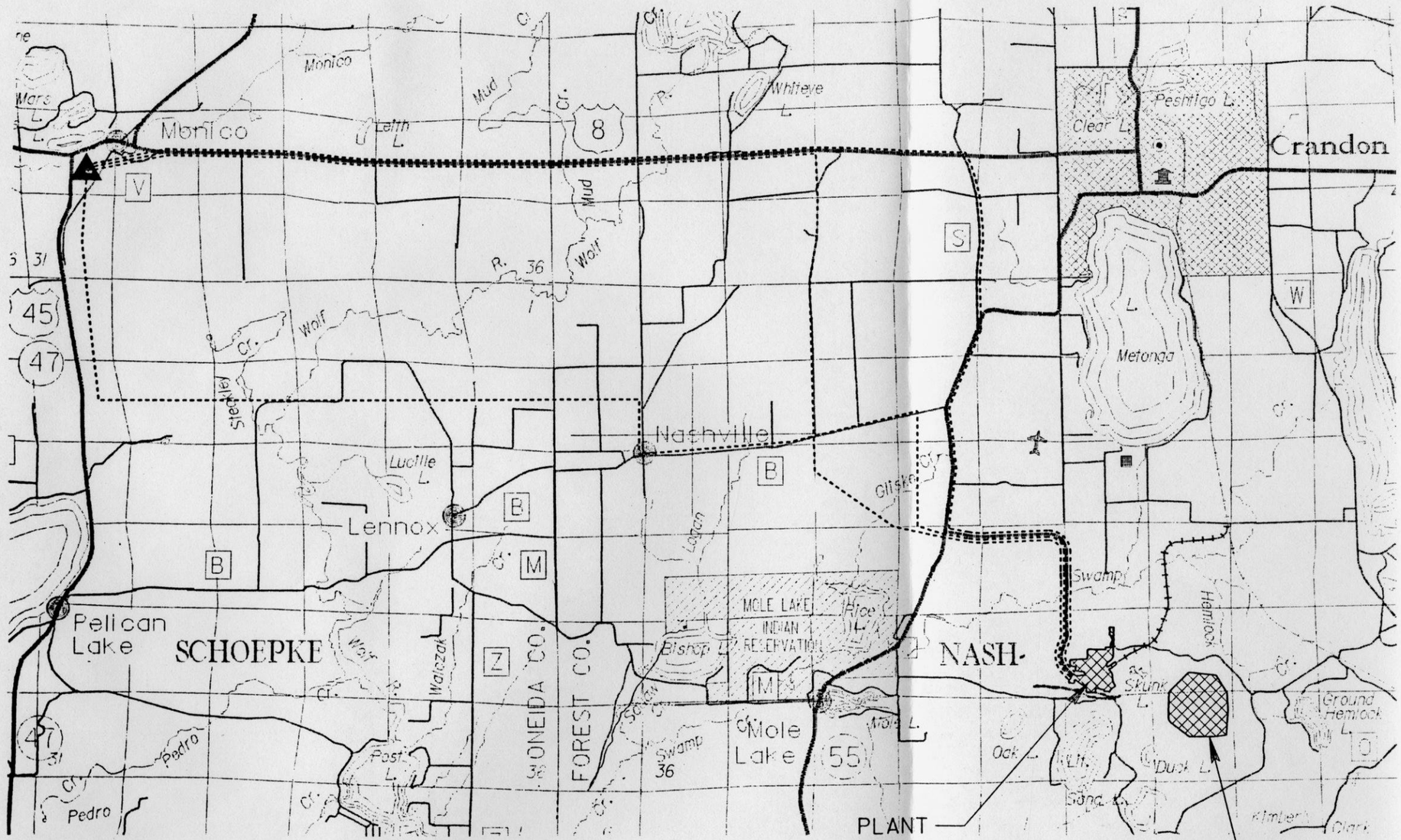
RUNOFF BASIN 3

PLAN AND SECTION

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	ARJ

c:\cadwork\4c56f710.dgn

94C056



LEGEND

- U.S. OR STATE HWY
- COUNTY TRUNK ROAD
- TOWN ROAD
- COUNTY BOUNDARY
- CIVIL TOWN BOUNDARY
- SECTION LINE
- (8) U.S. HWY NO.
- (47) STATE HWY NO.
- (W) COUNTY HIGHWAY LETTER
- CORPORATE LIMITS
- UNINCORPORATED VILLAGE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- EXISTING SUBSTATION
- ALTERNATIVE POWER LINE EXTENSION ROUTES

N

NOTES:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION.
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.
3. PROPOSED TRANSMISSION LINE ROUTES DERIVED FROM THE WISCONSIN PUBLIC SERVICE TRANSMISSION LINE APPLICATIONS (PSW NO. 6690-C6-165) DATED MARCH 1, 1995. REFER TO THIS DOCUMENT FOR DESCRIPTIONS OF EACH POSSIBLE ROUTE.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

Crandon Mining Company

FIGURE 4-27

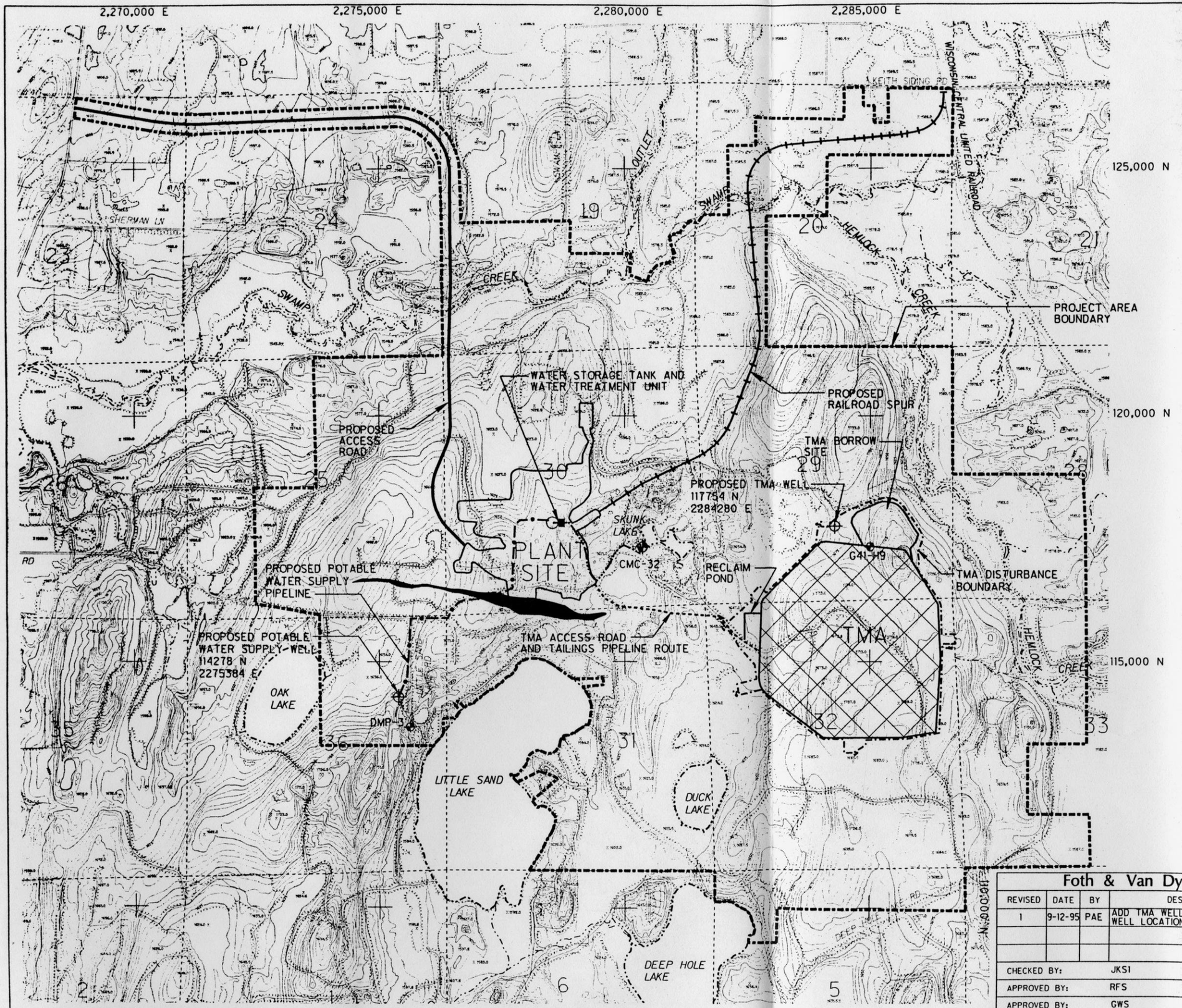
POSSIBLE ELECTRIC TRANSMISSION LINE ROUTES

Scale: 0 3750' 7000' Date: MAY, 1995

Prepared By: Foth & Van Dyke By: BSH

/d3/dl/users/jprl/4c62f30.dgn

93C049



LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- 1675 — EXISTING CONTOUR
- x 1692.0 — EXISTING SPOT ELEVATION
- SECTION LINE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- CMC-32 — PROPOSED SKUNK LAKE MONITORING WELL
- PROPOSED POTABLE WATER SUPPLY WELL
- G41-H9 — MONITORING WELL BORING
- PROPOSED POTABLE WATER SUPPLY PIPELINE
- SKUNK LAKE MITIGATION PIPELINE ROUTE

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1" = 1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS 25 FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
5. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

0 1000' 2000'
SCALE

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION
1	9-12-95	PAE	ADD TMA WELL/REVISE POTABLE WELL LOCATION

CHECKED BY:	JKSI	DATE: SEPT.'95
APPROVED BY:	RFS	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

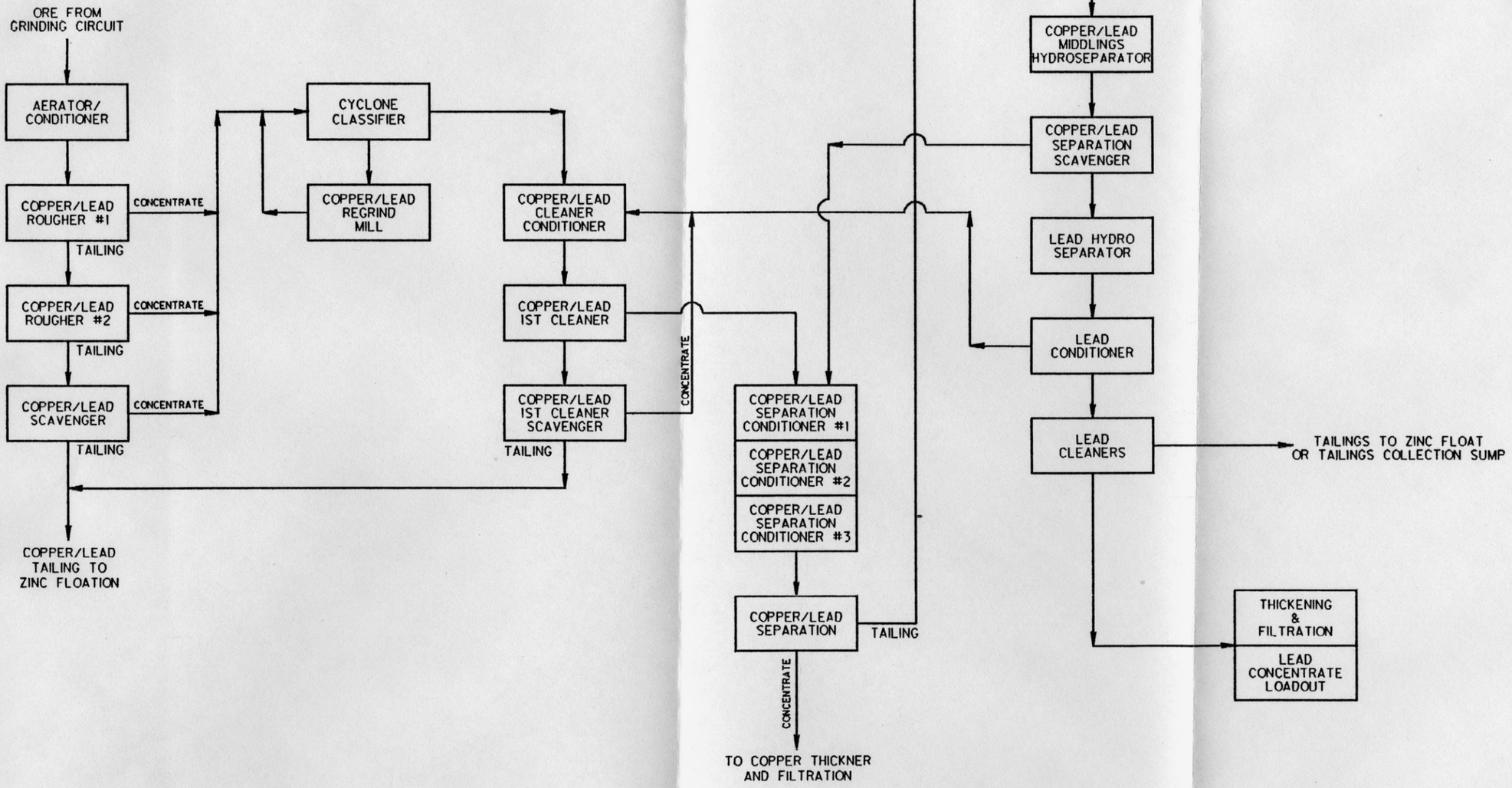
Crandon Mining Company

FIGURE 4-28
POTABLE AND NON-POTABLE WATER SUPPLY WELL

Scale:	AS SHOWN	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	JRB

/d3/dl/users/jpr1/4c62f61.dgn

93C049



Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

Crandon Mining Company

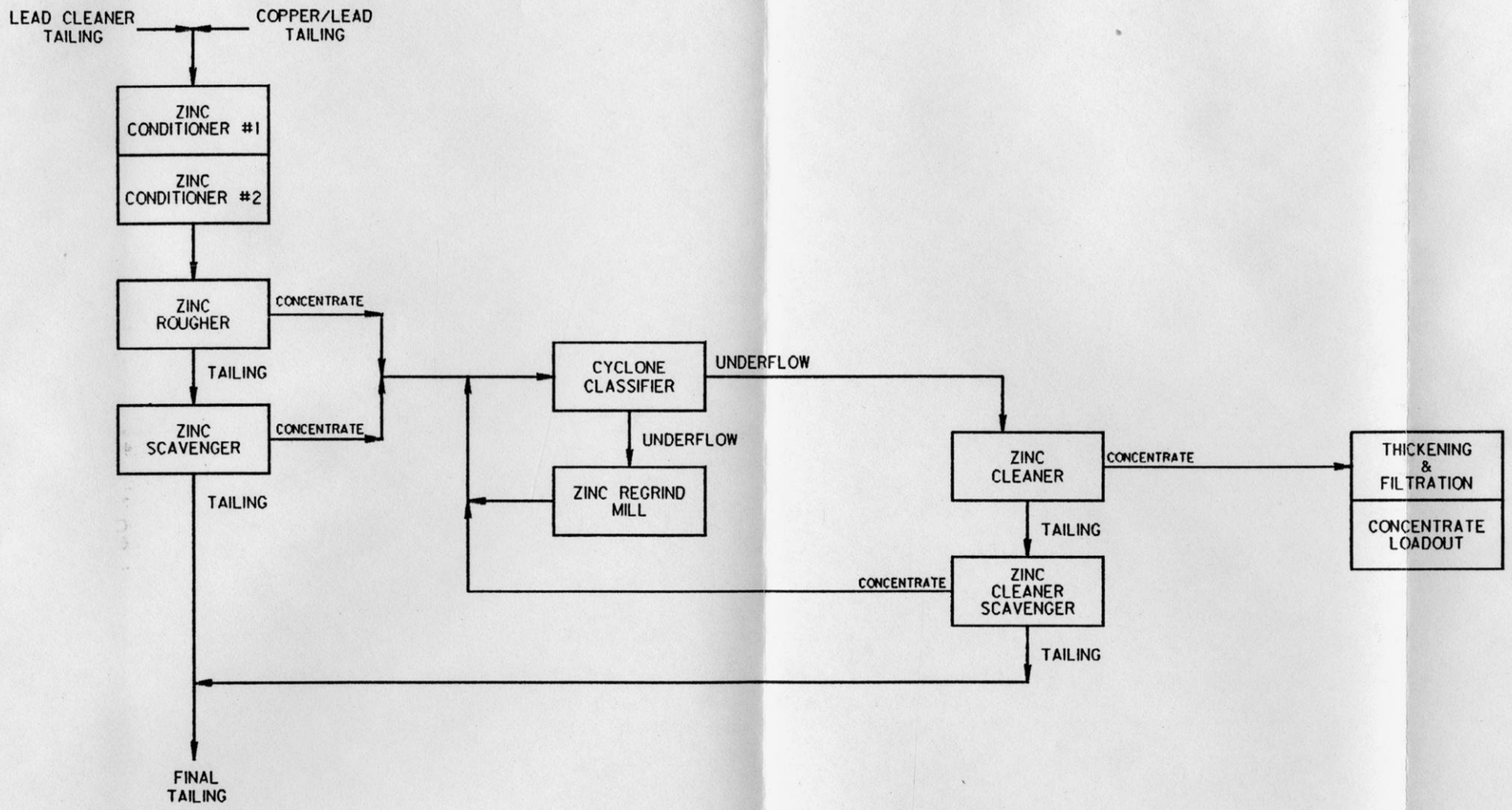
FIGURE 4-29

COPPER/LEAD FLOTATION & SEPARATION & LEAD FLOTATION FLOW DIAGRAM

Scale:	NOT TO SCALE	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	KMP

c:\cadwork\4c62f16.dgn

93C049



Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

Crandon Mining Company

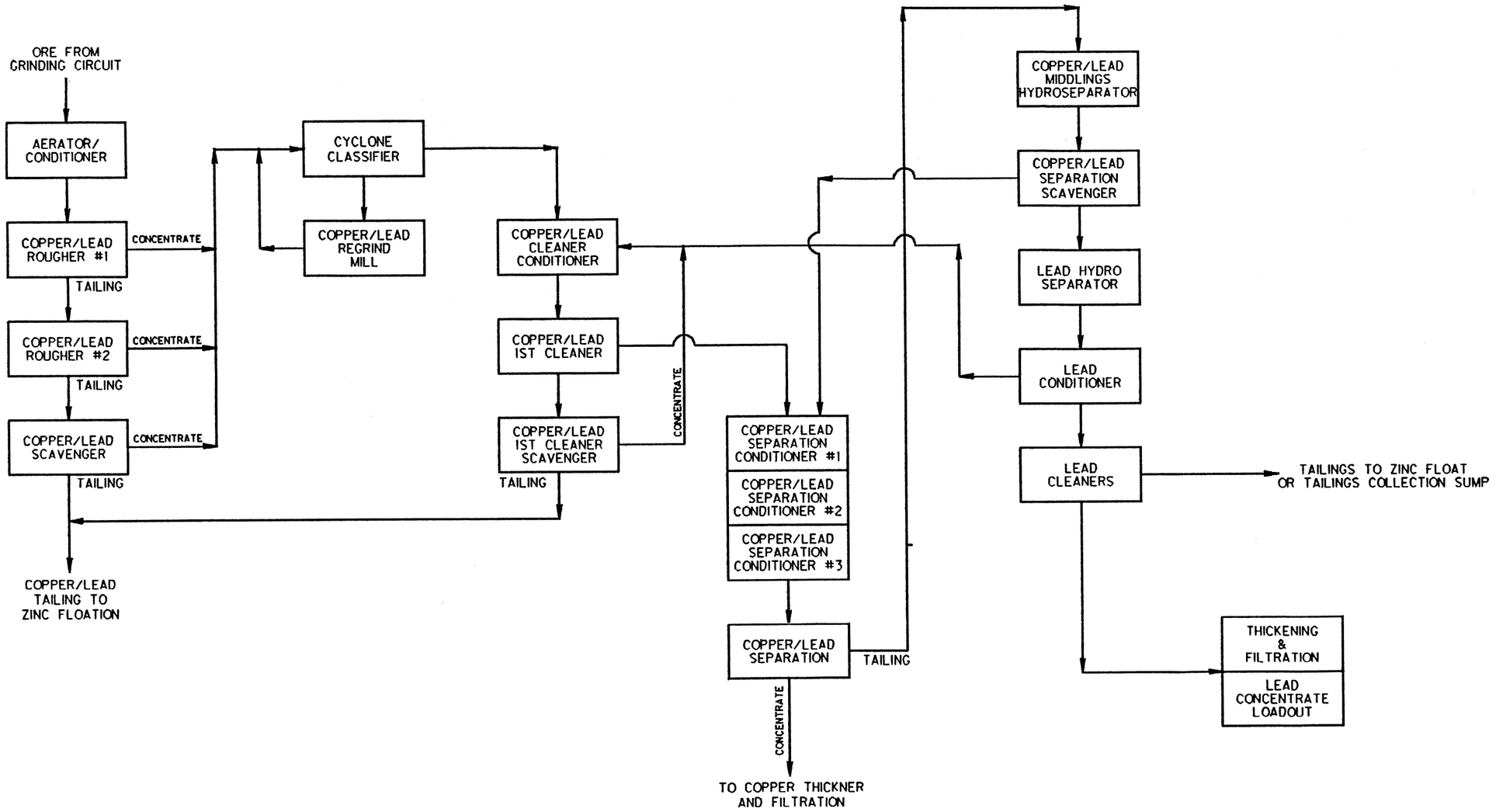
FIGURE 4-30

ZINC FLOTATION
FLOW DIAGRAM

Scale:	NOT TO SCALE	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	KMP

c:\cadwork\4c62f16.dgn

93C049



Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

Crandon Mining Company

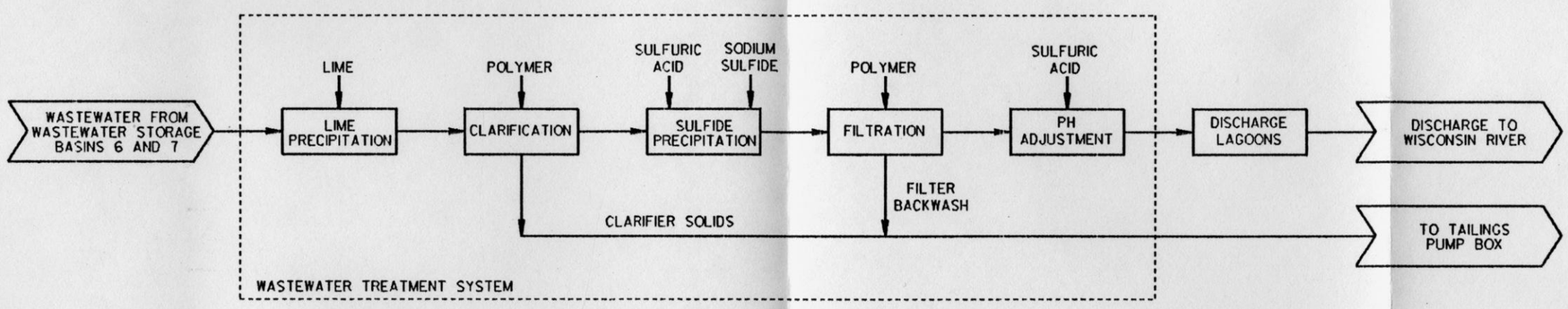
FIGURE 4-29

COPPER/LEAD FLOTATION & SEPARATION & LEAD FLOTATION FLOW DIAGRAM

Scale:	NOT TO SCALE	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	KMP

c:\cadwork\4c62f16.dgn

93C049



Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY'95
APPROVED BY:	JBH	DATE: MAY'95
APPROVED BY:	PAE	DATE: MAY'95

Crandon Mining Company

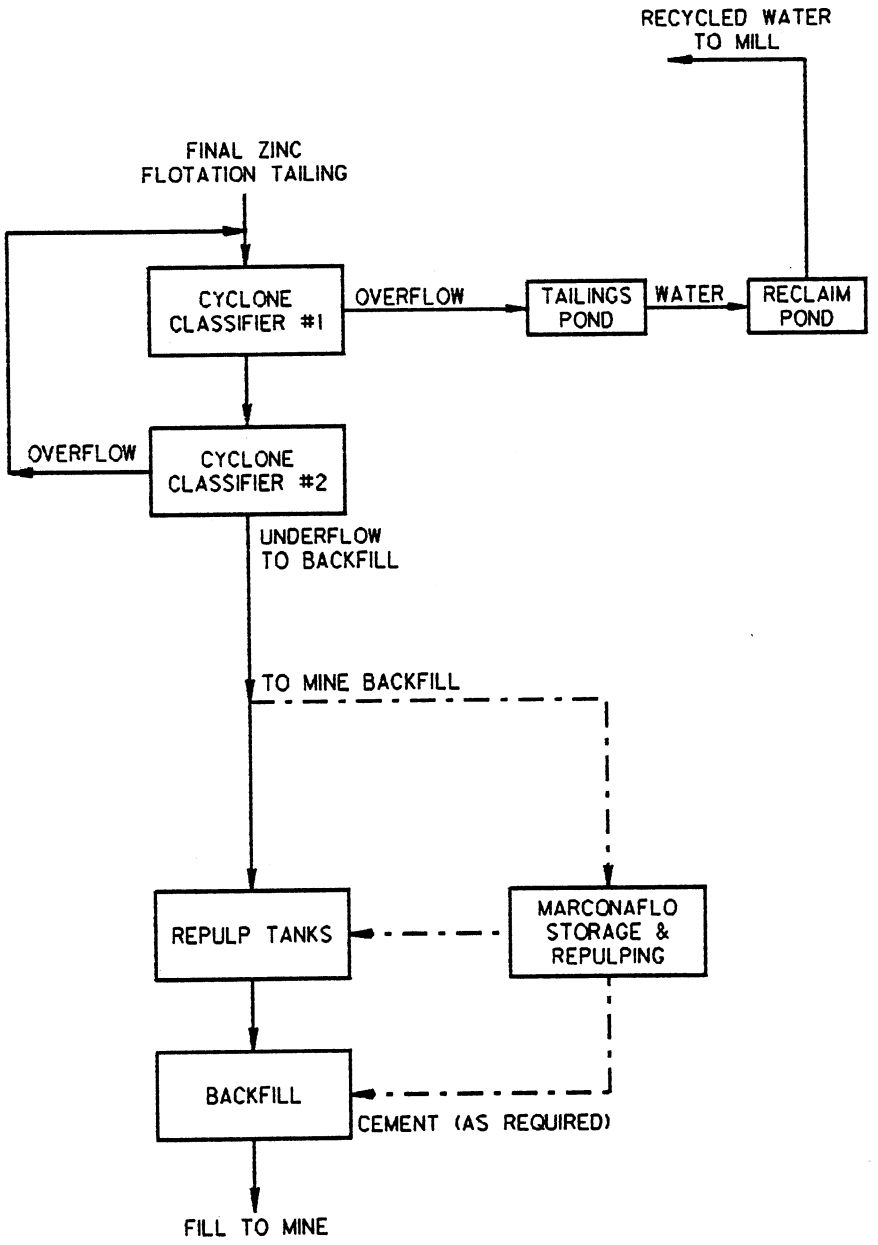
FIGURE 4-32

WASTEWATER TREATMENT SYSTEM
PROCESS FLOW DIAGRAM

Scale:	NONE	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	KMP

c:\cadwork\4c56f14.dgn

93C049



Foth & Van Dyke			
REVISED	DATE	BY	DESCRIPTION
CHECKED BY:	JKSI	DATE: MAY '95	
APPROVED BY:	JBH	DATE: MAY '95	
APPROVED BY:	PAE	DATE: MAY '95	

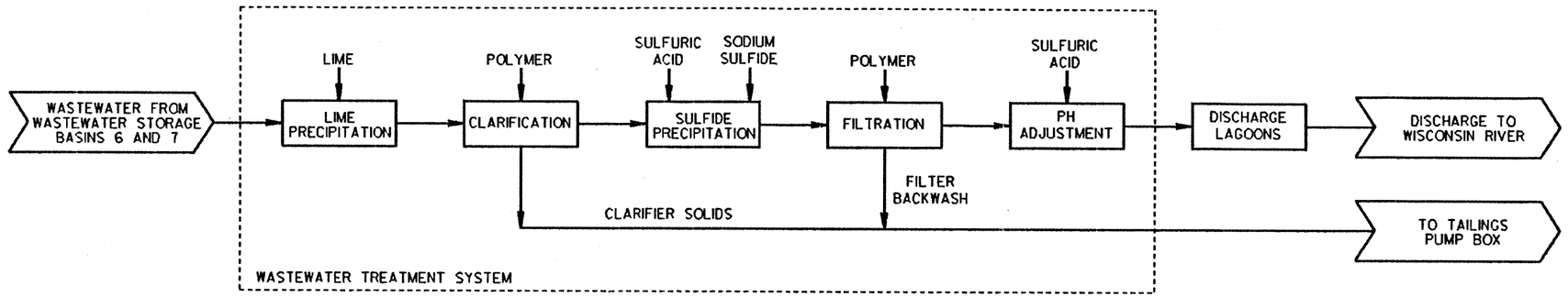
Crandon Mining Company

FIGURE 4-31
BACKFILL FLOW
DIAGRAM

Scale:	NOT TO SCALE	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	BSH

c:\cadwork\4c62f16.dgn

93C049



Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE:	MAY'95
APPROVED BY:	JBH	DATE:	MAY'95
APPROVED BY:	PAE	DATE:	MAY'95

Crandon Mining Company

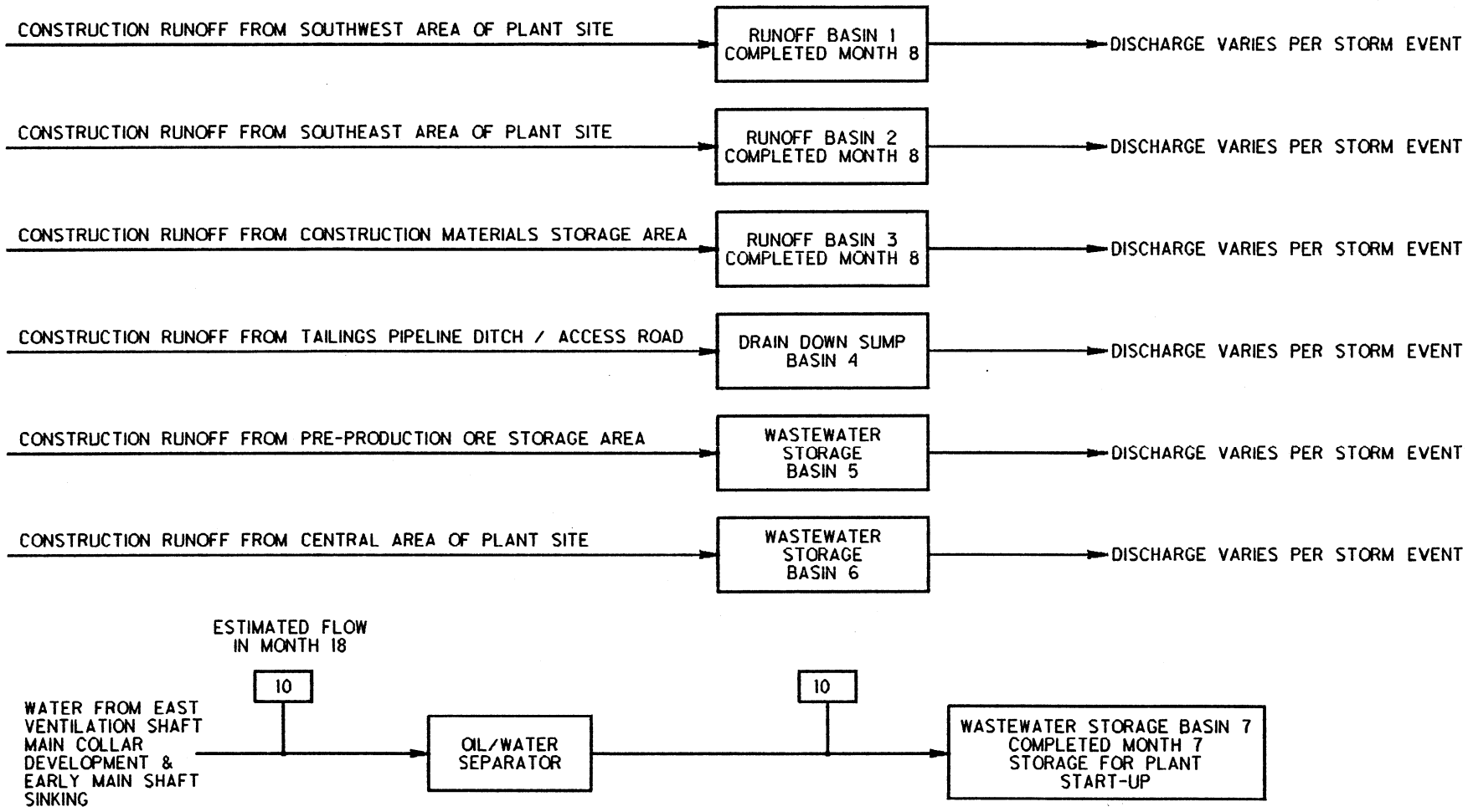
FIGURE 4-32

WASTEWATER TREATMENT SYSTEM
PROCESS FLOW DIAGRAM

Scale:	NONE	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	KMP

c:\cadwork\4c56f14.dgn

93C049



LEGEND

10 AVERAGE FLOWS

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

Crandon Mining Company

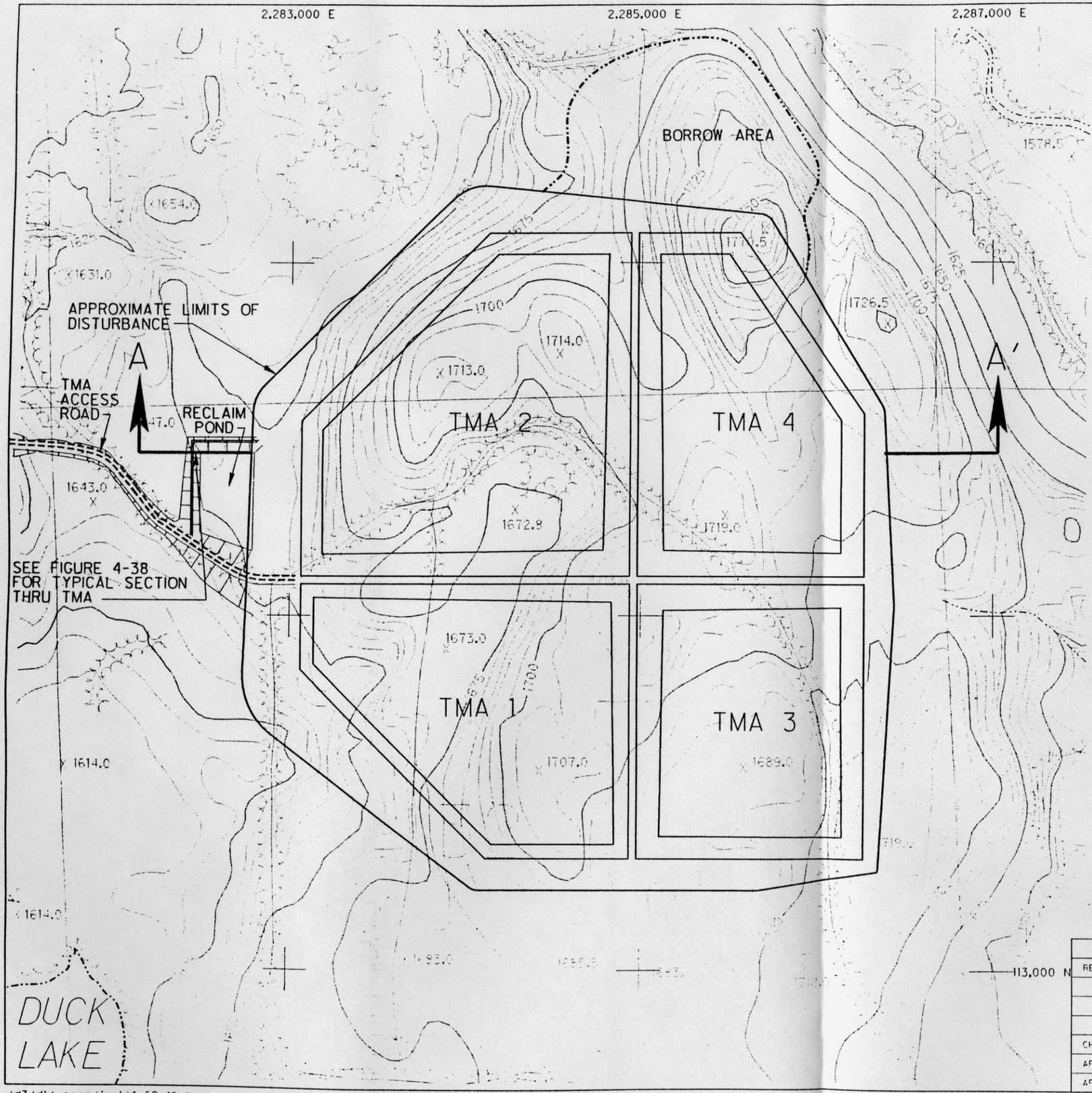
FIGURE 4-33

WATER MANAGEMENT
PHASE 1

Scale:	NOT TO SCALE	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	KMP

c:\cadwork\4c62f17.dgn

93C049



N

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- —1675— EXISTING CONTOUR
- 1692.0 SPOT ELEVATION
- SECTION LINE
- TMA APPROXIMATE LIMITS OF DISTURBANCE

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1"=1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS FIVE FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.

SCALE
0 300' 600'

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

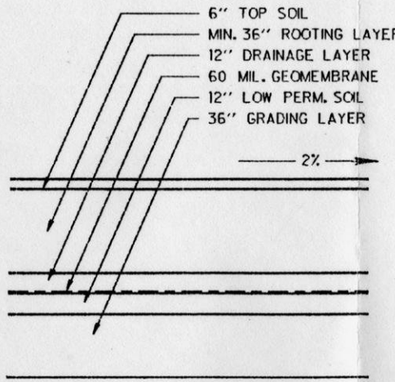
Crandon Mining Company

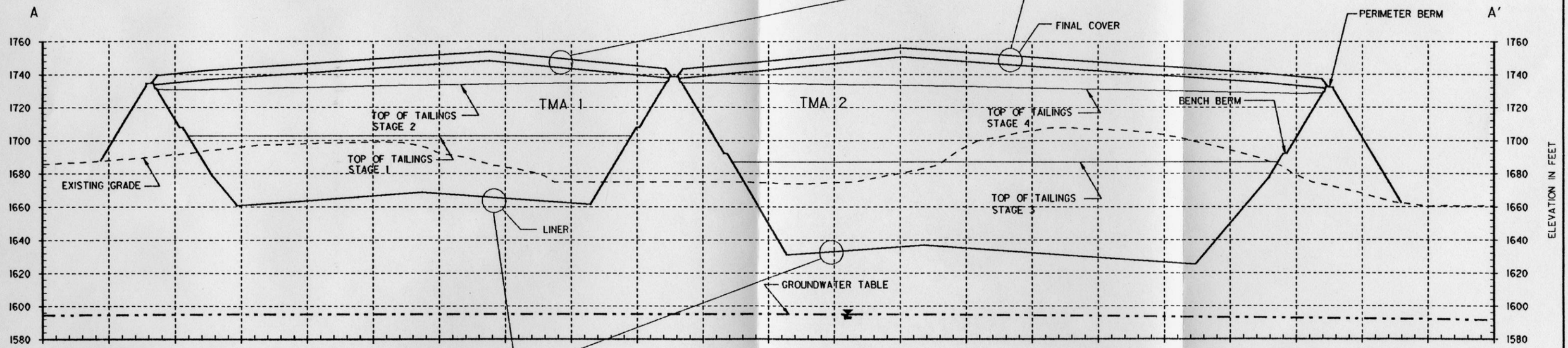
FIGURE 4-36
PROPOSED TMA LAYOUT

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	MRS

/d3/dl/users/jpr1/4c62m10.dgn

93C049

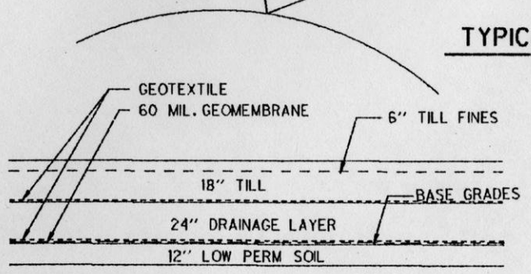


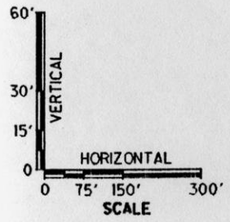


NOTE: VERTICAL SCALE IS EXAGGERATED

TYPICAL CROSS SECTION A-A' THROUGH TMA

NOT TO SCALE





TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

Crandon Mining Company

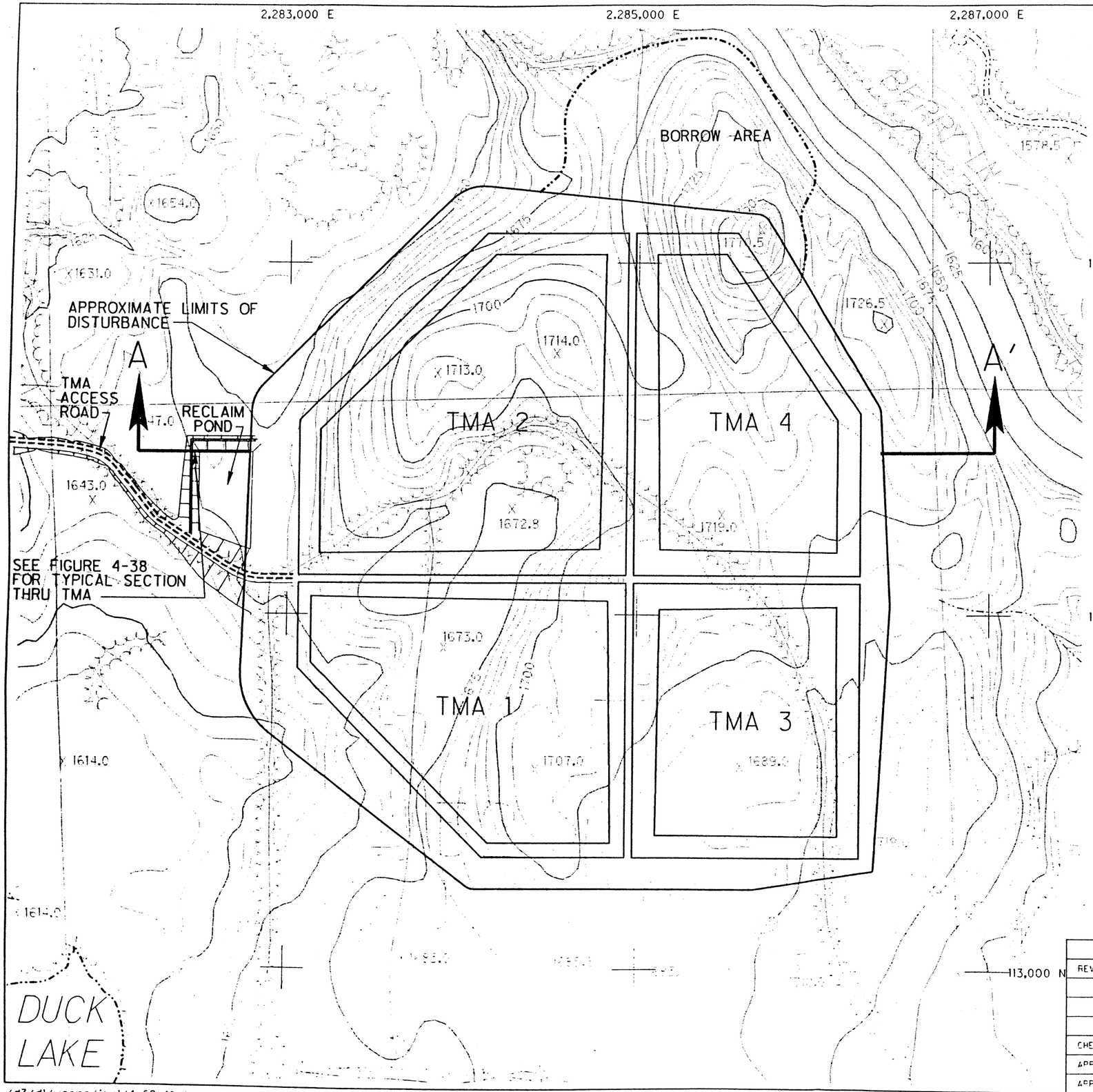
FIGURE 4-37

TYPICAL CROSS SECTION THROUGH TMA

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	MRS

c:\cadwork\3c49m11.dgn

93C049



N

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- —1675— EXISTING CONTOUR
- x 1692.0 SPOT ELEVATION
- SECTION LINE
- (TMA) APPROXIMATE LIMITS OF DISTURBANCE

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1"=1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS FIVE FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.

SCALE
0 300' 600'

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

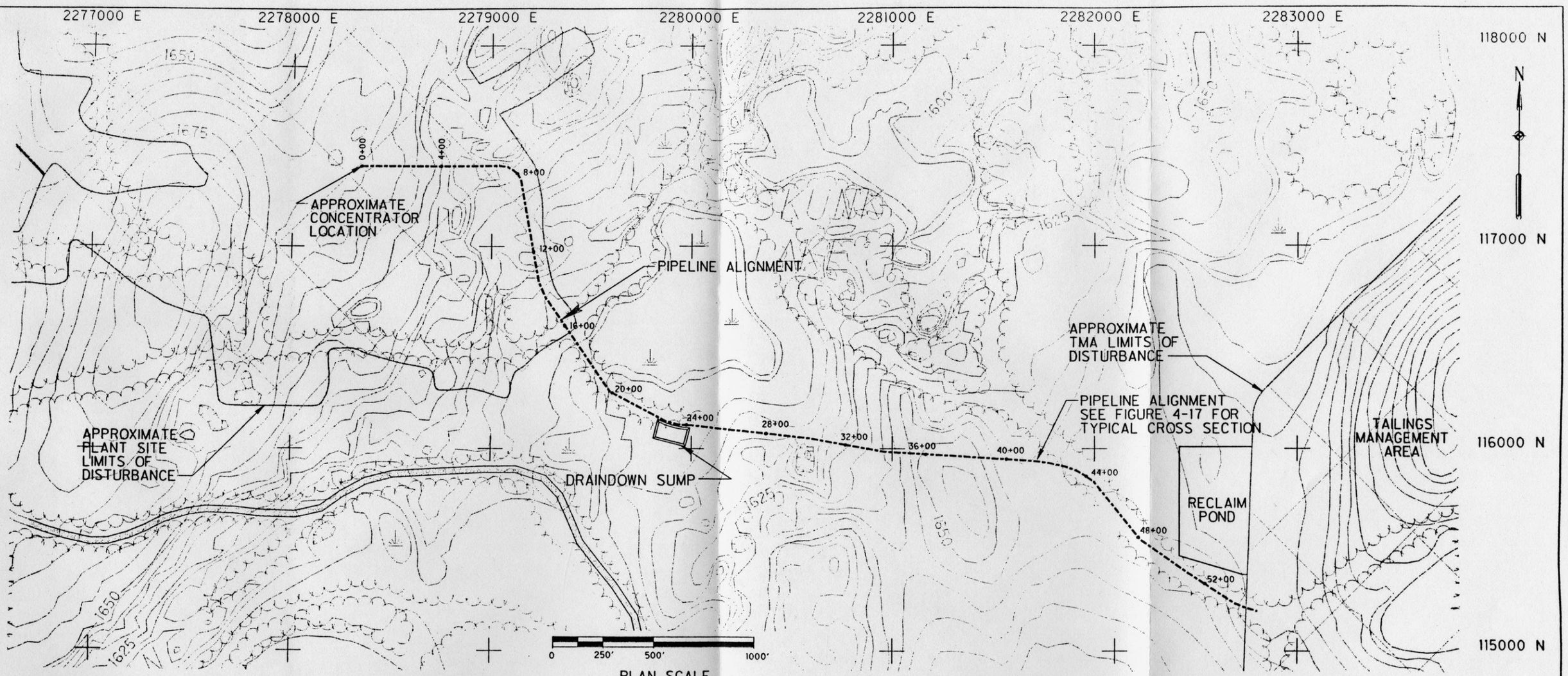
Crandon Mining Company

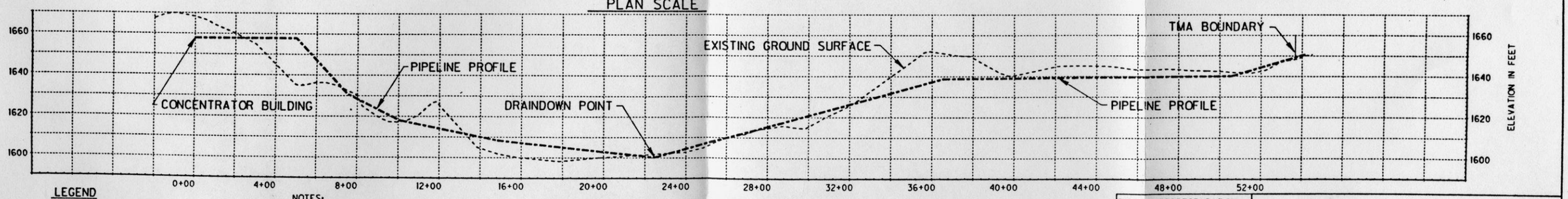
FIGURE 4-36
PROPOSED TMA LAYOUT

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	MRS

/d3/dl/users/jpr1/4c62m10.dgn

93C049



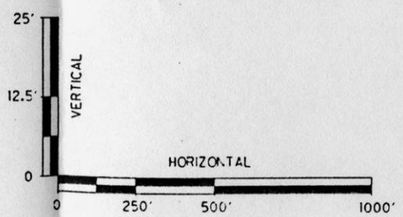


LEGEND

- EXISTING GRADE
- EXISTING SPOT ELEVATION
- PAVED ROAD
- UNPAVED ROAD/TRAIL
- TREES/BRUSH
- WETLAND

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1" = 1000' SCALE. 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS FIVE FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.



PROFILE SCALE

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY'95
APPROVED BY:	JBH	DATE: MAY'95
APPROVED BY:	PAE	DATE: MAY'95

Crandon Mining Company

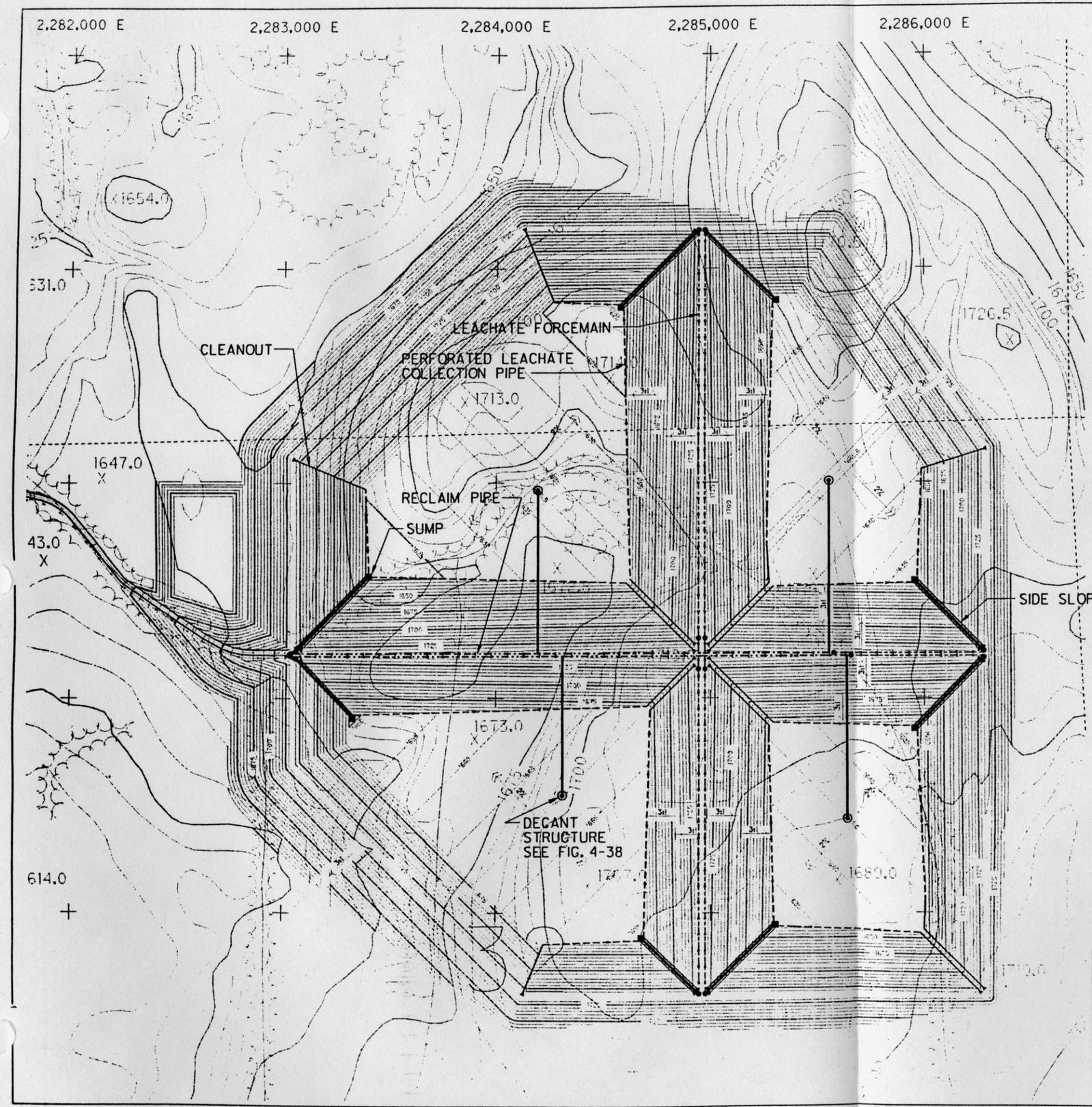
FIGURE 4-39

TAILINGS AND RETURN WATER PIPELINES PLAN AND PROFILE

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	GAM

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93C049



LEGEND

- EXISTING ROAD
- 1675 — EXISTING CONTOUR
- 1692.0 X — SPOT ELEVATION
- SECTION LINE
- 1725 — PROPOSED CONTOUR (BASE GRADE)
- 3:1 — PROPOSED SLOPE RATIO (TYP.)
- 2% — PROPOSED SLOPE (TYP.)
- PROPOSED RECLAIM PIPE
- PROPOSED LEACHATE FORCEMAIN
- PROPOSED PERFORATED LEACHATE COLLECTION PIPE
- PROPOSED DECANT STRUCTURE
- PROPOSED VALVE
- PROPOSED SIDE SLOPE RISER
- PROPOSED CLEANOUT RISER

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1"=1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS FIVE FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
5. THIS DRAWING SHOWS CONTOURS DEPICTING SITE BASE GRADES. (TOP OF 1' LOW PERMEABILITY SOIL LAYER).

0 250' 500'
SCALE

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY'95
APPROVED BY:	JBH	DATE: MAY'95
APPROVED BY:	PAE	DATE: MAY'95

Crandon Mining Company

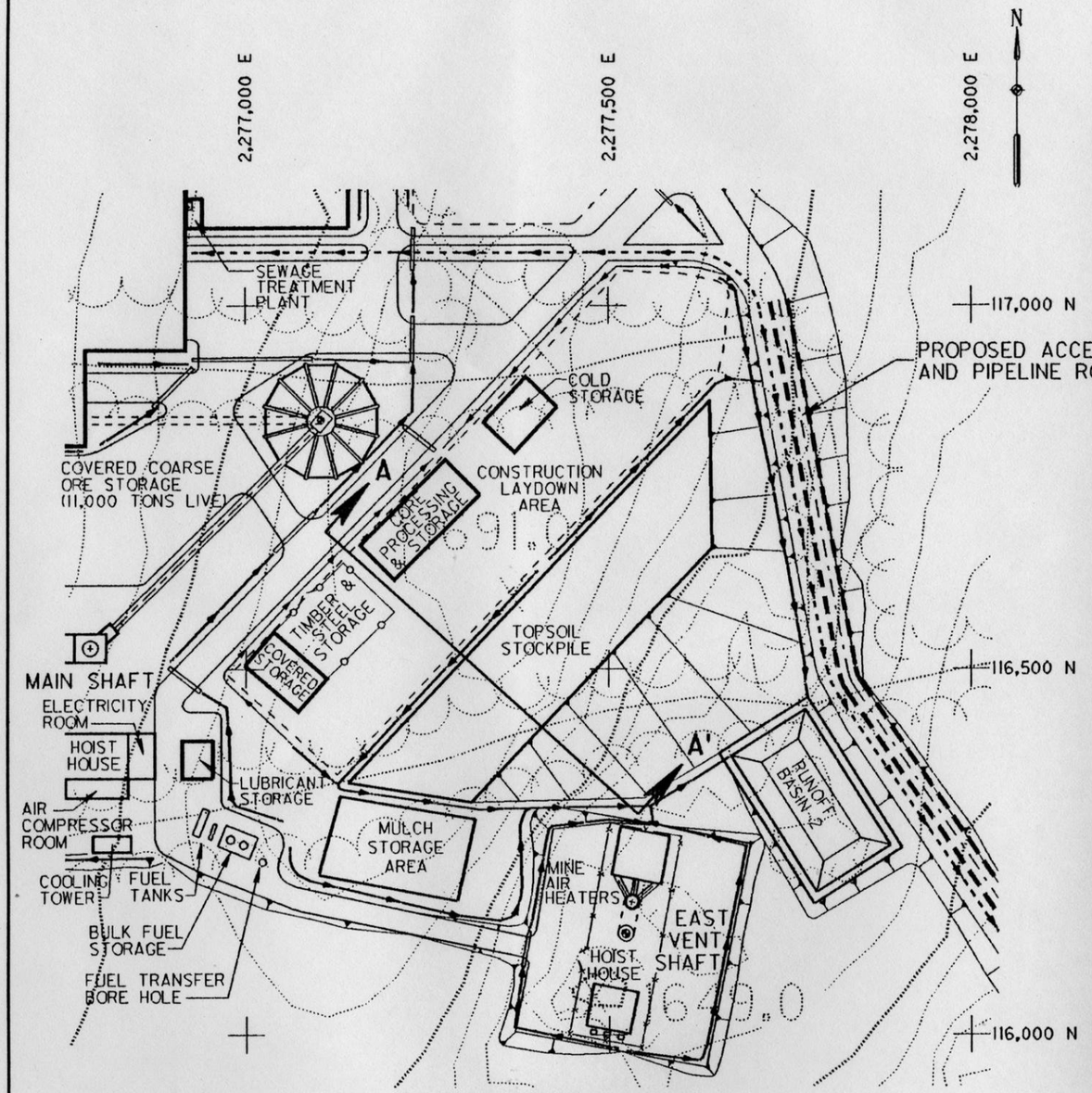
FIGURE 4-40

TMA WATER HANDLING SYSTEM

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	JRB2

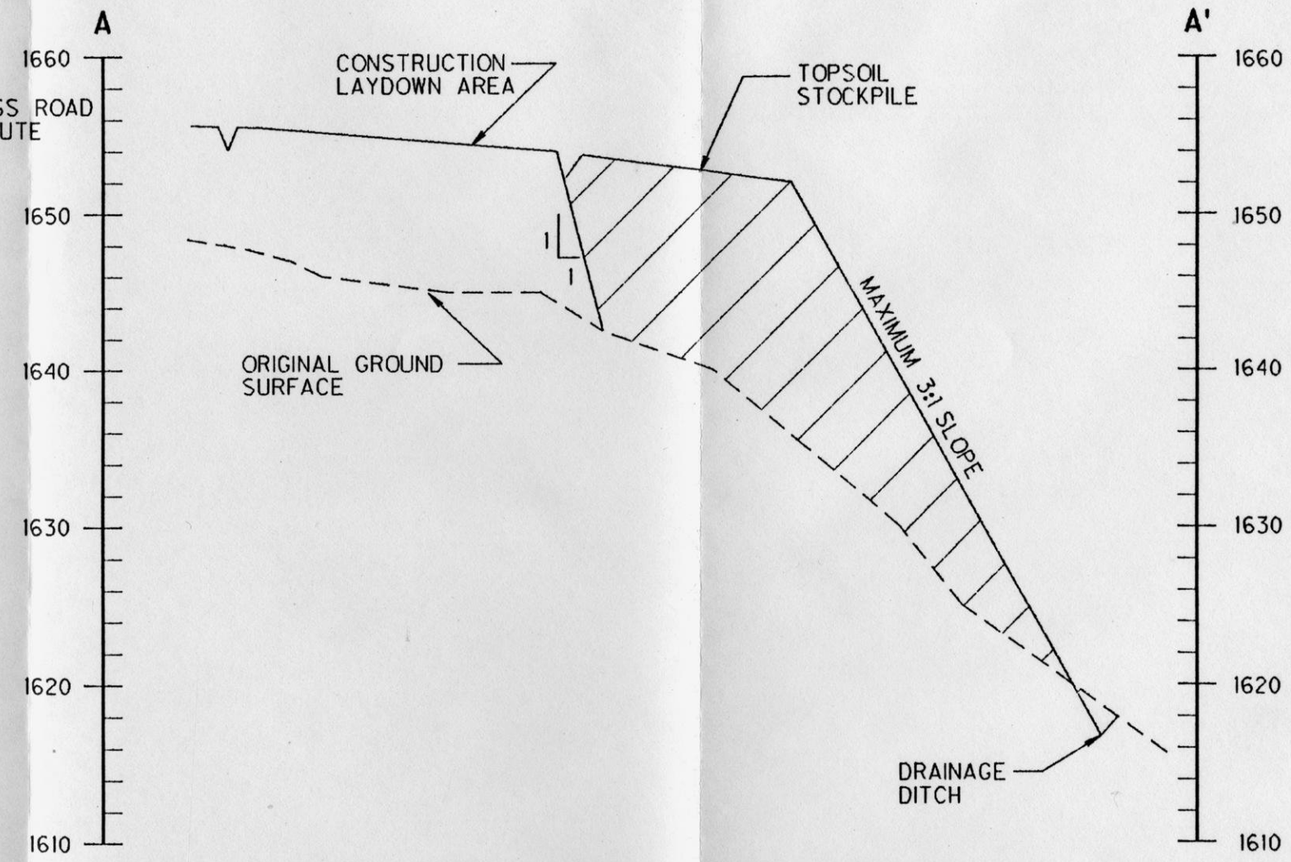
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93C049



PLAN VIEW

SCALE: 1" = 200'



SECTION A-A' THRU TOPSOIL STOCKPILE

SCALE: HORIZ. 1"=100'
VERT. 1"=10'

LEGEND

- 1600 — EXISTING CONTOUR
- RIVER/LAKE/WATERWAY
- x 1677.0 — EXISTING SPOT ELEVATION
- EXISTING ROADWAY
- EXISTING TRAIL
- EXISTING TREELINE
- ACCESS ROAD
- TAILING PIPELINE

NOTES:

1. BASE MAP DIGITIZED FROM 1" = 1000' SCALE, MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

Crandon Mining Company

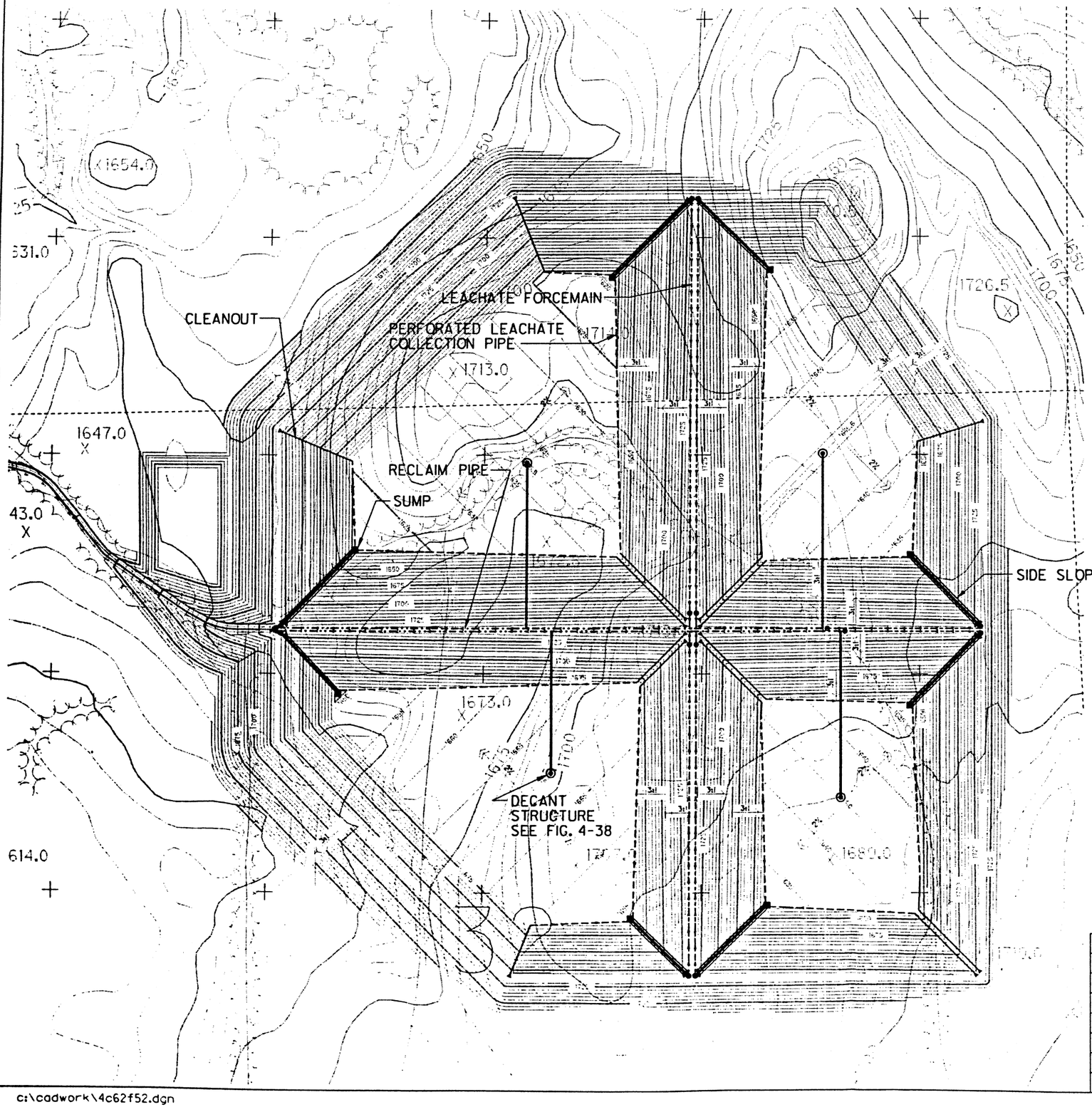
FIGURE 4-41

TOPSOIL STOCKPILE PLAN & SECTION

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	JPR

93C049

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LEGEND

- EXISTING ROAD
- 1675 — EXISTING CONTOUR
- 1693.0 X — SPOT ELEVATION
- SECTION LINE
- 1725 — PROPOSED CONTOUR (BASE GRADE)
- 3:1 — PROPOSED SLOPE RATIO (TYP.)
- 2% — PROPOSED SLOPE (TYP.)
- PROPOSED RECLAIM PIPE
- PROPOSED LEACHATE FORCEMAIN
- PROPOSED PERFORATED LEACHATE COLLECTION PIPE
- PROPOSED DECANT STRUCTURE
- PROPOSED VALVE
- PROPOSED SIDE SLOPE RISER
- PROPOSED CLEANOUT RISER

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1"=1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
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3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS FIVE FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
5. THIS DRAWING SHOWS CONTOURS DEPICTING SITE BASE GRADES. (TOP OF 1' LOW PERMEABILITY SOIL LAYER).

0 250' 500'
SCALE

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE:	MAY'95
APPROVED By:	JBH	DATE:	MAY'95
APPROVED By:	PAE	DATE:	MAY'95

Crandon Mining Company

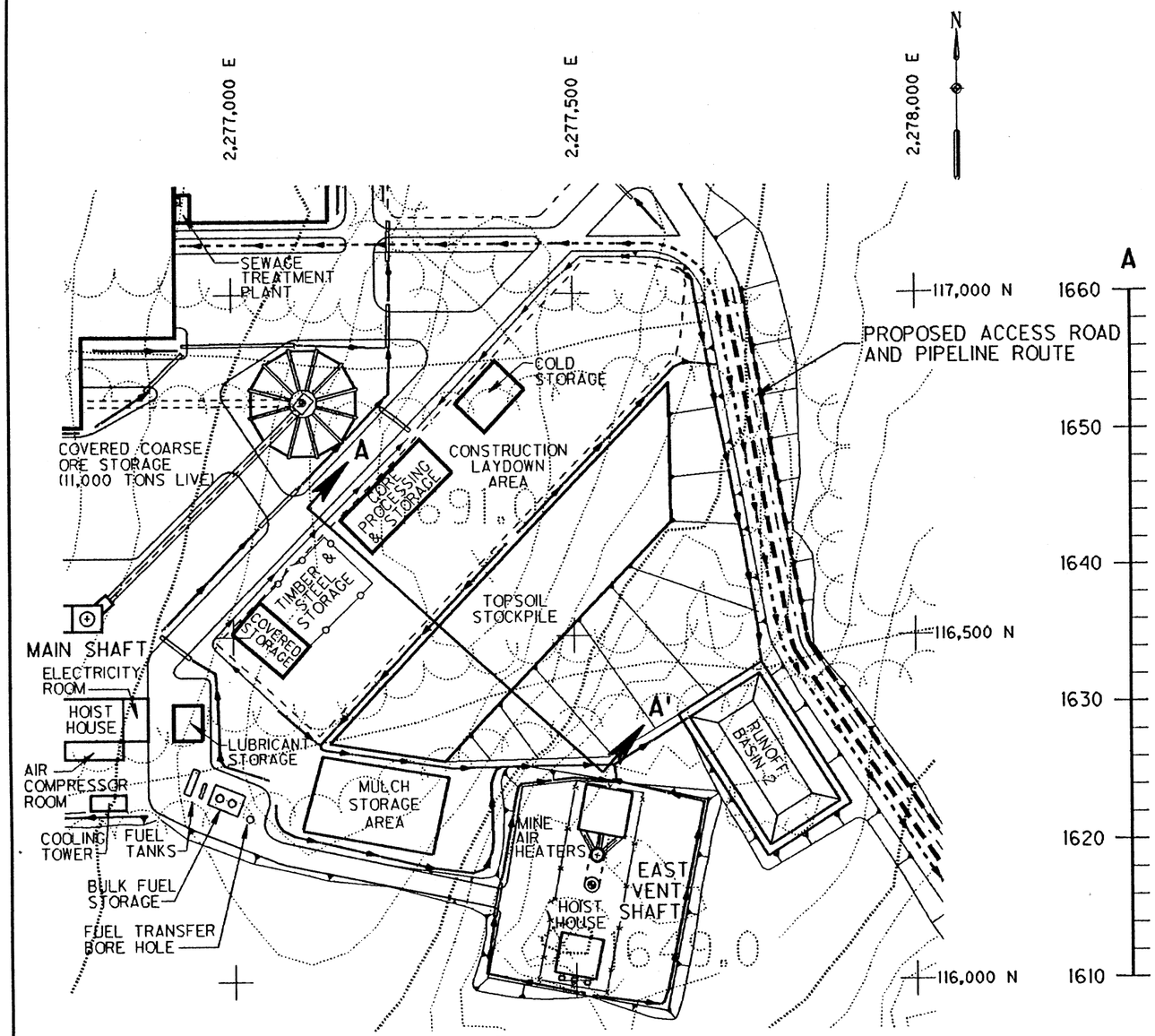
FIGURE 4-40

TMA WATER HANDLING SYSTEM

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	JRB2

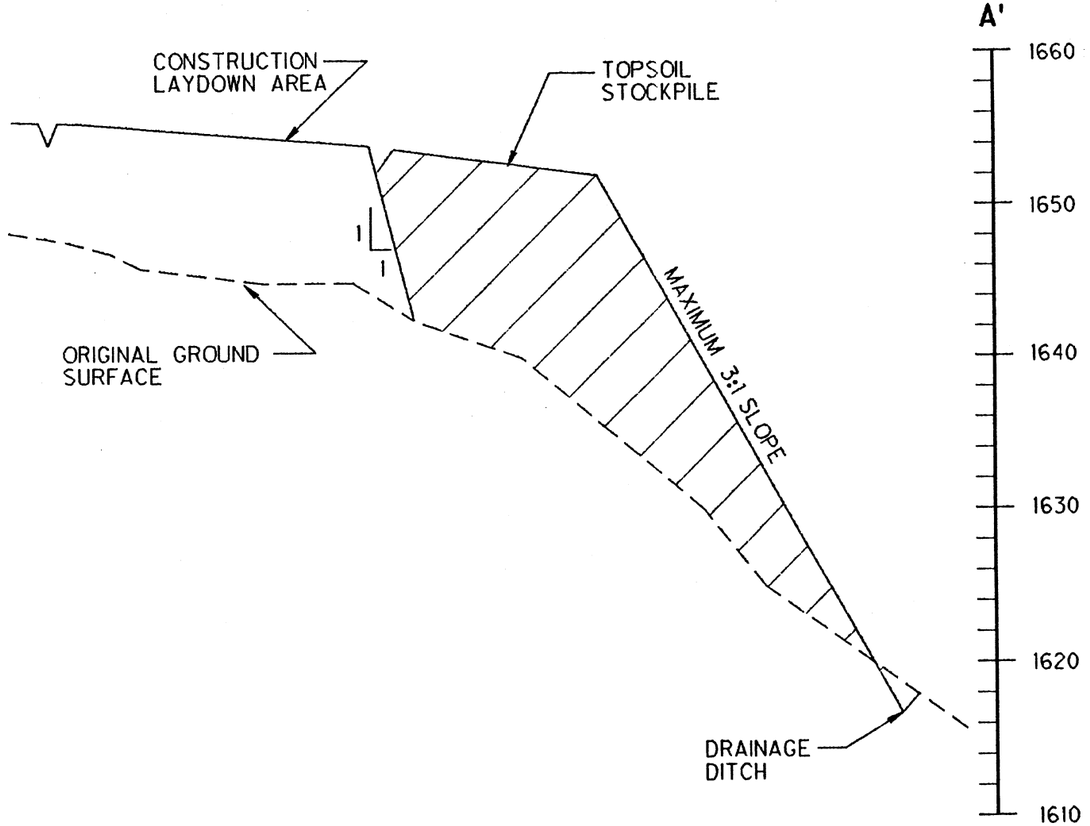
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PLAN VIEW

SCALE: 1" = 200'



SECTION A-A' THRU TOPSOIL STOCKPILE

SCALE: HORIZ. 1"=100'
VERT. 1"=10'

LEGEND

- EXISTING CONTOUR
- RIVER/LAKE/WATERWAY
- EXISTING SPOT ELEVATION
- EXISTING ROADWAY
- EXISTING TRAIL
- EXISTING TREELINE
- ACCESS ROAD
- TAILING PIPELINE

NOTES:

1. BASE MAP DIGITIZED FROM 1" = 1000' SCALE, MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.

TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

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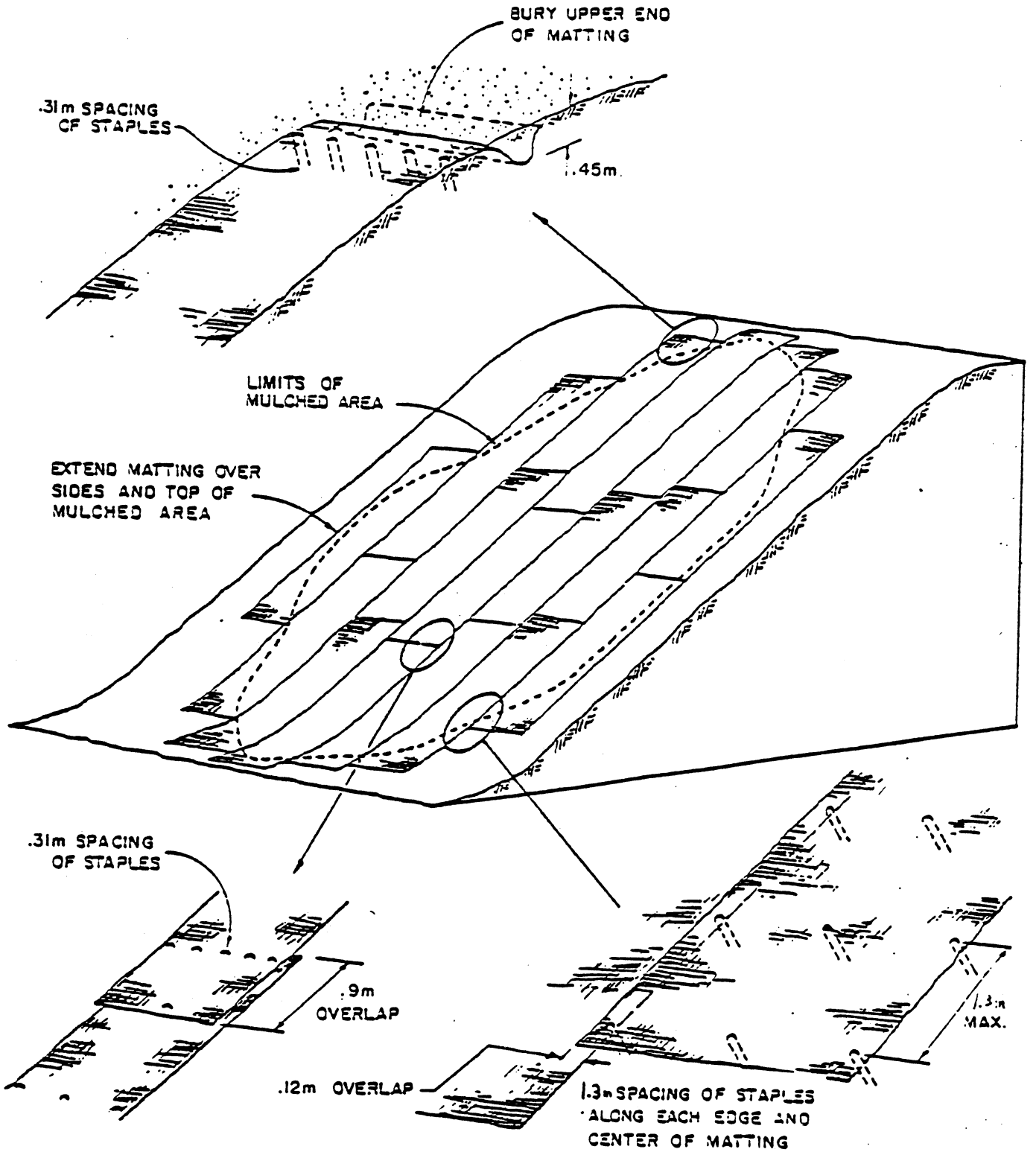
FIGURE 4-41

TOPSOIL STOCKPILE PLAN & SECTION

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	JPR

93C049

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SOURCE:
TAHOE REGIONAL PLANNING AGENCY, 1978

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REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBHI	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

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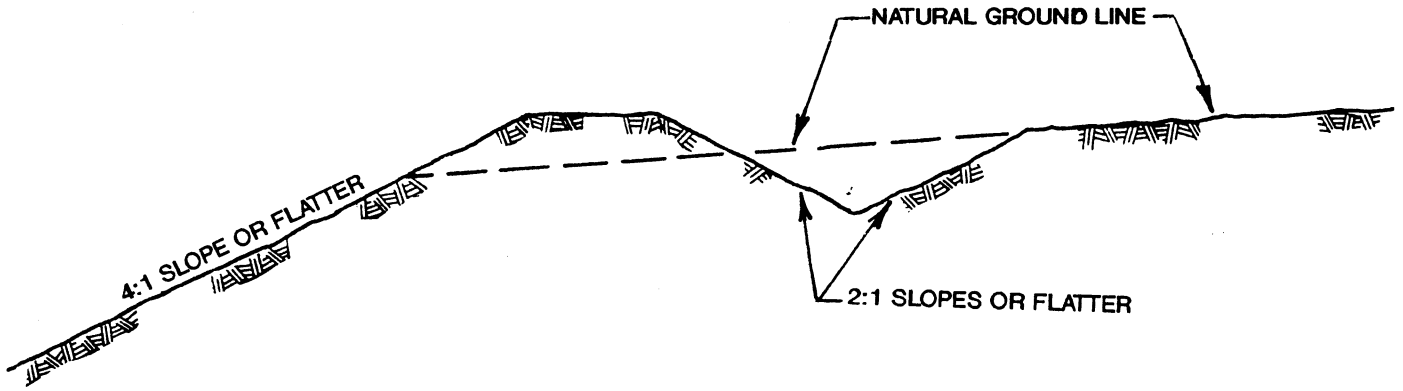
FIGURE 4-42

JUTE MATTING

Scale:	N.T.S.	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	KMP

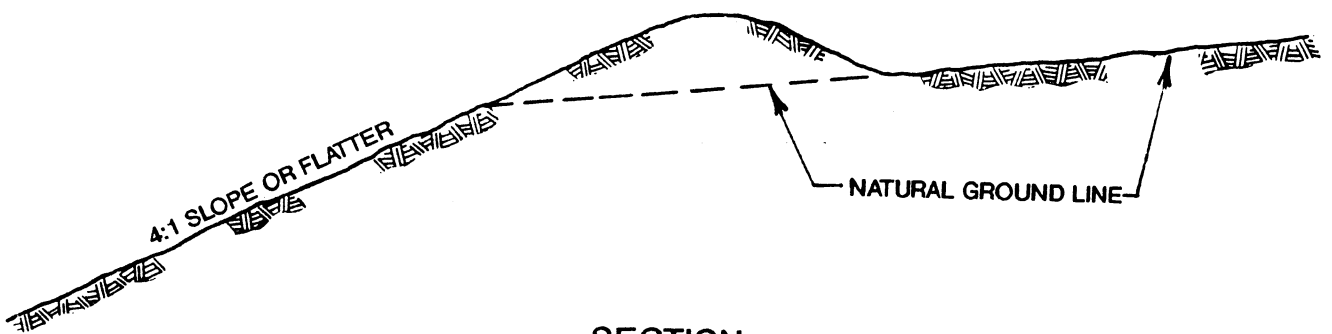
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SECTION

NOT TO SCALE



SECTION

NOT TO SCALE

SOURCE:
ENGINEERING SCIENCE, 1980

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBHI	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

Crandon Mining Company

FIGURE 4-43

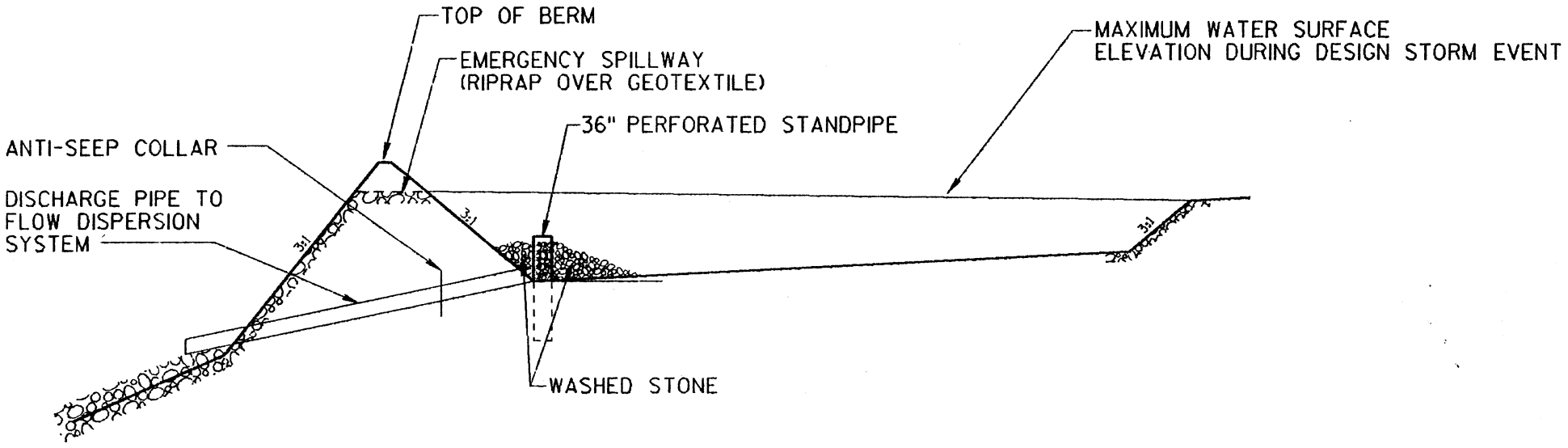
DIVERSION BERM

Scale:	N.T.S.	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	KMP

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93C049

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NOTE:
STANDPIPE TO INCLUDE
1) TRASH RACK
2) 9-½" DIA. HOLES PER ROW, ROWS 6" ON CENTER
3) WRAP WITH AKZO ENKADRAIN 9120 OR EQUAL

TYPICAL REPRESENTATION:
REFINEMENTS MAY BE MADE
PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

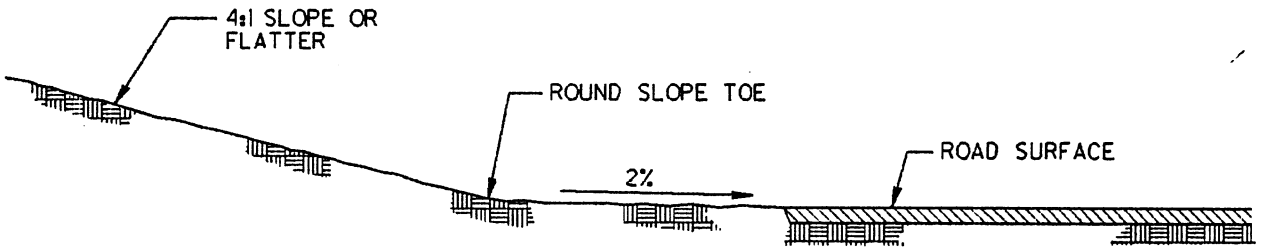
CHECKED BY:	JKSI	DATE:	MAY'95
APPROVED BY:	JBH	DATE:	MAY'95
APPROVED BY:	PAE	DATE:	MAY'95

Crandon Mining Company

FIGURE 4-44
TYPICAL RUNOFF BASIN

Scale:	N.T.S.	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	KMP

93C049



SECTION
NOT TO SCALE

SOURCE:
ENGINEERING SCIENCE, 1980

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBHI	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

Crandon Mining Company

FIGURE 4-45

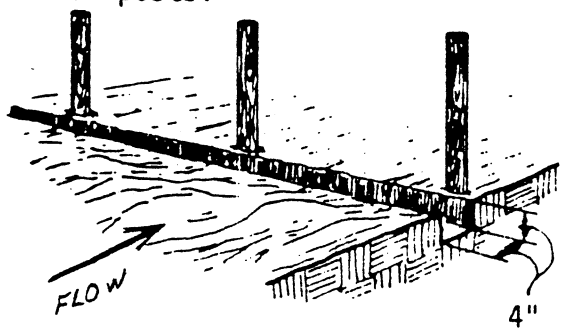
TYPICAL SLOPE BENCH

Scale:	N.T.S.	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	KMP

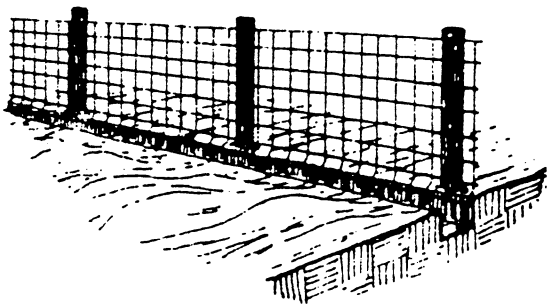
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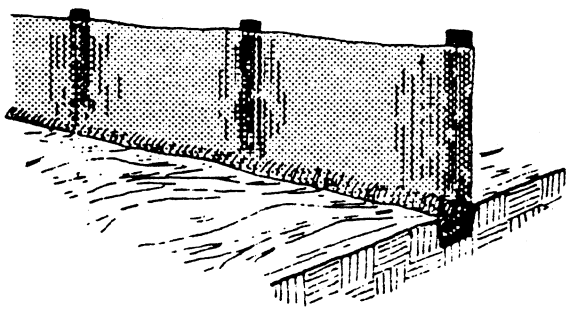
1. Set posts and excavate a 4"x4" trench upslope along the line of posts.



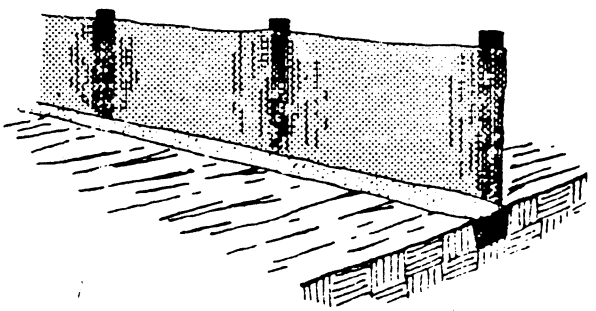
2. Staple wire fencing to the posts.



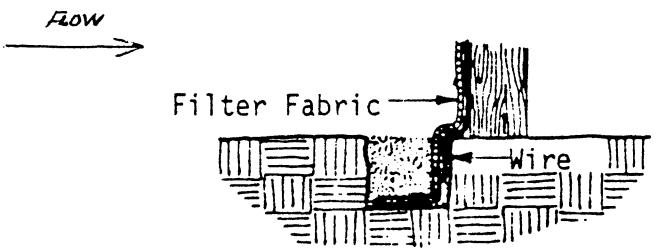
3. Attach the filter fabric to the wire fence and extend it into the trench.



4. Backfill and compact the excavated soil.



Extension of fabric and wire into the trench.



SOURCE:
ADAPTED FROM INSTALLATION OF STRAW AND FABRIC FILTER BARRIERS FOR SEDIMENT CONTROL, SHERWOOD AND WYANT

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBHI	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

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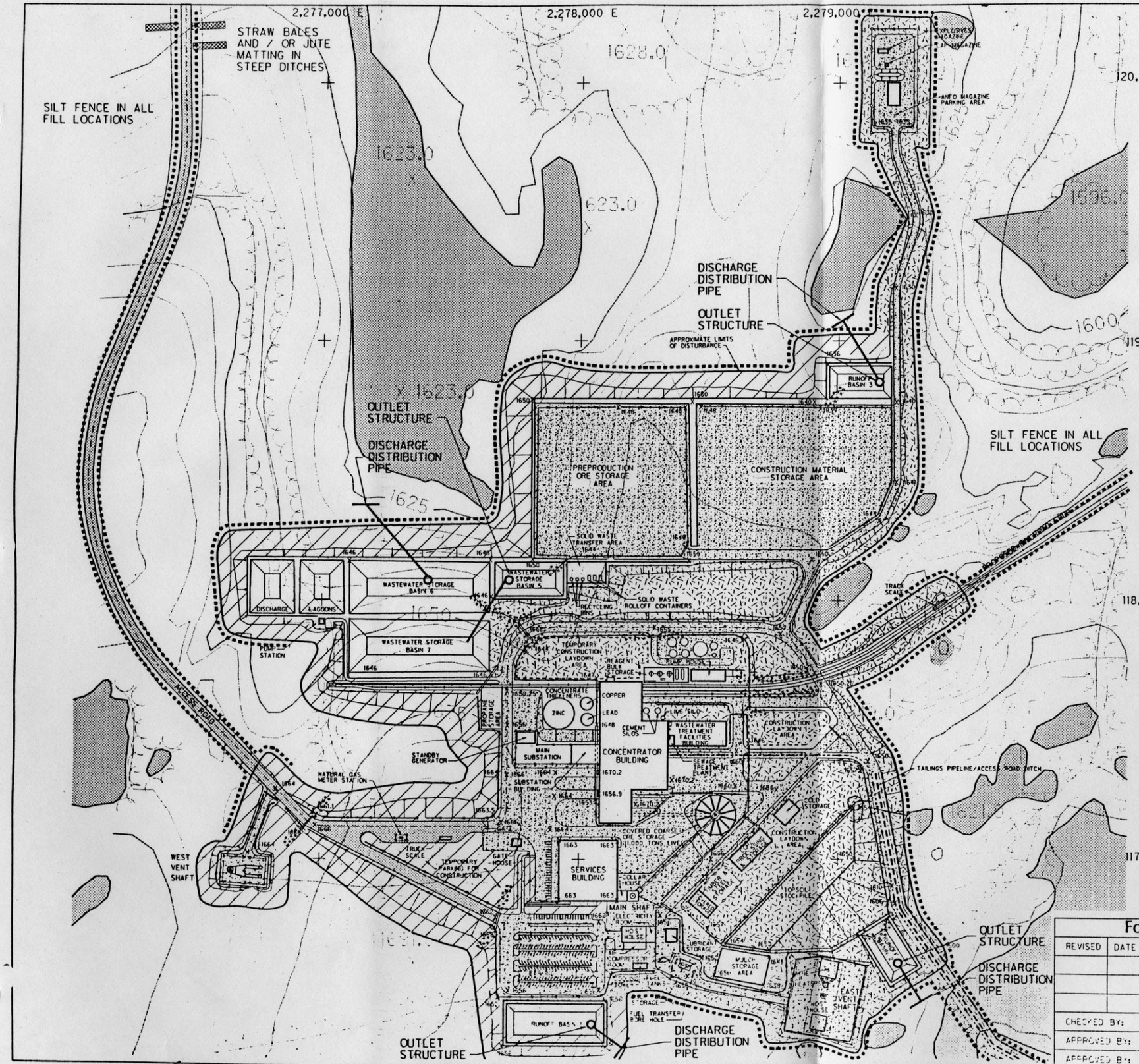
FIGURE 4-46

TYPICAL CONSTRUCTION OF A SILT FENCE

Scale:	N.T.S.	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	KMP

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LEGEND

- EXISTING CONTOUR
- RIVER/LAKE/WATERWAY
- EXISTING SPOT ELEVATION
- EXISTING ROADWAY
- EXISTING TRAIL
- EXISTING TREELINE
- PROPOSED LIMITS OF PLANT SITE DISTURBANCE
- PROPOSED STRUCTURE OR BUILDING
- PROPOSED RAILROAD SPUR
- PROPOSED CHAIN LINK FENCE
- PROPOSED WELDED WIRE FENCE
- PROPOSED DRAINAGE DITCH
- PROPOSED TAILINGS PIPELINE DITCH
- PROPOSED ASPHALT ACCESS ROAD
- EXISTING WETLAND
- PROPOSED SPOT ELEVATION
- PROPOSED CULVERT
- PROPOSED SLOPE DIRECTION
- GRAVEL AREA
- GRASSES AND FORBS
- SAVANNAH AREA
- SILT FENCE
- RIPRAP OVER GEOTEXTILE
- STRAW BALES / JUTE MATTING

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1" = 1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS FIVE FEET.
4. PLANT SITE BASED ON REFINEMENTS TO THE APRIL 1986 PLOT PLAN DEVELOPED BY RAYMOND KAISER ENGINEERS, INC.

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

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FIGURE 4-49

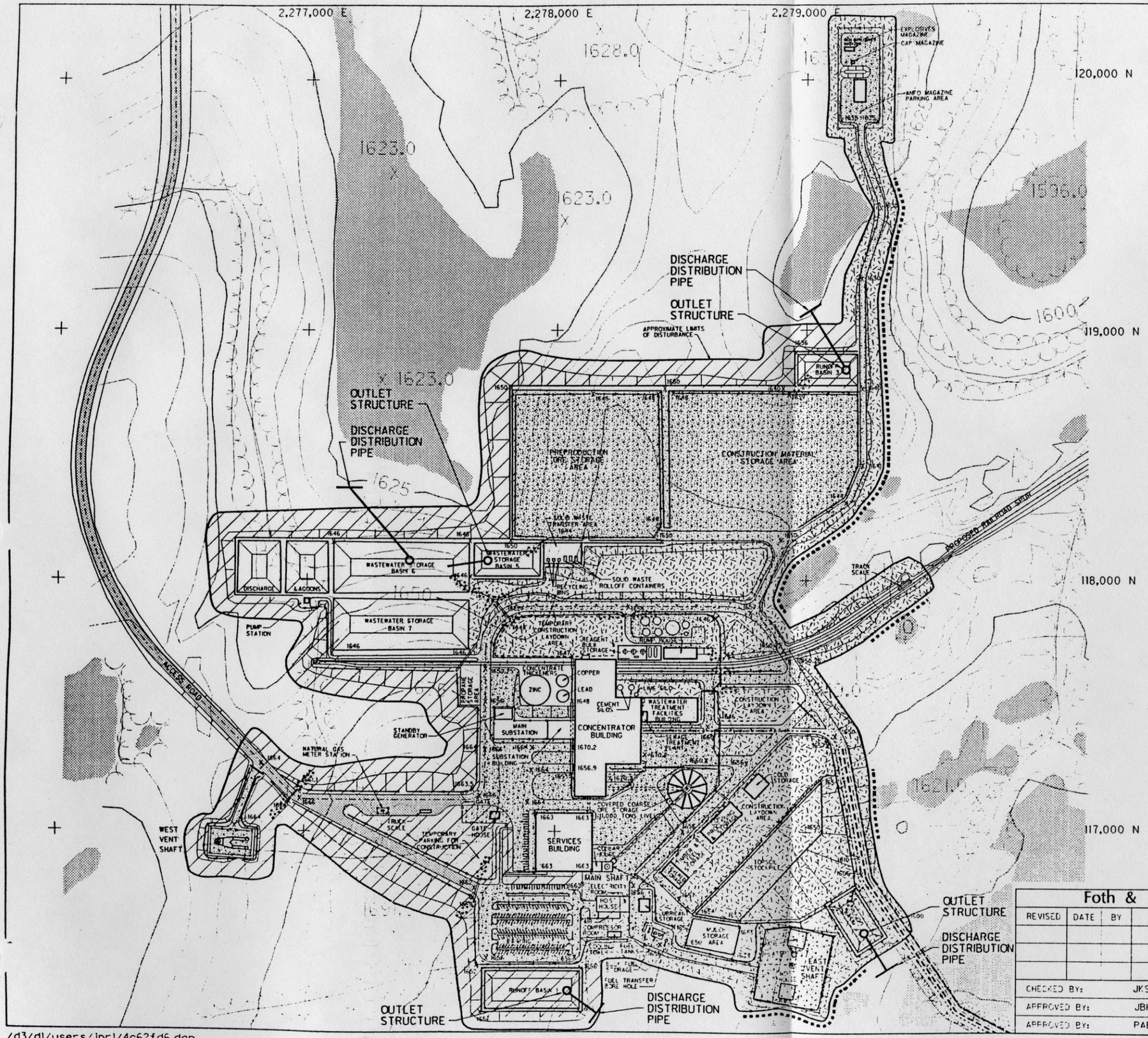
PLANT SITE EROSION CONTROL YEARS 1-3

Scale: 0 200' 400' | Date: MAY, 1995

Prepared By: Foth & Van Dyke | By: JPF

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LEGEND

- EXISTING CONTOUR
- RIVER/LAKE/WATERWAY
- x 1677.0 EXISTING SPOT ELEVATION
- EXISTING ROADWAY
- EXISTING TRAIL
- EXISTING TREELINE
- PROPOSED LIMITS OF PLANT SITE DISTURBANCE
- PROPOSED STRUCTURE OR BUILDING
- PROPOSED RAILROAD SPUR
- PROPOSED CHAIN LINK FENCE
- PROPOSED WELDED WIRE FENCE
- PROPOSED DRAINAGE DITCH
- PROPOSED TAILINGS PIPELINE DITCH
- PROPOSED ASPHALT ACCESS ROAD
- EXISTING WETLAND
- x 1677.0 PROPOSED SPOT ELEVATION
- PROPOSED CULVERT
- PROPOSED SLOPE DIRECTION
- GRAVEL AREA
- GRASSES AND FORBS
- SAVANNAH AREA
- SILT FENCE
- RIPRAP OVER GEOTEXTILE

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1" = 1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
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TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

Crandon Mining Company

FIGURE 4-50

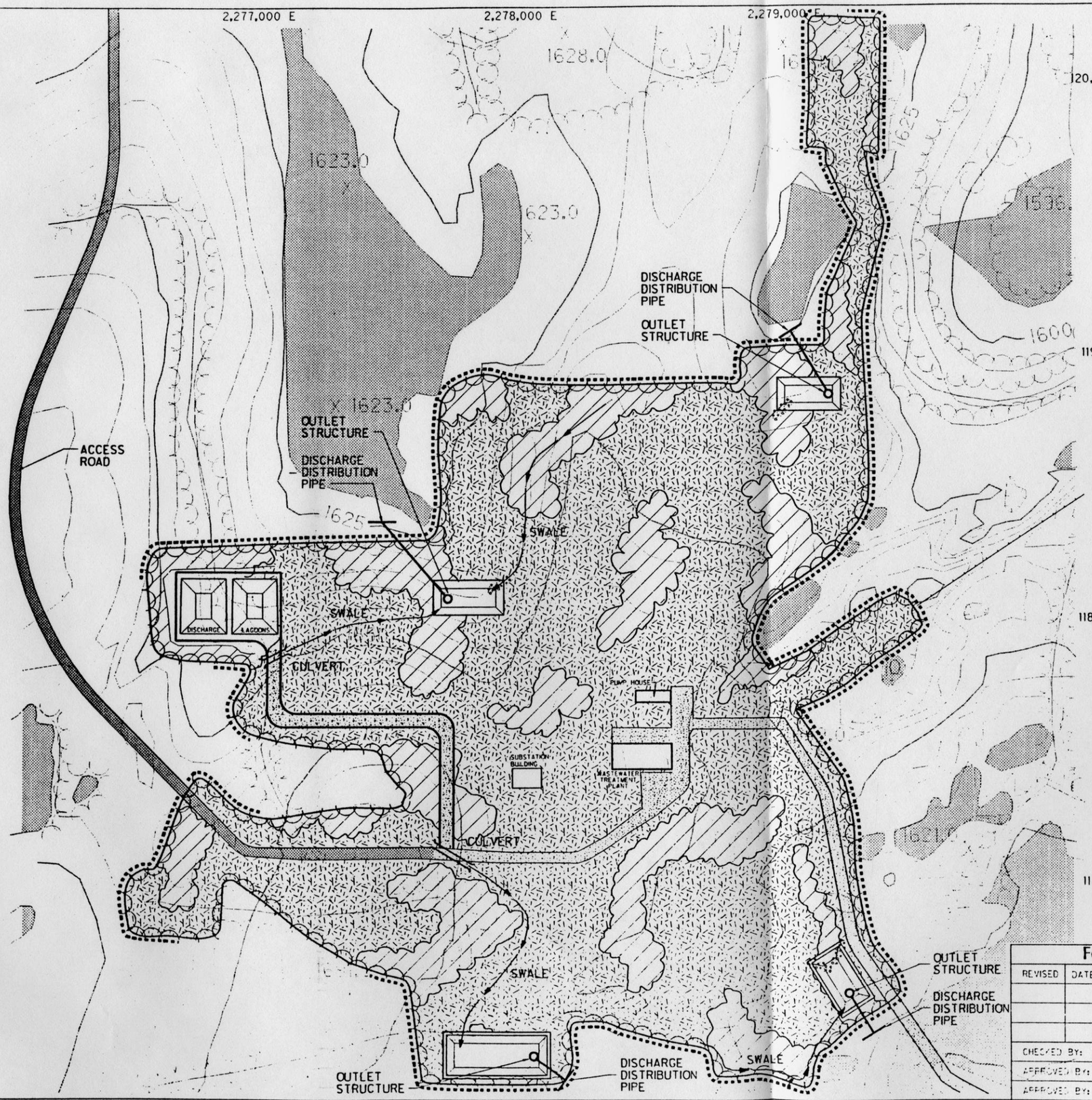
PLANT SITE EROSION CONTROL YEARS 4-12

Scale: 0 200' 400' | Date: MAY, 1995

Prepared By: Foth & Van Dyke | By: JPR

/d3/dl/users/jpr1/4c62fd6.dgn

93C049



LEGEND

- EXISTING CONTOUR (1600)
- RIVER/LAKE/WATERWAY
- EXISTING SPOT ELEVATION (1677.0)
- EXISTING ROADWAY
- EXISTING TRAIL
- EXISTING TREELINE
- PROPOSED LIMITS OF PLANT SITE DISTURBANCE
- PROPOSED STRUCTURE OR BUILDING
- PROPOSED RAILROAD SPUR
- PROPOSED ASPHALT ACCESS ROAD
- EXISTING WETLAND
- GRASSES AND FORBS
- SAVANNAH COPSES
- GRAVEL AREA
- SILT FENCE
- CULVERT

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1" = 1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS 25 FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
5. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

Crandon Mining Company

FIGURE 4-51

PLANT SITE EROSION CONTROL
MINE CESSATION (± YEAR 32)

Scale: 0 200' 400' | Date: MAY, 1995

Prepared By: Foth & Van Dyke | By: JPP

/d3/dl/users/jpr1/4c62fd7.dgn

93C049

2,277,000 E

2,278,000 E

2,279,000 E

120,000 N

119,000 N

118,000 N

117,000 N

1628.0

1623.0

623.0

1623.0

1596.

1600

1625

1630

1635

1640

1645

1650

1655

1660

1665

1670

1675

1680

1685

1690

LEGEND

- 1600 — EXISTING CONTOUR
- RIVER/LAKE/WATERWAY
- x1677.0 EXISTING SPOT ELEVATION
- EXISTING ROADWAY
- EXISTING TRAIL
- EXISTING TREELINE
- PROPOSED LIMITS OF PLANT SITE DISTURBANCE
- —1635— PROPOSED FINAL GRADE CONTOUR
- EXISTING WETLAND
- GRASSES AND FORBS
- SAVANNAH

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1" = 1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS FIVE FEET.
4. PLANT SITE BASED ON REFINEMENTS TO THE APRIL 1986 PLOT PLAN DEVELOPED BY RAYMOND KAISER ENGINEERS, INC.

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

Crandon Mining Company

FIGURE 4-52

PLANT SITE EROSION CONTROL

FINAL CLOSURE (YEAR 75)

Scale: 0 200' 400'

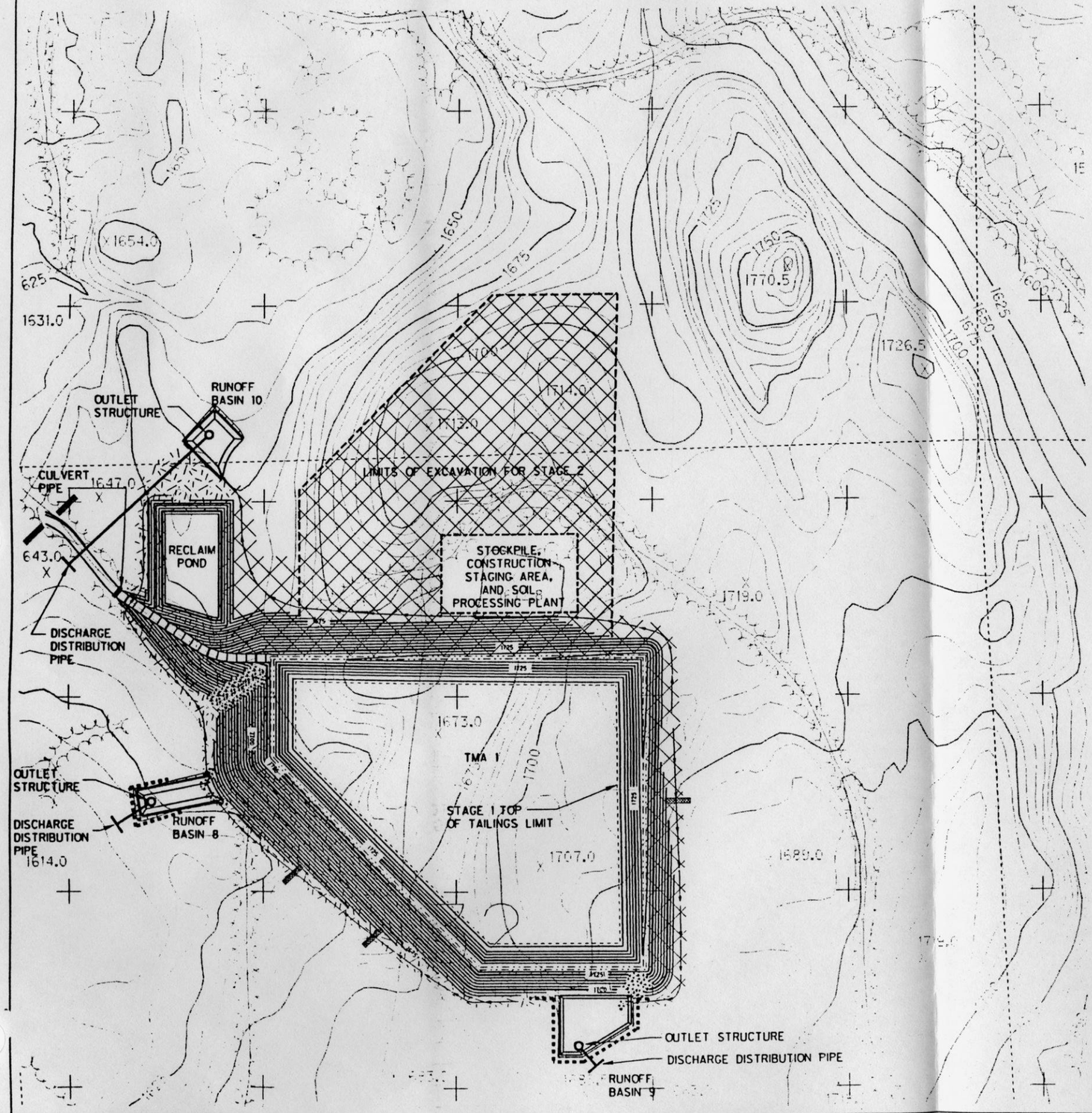
Date: MAY, 1995

Prepared By: Foth & Van Dyke

By: GAM

/d3/dl/users/jpr1/4c62fd8.dgn

930049



LEGEND

- EXISTING ROAD
- 1675 — EXISTING CONTOUR
- x 1692.0 SPOT ELEVATION
- SECTION LINE
- 1725 PROPOSED CONTOUR
- RIPRAP OVER GEOTEXTILE
- SILT FENCE
- STRAW BALES
- PROPOSED DRAINAGE FLOW
- GRASSES AND FORBS
- DOT MIX NO. 30

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1"=1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS FIVE FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

Crandon Mining Company

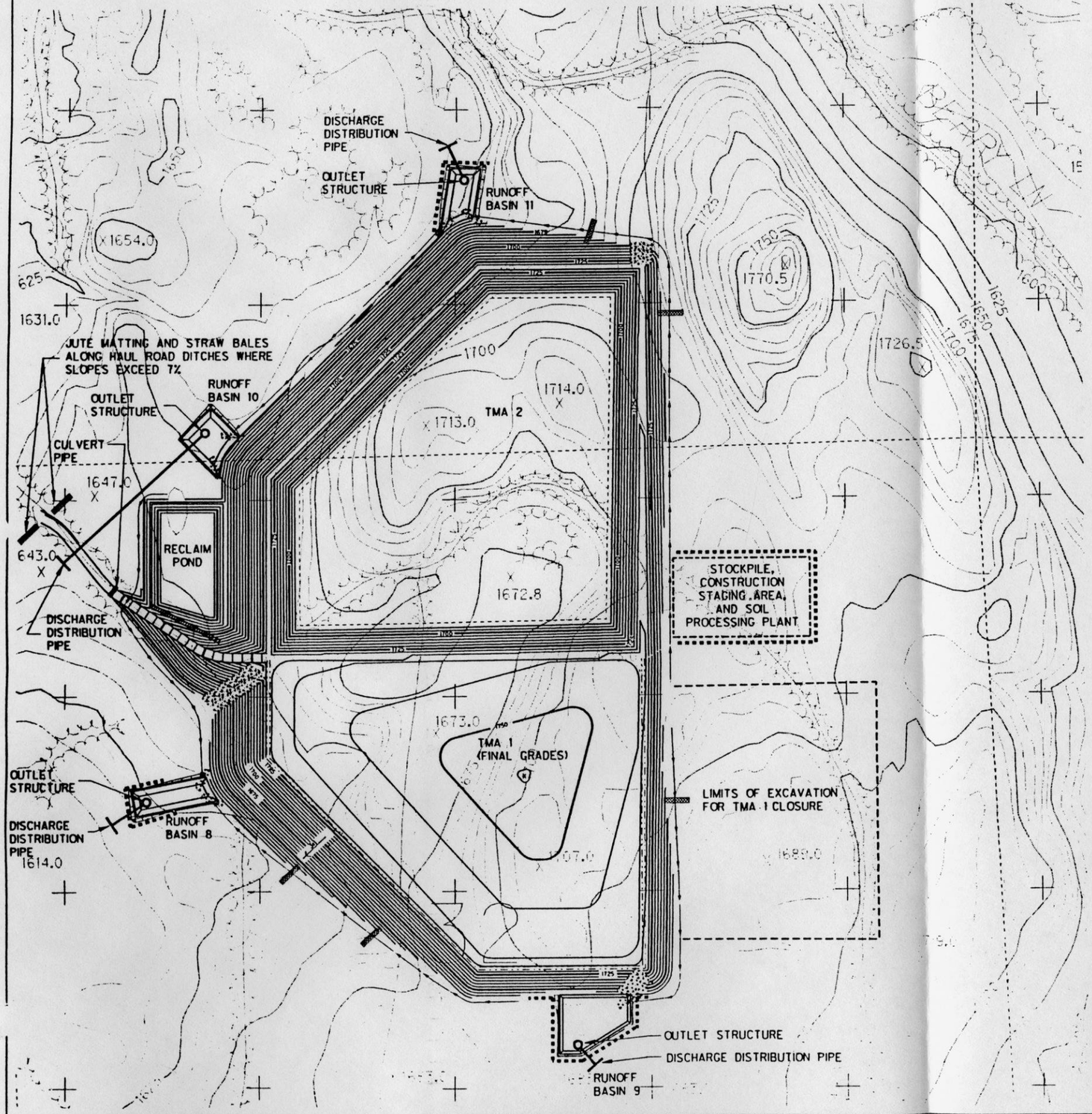
FIGURE 4-53
TMA EROSION CONTROL
YEAR 3 (APPROX.)

Scale: 0 300' 600' Date: MAY, 1995

Prepared By: Foth & Van Dyke By: JPR

/d3/dl/users/jprl/4c62fd9.dgn

93C049



LEGEND

- EXISTING ROAD
- —1675— EXISTING CONTOUR
- x1692.0 SPOT ELEVATION
- SECTION LINE
- PROPOSED CONTOUR
- RIPRAP OVER GEOTEXTILE
- SILT FENCE
- STRAW BALES
- PROPOSED DRAINAGE FLOW

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1"=1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS FIVE FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED By:	PAE	DATE: MAY '95

Crandon Mining Company

FIGURE 4-54
TMA EROSION CONTROL
YEAR 12 (APPROX.)

Scale: 0 300' 600' Date: MAY, 1995

Prepared By: Foth & Van Dyke By: GAM

930049

/d3/d1/users/jpr1/4c62fd2.dgn

2,282,000 E 2,283,000 E 2,284,000 E 2,285,000 E 2,286,000 E 2,287,000 E

118,000 N

117,000 N

116,000 N

115,000 N

114,000 N

113,000 N

DISCHARGE DISTRIBUTION PIPE
OUTLET STRUCTURE
RUNOFF BASIN 11
JUTE MATTING AND STRAW BALES ALONG HAUL ROAD DITCHES WHERE SLOPES EXCEED 7%
RUNOFF BASIN 10
OUTLET STRUCTURE
CULVERT PIPE
RECLAIM POND
DISCHARGE DISTRIBUTION PIPE
TMA 2 (FINAL GRADES)
LIMITS OF EXCAVATION FOR TMA 2 CLOSURE
STOCKPILE, CONSTRUCTION STAGING AREA, AND SOIL PROCESSING PLANT
TMA 1 (FINAL GRADES)
TMA 3
OUTLET STRUCTURE
DISCHARGE DISTRIBUTION PIPE
RUNOFF BASIN 8
OUTLET STRUCTURE
DISCHARGE DISTRIBUTION PIPE
RUNOFF BASIN 9
RUNOFF BASIN 12
OUTLET STRUCTURE
DISCHARGE DISTRIBUTION PIPE
BERRY LN

LEGEND

- EXISTING ROAD
- —1675— EXISTING CONTOUR
- X 1692.0 SPOT ELEVATION
- SECTION LINE
- PROPOSED CONTOUR
- RIPRAP OVER GEOTEXTILE
- SILT FENCE
- STRAW BALES
- PROPOSED DRAINAGE FLOW

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1"=1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS FIVE FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

Crandon Mining Company

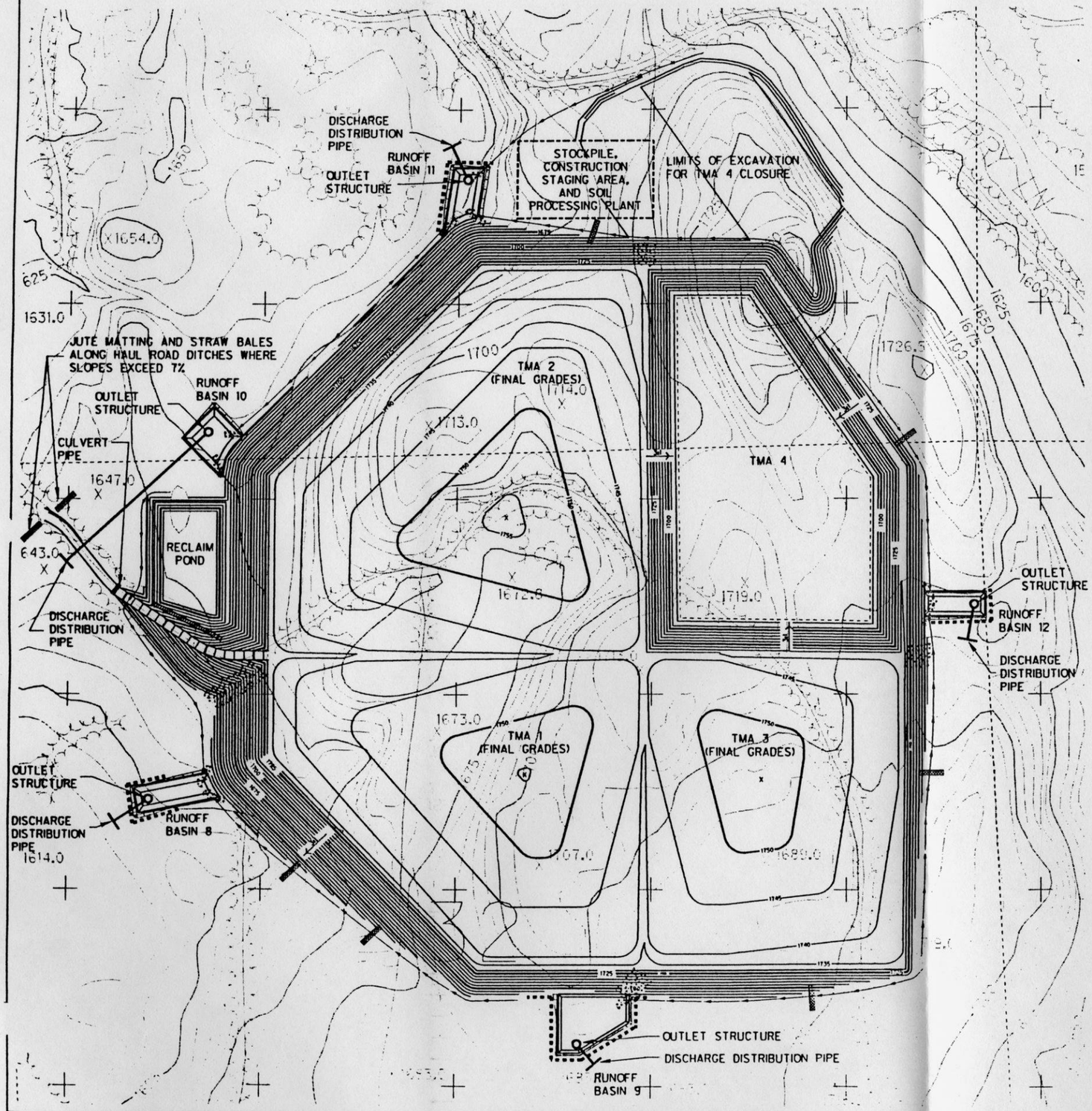
FIGURE 4-55
TMA EROSION CONTROL
YEAR 23 (APPROX.)

Scale: 0 300' 600' Date: MAY, 1995

Prepared By: Foth & Van Dyke By: GAM

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93C049



LEGEND

- STREAMS
- EXISTING ROAD
- —1675— EXISTING CONTOUR
- X 1692.0 SPOT ELEVATION
- SECTION LINE
- PROPOSED CONTOUR
- RIPRAP OVER GEOTEXTILE
- SILT FENCE
- STRAW BALES
- PROPOSED DRAINAGE FLOW

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1"=1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS FIVE FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JSK1	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

Crandon Mining Company

FIGURE 4-56

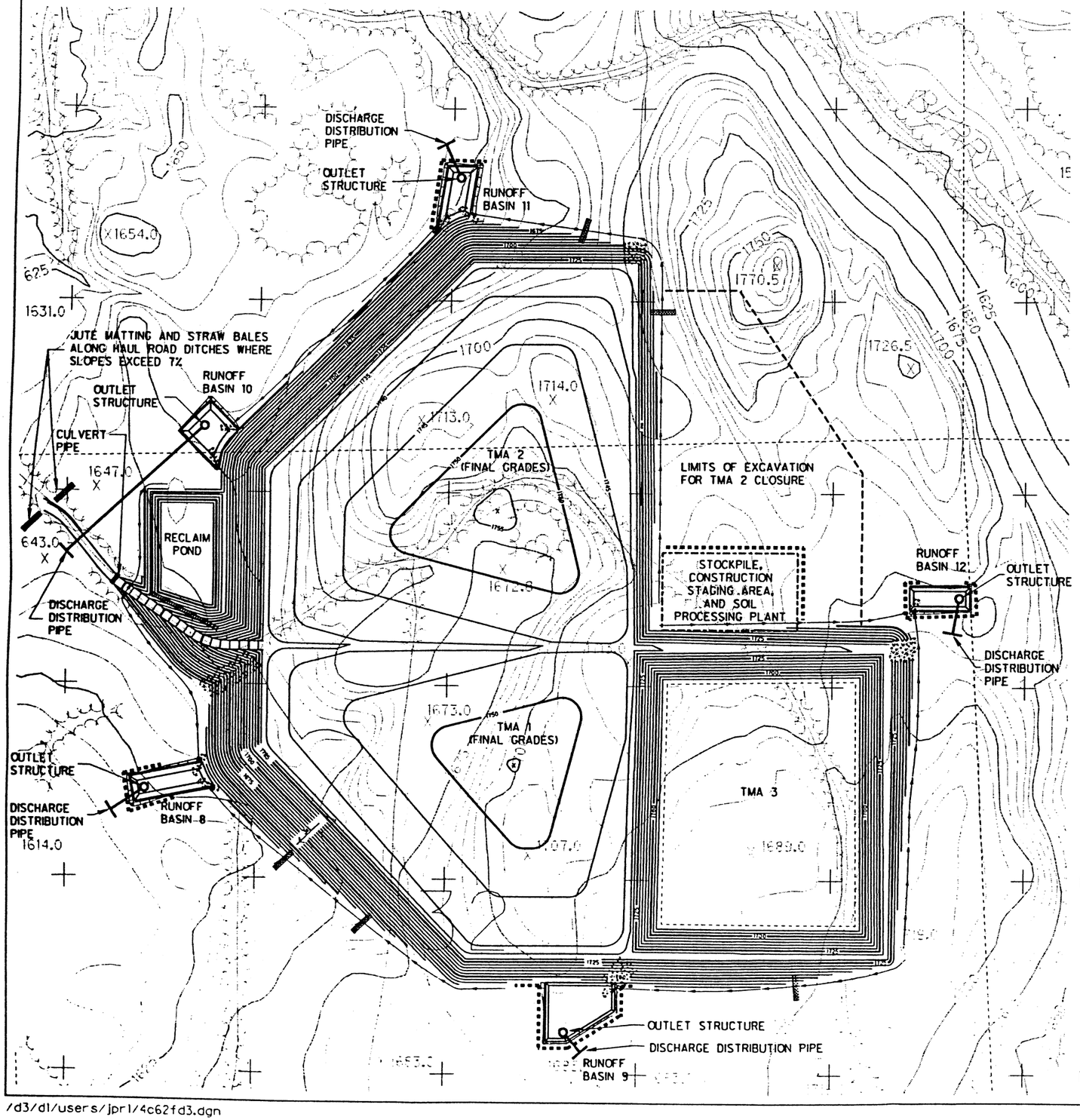
TMA EROSION CONTROL YEAR 28 (APPROX.)

Scale: 0 300' 600' Date: MAY, 1995

Prepared By: Foth & Van Dyke By: GAM

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93C049



LEGEND

- EXISTING ROAD
- —1675— EXISTING CONTOUR
- X 1692.0 SPOT ELEVATION
- SECTION LINE
- PROPOSED CONTOUR
- RIPRAP OVER GEOTEXTILE
- SILT FENCE
- STRAW BALES
- PROPOSED DRAINAGE FLOW

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1"=1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
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3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS FIVE FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

Crandon Mining Company

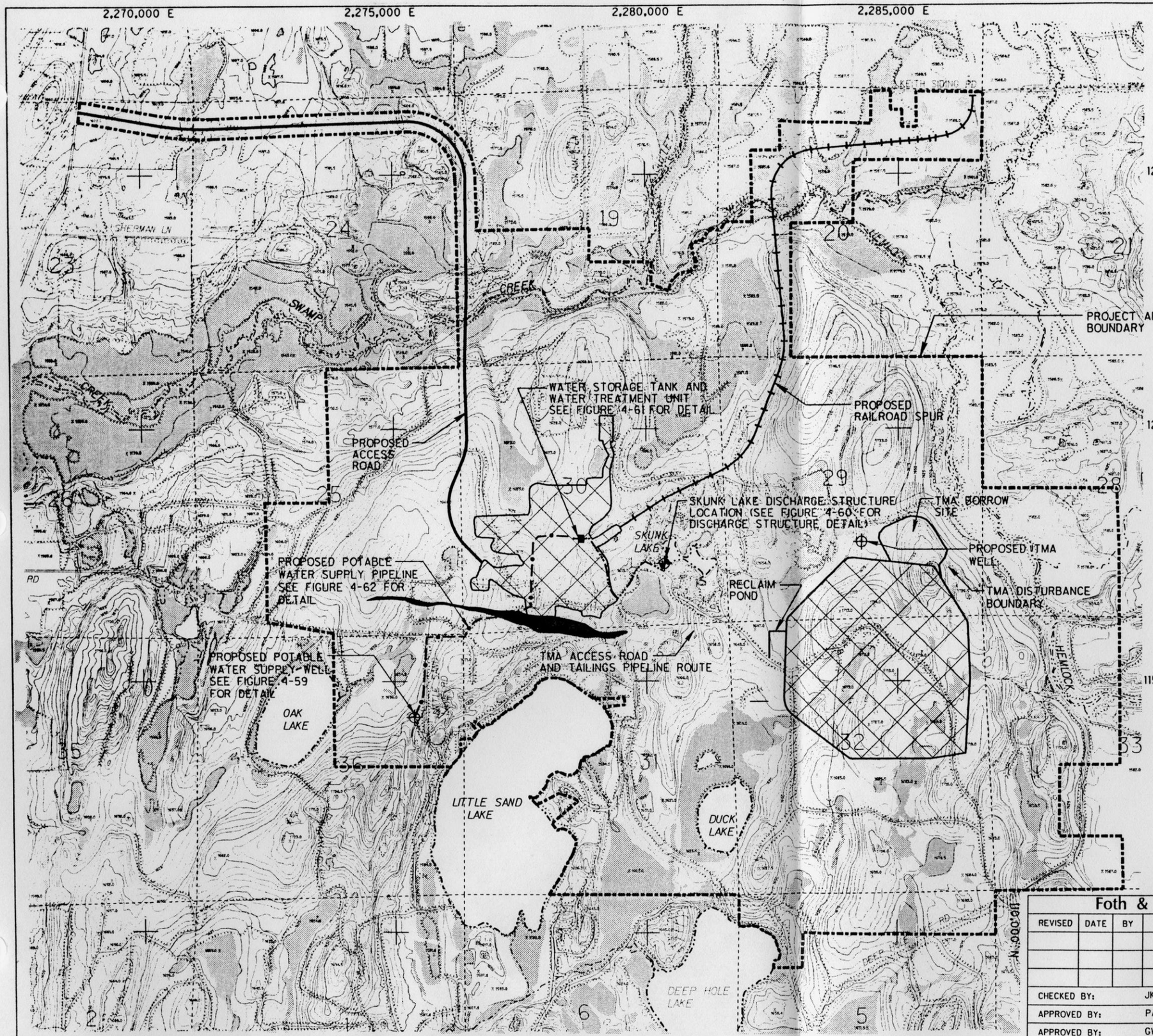
FIGURE 4-55
TMA EROSION CONTROL
YEAR 23 (APPROX.)

Scale: 0 300' 600' | Date: MAY, 1995

Prepared By: Foth & Van Dyke | By: GAM

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93C049



LEGEND

- LAKES
- STREAMS
- WETLANDS
- EXISTING ROAD
- 1675 — EXISTING CONTOUR
- 1692.0 EXISTING SPOT ELEVATION
- SECTION LINE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- ■ WATER TREATMENT UNIT
- CMC-32 PROPOSED SKUNK LAKE MONITORING WELL
- PROPOSED POTABLE WATER SUPPLY WELL
- SKUNK LAKE MITIGATION PIPELINE ROUTE

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1" = 1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS 25 FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
5. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

0 1000' 2000'
SCALE

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: SEPT.'95
APPROVED BY:	PAE	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

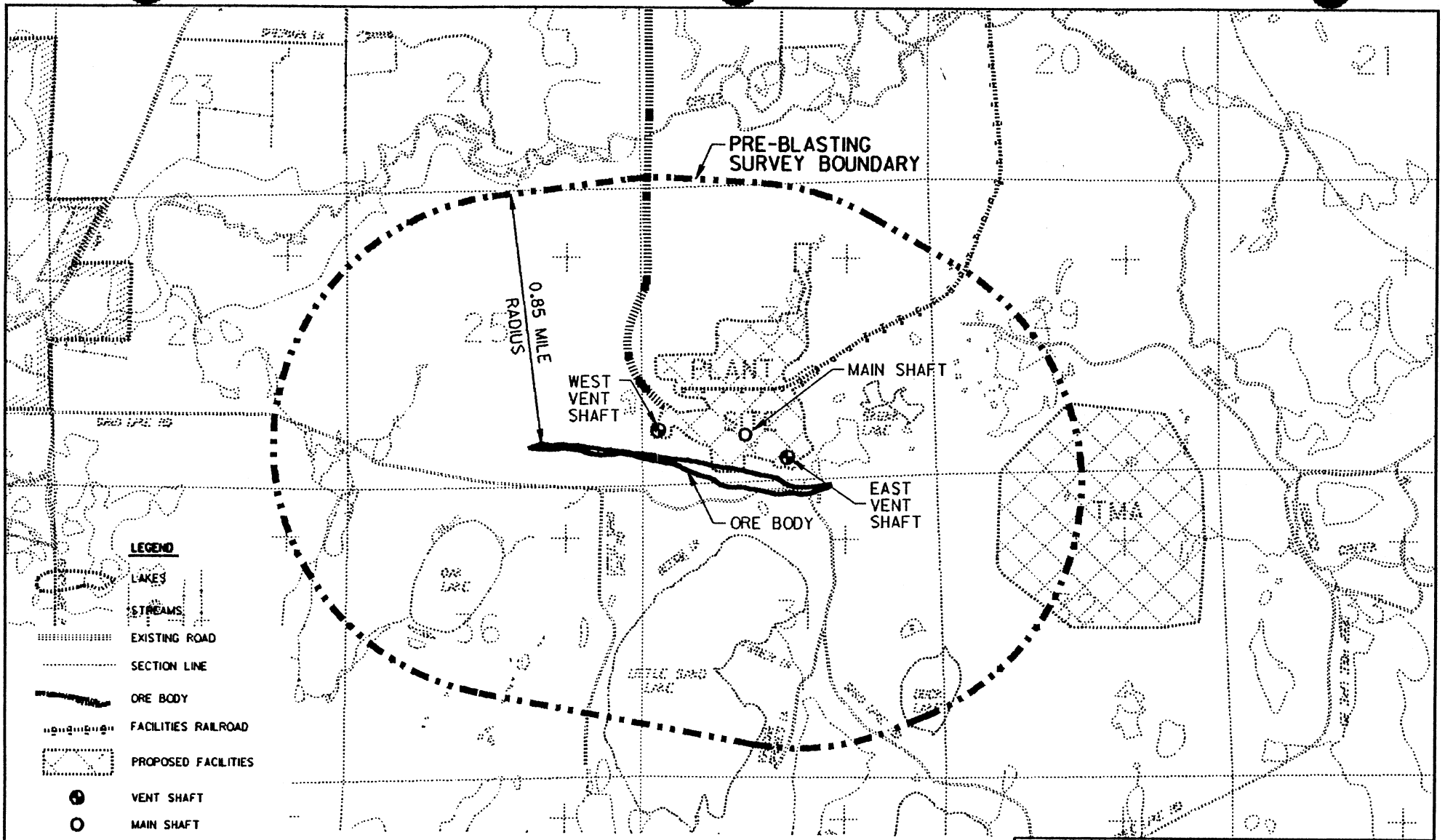
Crandon Mining Company

FIGURE 4-58
POTABLE WELL AND PIPELINE LOCATION MAP

Scale:	AS SHOWN	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	BSH

/d3/d1/users/jpr1/4c62z15.dgn

93C049



NOTES:

1. BASE MAP DIGITIZED FROM 1" = 1000' SCALE, MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
4. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

N

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY.'95
APPROVED BY:	JBH	DATE: MAY.'95
APPROVED BY:	PAE	DATE: MAY.'95

Crandon Mining Company

FIGURE 4-57

PRE-BLASTING SURVEY AREA

Scale:	1" = 2500'	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	GAM

/d3/dl/users/gam/3c49f132.dgn

93C049

2,270,000 E
2,275,000 E
2,280,000 E
2,285,000 E
125,000 N
120,000 N
115,000 N
110,000 N

PROJECT AREA BOUNDARY
WATER STORAGE TANK AND WATER TREATMENT UNIT SEE FIGURE 4-61 FOR DETAIL
PROPOSED RAILROAD SPUR
PROPOSED ACCESS ROAD
SKUNK LAKE DISCHARGE STRUCTURE LOCATION (SEE FIGURE 4-60 FOR DISCHARGE STRUCTURE DETAIL)
TMA BORROW SITE
PROPOSED TMA WELL
TMA DISTURBANCE BOUNDARY
RECLAIM POND
PROPOSED POTABLE WATER SUPPLY PIPELINE SEE FIGURE 4-62 FOR DETAIL
PROPOSED POTABLE WATER SUPPLY WELL SEE FIGURE 4-59 FOR DETAIL
TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
SHERMAN LN
SWAMP CREEK
SKUNK LAKE
OAK LAKE
LITTLE SAND LAKE
DUCK LAKE
DEEP HOLE LAKE
HEMLOCK

LEGEND

- LAKES
- STREAMS
- WETLANDS
- EXISTING ROAD
- 1675 — EXISTING CONTOUR
- 1692.0 x EXISTING SPOT ELEVATION
- SECTION LINE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR

PROPOSED FACILITIES

- WATER TREATMENT UNIT
- CMC-32 PROPOSED SKUNK LAKE MONITORING WELL
- PROPOSED POTABLE WATER SUPPLY WELL
- SKUNK LAKE MITIGATION PIPELINE ROUTE

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1" = 1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
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3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS 25 FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
5. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

0 1000' 2000'
SCALE

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: SEPT.'95
APPROVED BY:	PAE	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

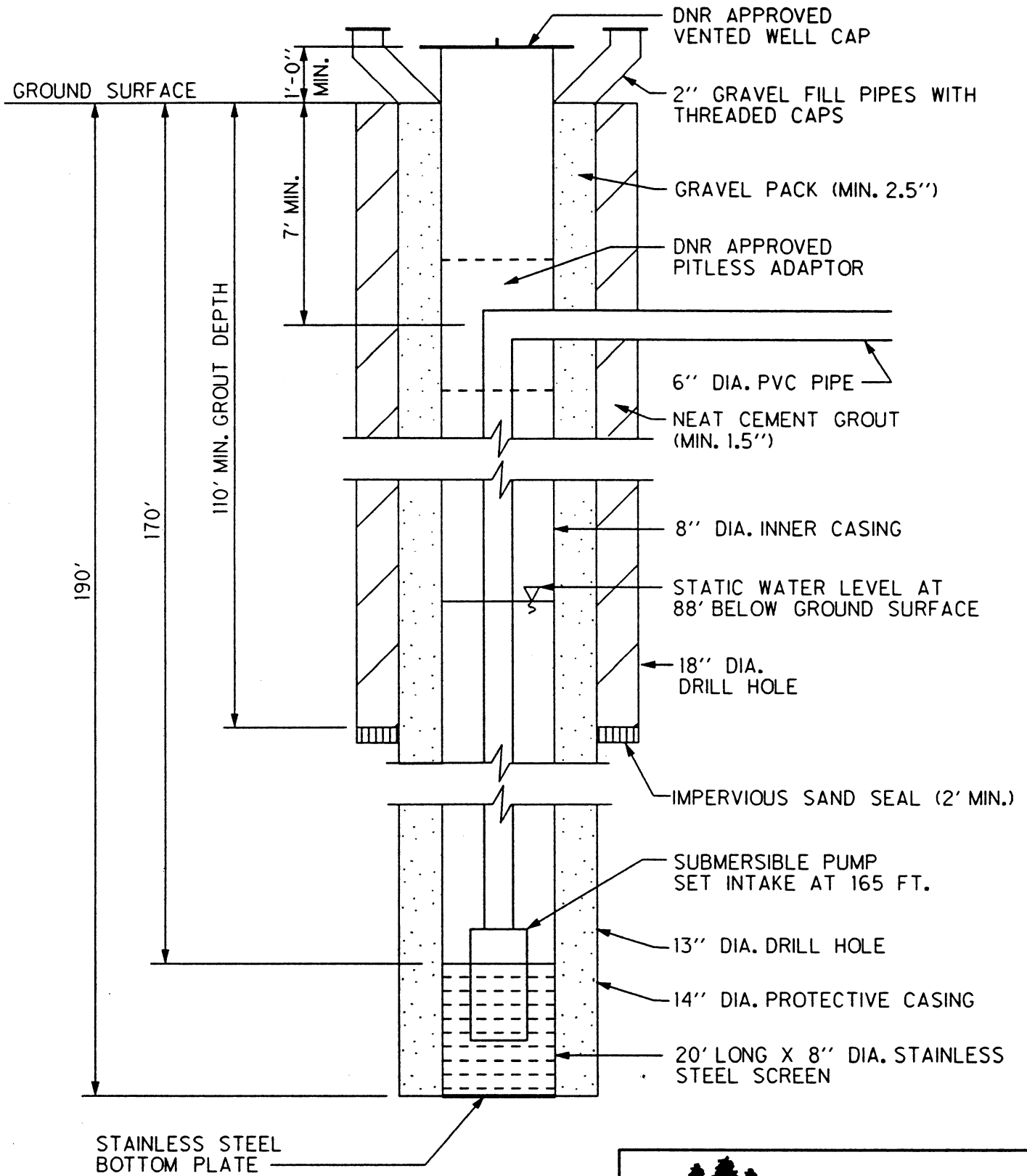
Crandon Mining Company

FIGURE 4-58
POTABLE WELL AND PIPELINE LOCATION MAP

Scale:	AS SHOWN	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	BSH

/d3/dl/users/jpr1/4c62z15.dgn

93C049



Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: SEPT.'95
APPROVED BY:	PAE	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

Crandon Mining Company

FIGURE 4-59

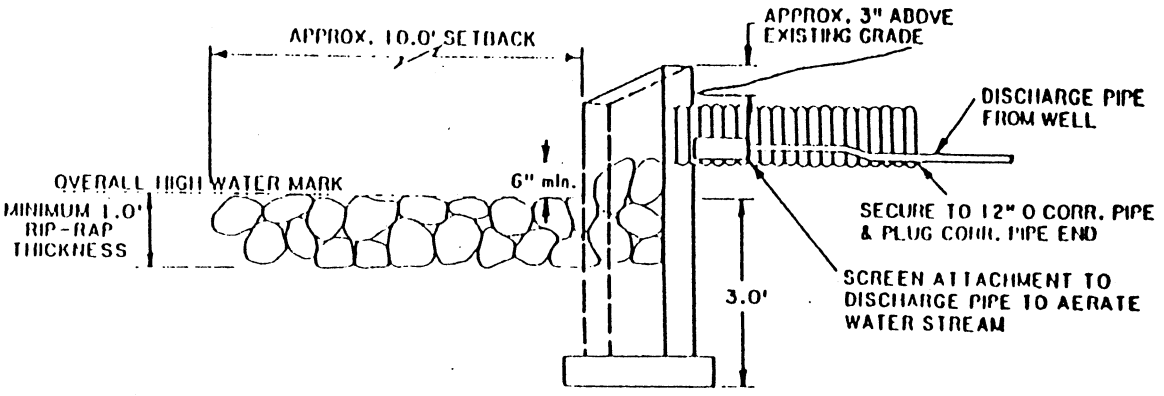
PROPOSED POTABLE
WELL CONSTRUCTION

Scale: N.T.S.	Date: SEPTEMBER, 1995	
Prepared By: Foth & Van Dyke		By: BSH

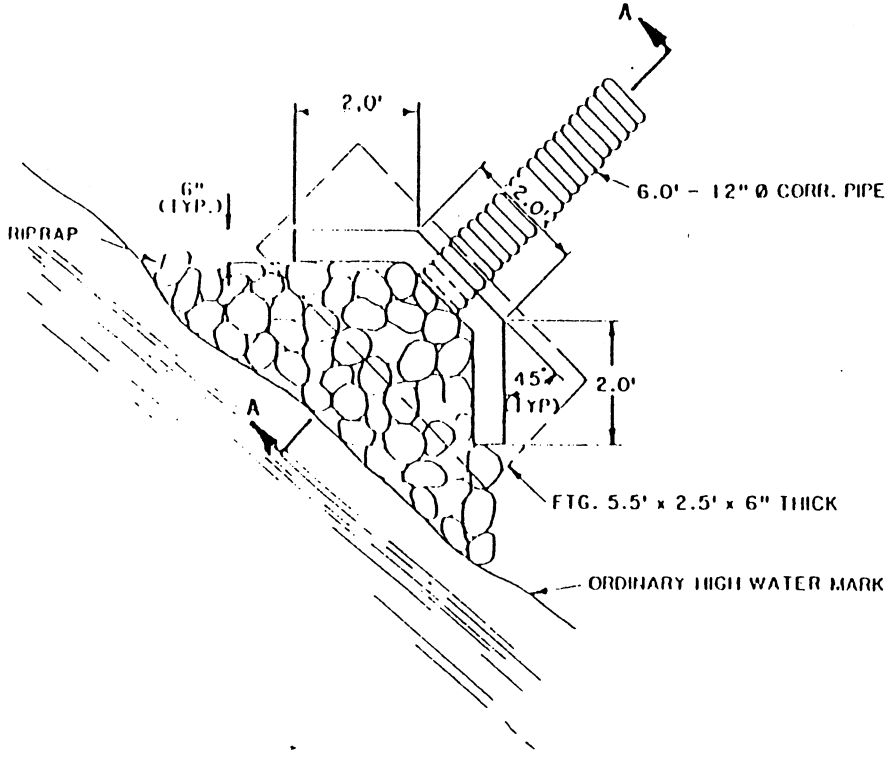
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/d3/dl/users/jpr1/4c62z9.dgn



SECTION A-A
TYPICAL DISCHARGE HEADWALL



TYPICAL DISCHARGE HEADWALL

Foth & Van Dyke				
REVISED	DATE	BY	DESCRIPTION	
CHECKED BY:		JKS1		DATE: SEPT.'95
APPROVED BY:		PAE		DATE: SEPT.'95
APPROVED BY:		GWS		DATE: SEPT.'95

Crandon Mining Company

FIGURE 4-60
TYPICAL SKUNK LAKE MITIGATION DISCHARGE STRUCTURE

Scale:	N.T.S.	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	BSH

93C049

2,270,000 E | 2,275,000 E | 2,280,000 E | 2,285,000 E | 2,290,000 E

125,000 N

120,000 N

115,000 N

PLANT SITE

TMA

OAK LAKE

LITTLE SAND LAKE

DUCK LAKE

DEEP HOLE LAKE

SKUNK LAKE

GROUND HEMLOCK LAKE

SWAMP CREEK

DW CREEK

HEMLOCK CREEK

SWAMP LN

TMA ACCESS ROAD

LITTLE SAND LAKE RD

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- PROPOSED ACCESS ROAD
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES

VEGETATION CLASSIFICATIONS

- B = BOGS
- C = SWAMP CONIFERS
- DW = DECIDUOUS FORESTED WETLANDS
- M = MARSHES
- S = SHRUB WETLANDS
- F = FIELDS AND UPLAND OPENINGS (INCLUDING TREES < 10' IN HEIGHT)
- A = AGRICULTURAL LANDS
- P = PINE PLANTATIONS
- N = NORTHERN HARDWOOD FORESTS (INCLUDING > 10' IN HEIGHT)

OTHER LAND CLASSIFICATIONS

- W = OPEN WATER
- U = URBAN, RESIDENTIAL OR DEVELOPED AREAS
- RECREATION/FORESTRY AFTER RECLAMATION

NOTES:

1. BASE MAP DIGITIZED FROM 1"=1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
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APPROVED BY:	PAE	DATE: MAY '95

Crandon Mining Company

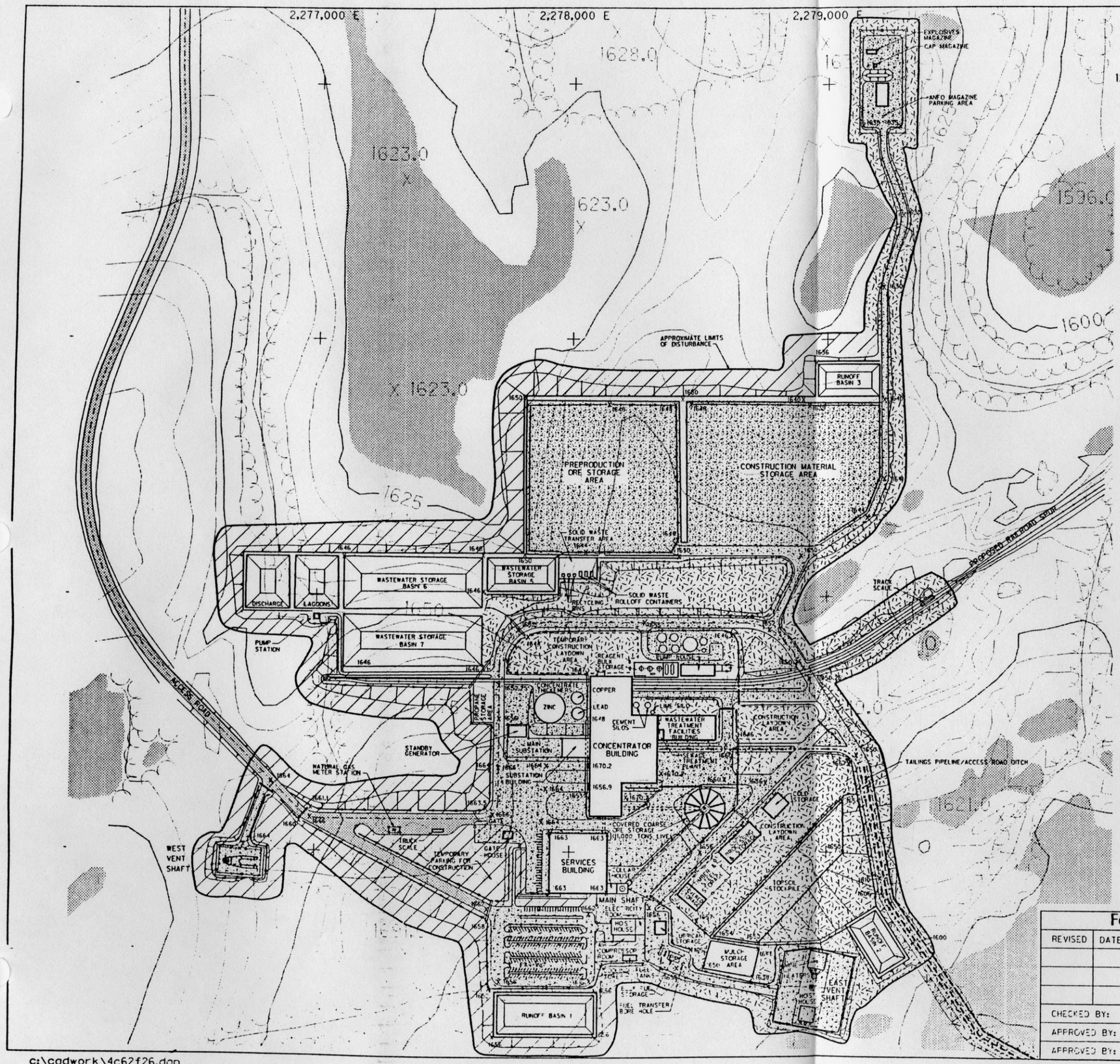
FIGURE 5-1

FINAL END USE MAP

Scale: 0 1000' 2000' | Date: MAY, 1995

Prepared By: Foth & Van Dyke | By: JPR

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LEGEND

- EXISTING CONTOUR
- RIVER/LAKE/WATERWAY
- x 1677.0 EXISTING SPOT ELEVATION
- EXISTING ROADWAY
- EXISTING TRAIL
- EXISTING TREELINE
- PROPOSED LIMITS OF PLANT SITE DISTURBANCE
- PROPOSED STRUCTURE OR BUILDING
- PROPOSED RAILROAD SPUR
- PROPOSED CHAIN LINK FENCE
- PROPOSED WELDED WIRE FENCE
- PROPOSED DRAINAGE DITCH
- PROPOSED TAILINGS PIPELINE DITCH
- PROPOSED ASPHALT ACCESS ROAD
- EXISTING WETLAND
- x 1677.0 PROPOSED SPOT ELEVATION
- PROPOSED CULVERT
- PROPOSED SLOPE DIRECTION
- GRAVEL AREA
- GRASSES AND FORBS
- SAVANNAH AREA

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1" = 1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS FIVE FEET.
4. PLANT SITE BASED ON REFINEMENTS TO THE APRIL 1986 PLOT PLAN DEVELOPED BY RAYMOND KAISER ENGINEERS, INC.

SCALE
0 200' 400'

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

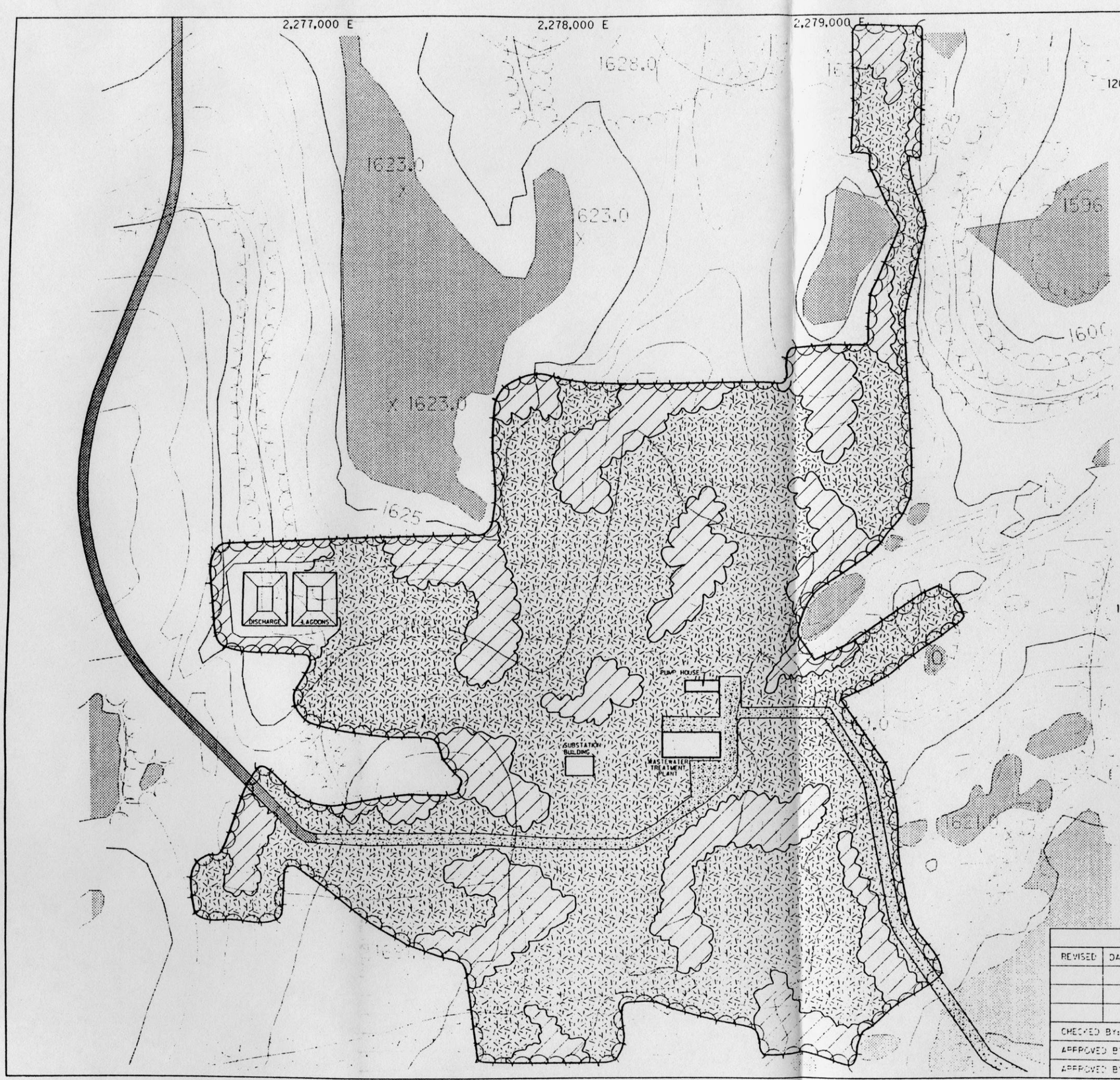
Crandon Mining Company

FIGURE 5-2
PLANT SITE RECLAMATION AFTER CONSTRUCTION YEAR 3

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	JPR

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930049



LEGEND

- EXISTING CONTOUR
- RIVER/LAKE/WATERWAY
- x1677.0 EXISTING SPOT ELEVATION
- EXISTING ROADWAY
- EXISTING TRAIL
- EXISTING TREELINE
- PROPOSED LIMITS OF PLANT SITE DISTURBANCE
- PROPOSED STRUCTURE OR BUILDING
- PROPOSED ASPHALT ACCESS ROAD
- EXISTING WETLAND
- x 1677.0 PROPOSED SPOT ELEVATION
- PROPOSED CULVERT
- PROPOSED SLOPE DIRECTION
- GRASSES AND FORBS
- SAVANNAH

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1" = 1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS FIVE FEET.
4. PLANT SITE BASED ON REFINEMENTS TO THE APRIL 1986 PLOT PLAN DEVELOPED BY RAYMOND KAISER ENGINEERS, INC.

SCALE
0 200' 400'

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95	
APPROVED BY:	JBH	DATE: MAY '95	
APPROVED BY:	PAE	DATE: MAY '95	

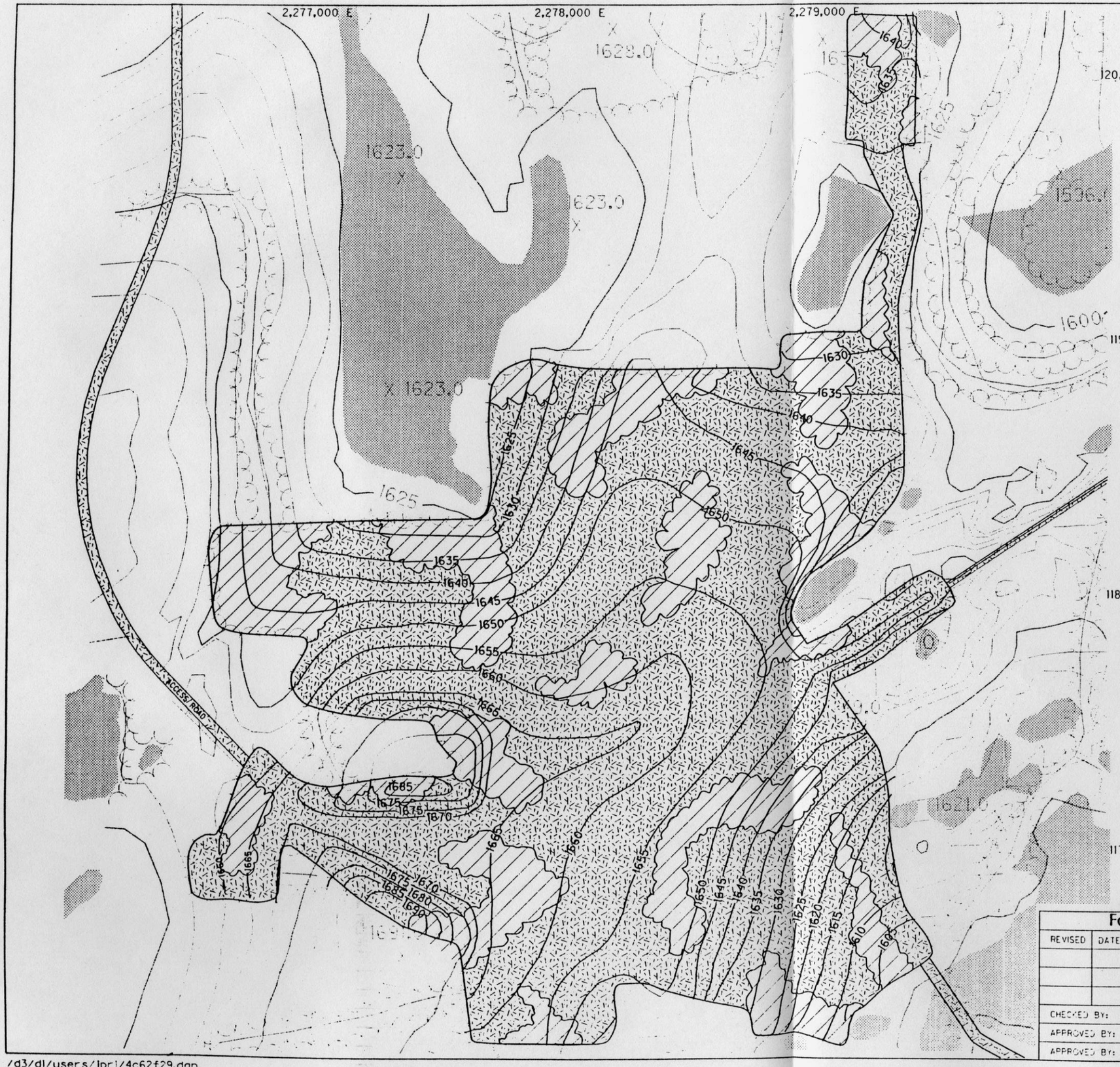
Crandon Mining Company

FIGURE 5-3
PLANT SITE RECLAMATION AT CESSATION OF CLOSURE, YEAR 35

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	JPR

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970649



LEGEND

- EXISTING CONTOUR
- RIVER/LAKE/WATERWAY
- EXISTING SPOT ELEVATION
- EXISTING ROADWAY
- EXISTING TRAIL
- EXISTING TREELINE
- PROPOSED LIMITS OF PLANT SITE DISTURBANCE
- EXISTING WETLAND
- PROPOSED FINAL GRADE CONTOUR
- PROPOSED CULVERT
- PROPOSED SLOPE DIRECTION
- GRASSES AND FORBS
- SAVANNAH

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1" = 1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
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3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS FIVE FEET.

SCALE
0 200' 400'

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

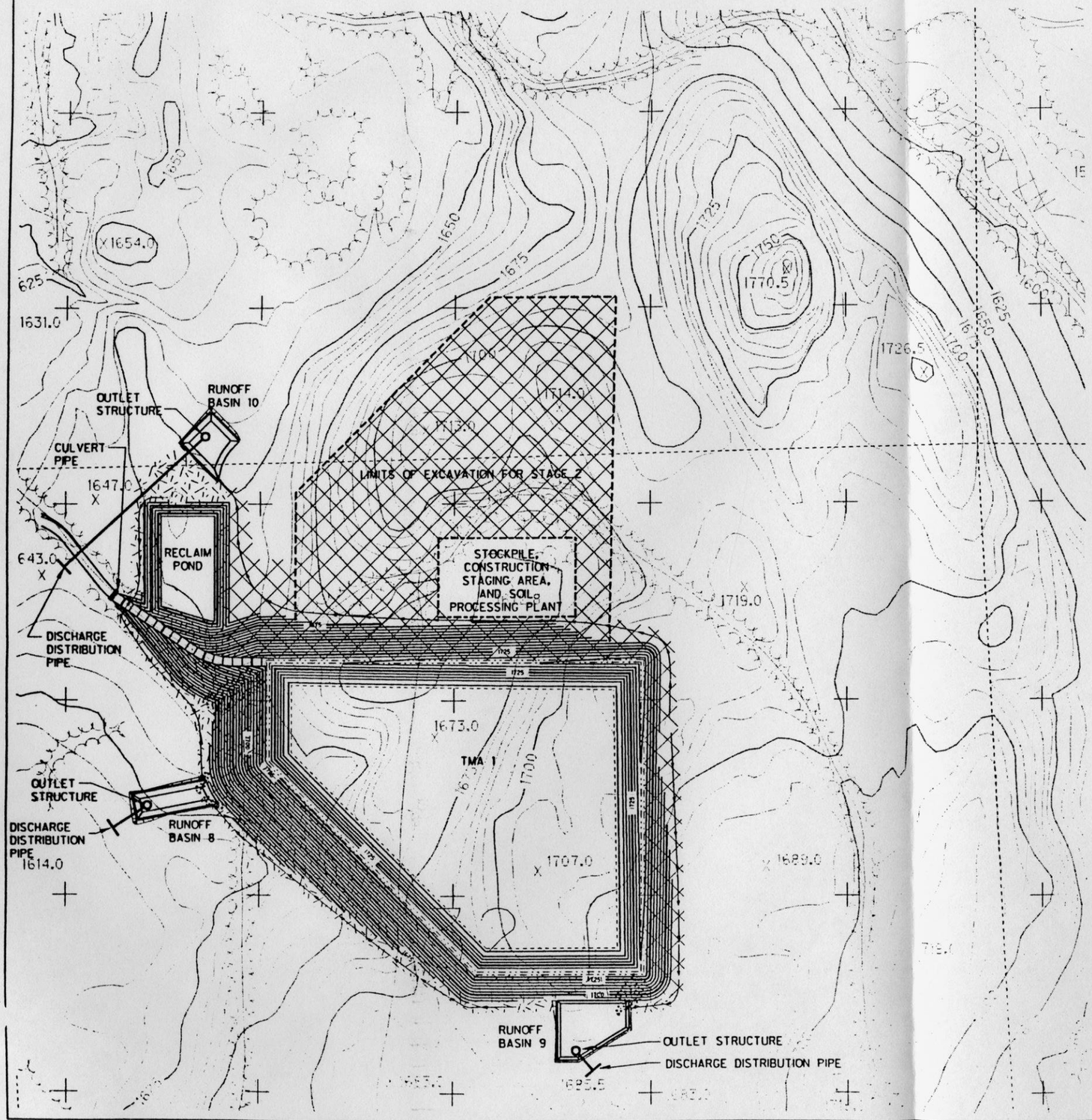
Crandon Mining Company

FIGURE 5-4
PLANT SITE FINAL RECLAMATION
YEAR 75

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	JPR

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370049



LEGEND

- EXISTING ROAD
- —1675— EXISTING CONTOUR
- x 1692.0 SPOT ELEVATION
- PROPOSED CONTOUR
- SECTION LINE
- PROPOSED DRAINAGE FLOW
- GRASSES AND FORBS
- DOT MIX NO. 30

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1"=1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
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3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS FIVE FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.

0 300' 600'
SCALE

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

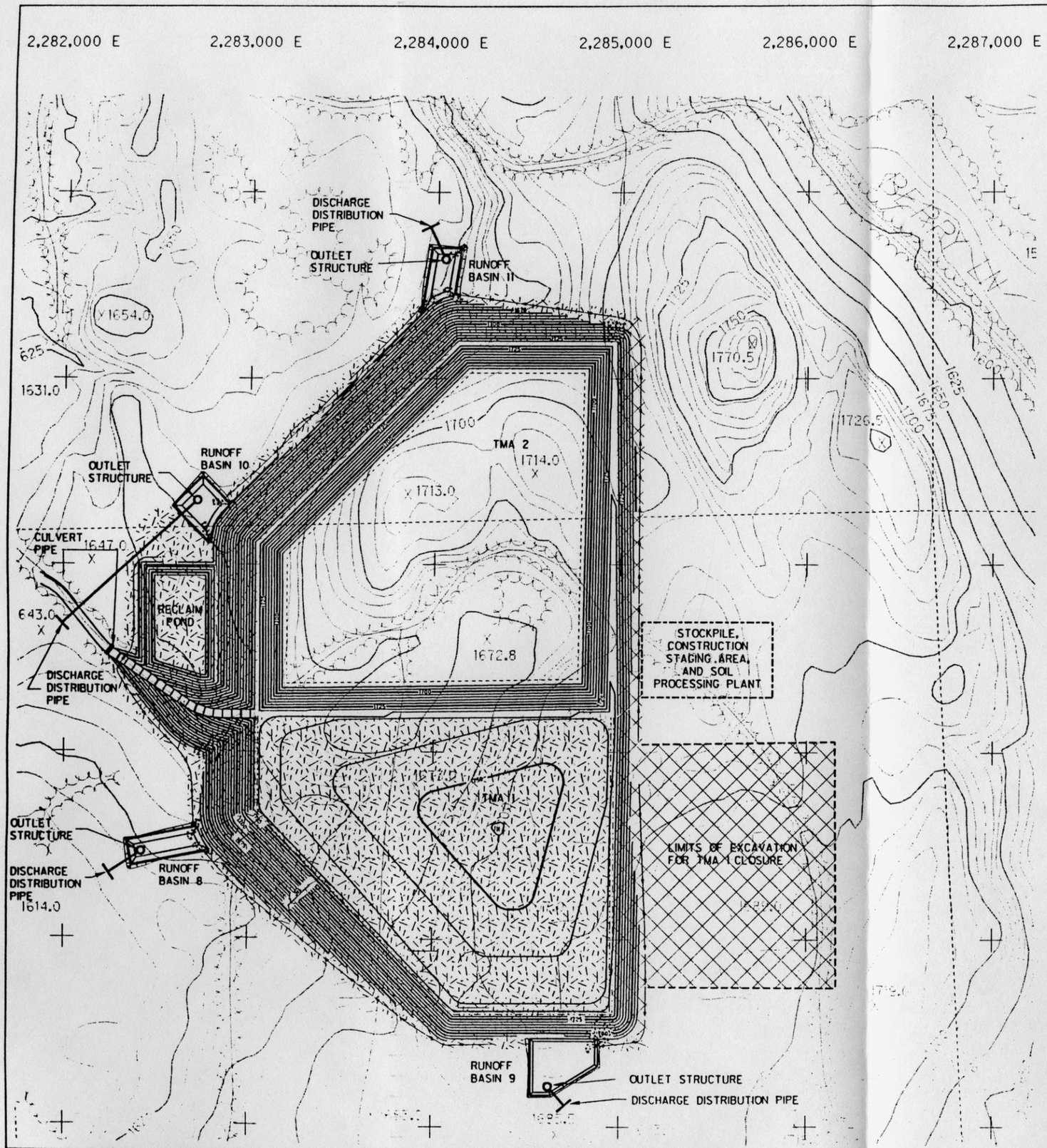
Crandon Mining Company

FIGURE 5-5
TMA RECLAMATION
YEAR 3 APPROX.

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	JOW

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930049



LEGEND

- EXISTING ROAD
- —1675— EXISTING CONTOUR
- X 1692.0 SPOT ELEVATION
- PROPOSED CONTOUR
- SECTION LINE
- PROPOSED DRAINAGE FLOW
- GRASSES AND FORBS
- DOT MIX NO. 30

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1"=1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
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3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS FIVE FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.

0 300' 600'
SCALE

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

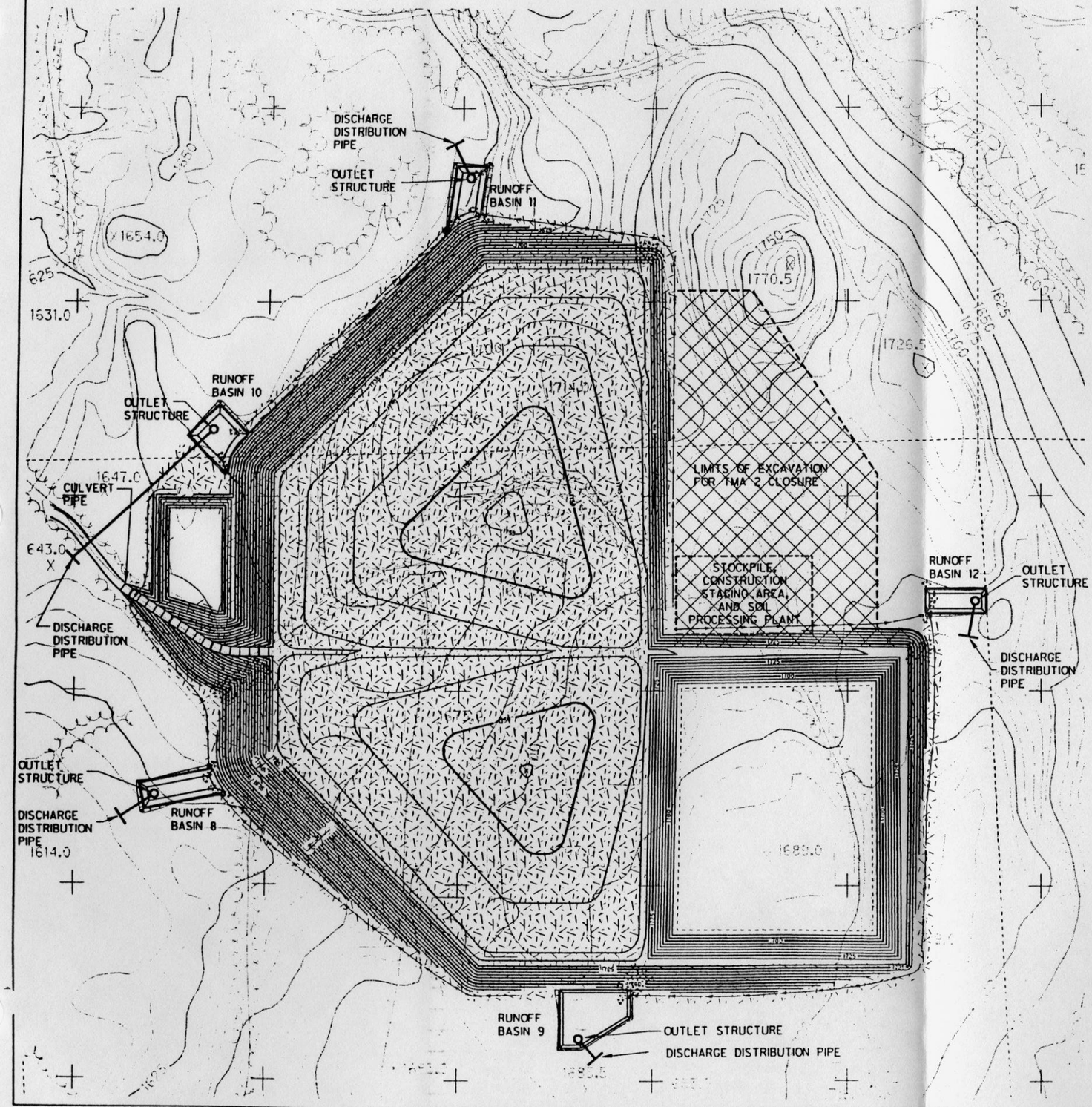
Crandon Mining Company

FIGURE 5-6
TMA RECLAMATION
YEAR 12 APPROX.

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	JPP

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93C049



LEGEND

- EXISTING ROAD
- —1675— EXISTING CONTOUR
- x 1692.0 SPOT ELEVATION
- —1700— PROPOSED CONTOUR
- SECTION LINE
- PROPOSED DRAINAGE FLOW
- GRASSES AND FORBS
- DOT MIX NO. 30

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1"=1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS FIVE FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.

0 300' 600'
SCALE

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

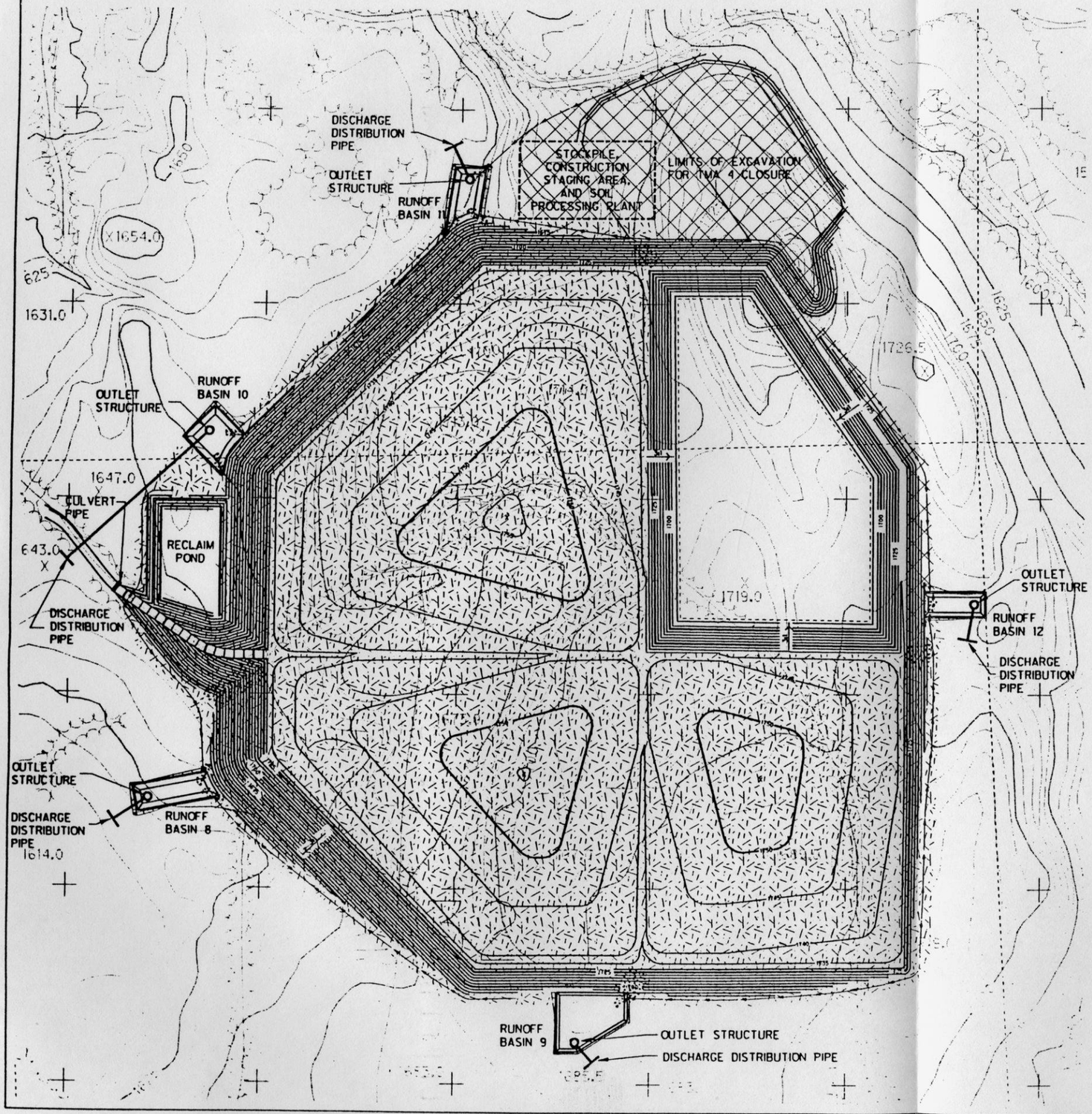
Crandon Mining Company

FIGURE 5-7
TMA RECLAMATION
YEAR 23 APPROX.

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	JPR

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930049



LEGEND

- EXISTING ROAD
- 1675 EXISTING CONTOUR
- x 1692.0 SPOT ELEVATION
- 1725 PROPOSED CONTOUR
- SECTION LINE
- PROPOSED DRAINAGE FLOW
- GRASSES AND FORBS
- DOT MIX NO. 30

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1"=1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
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3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS FIVE FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.

0 300' 600'
SCALE

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS!	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95

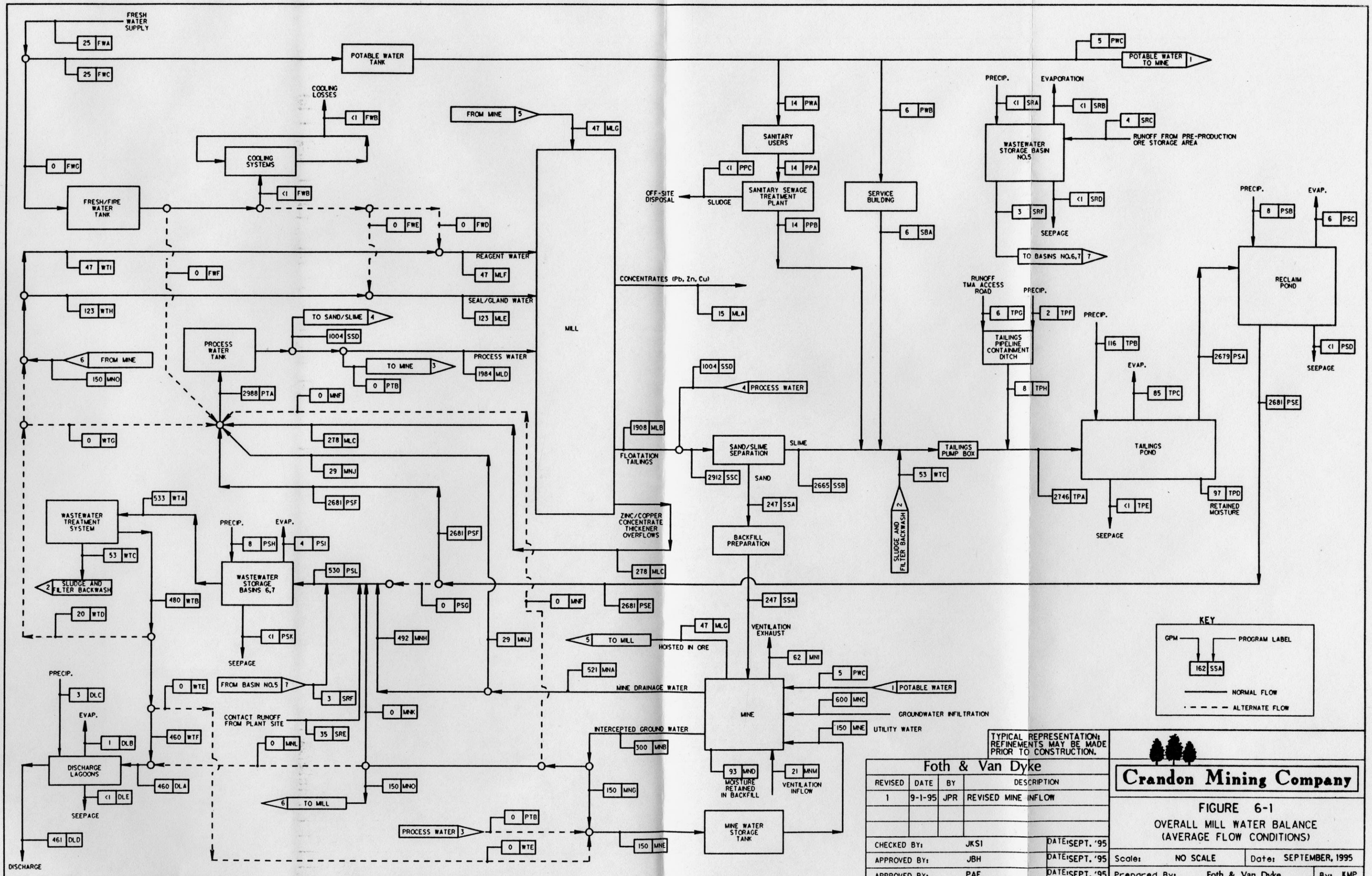
Crandon Mining Company

FIGURE 5-8
TMA RECLAMATION
YEAR 28 APPROX.

Scale: AS SHOWN | Date: MAY, 1995
Prepared By: Foth & Van Dyke | By: JPP

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870049



TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION
1	9-1-95	JPR	REVISED MINE INFLOW

CHECKED BY:	JKSI	DATE: SEPT. '95
APPROVED BY:	JBH	DATE: SEPT. '95
APPROVED BY:	PAE	DATE: SEPT. '95

Crandon Mining Company

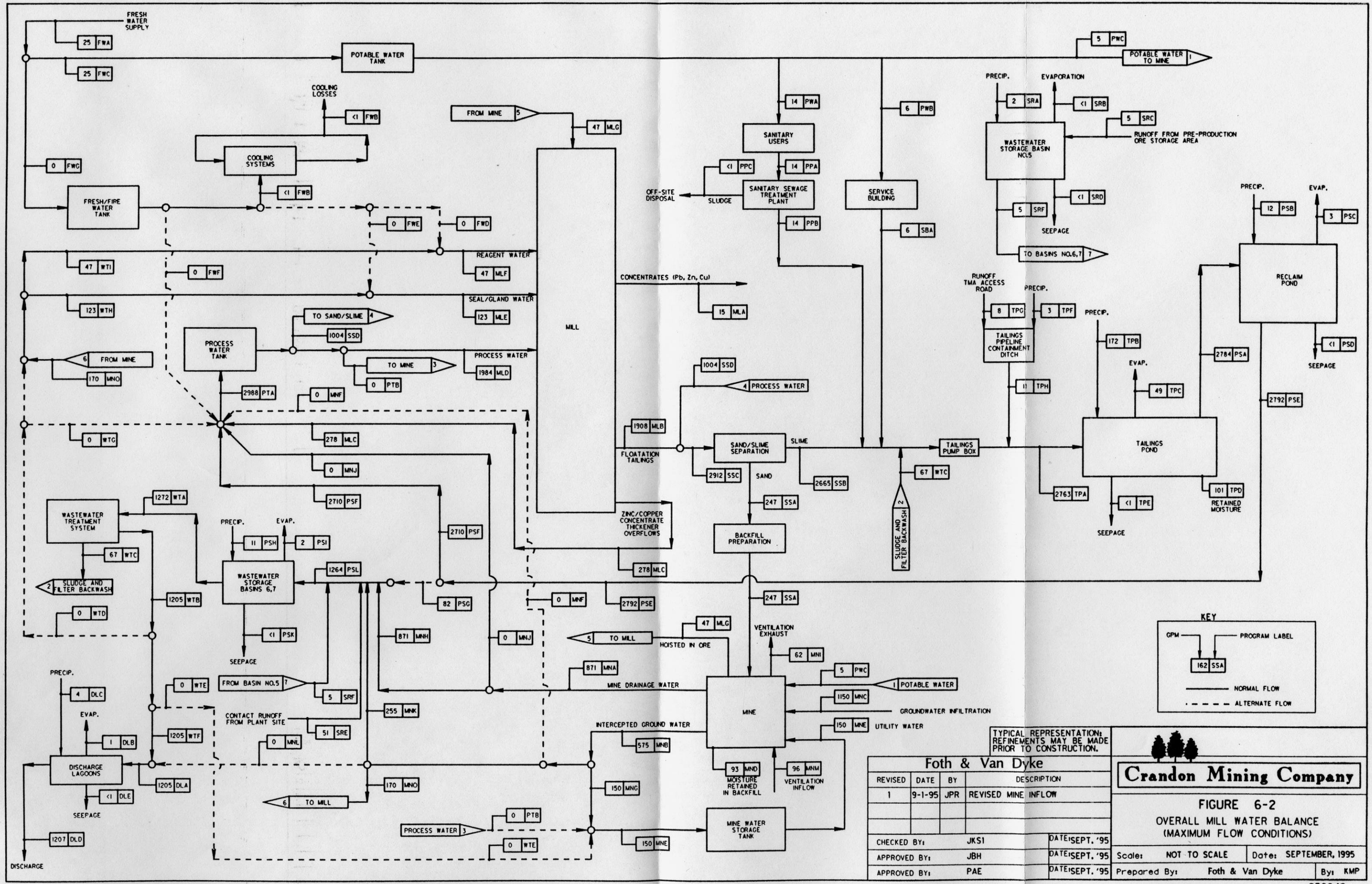
FIGURE 6-1

OVERALL MILL WATER BALANCE
(AVERAGE FLOW CONDITIONS)

Scale:	NO SCALE	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	KMP

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93C049



TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION
1	9-1-95	JPR	REVISED MINE INFLOW

CHECKED BY:	JKS1	DATE: SEPT. '95
APPROVED BY:	JBH	DATE: SEPT. '95
APPROVED BY:	PAE	DATE: SEPT. '95

Crandon Mining Company

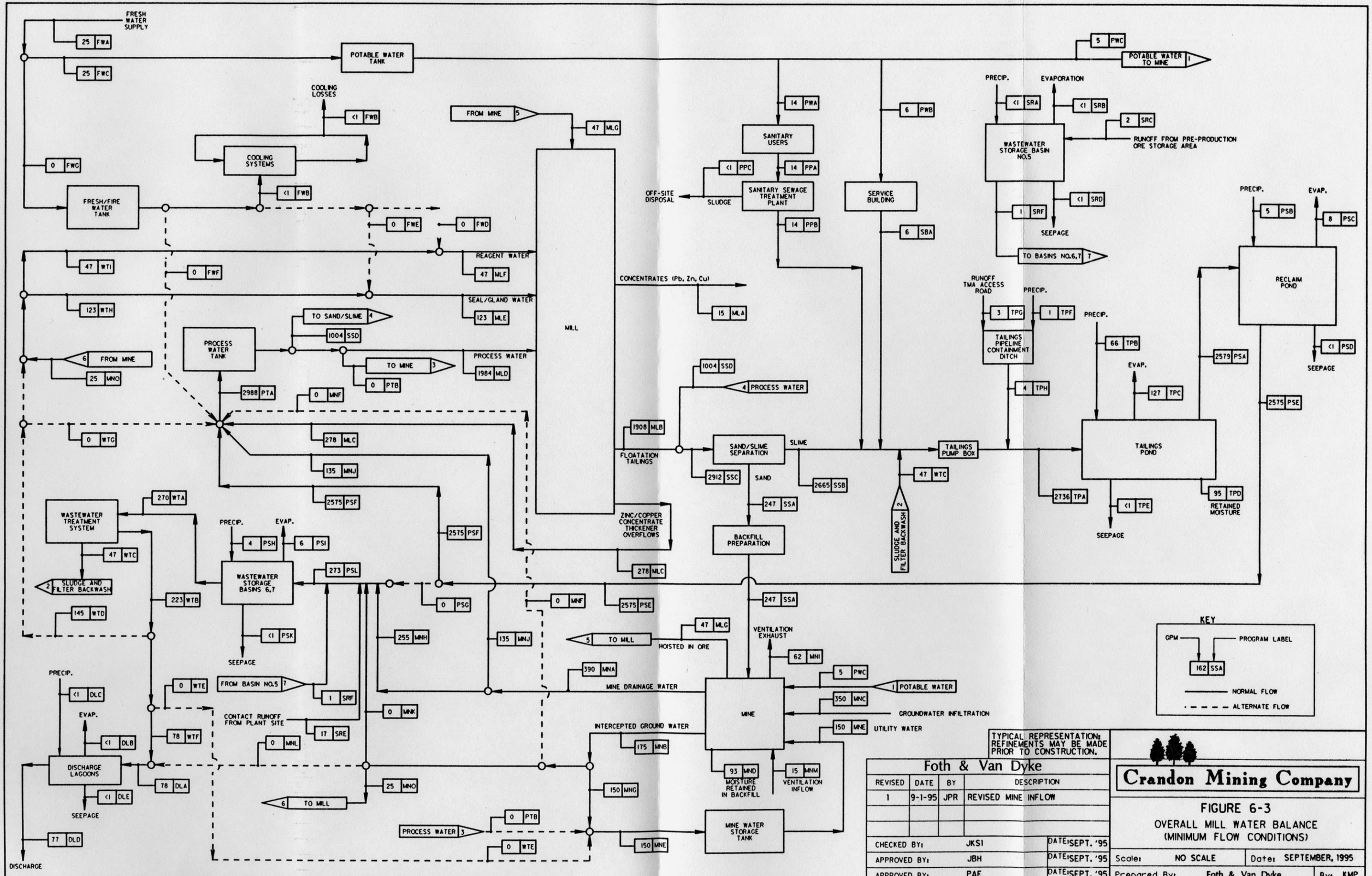
FIGURE 6-2

OVERALL MILL WATER BALANCE (MAXIMUM FLOW CONDITIONS)

Scale:	NOT TO SCALE	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	KMP

/d3/dl/users/jpr1/4c56f11b.dgn

93C049



TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION
1	9-1-95	JPR	REVISED MINE INFLOW

CHECKED BY:	JKS1	DATE: SEPT. '95
APPROVED BY:	JBH	DATE: SEPT. '95
APPROVED BY:	PAE	DATE: SEPT. '95

Crandon Mining Company

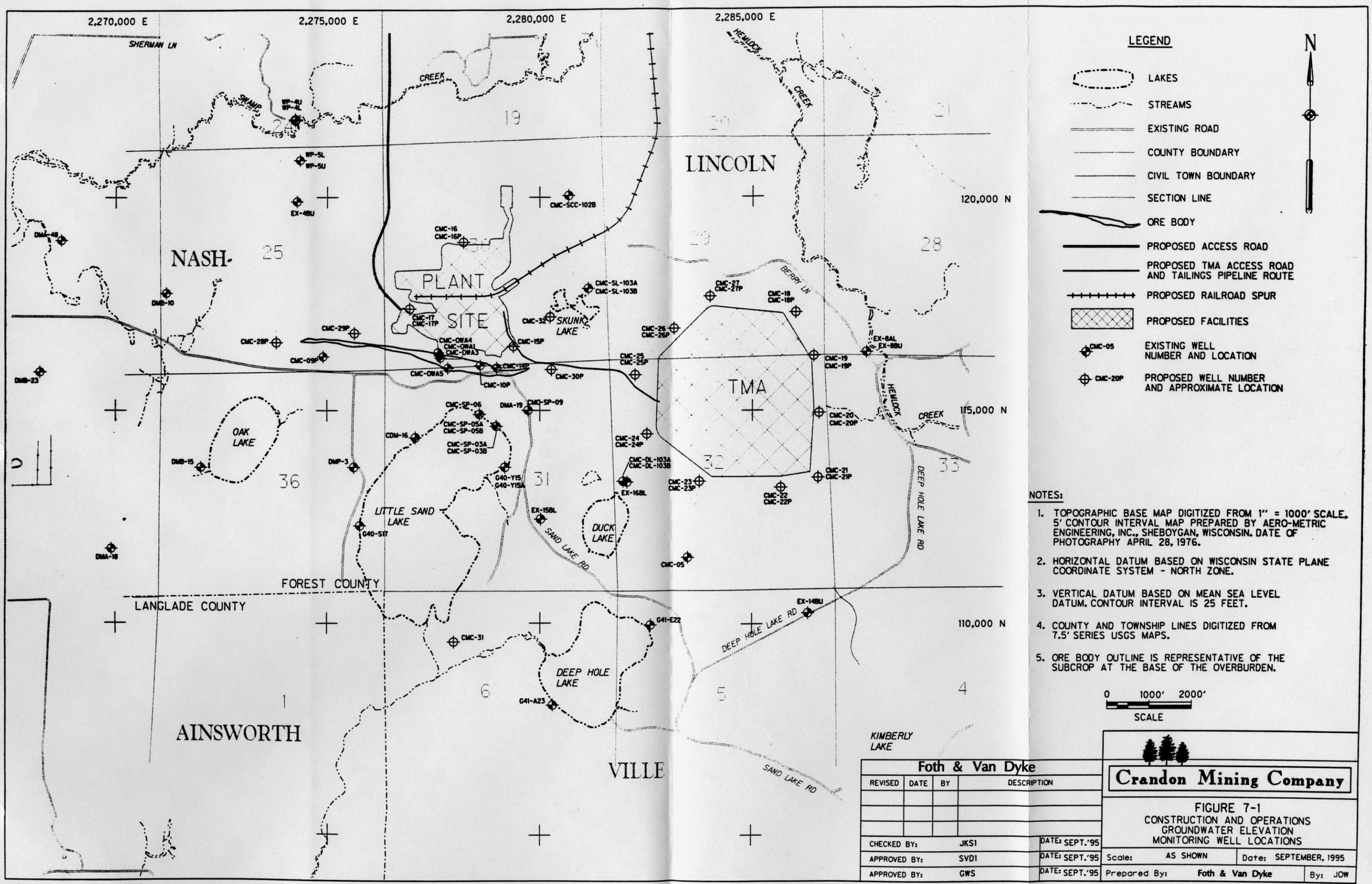
FIGURE 6-3

OVERALL MILL WATER BALANCE (MINIMUM FLOW CONDITIONS)

Scale:	NO SCALE	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	KMP

/d3/dl/users/jpr1/4c56f12b.dgn

93C049



LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- COUNTY BOUNDARY
- CIVIL TOWN BOUNDARY
- SECTION LINE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- CMC-05 — EXISTING WELL NUMBER AND LOCATION
- CMC-20P — PROPOSED WELL NUMBER AND APPROXIMATE LOCATION

N

NOTES:

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3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS 25 FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
5. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

0 1000' 2000'
SCALE

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: SEPT.'95
APPROVED BY:	SVD1	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

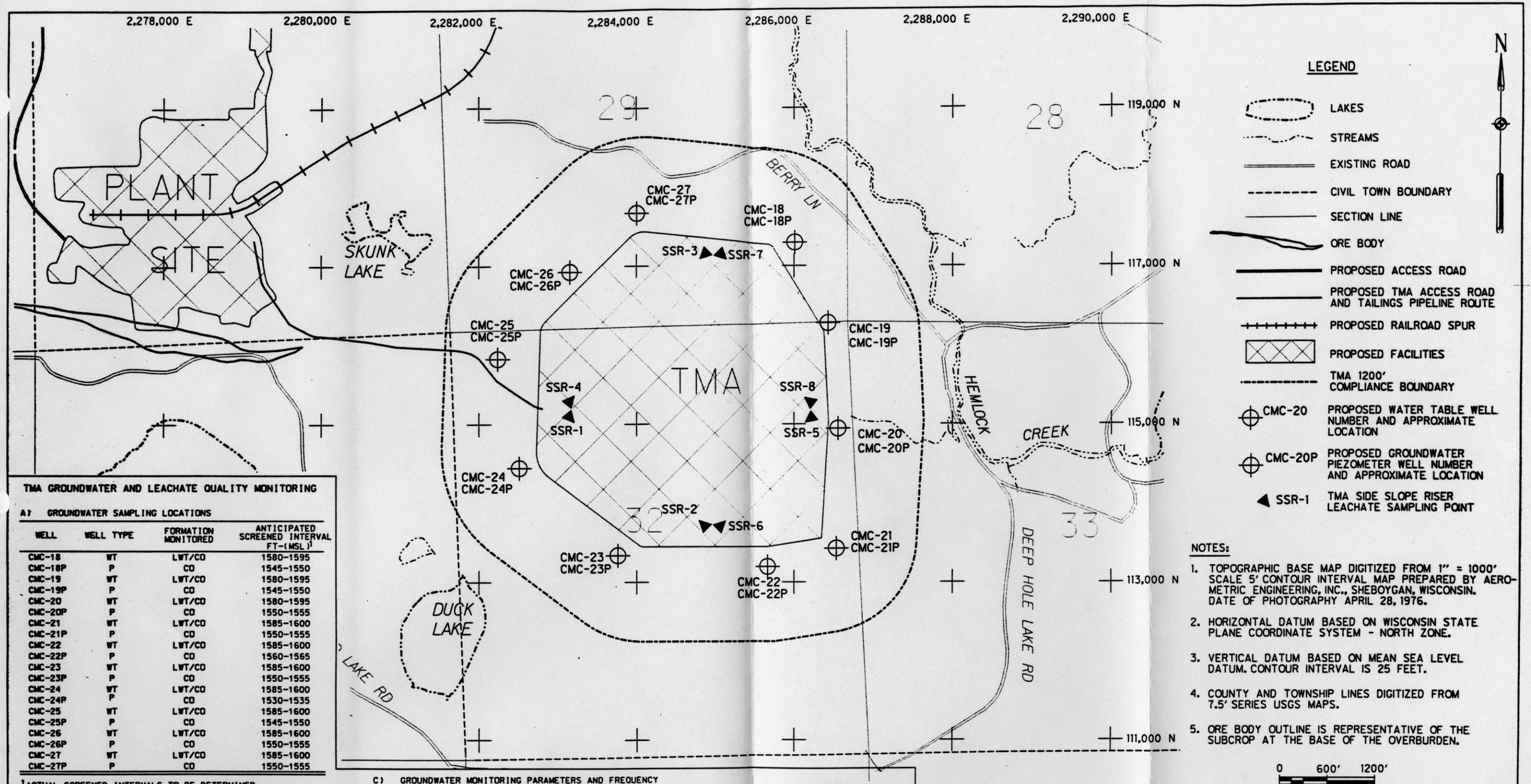
Crandon Mining Company

FIGURE 7-1
CONSTRUCTION AND OPERATIONS
GROUNDWATER ELEVATION
MONITORING WELL LOCATIONS

Scale:	AS SHOWN	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	JOW

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93C049



TMA GROUNDWATER AND LEACHATE QUALITY MONITORING

A) GROUNDWATER SAMPLING LOCATIONS

WELL	WELL TYPE	FORMATION MONITORED	ANTICIPATED SCREENED INTERVAL FT-(MSL)[1]
CMC-18	WT	LWT/CO	1580-1595
CMC-18P	P	CO	1545-1550
CMC-19	WT	LWT/CO	1580-1595
CMC-19P	P	CO	1545-1550
CMC-20	WT	LWT/CO	1580-1595
CMC-20P	P	CO	1550-1555
CMC-21	WT	LWT/CO	1585-1600
CMC-21P	P	CO	1550-1555
CMC-22	WT	LWT/CO	1585-1600
CMC-22P	P	CO	1560-1565
CMC-23	WT	LWT/CO	1585-1600
CMC-23P	P	CO	1550-1555
CMC-24	WT	LWT/CO	1585-1600
CMC-24P	P	CO	1530-1535
CMC-25	WT	LWT/CO	1585-1600
CMC-25P	P	CO	1545-1550
CMC-26	WT	LWT/CO	1585-1600
CMC-26P	P	CO	1550-1555
CMC-27	WT	LWT/CO	1585-1600
CMC-27P	P	CO	1550-1555

[1]ACTUAL SCREENED INTERVALS TO BE DETERMINED BASED ON FIELD CONDITIONS.

WT = WATER TABLE WELL LWT = LATE WISCONSINAN TILL
P = PIEZOMETER CO = COARSE OUTWASH

B) LEACHATE SAMPLING LOCATIONS

CELL	LOCATION	SIDESLOPE RISER NUMBER
TMA 1	NORTH SUMP	SSR-1
TMA 1	SOUTH SUMP	SSR-2
TMA 2	NORTH SUMP	SSR-3
TMA 2	SOUTH SUMP	SSR-4
TMA 3	NORTH SUMP	SSR-5
TMA 3	SOUTH SUMP	SSR-6
TMA 4	NORTH SUMP	SSR-7
TMA 4	SOUTH SUMP	SSR-8

C) GROUNDWATER MONITORING PARAMETERS AND FREQUENCY

* QUARTERLY (JANUARY, APRIL, JULY, OCTOBER) MONITORING: PH (FIELD AND LABORATORY), SPECIFIC CONDUCTANCE (FIELD), TEMPERATURE (FIELD), TOTAL HARDNESS, TOTAL DISSOLVED SOLIDS, TOTAL ALKALINITY, WATER LEVELS, CALCIUM, COPPER, LEAD, MANGANESE, SULFATE, AND ZINC.

* ONCE PER YEAR WITH THE JULY SAMPLING EVENT THE FOLLOWING ADDITIONAL PARAMETERS WILL BE INCLUDED IN THE MONITORING PROGRAM: ALUMINUM, ANTIMONY, ARSENIC, BARIUM, CADMIUM, COBALT, CYANIDE, IRON, MAGNESIUM, MERCURY, NICKEL, SELENIUM, SILVER, AND SODIUM.

D) LEACHATE MONITORING PARAMETERS AND FREQUENCY

* SEMI-ANNUAL (APRIL, OCTOBER) MONITORING: PH (FIELD AND LABORATORY), SPECIFIC CONDUCTANCE (FIELD), TEMPERATURE (FIELD), TOTAL HARDNESS, TOTAL DISSOLVED SOLIDS, TOTAL ALKALINITY, WATER LEVELS, ALUMINUM, ANTIMONY, ARSENIC, BARIUM, CADMIUM, CALCIUM, COBALT, COPPER, CYANIDE, IRON, LEAD, MAGNESIUM, MANGANESE, MERCURY, NICKEL, SELENIUM, SILVER, SODIUM, SULFATE, AND ZINC.

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1" = 1000' SCALE 5' CONTOUR INTERVAL MAP PREPARED BY AEROMETRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS 25 FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
5. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

0 600' 1200'
SCALE

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

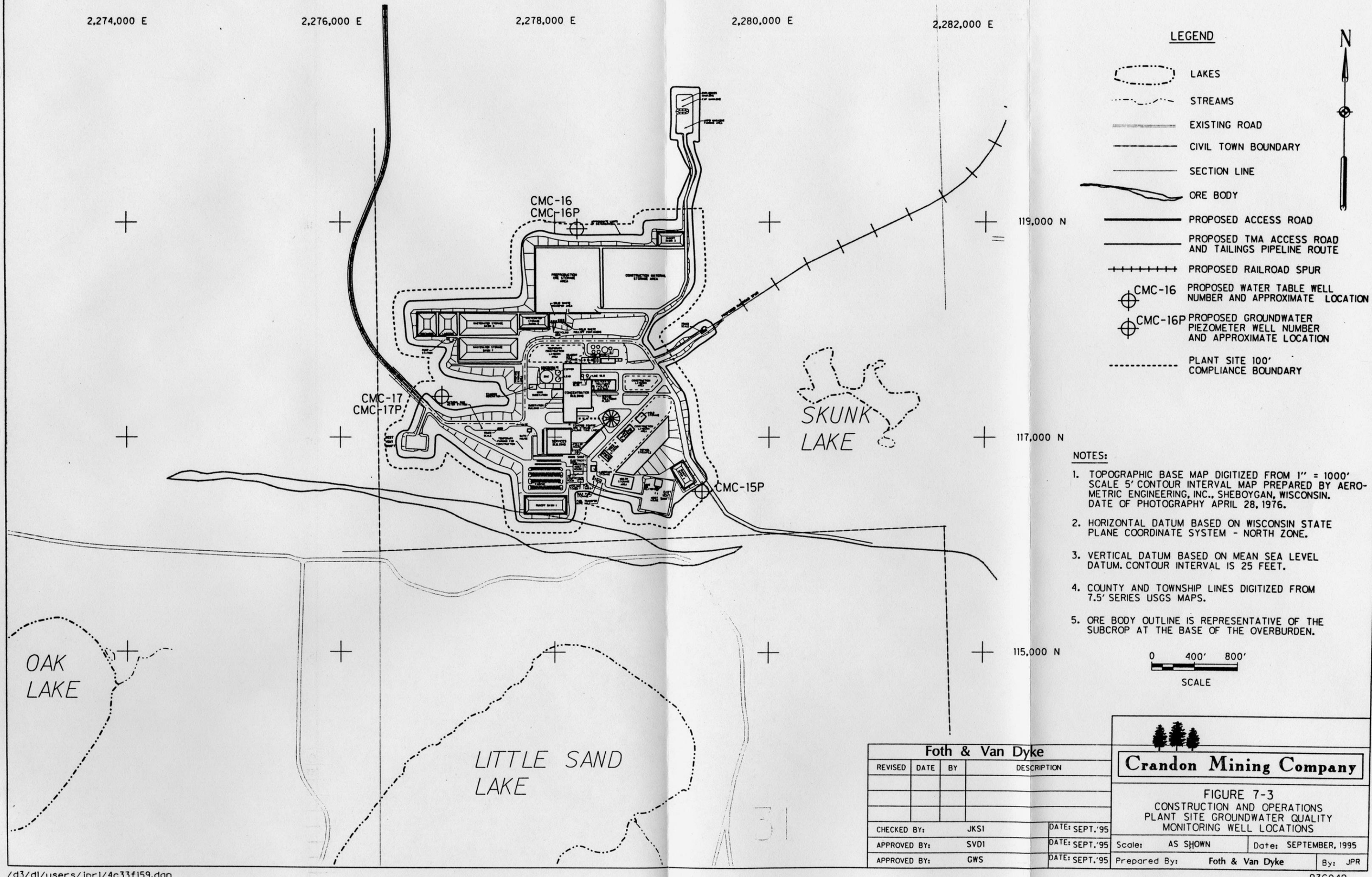
CHECKED BY:	JKS1	DATE: SEPT.'95
APPROVED BY:	SVD1	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

Crandon Mining Company

FIGURE 7-2
CONSTRUCTION AND OPERATIONS
TMA GROUNDWATER QUALITY AND
LEACHATE MONITORING LOCATIONS

Scale: AS SHOWN Date: SEPTEMBER, 1995
Prepared By: Foth & Van Dyke By: JPR

93C049



NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1" = 1000' SCALE 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
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4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
5. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: SEPT.'95
APPROVED BY:	SVD1	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

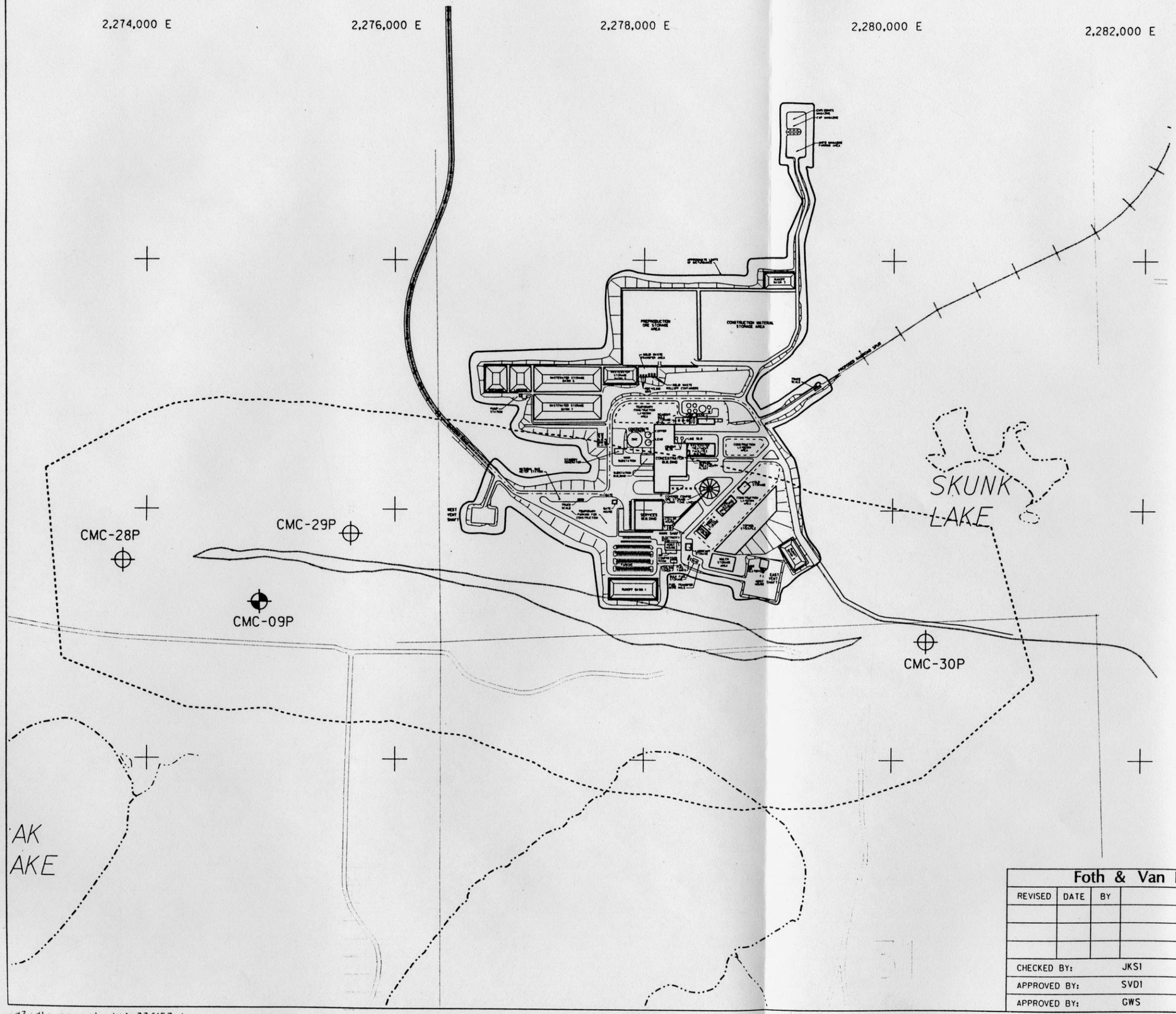
Crandon Mining Company

FIGURE 7-3
CONSTRUCTION AND OPERATIONS
PLANT SITE GROUNDWATER QUALITY
MONITORING WELL LOCATIONS

Scale:	AS SHOWN	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	JPR

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93C049



LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- CIVIL TOWN BOUNDARY
- SECTION LINE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- CMC-09P — EXISTING GROUNDWATER PIEZOMETER WELL NUMBER AND LOCATION
- CMC-30P — PROPOSED GROUNDWATER PIEZOMETER WELL NUMBER AND APPROXIMATE LOCATION
- ORE BODY 1200' COMPLIANCE BOUNDARY

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1" = 1000' SCALE 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS 25 FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
5. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

0 400' 800'
SCALE

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

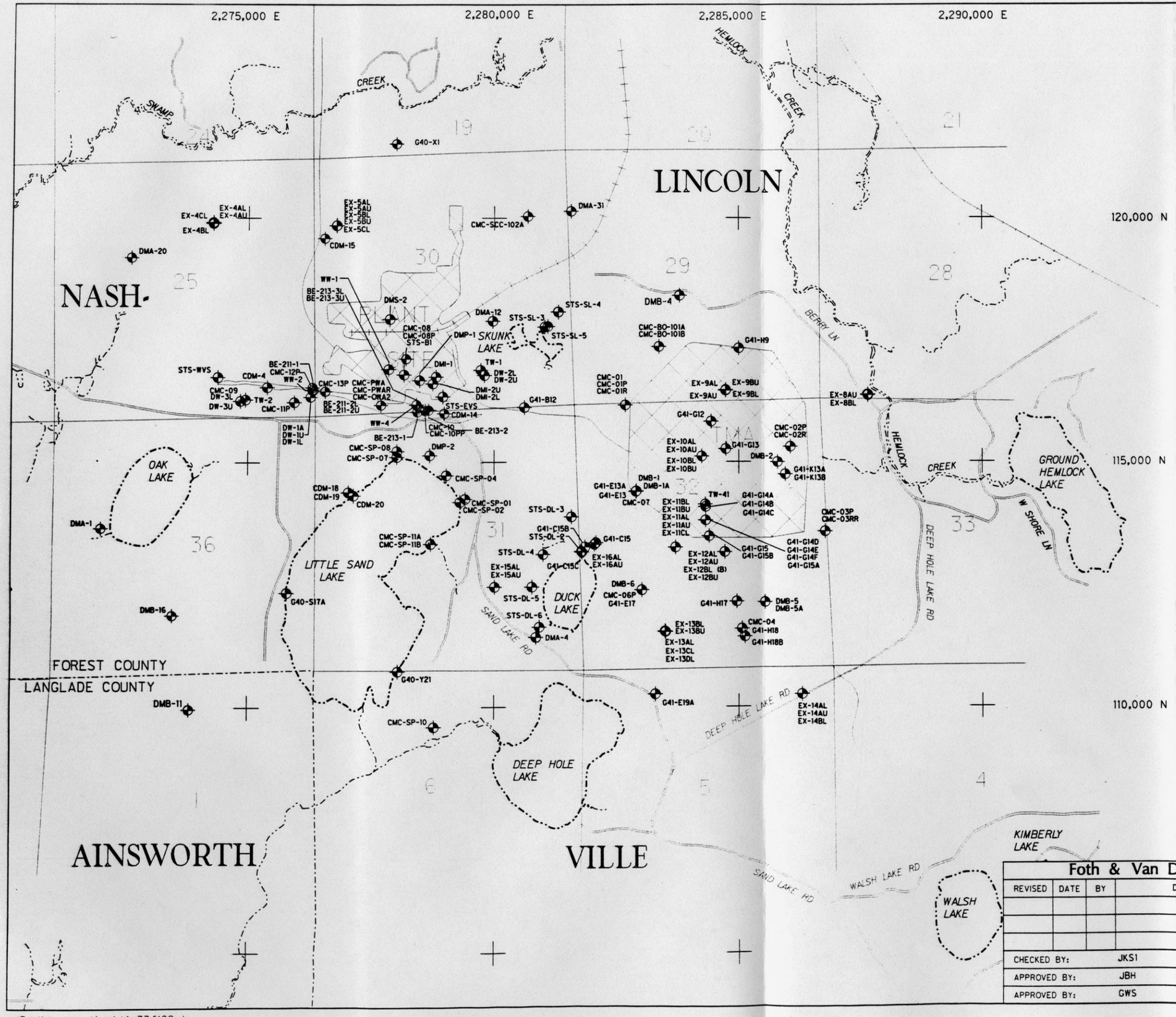
CHECKED BY:	JKSI	DATE: SEPT.'95
APPROVED BY:	SVDI	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

Crandon Mining Company

FIGURE 7-4
CONSTRUCTION AND OPERATIONS
MINE GROUNDWATER QUALITY
MONITORING WELL LOCATIONS

Scale:	AS SHOWN	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	JPR

93C049



LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- COUNTY BOUNDARY
- CIVIL TOWN BOUNDARY
- SECTION LINE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- DMP-1 — NUMBER AND LOCATION OF ACTIVE AND TEMPORARILY ABANDONED WELLS TO BE PERMANENTLY ABANDONED

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1" = 1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS 25 FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
5. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: SEPT. '95
APPROVED BY:	JBH	DATE: SEPT. '95
APPROVED BY:	GWS	DATE: SEPT. '95

Crandon Mining Company

FIGURE 7-5

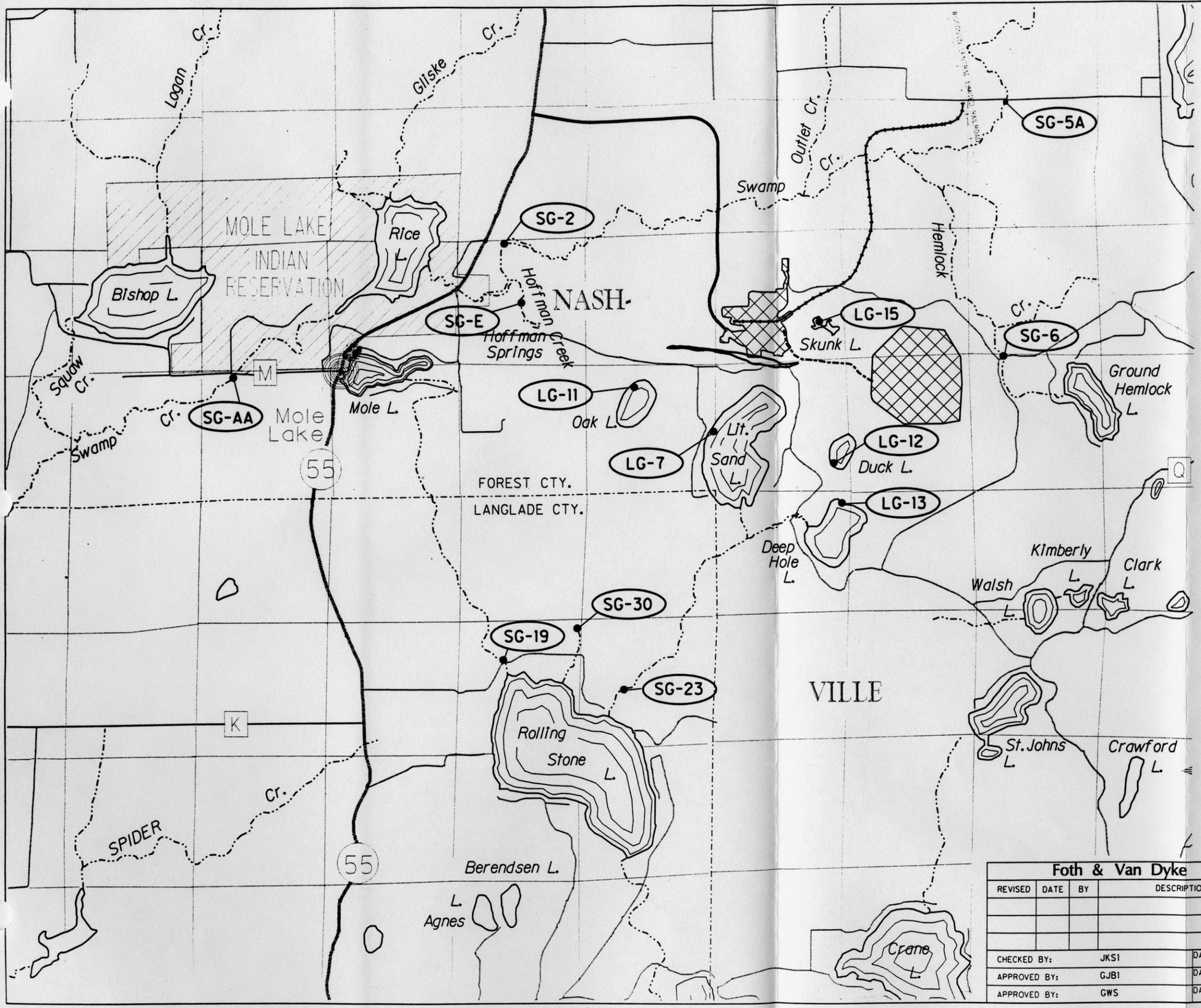
MONITORING WELLS AND PIEZOMETERS TO BE ABANDONED

Scale: 0 1000' 2000' | Date: SEPTEMBER, 1995

Prepared By: Foth & Van Dyke | By: JOW

93C049

/d3/dl/users/jpr1/4c33f129.dgn



NOTES:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION.
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: SEPT.'95
APPROVED BY:	GJB1	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

Crandon Mining Company

FIGURE 7-6
CONSTRUCTION AND OPERATIONS
SURFACE WATER MONITORING STATIONS

Scale: 0 2000' 4000' Date: SEPTEMBER, 1995

Prepared By: Foth & Van Dyke By: GAM

93C049

2,270,000 E
2,275,000 E
2,280,000 E
2,285,000 E
125,000 N
120,000 N
115,000 N
110,000 N

PLANT SITE
TMA
F15
F29
F66
01
SKUNK LAKE
OAK LAKE
LITTLE SAND LAKE
DUCK LAKE
DEEP HOLE LAKE
SHERMAN LN
LITTLE SAND LAKE RD
VALCAN SHORES LN
DEEP HOLE RD
WISCONSIN CENTRAL LIMITED RAILROAD
SWAMP
CREEK

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- SECTION LINE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- WETLANDS
- ▲M-1 WETLAND MONITORING LOCATION
- WETLAND DIVIDER

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1"=1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS FIVE FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
5. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: SEPT.'95
APPROVED BY:	RFS	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

Crandon Mining Company

FIGURE 7-7

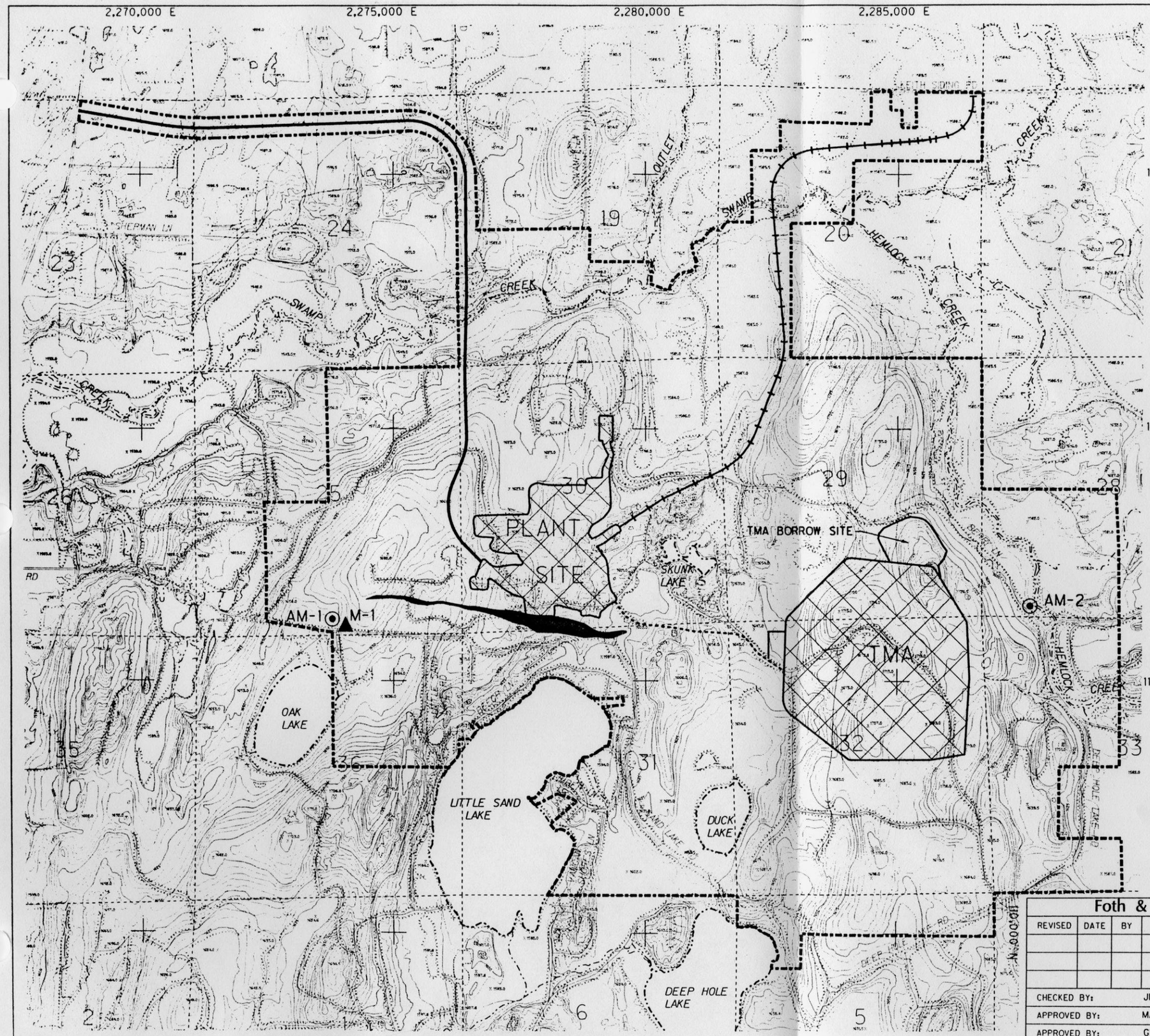
CONSTRUCTION AND OPERATIONS
WETLAND MONITORING LOCATIONS

Scale: 0 1000' 2000' | Date: SEPTEMBER, 1995

Prepared By: Foth & Van Dyke | By: JRB2

/d3/dl/users/jpr1/4c62f53.dgn

93C049



LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- 1675 EXISTING CONTOUR
- 1690.0 EXISTING SPOT ELEVATION
- SECTION LINE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- PROJECT AREA BOUNDARY
- ▲ M-1 METEOROLOGICAL LOCATION
- ⊙ AM-1 AIR MONITORING LOCATIONS

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1" = 1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS 25 FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
5. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: SEPT.'95
APPROVED BY:	MAD1	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

Crandon Mining Company

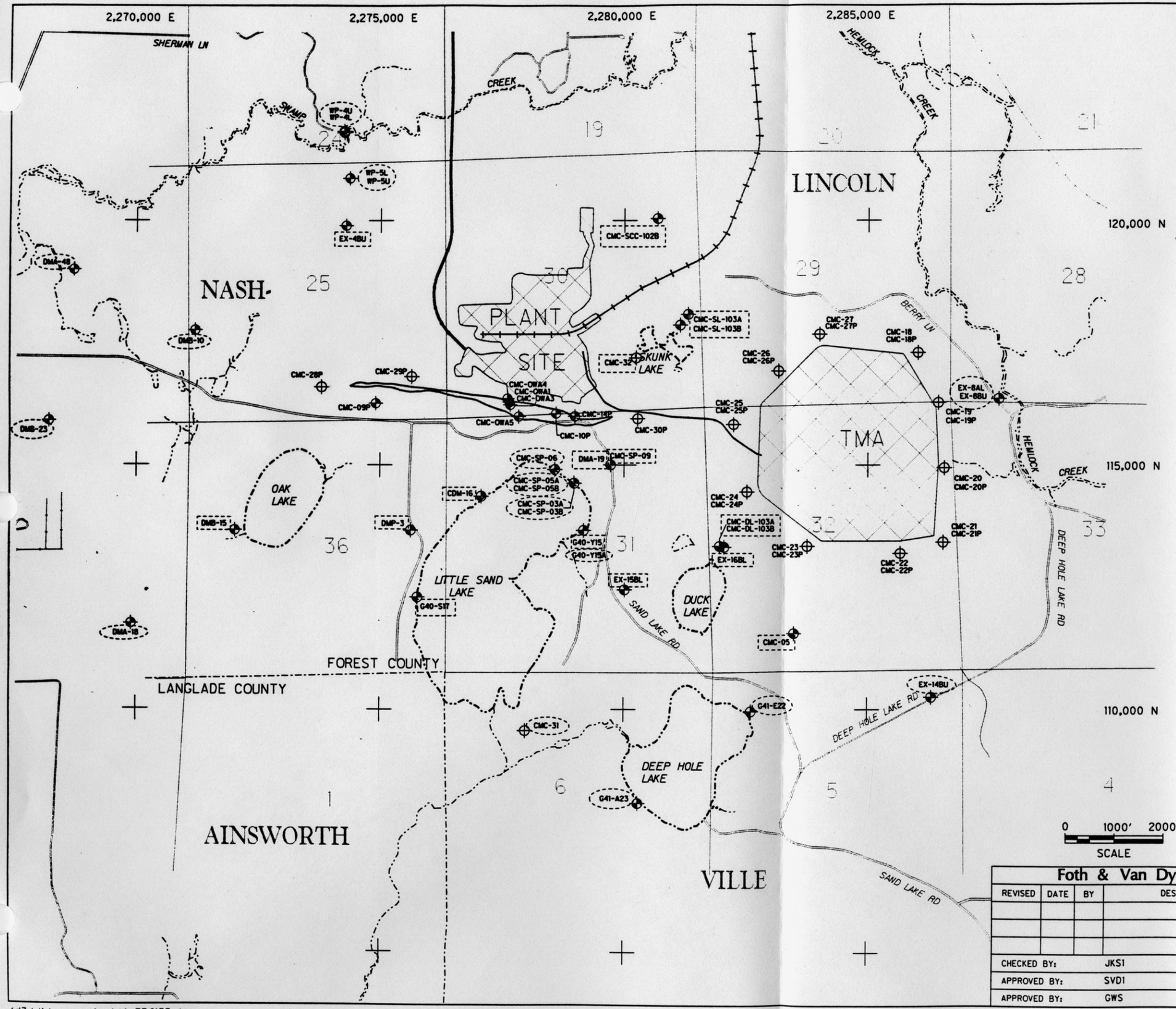
FIGURE 7-8

CONSTRUCTION AND OPERATIONS AIR MONITORING SITES

Scale: 0 1000' 2000' | Date: SEPTEMBER, 1995

Prepared By: Foth & Van Dyke | By: JRB

930049



LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- COUNTY BOUNDARY
- CIVIL TOWN BOUNDARY
- SECTION LINE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- EX-14BU — GROUNDWATER ELEVATION MONITORING WELL TO BE MONITORED FOR 4 YEARS AFTER CLOSURE
- EX-14BL — GROUNDWATER ELEVATION MONITORING WELL TO BE MONITORED FOR 8 YEARS AFTER CLOSURE
- CMC-14P — GROUNDWATER ELEVATION MONITORING WELL TO BE MONITORED UNTIL WATER TABLE IS RECOVERED AT APPROXIMATELY 15 YEARS.
- CMC-20 / CMC-20P — PROPOSED WELL NUMBER AND APPROXIMATE LOCATION

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1" = 1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS 25 FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
5. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.
6. MONITORING WELLS THAT WILL BE MONITORED FOR WATER QUALITY AS PART OF LONG-TERM CARE WILL CONTINUE TO BE MONITORED FOR WATER LEVELS AS PART OF THE WATER QUALITY MONITORING PROGRAMS DESCRIBED IN SECTION 10.2 AND 10.3.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: SEPT.'95
APPROVED BY:	SVD1	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

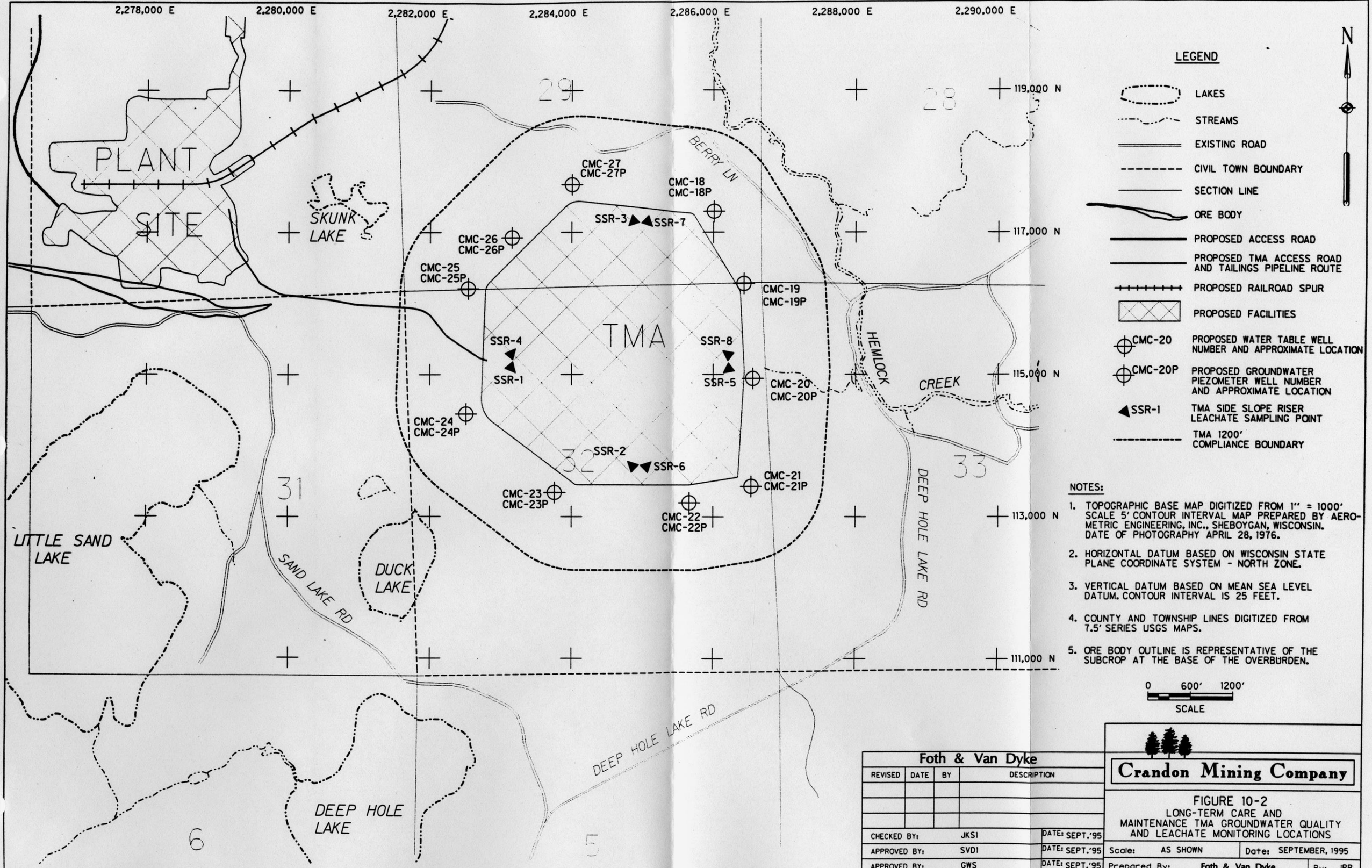
Crandon Mining Company

FIGURE 10-1
LONG-TERM CARE AND MAINTENANCE GROUNDWATER ELEVATION MONITORING WELL LOCATIONS

Scale:	AS SHOWN	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	JOW

/d3/d1/users/jpr1/4c33f155.dgn

93C049



NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1" = 1000' SCALE 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
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3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS 25 FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
5. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

0 600' 1200'
SCALE

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: SEPT.'95
APPROVED BY:	SVD1	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

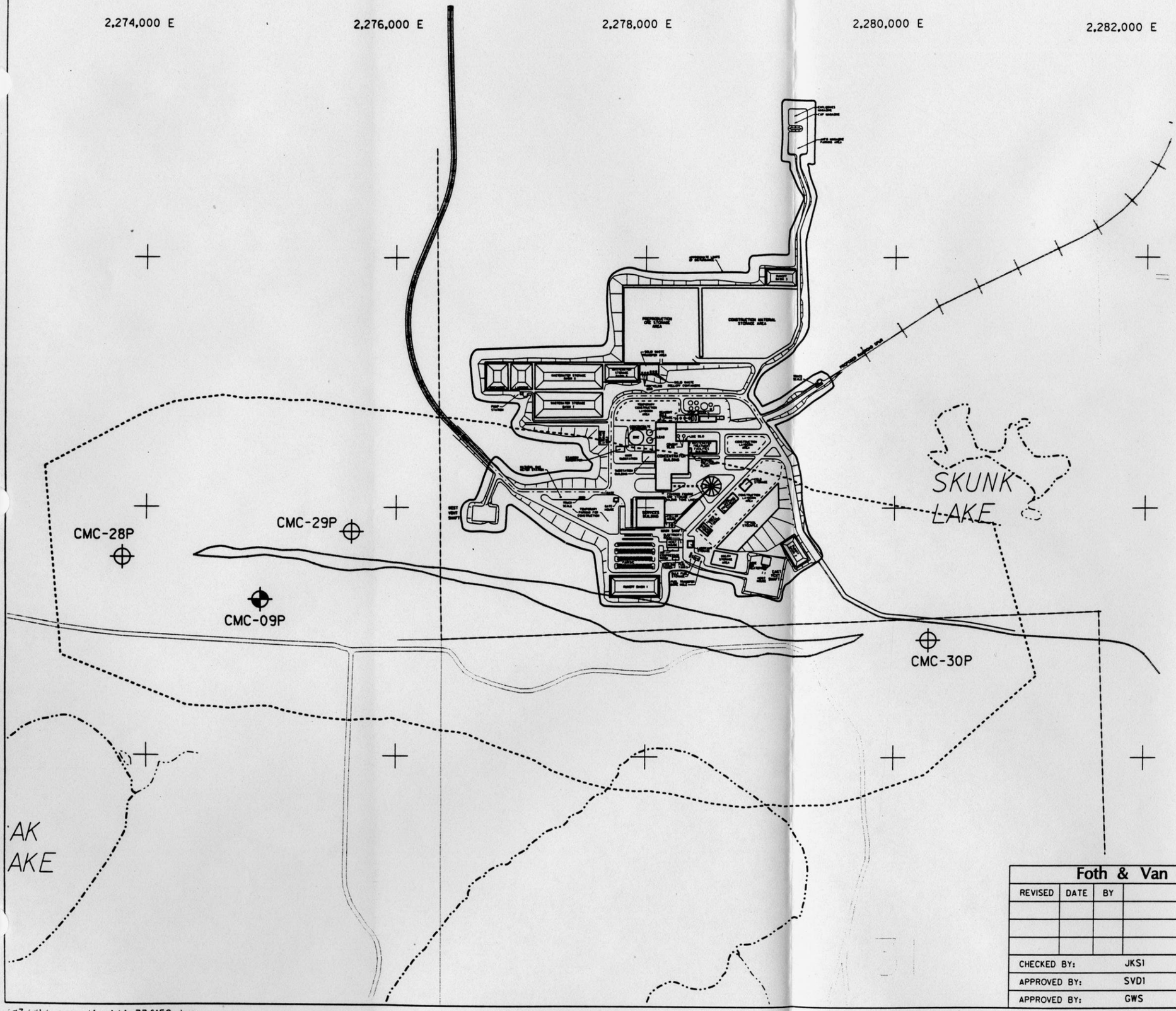
Crandon Mining Company

FIGURE 10-2
LONG-TERM CARE AND MAINTENANCE TMA GROUNDWATER QUALITY AND LEACHATE MONITORING LOCATIONS

Scale:	AS SHOWN	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	JPR

/d3/d1/users/jpr1/4c33f154.dgn

93C049



LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- CIVIL TOWN BOUNDARY
- SECTION LINE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- CMC-09B — EXISTING GROUNDWATER PIEZOMETER WELL NUMBER AND LOCATION
- CMC-16P — PROPOSED GROUNDWATER PIEZOMETER WELL NUMBER AND APPROXIMATE LOCATION
- ORE BODY 1200' COMPLIANCE BOUNDARY

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1" = 1000' SCALE 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS 25 FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
5. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

0 400' 800'

SCALE

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

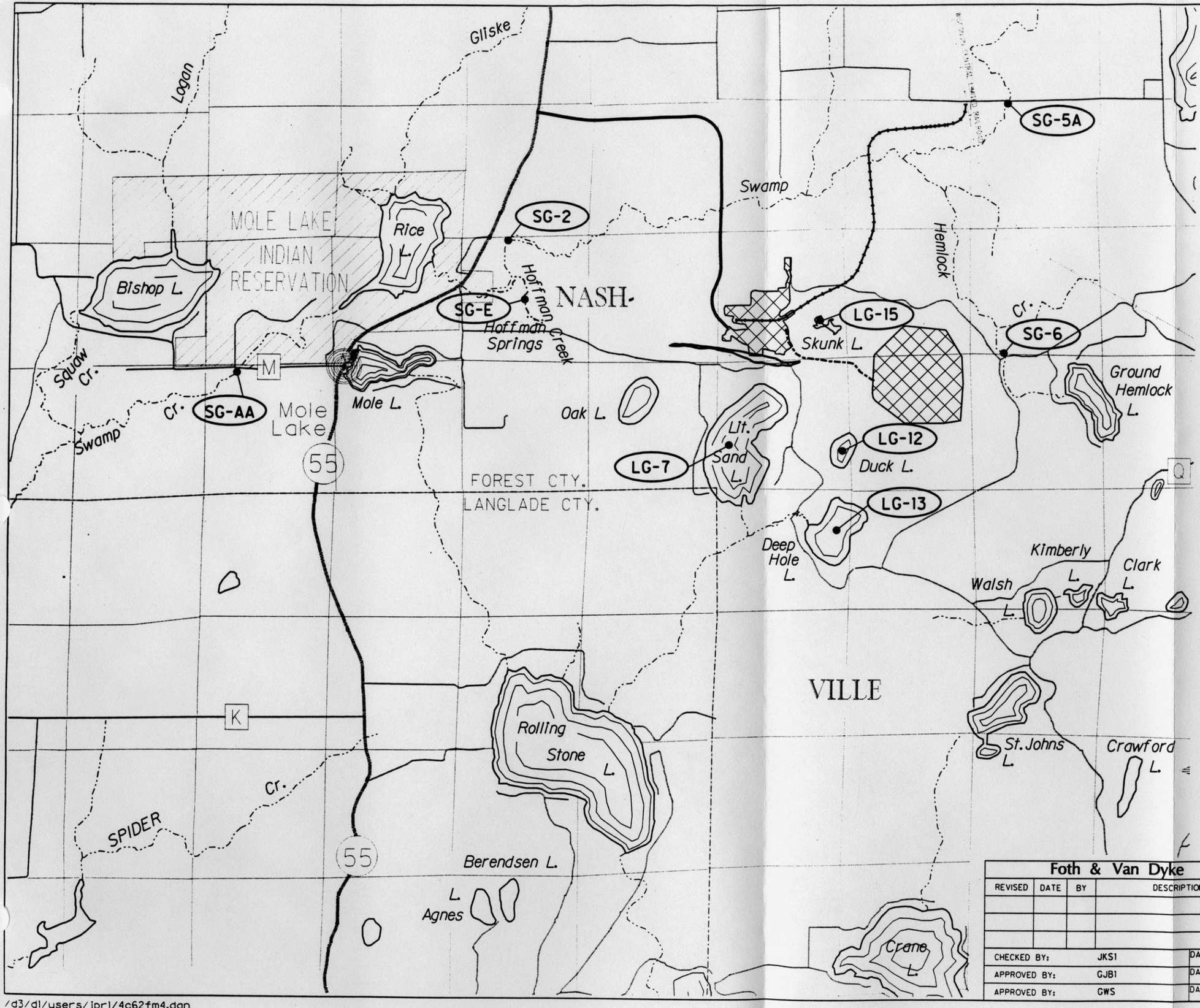
CHECKED BY:	JKS1	DATE: SEPT.'95
APPROVED BY:	SVD1	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

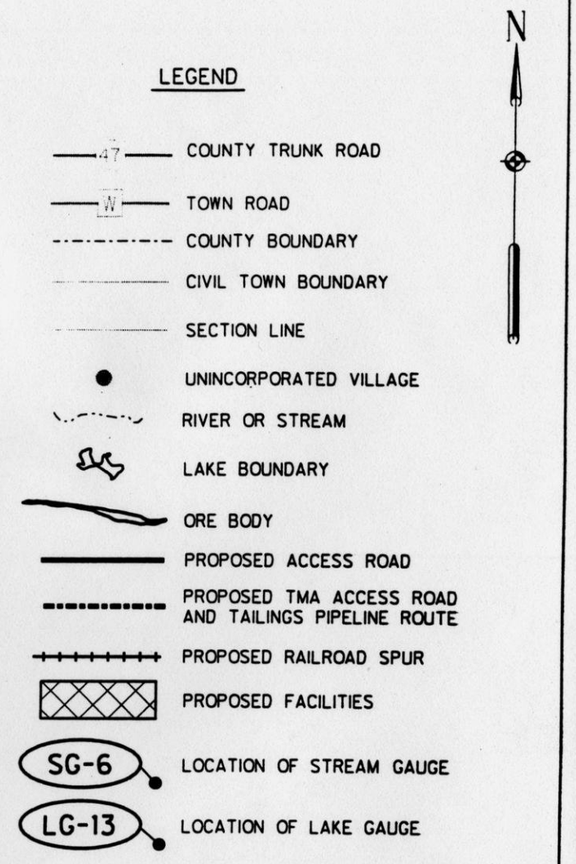
Crandon Mining Company

FIGURE 10-3
LONG-TERM CARE AND MAINTENANCE MINE GROUNDWATER QUALITY MONITORING WELL LOCATIONS

Scale:	AS SHOWN	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	JPR

93C049





NOTES:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION.
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: SEPT.'95
APPROVED BY:	GJB1	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

Crandon Mining Company

FIGURE 10-4

LONG TERM CARE AND MAINTENANCE SURFACE WATER MONITORING STATIONS

Scale: 0 2000' 4000' Date: SEPTEMBER, 1995

Prepared By: Foth & Van Dyke By: GAM

/d3/d1/users/jpr1/4c62fm4.dgn

93C049

2,274,000 E

2,276,000 E

2,278,000 E

2,280,000 E

2,282,000 E

119,000 N

117,000 N

115,000 N

CMC-28P

CMC-29P

CMC-09P

CMC-30P

SKUNK LAKE

AK AKE

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- CIVIL TOWN BOUNDARY
- SECTION LINE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- CMC-09B — EXISTING GROUNDWATER PIEZOMETER WELL NUMBER AND LOCATION
- CMC-16P — PROPOSED GROUNDWATER PIEZOMETER WELL NUMBER AND APPROXIMATE LOCATION
- ORE BODY 1200' COMPLIANCE BOUNDARY

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1" = 1000' SCALE 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS 25 FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
5. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

0 400' 800'

SCALE

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

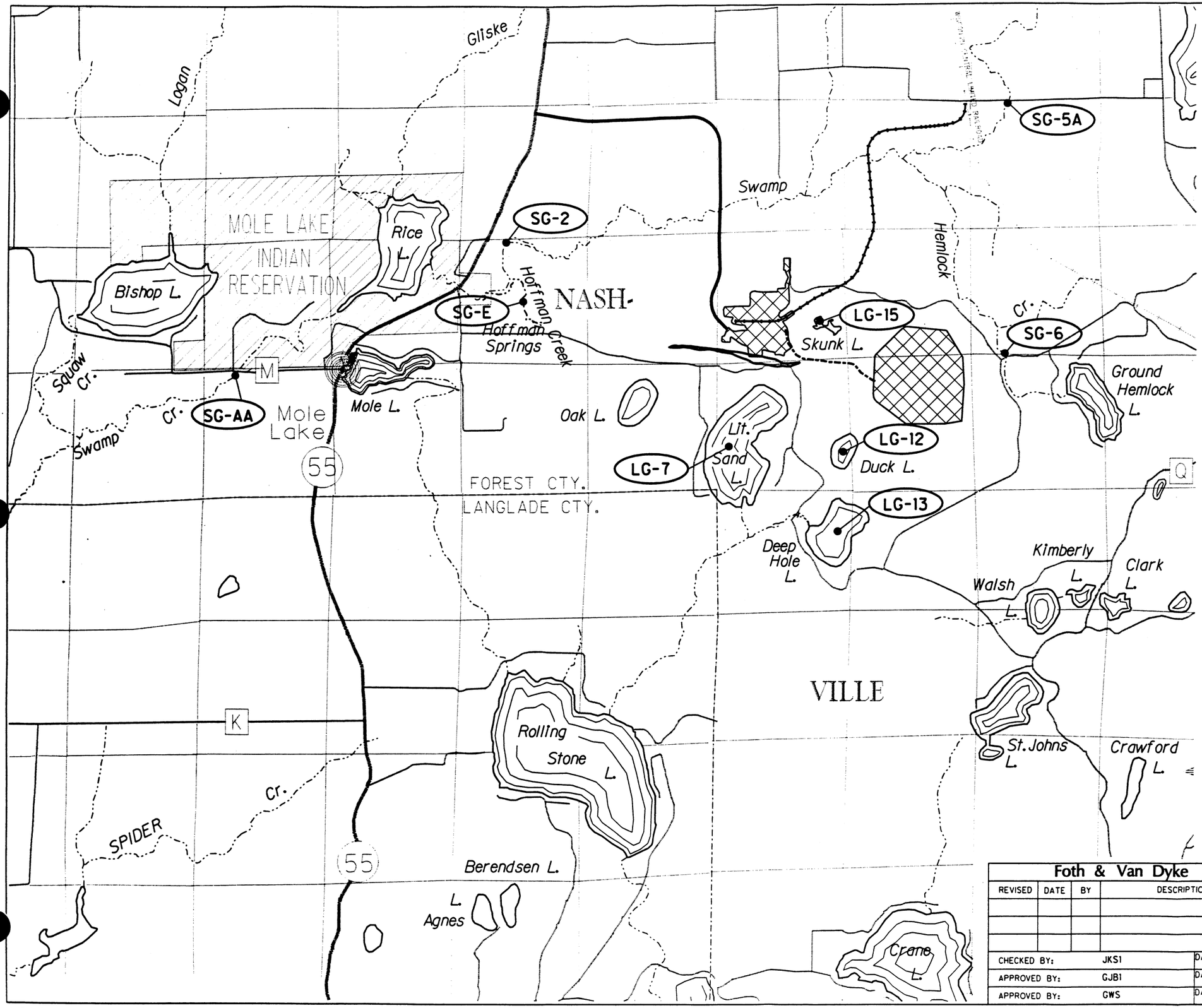
CHECKED BY:	JKS1	DATE: SEPT.'95
APPROVED BY:	SVD1	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

Crandon Mining Company

FIGURE 10-3
LONG-TERM CARE AND MAINTENANCE MINE GROUNDWATER QUALITY MONITORING WELL LOCATIONS

Scale:	AS SHOWN	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	JPR

93C049



NOTES:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION.
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: SEPT.'95
APPROVED BY:	GJB1	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

Crandon Mining Company

FIGURE 10-4

LONG TERM CARE AND MAINTENANCE SURFACE WATER MONITORING STATIONS

Scale: 0 2000' 4000' | Date: SEPTEMBER, 1995

Prepared By: Foth & Van Dyke | By: CAM

/d3/dl/users/jprl/4c62fm4.dgn

93C049

Appendix A

Exxon Annual Report
Rio Algom Annual Report

(Note: Enclosed is a copy of the cover page from the pertinent Exxon and Rio Algom 1994 Reports. Copies of the reports are available upon request.)

1994

SECURITIES AND EXCHANGE COMMISSION

WASHINGTON, D.C. 20549

FORM 10-K

[X] ANNUAL REPORT PURSUANT TO SECTION 13 OR 15(d) OF THE SECURITIES EXCHANGE ACT OF 1934

For the fiscal year ended December 31, 1994

OR

[ ] TRANSITION REPORT PURSUANT TO SECTION 13 OR 15(d) OF THE SECURITIES EXCHANGE ACT OF 1934

For the transition period from to

Commission File Number 1-2256

EXXON CORPORATION

(Exact name of registrant as specified in its charter)

NEW JERSEY	13-5409005
(State or other jurisdiction of incorporation or organization)	(I.R.S. Employer Identification Number)

225 E. JOHN W. CARPENTER FREEWAY, IRVING, TEXAS 75062-2298

(Address of principal executive offices) (Zip Code)

(214) 444-1000

(Registrant's telephone number, including area code)

Securities registered pursuant to Section 12(b) of the Act:

Title of Each Class	Name of Each Exchange on Which Registered
Common Stock, without par value (1,241,794,994 shares outstanding at February 28, 1995)	**New York Stock Exchange**
Registered securities guaranteed by Registrant:	
SeaRiver Maritime Financial Holdings, Inc.	
Twenty-Five Year Debt Securities due October 1, 2011	**New York Stock Exchange**
Exxon Capital Corporation	
Twelve Year 6% Notes due July 1, 2005	**New York Stock Exchange**

Indicate by check mark whether the registrant (1) has filed all reports required to be filed by Section 13 or 15(d) of the Securities Exchange Act of 1934 during the preceding 12 months (or for such shorter period that the registrant was required to file such reports), and (2) has been subject to such filing requirements for the past 90 days. Yes ✓ No ___

Indicate by check mark if disclosure of delinquent filers pursuant to Item 405 of Regulation S-K is not contained herein, and will not be contained, to the best of registrant's knowledge, in definitive proxy or information statements incorporated by reference in Part III of this Form 10-K or any amendment to this Form 10-K. ___

The aggregate market value of the voting stock held by non-affiliates of the registrant on February 28, 1995, based on the closing price on that date of $63⅞ on the New York Stock Exchange composite tape, was in excess of $79 billion.

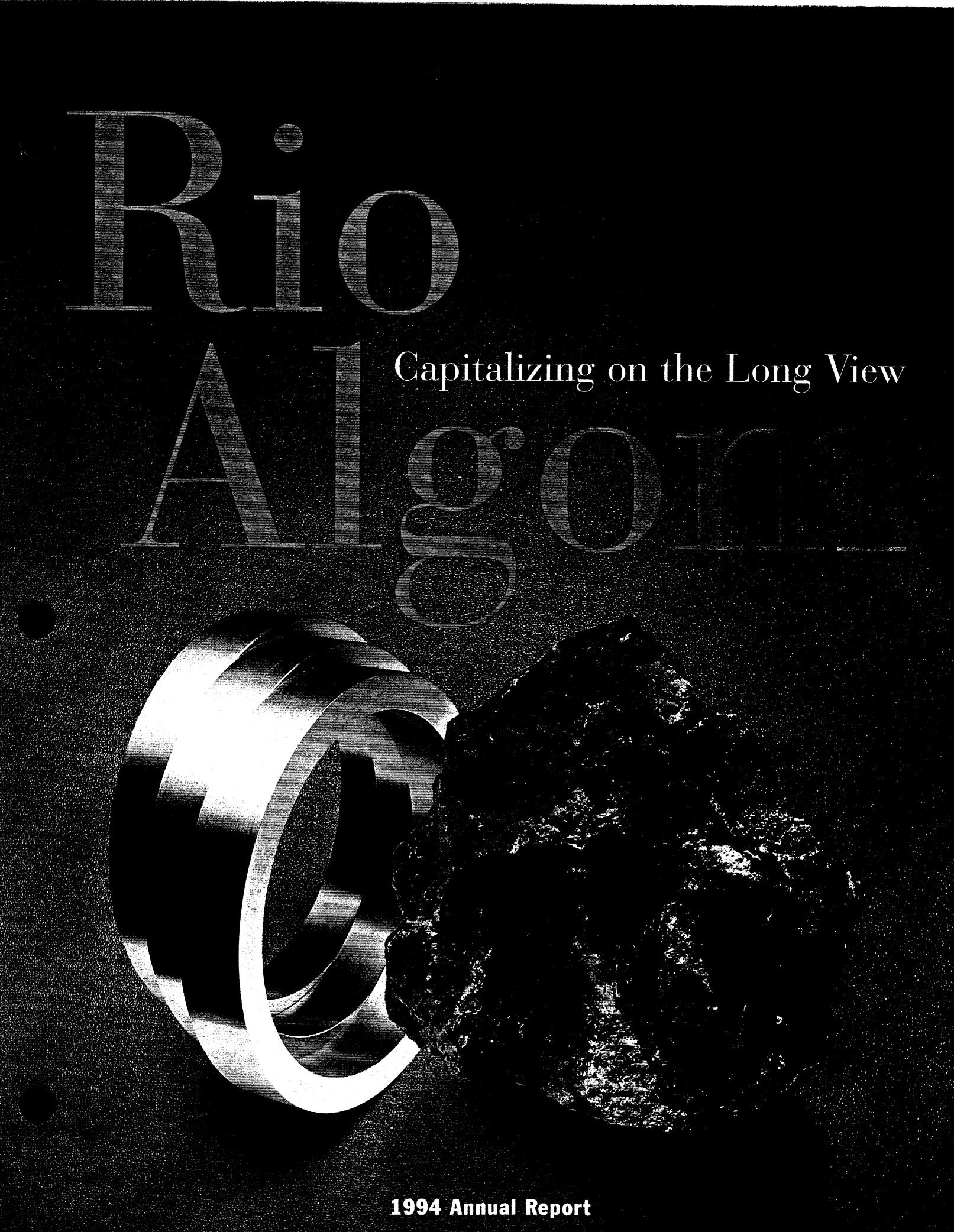
Documents Incorporated by Reference:

1994 Annual Report to Shareholders (Parts I, II and IV)

Proxy Statement dated March 10, 1995 (Part III)

Rio Algom

Capitalizing on the Long View



1994 Annual Report

RIO ALGOM LIMITED

ANNUAL INFORMATION FORM

1994

Rio Algom Limited

Registered and principal office
Suite 2600, 120 Adelaide Street West
Toronto, Ontario
M5H 1W5

March 21, 1995

Appendix B

Plant Site Surface Water Runoff Calculations

Developed by: SRB

Checked by: MDL

Crandon Mining Company

Plant Site Runoff Basin 1

QTR-55 Hydrology
Pond-2 Hydrology

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 04-13-1995 15:08:13
Watershed file: --> CMC2 .WSD
Hydrograph file: --> CMC2 .HYD

CRANDON MINING COMPANY
FOTH AND VAN DYKE 93C049.27
PROPOSED CONDITIONS 4/95
25 YR STORM EVENT

>>>> Input Parameters Used to Compute Hydrograph <<<<

Subarea Description	AREA (acres)	CN	Tc (hrs)	* Tt (hrs)	Precip. (in)	Runoff (in)	Ia/p input	Ia/p used
BASIN NO. 1	21.88	88.0	0.40	0.00	4.20	2.92	.06	.10

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 21.88 acres or 0.03419 sq.mi
Peak discharge = 59 cfs

>>>> Computer Modifications of Input Parameters <<<<<

Subarea Description	Input Values Tc (hr)	Input Values * Tt (hr)	Rounded Values Tc (hr)	Rounded Values * Tt (hr)	Ia/p Interpolated (Yes/No)	Ia/p Messages
BASIN NO. 1	0.38	0.00	0.40	0.00	No	Computed Ia/p < .1

* Travel time from subarea outfall to composite watershed outfall point.

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 04-13-1995 15:08:13
Watershed file: --> CMC2 .WSD
Hydrograph file: --> CMC2 .HYD

CRANDON MINING COMPANY
FOTH AND VAN DYKE 93C049.27
PROPOSED CONDITIONS 4/95
25 YR STORM EVENT

>>>> Summary of Subarea Times to Peak <<<<

Subarea	Peak Discharge at Composite Outfall (cfs)	Time to Peak at Composite Outfall (hrs)
BASIN NO. 1	59	12.3
Composite Watershed	59	12.3

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 04-13-1995 15:08:13
Watershed file: --> CMC2 .WSD
Hydrograph file: --> CMC2 .HYD

CRANDON MINING COMPANY
FOTH AND VAN DYKE 93C049.27
PROPOSED CONDITIONS 4/95
25 YR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	11.0 hr	11.3 hr	11.6 hr	11.9 hr	12.0 hr	12.1 hr	12.2 hr	12.3 hr	12.4 hr
BASIN NO. 1	2	2	4	8	14	27	47	59	57
Total (cfs)	2	2	4	8	14	27	47	59	57

Subarea Description	12.5 hr	12.6 hr	12.7 hr	12.8 hr	13.0 hr	13.2 hr	13.4 hr	13.6 hr	13.8 hr
BASIN NO. 1	43	30	22	16	10	8	6	5	5
Total (cfs)	43	30	22	16	10	8	6	5	5

Subarea Description	14.0 hr	14.3 hr	14.6 hr	15.0 hr	15.5 hr	16.0 hr	16.5 hr	17.0 hr	17.5 hr
BASIN NO. 1	4	4	3	3	3	2	2	2	2
Total (cfs)	4	4	3	3	3	2	2	2	2

Subarea Description	18.0 hr	19.0 hr	20.0 hr	22.0 hr	26.0 hr
BASIN NO. 1	2	2	1	1	0
Total (cfs)	2	2	1	1	0

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 04-13-1995 15:08:13
Watershed file: --> CMC2 .WSD
Hydrograph file: --> CMC2 .HYD

CRANDON MINING COMPANY
FOTH AND VAN DYKE 93C049.27
PROPOSED CONDITIONS 4/95
25 YR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
11.0	2	14.8	3
11.1	2	14.9	3
11.2	2	15.0	3
11.3	2	15.1	3
11.4	3	15.2	3
11.5	3	15.3	3
11.6	4	15.4	3
11.7	5	15.5	3
11.8	7	15.6	3
11.9	8	15.7	3
12.0	14	15.8	2
12.1	27	15.9	2
12.2	47	16.0	2
12.3	59	16.1	2
12.4	57	16.2	2
12.5	43	16.3	2
12.6	30	16.4	2
12.7	22	16.5	2
12.8	16	16.6	2
12.9	13	16.7	2
13.0	10	16.8	2
13.1	9	16.9	2
13.2	8	17.0	2
13.3	7	17.1	2
13.4	6	17.2	2
13.5	6	17.3	2
13.6	5	17.4	2
13.7	5	17.5	2
13.8	5	17.6	2
13.9	4	17.7	2
14.0	4	17.8	2
14.1	4	17.9	2
14.2	4	18.0	2
14.3	4	18.1	2
14.4	4	18.2	2
14.5	3	18.3	2
14.6	3	18.4	2

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 04-13-1995 15:08:13
Watershed file: --> CMC2 .WSD
Hydrograph file: --> CMC2 .HYD

CRANDON MINING COMPANY
FOTH AND VAN DYKE 93C049.27
PROPOSED CONDITIONS 4/95
25 YR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
18.6	2	22.4	1
18.7	2	22.5	1
18.8	2	22.6	1
18.9	2	22.7	1
19.0	2	22.8	1
19.1	2	22.9	1
19.2	2	23.0	1
19.3	2	23.1	1
19.4	2	23.2	1
19.5	2	23.3	1
19.6	1	23.4	1
19.7	1	23.5	1
19.8	1	23.6	1
19.9	1	23.7	1
20.0	1	23.8	1
20.1	1	23.9	1
20.2	1	24.0	0
20.3	1	24.1	0
20.4	1	24.2	0
20.5	1	24.3	0
20.6	1	24.4	0
20.7	1	24.5	0
20.8	1	24.6	0
20.9	1	24.7	0
21.0	1	24.8	0
21.1	1	24.9	0
21.2	1	25.0	0
21.3	1	25.1	0
21.4	1	25.2	0
21.5	1	25.3	0
21.6	1	25.4	0
21.7	1	25.5	0
21.8	1	25.6	0
21.9	1	25.7	0
22.0	1	25.8	0
22.1	1	25.9	0
22.2	1		
22.3	1		

****
* *
* CRANDON MINING COMPANY 93C049.27 FOTH & VAN DYKE *
* RUNOFF BASIN NO. 1 4/95 *
* *
* *
* *
****

Inflow Hydrograph: CMC2 .HYD
Rating Table file: CMC2 .PND

----INITIAL CONDITIONS----
Elevation = 1646.00 ft
Outflow = 0.00 cfs
Storage = 0.00 ac-ft

GIVEN POND DATA			INTERMEDIATE ROUTING COMPUTATIONS	
ELEVATION (ft)	OUTFLOW (cfs)	STORAGE (ac-ft)	2S/t (cfs)	2S/t + O (cfs)
1646.00	0.0	0.000	0.0	0.0
1646.50	0.0	0.006	1.4	1.4
1647.00	0.0	0.014	3.3	3.3
1647.50	0.0	0.024	5.8	5.8
1648.00	0.0	0.038	9.1	9.1
1648.50	0.0	0.055	13.3	13.3
1649.00	0.0	0.079	19.1	19.1
1649.50	0.0	0.500	121.1	121.1
1650.00	0.0	0.939	227.1	227.1
1650.50	0.0	1.394	337.3	337.3
1651.00	0.0	1.866	451.7	451.7
1651.50	2.2	2.357	570.3	572.5
1652.00	2.3	2.865	693.3	695.6
1652.50	2.4	3.392	820.8	823.2
1653.00	2.5	3.937	952.7	955.2
1653.50	2.6	4.501	1089.3	1091.9
1654.00	2.7	5.085	1230.5	1233.2
1654.50	2.8	5.688	1376.5	1379.3
1655.00	2.8	6.311	1527.3	1530.1
1655.50	2.9	6.955	1683.0	1685.9
1656.00	3.0	7.619	1843.7	1846.7

Time increment (t) = 0.100 hrs.

Pond File: CMC2 .PND
ow Hydrograph: CMC2 .HYD
Outflow Hydrograph: OUT .HYD

INFLOW HYDROGRAPH		ROUTING COMPUTATIONS				
TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
11.000	2.00	-----	0.0	0.0	0.00	1646.00
11.100	2.00	4.0	4.0	4.0	0.00	1647.14
11.200	2.00	4.0	8.0	8.0	0.00	1647.83
11.300	2.00	4.0	12.0	12.0	0.00	1648.35
11.400	3.00	5.0	17.0	17.0	0.00	1648.82
11.500	3.00	6.0	23.0	23.0	0.00	1649.02
11.600	4.00	7.0	30.0	30.0	0.00	1649.05
11.700	5.00	9.0	39.0	39.0	0.00	1649.10
11.800	7.00	12.0	51.0	51.0	0.00	1649.16
11.900	8.00	15.0	66.0	66.0	0.00	1649.23
12.000	14.00	22.0	88.0	88.0	0.00	1649.34
12.100	27.00	41.0	129.0	129.0	0.00	1649.54
12.200	47.00	74.0	203.0	203.0	0.00	1649.89
12.300	59.00	106.0	309.0	309.0	0.00	1650.37
12.400	57.00	116.0	425.0	425.0	0.00	1650.88
12.500	43.00	100.0	522.3	525.0	1.33	1651.30
12.600	30.00	73.0	590.9	595.3	2.22	1651.59
12.700	22.00	52.0	638.4	642.9	2.26	1651.79
12.800	16.00	38.0	671.8	676.4	2.28	1651.92
12.900	13.00	29.0	696.2	700.8	2.30	1652.02
13.000	10.00	23.0	714.6	719.2	2.32	1652.09
13.100	9.00	19.0	728.9	733.6	2.33	1652.15
13.200	8.00	17.0	741.2	745.9	2.34	1652.20
13.300	7.00	15.0	751.5	756.2	2.35	1652.24
13.400	6.00	13.0	759.8	764.5	2.35	1652.27
13.500	6.00	12.0	767.1	771.8	2.36	1652.30
13.600	5.00	11.0	773.4	778.1	2.36	1652.32
13.700	5.00	10.0	778.6	783.4	2.37	1652.34
13.800	5.00	10.0	783.9	788.6	2.37	1652.36
13.900	4.00	9.0	788.1	792.9	2.38	1652.38
14.000	4.00	8.0	791.4	796.1	2.38	1652.39
14.100	4.00	8.0	794.6	799.4	2.38	1652.41
14.200	4.00	8.0	797.9	802.6	2.38	1652.42
14.300	4.00	8.0	801.1	805.9	2.39	1652.43
14.400	4.00	8.0	804.3	809.1	2.39	1652.44
14.500	3.00	7.0	806.5	811.3	2.39	1652.45
14.600	3.00	6.0	807.7	812.5	2.39	1652.46
14.700	3.00	6.0	808.9	813.7	2.39	1652.46
14.800	3.00	6.0	810.2	814.9	2.39	1652.47
14.900	3.00	6.0	811.4	816.2	2.39	1652.47
15.000	3.00	6.0	812.6	817.4	2.40	1652.48
15.100	3.00	6.0	813.8	818.6	2.40	1652.48
15.200	3.00	6.0	815.0	819.8	2.40	1652.49
15.300	3.00	6.0	816.2	821.0	2.40	1652.49
15.400	3.00	6.0	817.4	822.2	2.40	1652.50

Pond File: CMC2 .PND
ow Hydrograph: CMC2 .HYD
...flow Hydrograph: OUT .HYD

INFLOW HYDROGRAPH		ROUTING COMPUTATIONS				
TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
15.500	3.00	6.0	818.6	823.4	2.40	1652.50
15.600	3.00	6.0	819.8	824.6	2.40	1652.51
15.700	3.00	6.0	821.0	825.8	2.40	1652.51
15.800	2.00	5.0	821.2	826.0	2.40	1652.51
15.900	2.00	4.0	820.4	825.2	2.40	1652.51
16.000	2.00	4.0	819.6	824.4	2.40	1652.50
16.100	2.00	4.0	818.8	823.6	2.40	1652.50
16.200	2.00	4.0	818.0	822.8	2.40	1652.50
16.300	2.00	4.0	817.2	822.0	2.40	1652.50
16.400	2.00	4.0	816.4	821.2	2.40	1652.49
16.500	2.00	4.0	815.6	820.4	2.40	1652.49
16.600	2.00	4.0	814.8	819.6	2.40	1652.49
16.700	2.00	4.0	814.0	818.8	2.40	1652.48
16.800	2.00	4.0	813.2	818.0	2.40	1652.48
16.900	2.00	4.0	812.4	817.2	2.40	1652.48
17.000	2.00	4.0	811.6	816.4	2.39	1652.47
17.100	2.00	4.0	810.8	815.6	2.39	1652.47
17.200	2.00	4.0	810.1	814.8	2.39	1652.47
17.300	2.00	4.0	809.3	814.1	2.39	1652.46
17.400	2.00	4.0	808.5	813.3	2.39	1652.46
17.500	2.00	4.0	807.7	812.5	2.39	1652.46
17.600	2.00	4.0	806.9	811.7	2.39	1652.46
17.700	2.00	4.0	806.1	810.9	2.39	1652.45
17.800	2.00	4.0	805.4	810.1	2.39	1652.45
17.900	2.00	4.0	804.6	809.4	2.39	1652.45
18.000	2.00	4.0	803.8	808.6	2.39	1652.44
18.100	2.00	4.0	803.0	807.8	2.39	1652.44
18.200	2.00	4.0	802.3	807.0	2.39	1652.44
18.300	2.00	4.0	801.5	806.3	2.39	1652.43
18.400	2.00	4.0	800.7	805.5	2.39	1652.43
18.500	2.00	4.0	799.9	804.7	2.39	1652.43
18.600	2.00	4.0	799.2	803.9	2.38	1652.42
18.700	2.00	4.0	798.4	803.2	2.38	1652.42
18.800	2.00	4.0	797.6	802.4	2.38	1652.42
18.900	2.00	4.0	796.9	801.6	2.38	1652.42
19.000	2.00	4.0	796.1	800.9	2.38	1652.41
19.100	2.00	4.0	795.3	800.1	2.38	1652.41
19.200	2.00	4.0	794.6	799.3	2.38	1652.41
19.300	2.00	4.0	793.8	798.6	2.38	1652.40
19.400	2.00	4.0	793.1	797.8	2.38	1652.40
19.500	2.00	4.0	792.3	797.1	2.38	1652.40
19.600	1.00	3.0	790.5	795.3	2.38	1652.39
19.700	1.00	2.0	787.8	792.5	2.38	1652.38
19.800	1.00	2.0	785.0	789.8	2.37	1652.37
19.900	1.00	2.0	782.3	787.0	2.37	1652.36
20.000	1.00	2.0	779.6	784.3	2.37	1652.35

Pond File: CMC2 .PND
ow Hydrograph: CMC2 .HYD
Outflow Hydrograph: OUT .HYD

INFLOW HYDROGRAPH		ROUTING COMPUTATIONS				
TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
20.100	1.00	2.0	776.8	781.6	2.37	1652.34
20.200	1.00	2.0	774.1	778.8	2.37	1652.33
20.300	1.00	2.0	771.4	776.1	2.36	1652.32
20.400	1.00	2.0	768.6	773.4	2.36	1652.30
20.500	1.00	2.0	765.9	770.6	2.36	1652.29
20.600	1.00	2.0	763.2	767.9	2.36	1652.28
20.700	1.00	2.0	760.5	765.2	2.35	1652.27
20.800	1.00	2.0	757.8	762.5	2.35	1652.26
20.900	1.00	2.0	755.1	759.8	2.35	1652.25
21.000	1.00	2.0	752.4	757.1	2.35	1652.24
21.100	1.00	2.0	749.7	754.4	2.35	1652.23
21.200	1.00	2.0	747.0	751.7	2.34	1652.22
21.300	1.00	2.0	744.3	749.0	2.34	1652.21
21.400	1.00	2.0	741.7	746.3	2.34	1652.20
21.500	1.00	2.0	739.0	743.7	2.34	1652.19
21.600	1.00	2.0	736.3	741.0	2.34	1652.18
21.700	1.00	2.0	733.6	738.3	2.33	1652.17
21.800	1.00	2.0	731.0	735.6	2.33	1652.16
21.900	1.00	2.0	728.3	733.0	2.33	1652.15
22.000	1.00	2.0	725.7	730.3	2.33	1652.14
22.100	1.00	2.0	723.0	727.7	2.33	1652.13
22.200	1.00	2.0	720.4	725.0	2.32	1652.12
22.300	1.00	2.0	717.7	722.4	2.32	1652.10
22.400	1.00	2.0	715.1	719.7	2.32	1652.09
22.500	1.00	2.0	712.5	717.1	2.32	1652.08
22.600	1.00	2.0	709.8	714.5	2.31	1652.07
22.700	1.00	2.0	707.2	711.8	2.31	1652.06
22.800	1.00	2.0	704.6	709.2	2.31	1652.05
22.900	1.00	2.0	702.0	706.6	2.31	1652.04
23.000	1.00	2.0	699.4	704.0	2.31	1652.03
23.100	1.00	2.0	696.7	701.4	2.30	1652.02
23.200	1.00	2.0	694.1	698.7	2.30	1652.01
23.300	1.00	2.0	691.5	696.1	2.30	1652.00
23.400	1.00	2.0	688.9	693.5	2.30	1651.99
23.500	1.00	2.0	686.3	690.9	2.30	1651.98
23.600	1.00	2.0	683.8	688.3	2.29	1651.97
23.700	1.00	2.0	681.2	685.8	2.29	1651.96
23.800	1.00	2.0	678.6	683.2	2.29	1651.95
23.900	1.00	2.0	676.0	680.6	2.29	1651.94
24.000	0.00	1.0	672.5	677.0	2.28	1651.92
24.100	0.00	0.0	667.9	672.5	2.28	1651.91
24.200	0.00	0.0	663.3	667.9	2.28	1651.89
24.300	0.00	0.0	658.8	663.3	2.27	1651.87
24.400	0.00	0.0	654.2	658.8	2.27	1651.85
24.500	0.00	0.0	649.7	654.2	2.27	1651.83
24.600	0.00	0.0	645.2	649.7	2.26	1651.81

Pond File: CMC2 .PND
Inflow Hydrograph: CMC2 .HYD
Outflow Hydrograph: OUT .HYD

INFLOW HYDROGRAPH		ROUTING COMPUTATIONS				
TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
24.700	0.00	0.0	640.7	645.2	2.26	1651.80
24.800	0.00	0.0	636.2	640.7	2.26	1651.78
24.900	0.00	0.0	631.7	636.2	2.25	1651.76
25.000	0.00	0.0	627.2	631.7	2.25	1651.74
25.100	0.00	0.0	622.7	627.2	2.24	1651.72
25.200	0.00	0.0	618.2	622.7	2.24	1651.70
25.300	0.00	0.0	613.7	618.2	2.24	1651.69
25.400	0.00	0.0	609.2	613.7	2.23	1651.67
25.500	0.00	0.0	604.8	609.2	2.23	1651.65
25.600	0.00	0.0	600.3	604.8	2.23	1651.63
25.700	0.00	0.0	595.9	600.3	2.22	1651.61
25.800	0.00	0.0	591.5	595.9	2.22	1651.59
25.900	0.00	0.0	587.0	591.5	2.22	1651.58

****************** SUMMARY OF ROUTING COMPUTATIONS ******************

Pond File: CMC2 .PND
Inflow Hydrograph: CMC2 .HYD
Outflow Hydrograph: OUT .HYD

Starting Pond W.S. Elevation = 1646.00 ft

***** Summary of Peak Outflow and Peak Elevation *****

Peak Inflow = 59.00 cfs
Peak Outflow = 2.40 cfs
Peak Elevation = 1652.51 ft

***** Summary of Approximate Peak Storage *****

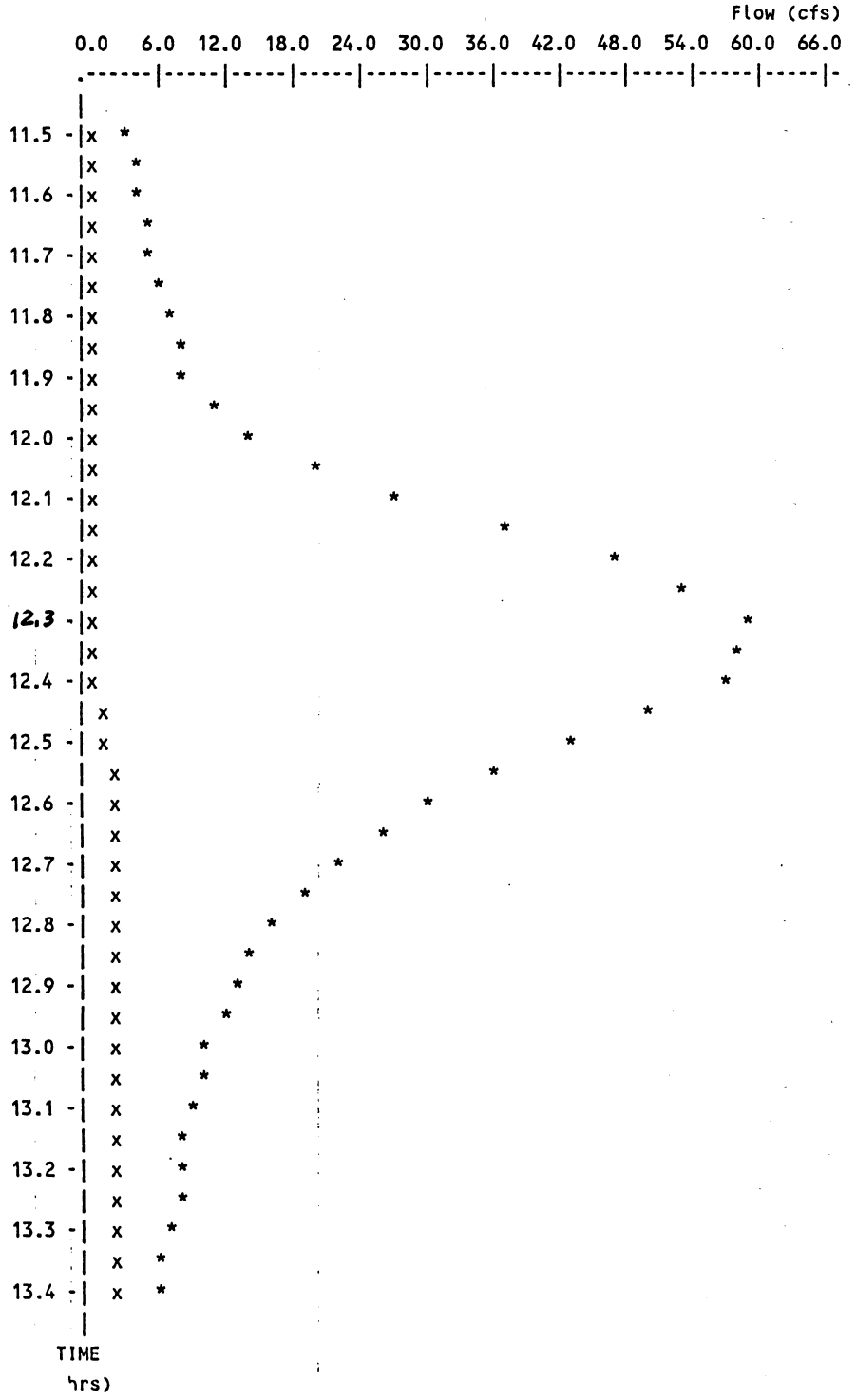
Initial Storage	=	0.00 ac-ft
Peak Storage From Storm	=	3.40 ac-ft
Total Storage in Pond	=	3.40 ac-ft

Warning: Inflow hydrograph truncated on left side.

Pond File: CMC2 .PND
Inflow Hydrograph: CMC2 .HYD
Outflow Hydrograph: OUT .HYD

EXECUTED: 04-25-1995
06:30:13

Peak Inflow = 59.00 cfs
Peak Outflow = 2.40 cfs
Peak Elevation = 1652.51 ft



* File: CMC2 .HYD Qmax = 59.0 cfs
x File: OUT .HYD Qmax = 2.4 cfs

Crandon Mining Company

Plant Site Runoff Basin 2

QTR-55 Hydrology
Pond-2 Hydrology

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 04-13-1995 15:09:28
Watershed file: --> CMC3 .WSD
Hydrograph file: --> CMC3 .HYD

CRANDON MINING COMPANY
FOTH AND VAN DYKE 93C049.27
PROPOSED CONDITIONS 4/95
25 YR STORM EVENT

>>>> Input Parameters Used to Compute Hydrograph <<<<

Subarea Description	AREA (acres)	CN	Tc (hrs)	* Tt (hrs)	Precip. (in)	Runoff (in)	Ia/p input	Ia/p used
BASIN NO. 2	12.76	88.0	0.30	0.00	4.20	2.92	.06	.10

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 12.76 acres or 0.01994 sq.mi
Peak discharge = 39 cfs

>>>> Computer Modifications of Input Parameters <<<<<

Subarea Description	Input Values Tc (hr)	Input Values * Tt (hr)	Rounded Values Tc (hr)	Rounded Values * Tt (hr)	Ia/p Interpolated (Yes/No)	Ia/p Messages
BASIN NO. 2	0.34	0.00	0.30	0.00	No	Computed Ia/p < .1

* Travel time from subarea outfall to composite watershed outfall point.

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 04-13-1995 15:09:28
Watershed file: --> CMC3 .WSD
Hydrograph file: --> CMC3 .HYD

CRANDON MINING COMPANY
FOTH AND VAN DYKE 93C049.27
PROPOSED CONDITIONS 4/95
25 YR STORM EVENT

>>>> Summary of Subarea Times to Peak <<<<

Subarea	Peak Discharge at Composite Outfall (cfs)	Time to Peak at Composite Outfall (hrs)
BASIN NO. 2	39	12.2
Composite Watershed	39	12.2

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 04-13-1995 15:09:28
Watershed file: --> CMC3 .WSD
Hydrograph file: --> CMC3 .HYD

CRANDON MINING COMPANY
FOTH AND VAN DYKE 93C049.27
PROPOSED CONDITIONS 4/95
25 YR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	11.0 hr	11.3 hr	11.6 hr	11.9 hr	12.0 hr	12.1 hr	12.2 hr	12.3 hr	12.4 hr
BASIN NO. 2	1	2	2	7	14	26	39	39	27
Total (cfs)	1	2	2	7	14	26	39	39	27

Subarea Description	12.5 hr	12.6 hr	12.7 hr	12.8 hr	13.0 hr	13.2 hr	13.4 hr	13.6 hr	13.8 hr
BASIN NO. 2	16	11	8	7	5	4	3	3	3
Total (cfs)	16	11	8	7	5	4	3	3	3

Subarea Description	14.0 hr	14.3 hr	14.6 hr	15.0 hr	15.5 hr	16.0 hr	16.5 hr	17.0 hr	17.5 hr
BASIN NO. 2	2	2	2	2	2	1	1	1	1
Total (cfs)	2	2	2	2	2	1	1	1	1

Subarea Description	18.0 hr	19.0 hr	20.0 hr	22.0 hr	26.0 hr
BASIN NO. 2	1	1	1	1	0
Total (cfs)	1	1	1	1	0

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 04-13-1995 15:09:28
Watershed file: --> CMC3 .WSD
Hydrograph file: --> CMC3 .HYD

CRANDON MINING COMPANY
FOTH AND VAN DYKE 93C049.27
PROPOSED CONDITIONS 4/95
25 YR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
11.0	1	14.8	2
11.1	1	14.9	2
11.2	2	15.0	2
11.3	2	15.1	2
11.4	2	15.2	2
11.5	2	15.3	2
11.6	2	15.4	2
11.7	4	15.5	2
11.8	5	15.6	2
11.9	7	15.7	2
12.0	14	15.8	1
12.1	26	15.9	1
12.2	39	16.0	1
12.3	39	16.1	1
12.4	27	16.2	1
12.5	16	16.3	1
12.6	11	16.4	1
12.7	8	16.5	1
12.8	7	16.6	1
12.9	6	16.7	1
13.0	5	16.8	1
13.1	4	16.9	1
13.2	4	17.0	1
13.3	4	17.1	1
13.4	3	17.2	1
13.5	3	17.3	1
13.6	3	17.4	1
13.7	3	17.5	1
13.8	3	17.6	1
13.9	2	17.7	1
14.0	2	17.8	1
14.1	2	17.9	1
14.2	2	18.0	1
14.3	2	18.1	1
14.4	2	18.2	1
14.5	2	18.3	1
14.6	2	18.4	1

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 04-13-1995 15:09:28
Watershed file: --> CMC3 .WSD
Hydrograph file: --> CMC3 .HYD

CRANDON MINING COMPANY
FOTH AND VAN DYKE 93C049.27
PROPOSED CONDITIONS 4/95
25 YR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
18.6	1	22.4	1
18.7	1	22.5	1
18.8	1	22.6	1
18.9	1	22.7	1
19.0	1	22.8	1
19.1	1	22.9	1
19.2	1	23.0	1
19.3	1	23.1	1
19.4	1	23.2	1
19.5	1	23.3	1
19.6	1	23.4	1
19.7	1	23.5	1
19.8	1	23.6	1
19.9	1	23.7	1
20.0	1	23.8	1
20.1	1	23.9	1
20.2	1	24.0	0
20.3	1	24.1	0
20.4	1	24.2	0
20.5	1	24.3	0
20.6	1	24.4	0
20.7	1	24.5	0
20.8	1	24.6	0
20.9	1	24.7	0
21.0	1	24.8	0
21.1	1	24.9	0
21.2	1	25.0	0
21.3	1	25.1	0
21.4	1	25.2	0
21.5	1	25.3	0
21.6	1	25.4	0
21.7	1	25.5	0
21.8	1	25.6	0
21.9	1	25.7	0
22.0	1	25.8	0
22.1	1	25.9	0
22.2	1		
22.3	1		

```
**********************************************************************
*                                                                    *
* CRANDON MINING COMPANY          93C049.27      FOTH & VAN DYKE     *
*          RUNOFF  BASIN NO. 2                       4/95            *
*                                                                    *
*                                                                    *
*                                                                    *
**********************************************************************
```

Inflow Hydrograph: CMC3 .HYD
Rating Table file: CMC3 .PND

----INITIAL CONDITIONS----
Elevation = 1605.00 ft
Outflow = 0.00 cfs
Storage = 0.00 ac-ft

GIVEN POND DATA			INTERMEDIATE ROUTING COMPUTATIONS	
ELEVATION (ft)	OUTFLOW (cfs)	STORAGE (ac-ft)	2S/t (cfs)	2S/t + O (cfs)
1605.00	0.0	0.000	0.0	0.0
1605.50	0.0	0.006	1.4	1.4
1606.00	0.0	0.014	3.3	3.3
1606.50	0.0	0.024	5.8	5.8
1607.00	0.0	0.038	9.1	9.1
1607.50	0.0	0.055	13.3	13.3
1608.00	0.0	0.077	18.6	18.6
1608.50	0.0	0.243	58.8	58.8
1609.00	0.0	0.420	101.7	101.7
1609.50	0.0	0.609	147.3	147.3
1610.00	0.0	0.809	195.8	195.8
1610.50	2.2	1.022	247.2	249.4
1611.00	2.3	1.247	301.7	304.0
1611.50	2.4	1.484	359.2	361.6
1612.00	2.5	1.735	420.0	422.5
1612.50	2.6	2.000	484.0	486.6
1613.00	2.7	2.278	551.4	554.1
1613.50	2.8	2.571	622.2	625.0
1614.00	2.8	2.878	696.6	699.4
1614.50	2.9	3.201	774.6	777.5
1615.00	3.0	3.538	856.3	859.3

Time increment (t) = 0.100 hrs.

P File: CMC3 .PND
Inflow Hydrograph: CMC3 .HYD
Outflow Hydrograph: OUT .HYD

INFLOW HYDROGRAPH		ROUTING COMPUTATIONS				
TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
11.000	1.00	-----	0.0	0.0	0.00	1605.00
11.100	1.00	2.0	2.0	2.0	0.00	1605.67
11.200	2.00	3.0	5.0	5.0	0.00	1606.34
11.300	2.00	4.0	9.0	9.0	0.00	1606.98
11.400	2.00	4.0	13.0	13.0	0.00	1607.47
11.500	2.00	4.0	17.0	17.0	0.00	1607.85
11.600	2.00	4.0	21.0	21.0	0.00	1608.03
11.700	4.00	6.0	27.0	27.0	0.00	1608.10
11.800	5.00	9.0	36.0	36.0	0.00	1608.22
11.900	7.00	12.0	48.0	48.0	0.00	1608.37
12.000	14.00	21.0	69.0	69.0	0.00	1608.62
12.100	26.00	40.0	109.0	109.0	0.00	1609.08
12.200	39.00	65.0	174.0	174.0	0.00	1609.77
12.300	39.00	78.0	247.6	252.0	2.20	1610.52
12.400	27.00	66.0	309.0	313.6	2.32	1611.08
12.500	16.00	43.0	347.2	352.0	2.38	1611.42
12.600	11.00	27.0	369.3	374.2	2.42	1611.60
12.700	8.00	19.0	383.5	388.3	2.44	1611.72
12.800	7.00	15.0	393.5	398.5	2.46	1611.80
12.900	6.00	13.0	401.6	406.5	2.47	1611.87
13.000	5.00	11.0	407.6	412.6	2.48	1611.92
13.100	4.00	9.0	411.6	416.6	2.49	1611.95
13.200	4.00	8.0	414.7	419.6	2.50	1611.98
13.300	4.00	8.0	417.7	422.7	2.50	1612.00
13.400	3.00	7.0	419.6	424.7	2.50	1612.02
13.500	3.00	6.0	420.6	425.6	2.50	1612.02
13.600	3.00	6.0	421.6	426.6	2.51	1612.03
13.700	3.00	6.0	422.6	427.6	2.51	1612.04
13.800	3.00	6.0	423.6	428.6	2.51	1612.05
13.900	2.00	5.0	423.6	428.6	2.51	1612.05
14.000	2.00	4.0	422.6	427.6	2.51	1612.04
14.100	2.00	4.0	421.5	426.6	2.51	1612.03
14.200	2.00	4.0	420.5	425.5	2.50	1612.02
14.300	2.00	4.0	419.5	424.5	2.50	1612.02
14.400	2.00	4.0	418.5	423.5	2.50	1612.01
14.500	2.00	4.0	417.5	422.5	2.50	1612.00
14.600	2.00	4.0	416.5	421.5	2.50	1611.99
14.700	2.00	4.0	415.5	420.5	2.50	1611.98
14.800	2.00	4.0	414.5	419.5	2.50	1611.98
14.900	2.00	4.0	413.6	418.5	2.49	1611.97
15.000	2.00	4.0	412.6	417.6	2.49	1611.96
15.100	2.00	4.0	411.6	416.6	2.49	1611.95
15.200	2.00	4.0	410.6	415.6	2.49	1611.94
15.300	2.00	4.0	409.6	414.6	2.49	1611.94
15.400	2.00	4.0	408.7	413.6	2.49	1611.93

P File: CMC3 .PND
Inflow Hydrograph: CMC3 .HYD
Outflow Hydrograph: OUT .HYD

INFLOW HYDROGRAPH / ROUTING COMPUTATIONS

TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
15.500	2.00	4.0	407.7	412.7	2.48	1611.92
15.600	2.00	4.0	406.7	411.7	2.48	1611.91
15.700	2.00	4.0	405.8	410.7	2.48	1611.90
15.800	1.00	3.0	403.8	408.8	2.48	1611.89
15.900	1.00	2.0	400.9	405.8	2.47	1611.86
16.000	1.00	2.0	397.9	402.9	2.47	1611.84
16.100	1.00	2.0	395.0	399.9	2.46	1611.81
16.200	1.00	2.0	392.1	397.0	2.46	1611.79
16.300	1.00	2.0	389.2	394.1	2.45	1611.77
16.400	1.00	2.0	386.3	391.2	2.45	1611.74
16.500	1.00	2.0	383.4	388.3	2.44	1611.72
16.600	1.00	2.0	380.5	385.4	2.44	1611.70
16.700	1.00	2.0	377.7	382.5	2.43	1611.67
16.800	1.00	2.0	374.8	379.7	2.43	1611.65
16.900	1.00	2.0	371.9	376.8	2.42	1611.62
17.000	1.00	2.0	369.1	373.9	2.42	1611.60
17.100	1.00	2.0	366.3	371.1	2.42	1611.58
17.200	1.00	2.0	363.5	368.3	2.41	1611.55
17.300	1.00	2.0	360.6	365.5	2.41	1611.53
17.400	1.00	2.0	357.8	362.6	2.40	1611.51
17.500	1.00	2.0	355.0	359.8	2.40	1611.48
17.600	1.00	2.0	352.3	357.0	2.39	1611.46
17.700	1.00	2.0	349.5	354.3	2.39	1611.44
17.800	1.00	2.0	346.7	351.5	2.38	1611.41
17.900	1.00	2.0	344.0	348.7	2.38	1611.39
18.000	1.00	2.0	341.2	346.0	2.37	1611.36
18.100	1.00	2.0	338.5	343.2	2.37	1611.34
18.200	1.00	2.0	335.8	340.5	2.36	1611.32
18.300	1.00	2.0	333.0	337.8	2.36	1611.29
18.400	1.00	2.0	330.3	335.0	2.35	1611.27
18.500	1.00	2.0	327.6	332.3	2.35	1611.25
18.600	1.00	2.0	324.9	329.6	2.34	1611.22
18.700	1.00	2.0	322.3	326.9	2.34	1611.20
18.800	1.00	2.0	319.6	324.3	2.34	1611.18
18.900	1.00	2.0	316.9	321.6	2.33	1611.15
19.000	1.00	2.0	314.3	318.9	2.33	1611.13
19.100	1.00	2.0	311.6	316.3	2.32	1611.11
19.200	1.00	2.0	309.0	313.6	2.32	1611.08
19.300	1.00	2.0	306.4	311.0	2.31	1611.06
19.400	1.00	2.0	303.8	308.4	2.31	1611.04
19.500	1.00	2.0	301.2	305.8	2.30	1611.02
19.600	1.00	2.0	298.6	303.2	2.30	1610.99
19.700	1.00	2.0	296.0	300.6	2.29	1610.97
19.300	1.00	2.0	293.4	298.0	2.29	1610.94
19.900	1.00	2.0	290.8	295.4	2.28	1610.92
20.000	1.00	2.0	288.3	292.8	2.28	1610.90

Input File: CMC3 .PND
Inflow Hydrograph: CMC3 .HYD
Outflow Hydrograph: OUT .HYD

INFLOW HYDROGRAPH		ROUTING COMPUTATIONS				
TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
20.100	1.00	2.0	285.7	290.3	2.27	1610.87
20.200	1.00	2.0	283.2	287.7	2.27	1610.85
20.300	1.00	2.0	280.6	285.2	2.27	1610.83
20.400	1.00	2.0	278.1	282.6	2.26	1610.80
20.500	1.00	2.0	275.6	280.1	2.26	1610.78
20.600	1.00	2.0	273.1	277.6	2.25	1610.76
20.700	1.00	2.0	270.6	275.1	2.25	1610.74
20.800	1.00	2.0	268.1	272.6	2.24	1610.71
20.900	1.00	2.0	265.7	270.1	2.24	1610.69
21.000	1.00	2.0	263.2	267.7	2.23	1610.67
21.100	1.00	2.0	260.7	265.2	2.23	1610.64
21.200	1.00	2.0	258.3	262.7	2.22	1610.62
21.300	1.00	2.0	255.8	260.3	2.22	1610.60
21.400	1.00	2.0	253.4	257.8	2.22	1610.58
21.500	1.00	2.0	251.0	255.4	2.21	1610.55
21.600	1.00	2.0	248.6	253.0	2.21	1610.53
21.700	1.00	2.0	246.2	250.6	2.20	1610.51
21.800	1.00	2.0	243.9	248.2	2.15	1610.49
21.900	1.00	2.0	241.8	245.9	2.05	1610.47
22.000	1.00	2.0	239.8	243.8	1.97	1610.45
22.100	1.00	2.0	238.1	241.8	1.89	1610.43
22.200	1.00	2.0	236.4	240.1	1.81	1610.41
22.300	1.00	2.0	234.9	238.4	1.75	1610.40
22.400	1.00	2.0	233.6	236.9	1.69	1610.38
22.500	1.00	2.0	232.3	235.6	1.63	1610.37
22.600	1.00	2.0	231.1	234.3	1.58	1610.36
22.700	1.00	2.0	230.1	233.1	1.53	1610.35
22.800	1.00	2.0	229.1	232.1	1.49	1610.34
22.900	1.00	2.0	228.2	231.1	1.45	1610.33
23.000	1.00	2.0	227.4	230.2	1.41	1610.32
23.100	1.00	2.0	226.6	229.4	1.38	1610.31
23.200	1.00	2.0	225.9	228.6	1.35	1610.31
23.300	1.00	2.0	225.3	227.9	1.32	1610.30
23.400	1.00	2.0	224.7	227.3	1.29	1610.29
23.500	1.00	2.0	224.2	226.7	1.27	1610.29
23.600	1.00	2.0	223.7	226.2	1.25	1610.28
23.700	1.00	2.0	223.2	225.7	1.23	1610.28
23.800	1.00	2.0	222.8	225.2	1.21	1610.27
23.900	1.00	2.0	222.5	224.8	1.19	1610.27
24.000	0.00	1.0	221.2	223.5	1.13	1610.26
24.100	0.00	0.0	219.1	221.2	1.04	1610.24
24.200	0.00	0.0	217.2	219.1	0.96	1610.22
24.300	0.00	0.0	215.4	217.2	0.88	1610.20
24.400	0.00	0.0	213.8	215.4	0.80	1610.18
24.500	0.00	0.0	212.4	213.8	0.74	1610.17
24.600	0.00	0.0	211.0	212.4	0.68	1610.15

File: CMC3 .PND
Inflow Hydrograph: CMC3 .HYD
Outflow Hydrograph: OUT .HYD

INFLOW HYDROGRAPH		ROUTING COMPUTATIONS				
TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
24.700	0.00	0.0	209.8	211.0	0.62	1610.14
24.800	0.00	0.0	208.6	209.8	0.57	1610.13
24.900	0.00	0.0	207.6	208.6	0.52	1610.12
25.000	0.00	0.0	206.6	207.6	0.48	1610.11
25.100	0.00	0.0	205.7	206.6	0.44	1610.10
25.200	0.00	0.0	204.9	205.7	0.41	1610.09
25.300	0.00	0.0	204.2	204.9	0.37	1610.08
25.400	0.00	0.0	203.5	204.2	0.34	1610.08
25.500	0.00	0.0	202.8	203.5	0.31	1610.07
25.600	0.00	0.0	202.3	202.8	0.29	1610.07
25.700	0.00	0.0	201.7	202.3	0.26	1610.06
25.800	0.00	0.0	201.3	201.7	0.24	1610.06
25.900	0.00	0.0	200.8	201.3	0.22	1610.05

********** SUMMARY OF ROUTING COMPUTATIONS **********

Pond File: CMC3 .PND
Inflow Hydrograph: CMC3 .HYD
Outflow Hydrograph: OUT .HYD

Starting Pond W.S. Elevation = 1605.00 ft

***** Summary of Peak Outflow and Peak Elevation *****

Peak Inflow	=	39.00 cfs
Peak Outflow	=	2.51 cfs
Peak Elevation	=	1612.05 ft

***** Summary of Approximate Peak Storage *****

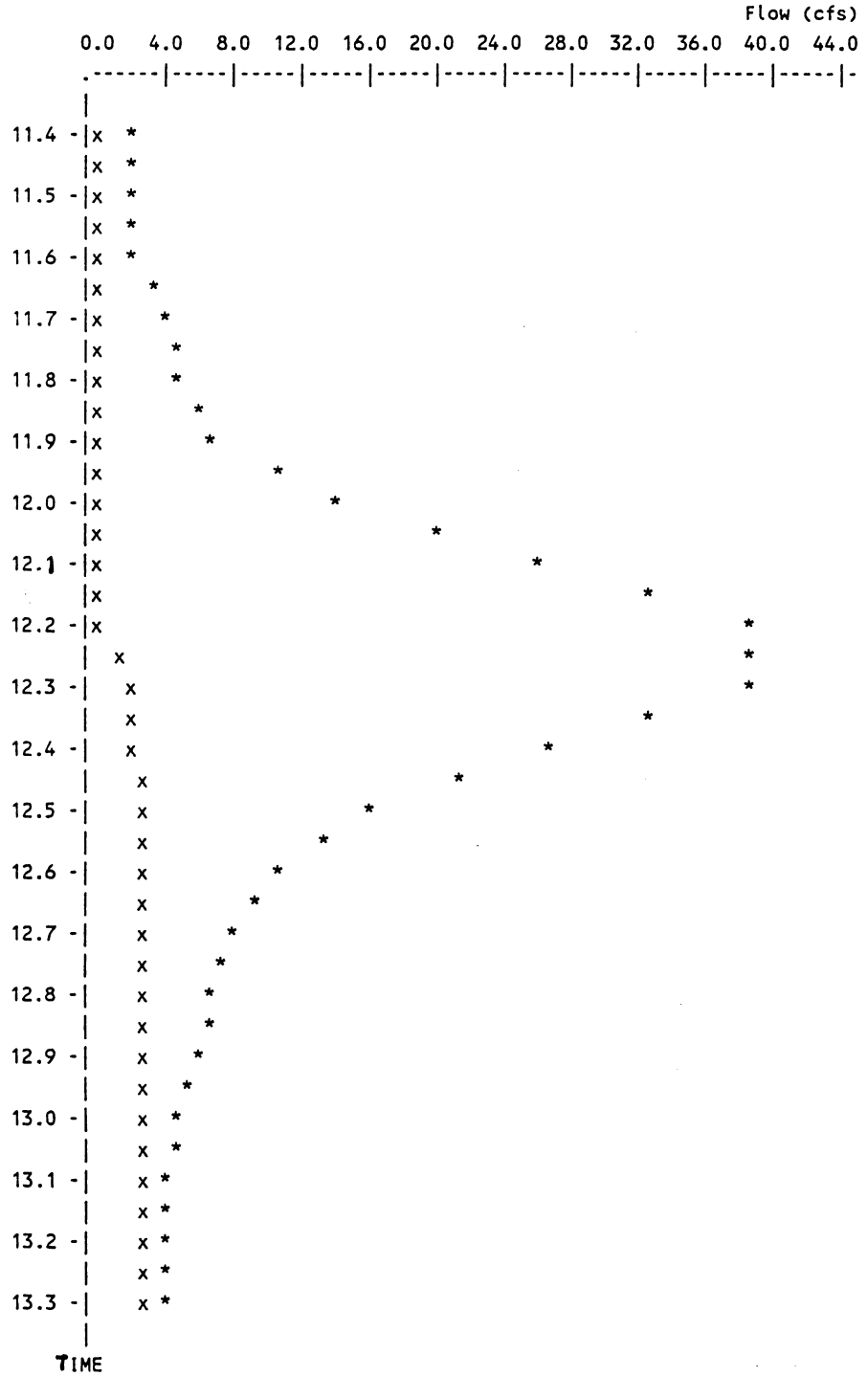
Initial Storage	=	0.00 ac-ft
Peak Storage From Storm	=	1.76 ac-ft
Total Storage in Pond	=	1.76 ac-ft

Warning: Inflow hydrograph truncated on left side.

Pond File: CMC3 .PND
Inflow Hydrograph: CMC3 .HYD
Outflow Hydrograph: OUT .HYD

EXECUTED: 04-27-1995
07:29:11

Peak Inflow = 39.00 cfs
Peak Outflow = 2.51 cfs
Peak Elevation = 1612.05 ft



* File: CMC3 .HYD Qmax = 39.0 cfs
x File: OUT .HYD Qmax = 2.5 cfs

Crandon Mining Company

Plant Site Runoff Basin 3

QTR-55 Hydrology
Pond-2 Hydrology

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 04-13-1995 15:11:23
Watershed file: --> CMC4 .WSD
Hydrograph file: --> CMC4 .HYD

CRANDON MINING COMPANY
FOTH AND VAN DYKE 93C049.27
PROPOSED CONDITIONS 4/95
25 YR STORM EVENT

>>>> Input Parameters Used to Compute Hydrograph <<<<

Subarea Description	AREA (acres)	CN	Tc (hrs)	* Tt (hrs)	Precip. (in)	Runoff (in)	Ia/p input/used
BASIN NO. 3	11.04	88.0	0.40	0.00	4.20	2.92	.06 .10

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 11.04 acres or 0.01725 sq.mi
Peak discharge = 30 cfs

>>>> Computer Modifications of Input Parameters <<<<<

Subarea Description	Input Values Tc (hr)	Input Values * Tt (hr)	Rounded Values Tc (hr)	Rounded Values * Tt (hr)	Ia/p Interpolated (Yes/No)	Ia/p Messages
BASIN NO. 3	0.35	0.00	0.40	0.00	No	Computed Ia/p < .1

* Travel time from subarea outfall to composite watershed outfall point.

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 04-13-1995 15:11:23
Watershed file: --> CMC4 .WSD
Hydrograph file: --> CMC4 .HYD

CRANDON MINING COMPANY
FOTH AND VAN DYKE 93C049.27
PROPOSED CONDITIONS 4/95
25 YR STORM EVENT

>>>> Summary of Subarea Times to Peak <<<<

Subarea	Peak Discharge at Composite Outfall (cfs)	Time to Peak at Composite Outfall (hrs)
BASIN NO. 3	30	12.3
Composite Watershed	30	12.3

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 04-13-1995 15:11:23
Watershed file: --> CMC4 .WSD
Hydrograph file: --> CMC4 .HYD

CRANDON MINING COMPANY
FOTH AND VAN DYKE 93C049.27
PROPOSED CONDITIONS 4/95
25 YR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	11.0 hr	11.3 hr	11.6 hr	11.9 hr	12.0 hr	12.1 hr	12.2 hr	12.3 hr	12.4 hr
BASIN NO. 3	1	1	2	4	7	14	24	30	29
Total (cfs)	1	1	2	4	7	14	24	30	29

Subarea Description	12.5 hr	12.6 hr	12.7 hr	12.8 hr	13.0 hr	13.2 hr	13.4 hr	13.6 hr	13.8 hr
BASIN NO. 3	22	15	11	8	5	4	3	3	2
Total (cfs)	22	15	11	8	5	4	3	3	2

Subarea Description	14.0 hr	14.3 hr	14.6 hr	15.0 hr	15.5 hr	16.0 hr	16.5 hr	17.0 hr	17.5 hr
BASIN NO. 3	2	2	2	2	1	1	1	1	1
Total (cfs)	2	2	2	2	1	1	1	1	1

Subarea Description	18.0 hr	19.0 hr	20.0 hr	22.0 hr	26.0 hr
BASIN NO. 3	1	1	1	1	0
Total (cfs)	1	1	1	1	0

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 04-13-1995 15:11:23
Watershed file: --> CMC4 .WSD
Hydrograph file: --> CMC4 .HYD

CRANDON MINING COMPANY
FOTH AND VAN DYKE 93C049.27
PROPOSED CONDITIONS 4/95
25 YR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
11.0	1	14.8	2
11.1	1	14.9	2
11.2	1	15.0	2
11.3	1	15.1	2
11.4	1	15.2	2
11.5	2	15.3	1
11.6	2	15.4	1
11.7	3	15.5	1
11.8	3	15.6	1
11.9	4	15.7	1
12.0	7	15.8	1
12.1	14	15.9	1
12.2	24	16.0	1
12.3	30	16.1	1
12.4	29	16.2	1
12.5	22	16.3	1
12.6	15	16.4	1
12.7	11	16.5	1
12.8	8	16.6	1
12.9	6	16.7	1
13.0	5	16.8	1
13.1	4	16.9	1
13.2	4	17.0	1
13.3	4	17.1	1
13.4	3	17.2	1
13.5	3	17.3	1
13.6	3	17.4	1
13.7	2	17.5	1
13.8	2	17.6	1
13.9	2	17.7	1
14.0	2	17.8	1
14.1	2	17.9	1
14.2	2	18.0	1
14.3	2	18.1	1
14.4	2	18.2	1
14.5	2	18.3	1
14.6	2	18.4	1

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 04-13-1995 15:11:23
Watershed file: --> CMC4 .WSD
Hydrograph file: --> CMC4 .HYD

CRANDON MINING COMPANY
FOTH AND VAN DYKE 93C049.27
PROPOSED CONDITIONS 4/95
25 YR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
18.6	1	22.4	1
18.7	1	22.5	1
18.8	1	22.6	1
18.9	1	22.7	1
19.0	1	22.8	1
19.1	1	22.9	1
19.2	1	23.0	1
19.3	1	23.1	1
19.4	1	23.2	1
19.5	1	23.3	1
19.6	1	23.4	1
19.7	1	23.5	1
19.8	1	23.6	1
19.9	1	23.7	1
20.0	1	23.8	1
20.1	1	23.9	1
20.2	1	24.0	0
20.3	1	24.1	0
20.4	1	24.2	0
20.5	1	24.3	0
20.6	1	24.4	0
20.7	1	24.5	0
20.8	1	24.6	0
20.9	1	24.7	0
21.0	1	24.8	0
21.1	1	24.9	0
21.2	1	25.0	0
21.3	1	25.1	0
21.4	1	25.2	0
21.5	1	25.3	0
21.6	1	25.4	0
21.7	1	25.5	0
21.8	1	25.6	0
21.9	1	25.7	0
22.0	1	25.8	0
22.1	1	25.9	0
22.2	1		
22.3	1		

****
*
* CRANDON MINING COMPANY 93C049.27 FOTH & VAN DYKE *
* RUNOFF BASIN NO. 3 4/95 *
*
*
*
****

Inflow Hydrograph: CMC4 .HYD
Rating Table file: CMC4 .PND

----INITIAL CONDITIONS----
Elevation = 1629.00 ft
Outflow = 0.00 cfs
Storage = 0.00 ac-ft

GIVEN POND DATA			INTERMEDIATE ROUTING COMPUTATIONS	
ELEVATION (ft)	OUTFLOW (cfs)	STORAGE (ac-ft)	2S/t (cfs)	2S/t + O (cfs)
1629.00	0.0	0.000	0.0	0.0
1629.50	0.0	0.006	1.4	1.4
1630.00	0.0	0.014	3.3	3.3
1630.50	0.0	0.024	5.8	5.8
1631.00	0.0	0.038	9.1	9.1
1631.50	0.0	0.055	13.3	13.3
1632.00	0.0	0.077	18.7	18.7
1632.50	0.0	0.255	61.8	61.8
1633.00	0.0	0.445	107.6	107.6
1633.50	0.0	0.646	156.2	156.2
1634.00	0.0	0.858	207.7	207.7
1634.50	2.2	1.084	262.2	264.4
1635.00	2.3	1.321	319.7	322.0
1635.50	2.4	1.572	380.4	382.8
1636.00	2.5	1.836	444.3	446.8
1636.50	2.6	2.114	511.5	514.1
1637.00	2.7	2.405	582.0	584.7
1637.50	2.8	2.711	656.1	658.9
1638.00	2.8	3.032	733.7	736.5
1638.50	2.9	3.367	814.9	817.8
1639.00	3.0	3.718	899.8	902.8

Time increment (t) = 0.100 hrs.

I File: CMC4 .PND
Inflow Hydrograph: CMC4 .HYD
Outflow Hydrograph: OUT .HYD

INFLOW HYDROGRAPH		ROUTING COMPUTATIONS				
TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
11.000	1.00	-----	0.0	0.0	0.00	1629.00
11.100	1.00	2.0	2.0	2.0	0.00	1629.67
11.200	1.00	2.0	4.0	4.0	0.00	1630.14
11.300	1.00	2.0	6.0	6.0	0.00	1630.53
11.400	1.00	2.0	8.0	8.0	0.00	1630.83
11.500	2.00	3.0	11.0	11.0	0.00	1631.23
11.600	2.00	4.0	15.0	15.0	0.00	1631.66
11.700	3.00	5.0	20.0	20.0	0.00	1632.02
11.800	3.00	6.0	26.0	26.0	0.00	1632.09
11.900	4.00	7.0	33.0	33.0	0.00	1632.17
12.000	7.00	11.0	44.0	44.0	0.00	1632.29
12.100	14.00	21.0	65.0	65.0	0.00	1632.54
12.200	24.00	38.0	103.0	103.0	0.00	1632.95
12.300	30.00	54.0	157.0	157.0	0.00	1633.51
12.400	29.00	59.0	215.4	216.0	0.32	1634.07
12.500	22.00	51.0	262.0	266.4	2.20	1634.52
12.600	15.00	37.0	294.4	299.0	2.26	1634.80
12.700	11.00	26.0	315.8	320.4	2.30	1634.99
12.800	8.00	19.0	330.2	334.8	2.32	1635.11
12.900	6.00	14.0	339.5	344.2	2.34	1635.18
13.000	5.00	11.0	345.8	350.5	2.35	1635.23
13.100	4.00	9.0	350.1	354.8	2.35	1635.27
13.200	4.00	8.0	353.4	358.1	2.36	1635.30
13.300	4.00	8.0	356.7	361.4	2.36	1635.32
13.400	3.00	7.0	358.9	363.7	2.37	1635.34
13.500	3.00	6.0	360.2	364.9	2.37	1635.35
13.600	3.00	6.0	361.4	366.2	2.37	1635.36
13.700	2.00	5.0	361.7	366.4	2.37	1635.37
13.800	2.00	4.0	361.0	365.7	2.37	1635.36
13.900	2.00	4.0	360.2	365.0	2.37	1635.35
14.000	2.00	4.0	359.5	364.2	2.37	1635.35
14.100	2.00	4.0	358.7	363.5	2.37	1635.34
14.200	2.00	4.0	358.0	362.7	2.37	1635.33
14.300	2.00	4.0	357.3	362.0	2.37	1635.33
14.400	2.00	4.0	356.5	361.3	2.36	1635.32
14.500	2.00	4.0	355.8	360.5	2.36	1635.32
14.600	2.00	4.0	355.1	359.8	2.36	1635.31
14.700	2.00	4.0	354.4	359.1	2.36	1635.30
14.800	2.00	4.0	353.7	358.4	2.36	1635.30
14.900	2.00	4.0	352.9	357.7	2.36	1635.29
15.000	2.00	4.0	352.2	356.9	2.36	1635.29
15.100	2.00	4.0	351.5	356.2	2.36	1635.28
15.200	2.00	4.0	350.8	355.5	2.36	1635.28
15.300	1.00	3.0	349.1	353.8	2.35	1635.26
15.400	1.00	2.0	346.4	351.1	2.35	1635.24

File: CMC4 .PND
Inflow Hydrograph: CMC4 .HYD
Outflow Hydrograph: OUT .HYD

INFLOW HYDROGRAPH		ROUTING COMPUTATIONS				
TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
15.500	1.00	2.0	343.7	348.4	2.34	1635.22
15.600	1.00	2.0	341.0	345.7	2.34	1635.19
15.700	1.00	2.0	338.4	343.0	2.33	1635.17
15.800	1.00	2.0	335.7	340.4	2.33	1635.15
15.900	1.00	2.0	333.1	337.7	2.33	1635.13
16.000	1.00	2.0	330.4	335.1	2.32	1635.11
16.100	1.00	2.0	327.8	332.4	2.32	1635.09
16.200	1.00	2.0	325.2	329.8	2.31	1635.06
16.300	1.00	2.0	322.5	327.2	2.31	1635.04
16.400	1.00	2.0	319.9	324.5	2.30	1635.02
16.500	1.00	2.0	317.3	321.9	2.30	1635.00
16.600	1.00	2.0	314.7	319.3	2.30	1634.98
16.700	1.00	2.0	312.2	316.7	2.29	1634.95
16.800	1.00	2.0	309.6	314.2	2.29	1634.93
16.900	1.00	2.0	307.0	311.6	2.28	1634.91
17.000	1.00	2.0	304.5	309.0	2.28	1634.89
17.100	1.00	2.0	301.9	306.5	2.27	1634.86
17.200	1.00	2.0	299.4	303.9	2.27	1634.84
17.300	1.00	2.0	296.9	301.4	2.26	1634.82
17.400	1.00	2.0	294.3	298.9	2.26	1634.80
17.500	1.00	2.0	291.8	296.3	2.26	1634.78
17.600	1.00	2.0	289.3	293.8	2.25	1634.76
17.700	1.00	2.0	286.8	291.3	2.25	1634.73
17.800	1.00	2.0	284.3	288.8	2.24	1634.71
17.900	1.00	2.0	281.9	286.3	2.24	1634.69
18.000	1.00	2.0	279.4	283.9	2.23	1634.67
18.100	1.00	2.0	276.9	281.4	2.23	1634.65
18.200	1.00	2.0	274.5	278.9	2.23	1634.63
18.300	1.00	2.0	272.0	276.5	2.22	1634.60
18.400	1.00	2.0	269.6	274.0	2.22	1634.58
18.500	1.00	2.0	267.2	271.6	2.21	1634.56
18.600	1.00	2.0	264.8	269.2	2.21	1634.54
18.700	1.00	2.0	262.4	266.8	2.20	1634.52
18.800	1.00	2.0	260.0	264.4	2.20	1634.50
18.900	1.00	2.0	257.8	262.0	2.11	1634.48
19.000	1.00	2.0	255.7	259.8	2.02	1634.46
19.100	1.00	2.0	253.8	257.7	1.94	1634.44
19.200	1.00	2.0	252.1	255.8	1.87	1634.42
19.300	1.00	2.0	250.5	254.1	1.80	1634.41
19.400	1.00	2.0	249.0	252.5	1.74	1634.39
19.500	1.00	2.0	247.7	251.0	1.68	1634.38
19.600	1.00	2.0	246.4	249.7	1.63	1634.37
19.700	1.00	2.0	245.3	248.4	1.58	1634.36
19.800	1.00	2.0	244.2	247.3	1.53	1634.35
19.900	1.00	2.0	243.2	246.2	1.49	1634.34
20.000	1.00	2.0	242.3	245.2	1.45	1634.33

File: CMC4 .PND
Inflow Hydrograph: CMC4 .HYD
Outflow Hydrograph: OUT .HYD

INFLOW HYDROGRAPH		ROUTING COMPUTATIONS				
TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
20.100	1.00	2.0	241.5	244.3	1.42	1634.32
20.200	1.00	2.0	240.7	243.5	1.39	1634.32
20.300	1.00	2.0	240.0	242.7	1.36	1634.31
20.400	1.00	2.0	239.3	242.0	1.33	1634.30
20.500	1.00	2.0	238.7	241.3	1.30	1634.30
20.600	1.00	2.0	238.1	240.7	1.28	1634.29
20.700	1.00	2.0	237.6	240.1	1.26	1634.29
20.800	1.00	2.0	237.2	239.6	1.24	1634.28
20.900	1.00	2.0	236.7	239.2	1.22	1634.28
21.000	1.00	2.0	236.3	238.7	1.20	1634.27
21.100	1.00	2.0	235.9	238.3	1.19	1634.27
21.200	1.00	2.0	235.6	237.9	1.17	1634.27
21.300	1.00	2.0	235.3	237.6	1.16	1634.26
21.400	1.00	2.0	235.0	237.3	1.15	1634.26
21.500	1.00	2.0	234.7	237.0	1.14	1634.26
21.600	1.00	2.0	234.5	236.7	1.12	1634.26
21.700	1.00	2.0	234.2	236.5	1.12	1634.25
21.800	1.00	2.0	234.0	236.2	1.11	1634.25
21.900	1.00	2.0	233.8	236.0	1.10	1634.25
22.000	1.00	2.0	233.6	235.8	1.09	1634.25
22.100	1.00	2.0	233.5	235.6	1.08	1634.25
22.200	1.00	2.0	233.3	235.5	1.08	1634.24
22.300	1.00	2.0	233.2	235.3	1.07	1634.24
22.400	1.00	2.0	233.1	235.2	1.07	1634.24
22.500	1.00	2.0	232.9	235.1	1.06	1634.24
22.600	1.00	2.0	232.8	234.9	1.06	1634.24
22.700	1.00	2.0	232.7	234.8	1.05	1634.24
22.800	1.00	2.0	232.6	234.7	1.05	1634.24
22.900	1.00	2.0	232.5	234.6	1.04	1634.24
23.000	1.00	2.0	232.5	234.5	1.04	1634.24
23.100	1.00	2.0	232.4	234.5	1.04	1634.24
23.200	1.00	2.0	232.3	234.4	1.03	1634.24
23.300	1.00	2.0	232.3	234.3	1.03	1634.23
23.400	1.00	2.0	232.2	234.3	1.03	1634.23
23.500	1.00	2.0	232.1	234.2	1.03	1634.23
23.600	1.00	2.0	232.1	234.1	1.02	1634.23
23.700	1.00	2.0	232.0	234.1	1.02	1634.23
23.800	1.00	2.0	232.0	234.0	1.02	1634.23
23.900	1.00	2.0	232.0	234.0	1.02	1634.23
24.000	0.00	1.0	231.0	233.0	0.98	1634.22
24.100	0.00	0.0	229.2	231.0	0.90	1634.21
24.200	0.00	0.0	227.5	229.2	0.83	1634.19
24.300	0.00	0.0	226.0	227.5	0.77	1634.17
24.400	0.00	0.0	224.6	226.0	0.71	1634.16
24.500	0.00	0.0	223.3	224.6	0.65	1634.15
24.600	0.00	0.0	222.1	223.3	0.60	1634.14

File: CMC4 .PND
Inflow Hydrograph: CMC4 .HYD
Outflow Hydrograph: OUT .HYD

INFLOW HYDROGRAPH		ROUTING COMPUTATIONS				
TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
24.700	0.00	0.0	221.0	222.1	0.56	1634.13
24.800	0.00	0.0	219.9	221.0	0.51	1634.12
24.900	0.00	0.0	219.0	219.9	0.47	1634.11
25.000	0.00	0.0	218.1	219.0	0.44	1634.10
25.100	0.00	0.0	217.3	218.1	0.40	1634.09
25.200	0.00	0.0	216.6	217.3	0.37	1634.08
25.300	0.00	0.0	215.9	216.6	0.34	1634.08
25.400	0.00	0.0	215.2	215.9	0.32	1634.07
25.500	0.00	0.0	214.7	215.2	0.29	1634.07
25.600	0.00	0.0	214.1	214.7	0.27	1634.06
25.700	0.00	0.0	213.6	214.1	0.25	1634.06
25.800	0.00	0.0	213.2	213.6	0.23	1634.05
25.900	0.00	0.0	212.7	213.2	0.21	1634.05

********** SUMMARY OF ROUTING COMPUTATIONS **********

Pond File: CMC4 .PND
Inflow Hydrograph: CMC4 .HYD
Outflow Hydrograph: OUT .HYD

Starting Pond W.S. Elevation = 1629.00 ft

***** Summary of Peak Outflow and Peak Elevation *****

Peak Inflow = 30.00 cfs
Peak Outflow = 2.37 cfs
Peak Elevation = 1635.37 ft

***** Summary of Approximate Peak Storage *****

Initial Storage = 0.00 ac-ft
Peak Storage From Storm = 1.50 ac-ft

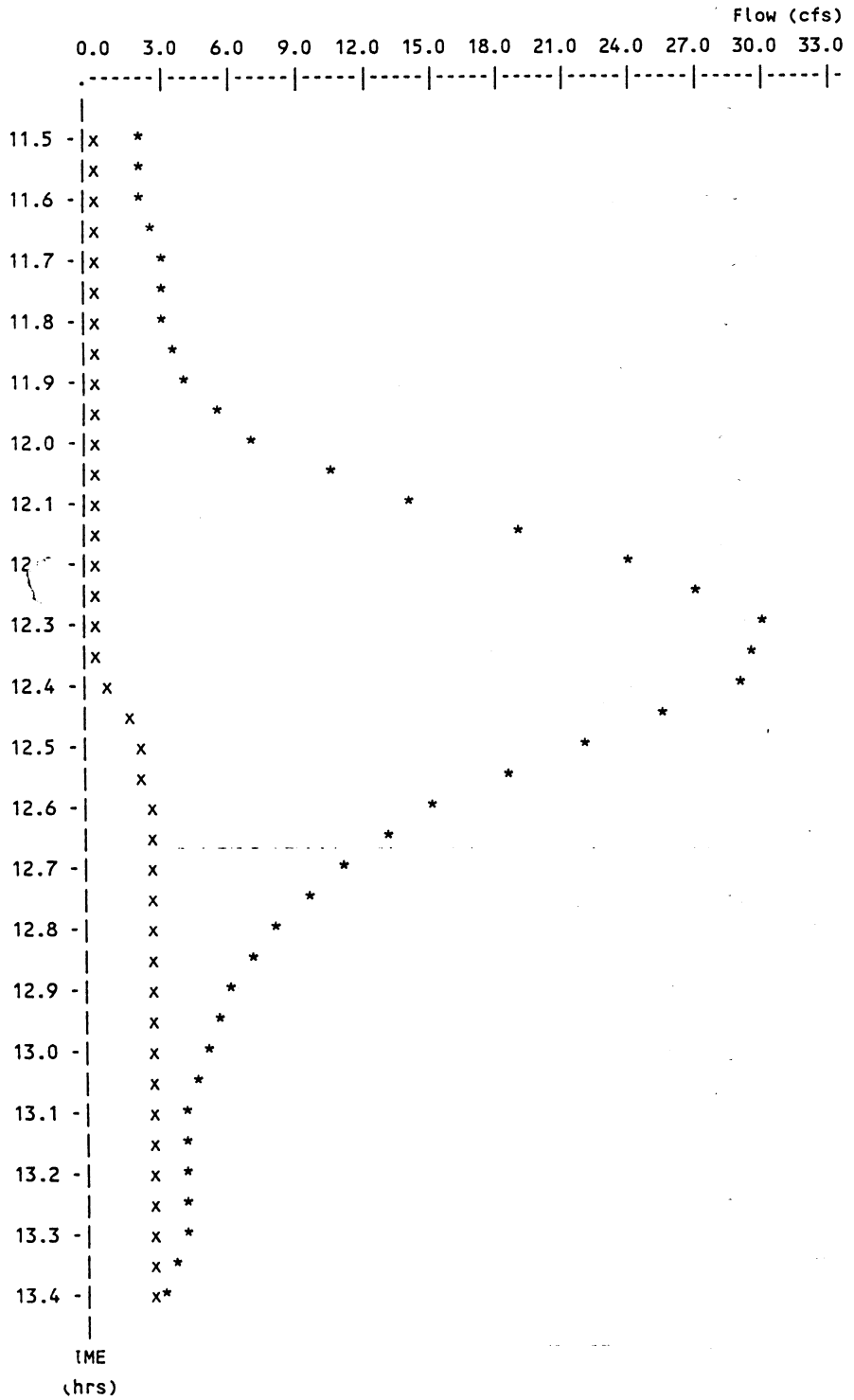
Total Storage in Pond = 1.50 ac-ft

Warning: Inflow hydrograph truncated on left side.

Pond File: CMC4 .PND
Inflow Hydrograph: CMC4 .HYD
Outflow Hydrograph: OUT .HYD

EXECUTED: 04-27-1995
07:30:23

Peak Inflow = 30.00 cfs
Peak Outflow = 2.37 cfs
Peak Elevation = 1635.37 ft



* File: CMC4 .HYD Qmax = 30.0 cfs
x File: OUT .HYD Qmax = 2.4 cfs

Crandon Mining Company

Plant Site Runoff Basin 5

QTR-55 Hydrology
Pond-2 Hydrology

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 04-13-1995 15:54:45
Watershed file: --> CMC188 .WSD
Hydrograph file: --> CMC188 .HYD

CRANDON MINING COMPANY
FOTH AND VAN DYKE 93C049.27
PROPOSED CONDITIONS: DURING OPERATION 4/95
25 YR STORM EVENT

>>>> Input Parameters Used to Compute Hydrograph <<<<

Subarea Description	AREA (acres)	CN	Tc (hrs)	* Tt (hrs)	Precip. (in)	Runoff (in)	Ia/p input/used
BASIN NO. 5	10.60	88.0	0.30	0.00	4.20	2.92	.06 .10

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 10.60 acres or 0.01656 sq.mi
Peak discharge = 33 cfs

>>>> Computer Modifications of Input Parameters <<<<<

Subarea Description	Input Values Tc (hr)	Input Values * Tt (hr)	Rounded Values Tc (hr)	Rounded Values * Tt (hr)	Ia/p Interpolated (Yes/No)	Ia/p Messages
BASIN NO. 5	0.34	0.00	0.30	0.00	No	Computed Ia/p < .1

* Travel time from subarea outfall to composite watershed outfall point.

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 04-13-1995 15:54:45
Watershed file: --> CMC188 .WSD
Hydrograph file: --> CMC188 .HYD

CRANDON MINING COMPANY
FOTH AND VAN DYKE 93C049.27
PROPOSED CONDITIONS: DURING OPERATION 4/95
25 YR STORM EVENT

>>>> Summary of Subarea Times to Peak <<<<

Subarea	Peak Discharge at Composite Outfall (cfs)	Time to Peak at Composite Outfall (hrs)
BASIN NO. 5	33	12.2
Composite Watershed	33	12.2

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 04-13-1995 15:54:45
Watershed file: --> CMC188 .WSD
Hydrograph file: --> CMC188 .HYD

CRANDON MINING COMPANY
FOTH AND VAN DYKE 93C049.27
PROPOSED CONDITIONS: DURING OPERATION 4/95
25 YR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	11.0 hr	11.3 hr	11.6 hr	11.9 hr	12.0 hr	12.1 hr	12.2 hr	12.3 hr	12.4 hr
BASIN NO. 5	1	1	2	6	11	22	33	33	22
Total (cfs)	1	1	2	6	11	22	33	33	22

Subarea Description	12.5 hr	12.6 hr	12.7 hr	12.8 hr	13.0 hr	13.2 hr	13.4 hr	13.6 hr	13.8 hr
BASIN NO. 5	14	9	7	6	4	3	3	2	2
Total (cfs)	14	9	7	6	4	3	3	2	2

Subarea Description	14.0 hr	14.3 hr	14.6 hr	15.0 hr	15.5 hr	16.0 hr	16.5 hr	17.0 hr	17.5 hr
BASIN NO. 5	2	2	2	1	1	1	1	1	1
Total (cfs)	2	2	2	1	1	1	1	1	1

Subarea Description	18.0 hr	19.0 hr	20.0 hr	22.0 hr	26.0 hr
BASIN NO. 5	1	1	1	1	0
Total (cfs)	1	1	1	1	0

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 04-13-1995 15:54:45
Watershed file: --> CMC188 .WSD
Hydrograph file: --> CMC188 .HYD

CRANDON MINING COMPANY
FOTH AND VAN DYKE 93C049.27
PROPOSED CONDITIONS: DURING OPERATION 4/95
25 YR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
11.0	1	14.8	2
11.1	1	14.9	1
11.2	1	15.0	1
11.3	1	15.1	1
11.4	1	15.2	1
11.5	2	15.3	1
11.6	2	15.4	1
11.7	3	15.5	1
11.8	5	15.6	1
11.9	6	15.7	1
12.0	11	15.8	1
12.1	22	15.9	1
12.2	33	16.0	1
12.3	33	16.1	1
12.4	22	16.2	1
12.5	14	16.3	1
12.6	9	16.4	1
12.7	7	16.5	1
12.8	6	16.6	1
12.9	5	16.7	1
13.0	4	16.8	1
13.1	4	16.9	1
13.2	3	17.0	1
13.3	3	17.1	1
13.4	3	17.2	1
13.5	3	17.3	1
13.6	2	17.4	1
13.7	2	17.5	1
13.8	2	17.6	1
13.9	2	17.7	1
14.0	2	17.8	1
14.1	2	17.9	1
14.2	2	18.0	1
14.3	2	18.1	1
14.4	2	18.2	1
14.5	2	18.3	1
14.6	2	18.4	1

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 04-13-1995 15:54:45
Watershed file: --> CMC188 .WSD
Hydrograph file: --> CMC188 .HYD

CRANDON MINING COMPANY
FOTH AND VAN DYKE 93C049.27
PROPOSED CONDITIONS: DURING OPERATION 4/95
25 YR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
18.6	1	22.4	1
18.7	1	22.5	1
18.8	1	22.6	1
18.9	1	22.7	1
19.0	1	22.8	1
19.1	1	22.9	1
19.2	1	23.0	1
19.3	1	23.1	1
19.4	1	23.2	1
19.5	1	23.3	1
19.6	1	23.4	1
19.7	1	23.5	1
19.8	1	23.6	1
19.9	1	23.7	1
20.0	1	23.8	1
20.1	1	23.9	1
20.2	1	24.0	0
20.3	1	24.1	0
20.4	1	24.2	0
20.5	1	24.3	0
20.6	1	24.4	0
20.7	1	24.5	0
20.8	1	24.6	0
20.9	1	24.7	0
21.0	1	24.8	0
21.1	1	24.9	0
21.2	1	25.0	0
21.3	1	25.1	0
21.4	1	25.2	0
21.5	1	25.3	0
21.6	1	25.4	0
21.7	1	25.5	0
21.8	1	25.6	0
21.9	1	25.7	0
22.0	1	25.8	0
22.1	1	25.9	0
22.2	1		
22.3	1		

POND-2 Version: 5.16 S/N: 1295130172
EXECUTED: 04-27-1995 07:27:31

****

* CRANDON MINING COMPANY 93C049.27 FOTH & VAN DYKE *
* RUNOFF BASIN NO. 5 4/95 *

****

Inflow Hydrograph: CMC188 .HYD
Rating Table file: CMC188 .PND

----INITIAL CONDITIONS----
Elevation = 1636.00 ft
Outflow = 0.00 cfs
Storage = 0.00 ac-ft

GIVEN POND DATA

ELEVATION (ft)	OUTFLOW (cfs)	STORAGE (ac-ft)
1636.00	0.0	0.000
1636.50	0.0	0.006
1637.00	0.0	0.014
1637.50	0.0	0.024
1638.00	0.0	0.038
1638.50	0.0	0.055
1639.00	0.0	0.077
1639.50	0.0	0.250
1640.00	0.0	0.435
1640.50	0.0	0.632
1641.00	0.0	0.842
1641.50	2.2	1.065
1642.00	2.3	1.301
1642.50	2.4	1.552
1643.00	2.5	1.816
1643.50	2.6	2.095
1644.00	2.7	2.390
1644.50	2.8	2.699
1645.00	2.8	3.025
1645.50	2.9	3.367
1646.00	3.0	3.725

INTERMEDIATE ROUTING COMPUTATIONS

2S/t (cfs)	2S/t + O (cfs)
0.0	0.0
1.4	1.4
3.3	3.3
5.9	5.9
9.2	9.2
13.3	13.3
18.7	18.7
60.6	60.6
105.3	105.3
153.0	153.0
203.8	203.8
257.7	259.9
314.9	317.2
375.5	377.9
439.5	442.0
507.1	509.7
578.3	581.0
653.3	656.1
732.1	734.9
814.8	817.7
901.6	904.6

Time increment (t) = 0.100 hrs.

F File: CMC188 .PND
Inflow Hydrograph: CMC188 .HYD
Outflow Hydrograph: OUT .HYD

INFLOW HYDROGRAPH		ROUTING COMPUTATIONS				
TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
11.000	1.00	-----	0.0	0.0	0.00	1636.00
11.100	1.00	2.0	2.0	2.0	0.00	1636.66
11.200	1.00	2.0	4.0	4.0	0.00	1637.14
11.300	1.00	2.0	6.0	6.0	0.00	1637.52
11.400	1.00	2.0	8.0	8.0	0.00	1637.82
11.500	2.00	3.0	11.0	11.0	0.00	1638.22
11.600	2.00	4.0	15.0	15.0	0.00	1638.66
11.700	3.00	5.0	20.0	20.0	0.00	1639.02
11.800	5.00	8.0	28.0	28.0	0.00	1639.11
11.900	6.00	11.0	39.0	39.0	0.00	1639.24
12.000	11.00	17.0	56.0	56.0	0.00	1639.45
12.100	22.00	33.0	89.0	89.0	0.00	1639.82
12.200	33.00	55.0	144.0	144.0	0.00	1640.41
12.300	33.00	66.0	209.5	210.0	0.24	1641.06
12.400	22.00	55.0	260.1	264.5	2.21	1641.54
12.500	14.00	36.0	291.6	296.1	2.26	1641.82
12.600	9.00	23.0	310.0	314.6	2.30	1641.98
12.700	7.00	16.0	321.4	326.0	2.31	1642.07
12.800	6.00	13.0	329.7	334.4	2.33	1642.14
12.900	5.00	11.0	336.0	340.7	2.34	1642.19
13.000	4.00	9.0	340.3	345.0	2.35	1642.23
13.100	4.00	8.0	343.6	348.3	2.35	1642.26
13.200	3.00	7.0	345.9	350.6	2.36	1642.28
13.300	3.00	6.0	347.2	351.9	2.36	1642.29
13.400	3.00	6.0	348.5	353.2	2.36	1642.30
13.500	3.00	6.0	349.8	354.5	2.36	1642.31
13.600	2.00	5.0	350.1	354.8	2.36	1642.31
13.700	2.00	4.0	349.3	354.1	2.36	1642.30
13.800	2.00	4.0	348.6	353.3	2.36	1642.30
13.900	2.00	4.0	347.9	352.6	2.36	1642.29
14.000	2.00	4.0	347.2	351.9	2.36	1642.29
14.100	2.00	4.0	346.5	351.2	2.36	1642.28
14.200	2.00	4.0	345.8	350.5	2.35	1642.27
14.300	2.00	4.0	345.1	349.8	2.35	1642.27
14.400	2.00	4.0	344.3	349.1	2.35	1642.26
14.500	2.00	4.0	343.6	348.3	2.35	1642.26
14.600	2.00	4.0	342.9	347.6	2.35	1642.25
14.700	2.00	4.0	342.2	346.9	2.35	1642.24
14.800	2.00	4.0	341.6	346.2	2.35	1642.24
14.900	1.00	3.0	339.9	344.6	2.35	1642.23
15.000	1.00	2.0	337.2	341.9	2.34	1642.20
15.100	1.00	2.0	334.5	339.2	2.34	1642.18
15.200	1.00	2.0	331.8	336.5	2.33	1642.16
15.300	1.00	2.0	329.2	333.8	2.33	1642.14
15.400	1.00	2.0	326.5	331.2	2.32	1642.12

F File: CMC188 .PND
Inflow Hydrograph: CMC188 .HYD
Outflow Hydrograph: OUT .HYD

INFLOW HYDROGRAPH		ROUTING COMPUTATIONS				
TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
15.500	1.00	2.0	323.9	328.5	2.32	1642.09
15.600	1.00	2.0	321.3	325.9	2.31	1642.07
15.700	1.00	2.0	318.7	323.3	2.31	1642.05
15.800	1.00	2.0	316.0	320.7	2.31	1642.03
15.900	1.00	2.0	313.4	318.0	2.30	1642.01
16.000	1.00	2.0	310.8	315.4	2.30	1641.98
16.100	1.00	2.0	308.3	312.8	2.29	1641.96
16.200	1.00	2.0	305.7	310.3	2.29	1641.94
16.300	1.00	2.0	303.1	307.7	2.28	1641.92
16.400	1.00	2.0	300.6	305.1	2.28	1641.89
16.500	1.00	2.0	298.0	302.6	2.27	1641.87
16.600	1.00	2.0	295.5	300.0	2.27	1641.85
16.700	1.00	2.0	292.9	297.5	2.27	1641.83
16.800	1.00	2.0	290.4	294.9	2.26	1641.81
16.900	1.00	2.0	287.9	292.4	2.26	1641.78
17.000	1.00	2.0	285.4	289.9	2.25	1641.76
17.100	1.00	2.0	282.9	287.4	2.25	1641.74
17.200	1.00	2.0	280.4	284.9	2.24	1641.72
17.300	1.00	2.0	277.9	282.4	2.24	1641.70
17.400	1.00	2.0	275.5	279.9	2.23	1641.67
17.500	1.00	2.0	273.0	277.5	2.23	1641.65
17.600	1.00	2.0	270.6	275.0	2.23	1641.63
17.700	1.00	2.0	268.1	272.6	2.22	1641.61
17.800	1.00	2.0	265.7	270.1	2.22	1641.59
17.900	1.00	2.0	263.3	267.7	2.21	1641.57
18.000	1.00	2.0	260.8	265.3	2.21	1641.55
18.100	1.00	2.0	258.4	262.8	2.21	1641.53
18.200	1.00	2.0	256.0	260.4	2.20	1641.50
18.300	1.00	2.0	253.8	258.0	2.13	1641.48
18.400	1.00	2.0	251.7	255.8	2.04	1641.46
18.500	1.00	2.0	249.8	253.7	1.96	1641.44
18.600	1.00	2.0	248.0	251.8	1.88	1641.43
18.700	1.00	2.0	246.4	250.0	1.81	1641.41
18.800	1.00	2.0	244.9	248.4	1.75	1641.40
18.900	1.00	2.0	243.5	246.9	1.69	1641.38
19.000	1.00	2.0	242.3	245.5	1.64	1641.37
19.100	1.00	2.0	241.1	244.3	1.59	1641.36
19.200	1.00	2.0	240.0	243.1	1.54	1641.35
19.300	1.00	2.0	239.0	242.0	1.50	1641.34
19.400	1.00	2.0	238.1	241.0	1.46	1641.33
19.500	1.00	2.0	237.2	240.1	1.42	1641.32
19.600	1.00	2.0	236.5	239.2	1.39	1641.32
19.700	1.00	2.0	235.7	238.5	1.36	1641.31
19.800	1.00	2.0	235.1	237.7	1.33	1641.30
19.900	1.00	2.0	234.5	237.1	1.30	1641.30
20.000	1.00	2.0	233.9	236.5	1.28	1641.29

' File: CMC188 .PND
Inrlow Hydrograph: CMC188 .HYD
Outflow Hydrograph: OUT .HYD

INFLOW HYDROGRAPH		ROUTING COMPUTATIONS				
TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
20.100	1.00	2.0	233.4	235.9	1.26	1641.29
20.200	1.00	2.0	232.9	235.4	1.24	1641.28
20.300	1.00	2.0	232.5	234.9	1.22	1641.28
20.400	1.00	2.0	232.1	234.5	1.20	1641.27
20.500	1.00	2.0	231.7	234.1	1.19	1641.27
20.600	1.00	2.0	231.4	233.7	1.17	1641.27
20.700	1.00	2.0	231.0	233.4	1.16	1641.26
20.800	1.00	2.0	230.7	233.0	1.15	1641.26
20.900	1.00	2.0	230.5	232.7	1.13	1641.26
21.000	1.00	2.0	230.2	232.5	1.12	1641.26
21.100	1.00	2.0	230.0	232.2	1.11	1641.25
21.200	1.00	2.0	229.8	232.0	1.11	1641.25
21.300	1.00	2.0	229.6	231.8	1.10	1641.25
21.400	1.00	2.0	229.4	231.6	1.09	1641.25
21.500	1.00	2.0	229.2	231.4	1.08	1641.25
21.600	1.00	2.0	229.1	231.2	1.08	1641.24
21.700	1.00	2.0	229.0	231.1	1.07	1641.24
21.800	1.00	2.0	228.8	231.0	1.06	1641.24
21.900	1.00	2.0	228.7	230.8	1.06	1641.24
22.000	1.00	2.0	228.6	230.7	1.05	1641.24
22.100	1.00	2.0	228.5	230.6	1.05	1641.24
22.200	1.00	2.0	228.4	230.5	1.05	1641.24
22.300	1.00	2.0	228.3	230.4	1.04	1641.24
22.400	1.00	2.0	228.2	230.3	1.04	1641.24
22.500	1.00	2.0	228.2	230.2	1.04	1641.24
22.600	1.00	2.0	228.1	230.2	1.03	1641.23
22.700	1.00	2.0	228.0	230.1	1.03	1641.23
22.800	1.00	2.0	228.0	230.0	1.03	1641.23
22.900	1.00	2.0	227.9	230.0	1.03	1641.23
23.000	1.00	2.0	227.9	229.9	1.02	1641.23
23.100	1.00	2.0	227.8	229.9	1.02	1641.23
23.200	1.00	2.0	227.8	229.8	1.02	1641.23
23.300	1.00	2.0	227.7	229.8	1.02	1641.23
23.400	1.00	2.0	227.7	229.7	1.02	1641.23
23.500	1.00	2.0	227.7	229.7	1.02	1641.23
23.600	1.00	2.0	227.6	229.7	1.01	1641.23
23.700	1.00	2.0	227.6	229.6	1.01	1641.23
23.800	1.00	2.0	227.6	229.6	1.01	1641.23
23.900	1.00	2.0	227.6	229.6	1.01	1641.23
24.000	0.00	1.0	226.6	228.6	0.97	1641.22
24.100	0.00	0.0	224.8	226.6	0.90	1641.20
24.200	0.00	0.0	223.2	224.8	0.83	1641.19
24.300	0.00	0.0	221.7	223.2	0.76	1641.17
24.400	0.00	0.0	220.3	221.7	0.70	1641.16
24.500	0.00	0.0	219.0	220.3	0.65	1641.15
24.600	0.00	0.0	217.8	219.0	0.60	1641.14

' File: CMC188 .PND
Inflow Hydrograph: CMC188 .HYD
Outflow Hydrograph: OUT .HYD

INFLOW HYDROGRAPH		ROUTING COMPUTATIONS				
TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
24.700	0.00	0.0	216.7	217.8	0.55	1641.12
24.800	0.00	0.0	215.7	216.7	0.51	1641.11
24.900	0.00	0.0	214.7	215.7	0.47	1641.11
25.000	0.00	0.0	213.9	214.7	0.43	1641.10
25.100	0.00	0.0	213.1	213.9	0.40	1641.09
25.200	0.00	0.0	212.4	213.1	0.36	1641.08
25.300	0.00	0.0	211.7	212.4	0.34	1641.08
25.400	0.00	0.0	211.1	211.7	0.31	1641.07
25.500	0.00	0.0	210.5	211.1	0.29	1641.06
25.600	0.00	0.0	210.0	210.5	0.26	1641.06
25.700	0.00	0.0	209.5	210.0	0.24	1641.06
25.800	0.00	0.0	209.0	209.5	0.22	1641.05
25.900	0.00	0.0	208.6	209.0	0.21	1641.05

****************** SUMMARY OF ROUTING COMPUTATIONS ******************

Pond File: CMC188 .PND
Inflow Hydrograph: CMC188 .HYD
Outflow Hydrograph: OUT .HYD

Starting Pond W.S. Elevation = 1636.00 ft

***** Summary of Peak Outflow and Peak Elevation *****

Peak Inflow = 33.00 cfs
Peak Outflow = 2.36 cfs
Peak Elevation = 1642.31 ft

***** Summary of Approximate Peak Storage *****

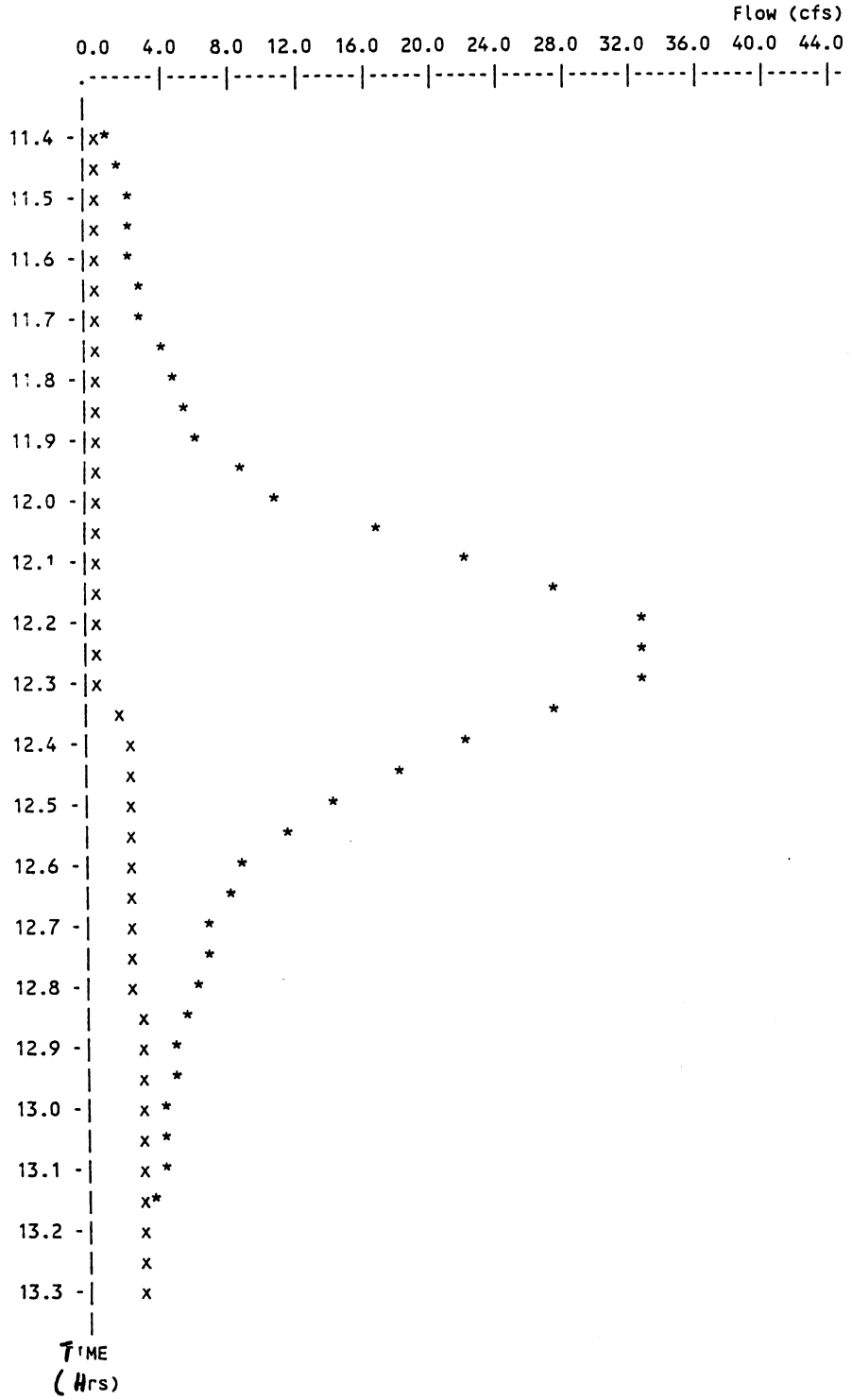
Initial Storage	=	0.00 ac-ft
Peak Storage From Storm	=	1.46 ac-ft
Total Storage in Pond	=	1.46 ac-ft

Warning: Inflow hydrograph truncated on left side.

Pond File: CMC188 .PND
Inflow Hydrograph: CMC188 .HYD
Outflow Hydrograph: OUT .HYD

EXECUTED: 04-27-1995
07:27:31

Peak Inflow = 33.00 cfs
Peak Outflow = 2.36 cfs
Peak Elevation = 1642.31 ft



* File: CMC188 .HYD Qmax = 33.0 cfs
x File: OUT .HYD Qmax = 2.4 cfs

Crandon Mining Company

Plant Site Storage Runoff Basin 6

QTR-55 Hydrology
Pond-2 Hydrology

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 04-13-1995 15:12:47
Watershed file: --> CMCWS .WSD
Hydrograph file: --> CMCWS .HYD

CRANDON MINING COMPANY
FOTH AND VAN DYKE 93C049.27
PROPOSED CONDITIONS 4/95
25 YR STORM EVENT

>>>> Input Parameters Used to Compute Hydrograph <<<<

Subarea Description	AREA (acres)	CN	Tc (hrs)	* Tt (hrs)	Precip. (in)	Runoff (in)	Ia/p input/used	
WATER STORAGE	41.44	88.0	0.40	0.00	4.20	2.92	.06	.10
BASIN 6 OUTLET	3.30	80.0	0.50	0.00	4.20	2.21	.12	.10

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 44.74 acres or 0.06991 sq.mi
Peak discharge = 117 cfs

WARNING: Drainage areas of two or more subareas
differ by a factor of 5 or greater.

>>>> Computer Modifications of Input Parameters <<<<<

Subarea Description	Input Values Tc (hr)	Input Values * Tt (hr)	Rounded Values Tc (hr)	Rounded Values * Tt (hr)	Ia/p Interpolated (Yes/No)	Ia/p Messages
WATER STORAGE	0.37	0.00	0.40	0.00	No	Computed Ia/p < .1
BASIN 6 OUTLET	0.50	0.00	**	**	No	--

* Travel time from subarea outfall to composite watershed outfall point.
** Tc & Tt are available in the hydrograph tables.

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 04-13-1995 15:12:47
Watershed file: --> CMCWS .WSD
Hydrograph file: --> CMCWS .HYD

CRANDON MINING COMPANY
FOTH AND VAN DYKE 93C049.27
PROPOSED CONDITIONS 4/95
25 YR STORM EVENT

>>>> Summary of Subarea Times to Peak <<<<

Subarea	Peak Discharge at Composite Outfall (cfs)	Time to Peak at Composite Outfall (hrs)
WATER STORAGE	112	12.3
BASIN 6 OUTLET	6	12.4
Composite Watershed	117	12.3

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 04-13-1995 15:12:47
Watershed file: --> CMCWS .WSD
Hydrograph file: --> CMCWS .HYD

CRANDON MINING COMPANY
FOTH AND VAN DYKE 93C049.27
PROPOSED CONDITIONS 4/95
25 YR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	11.0 hr	11.3 hr	11.6 hr	11.9 hr	12.0 hr	12.1 hr	12.2 hr	12.3 hr	12.4 hr
WATER STORAGE	3	5	7	15	27	51	88	112	109
BASIN 6 OUTLET	0	0	0	1	1	2	4	5	6
Total (cfs)	3	5	7	16	28	53	92	117	115

Subarea Description	12.5 hr	12.6 hr	12.7 hr	12.8 hr	13.0 hr	13.2 hr	13.4 hr	13.6 hr	13.8 hr
WATER STORAGE	81	56	41	31	20	15	12	10	9
BASIN 6 OUTLET	6	5	3	3	2	1	1	1	1
Total (cfs)	87	61	44	34	22	16	13	11	10

Subarea Description	14.0 hr	14.3 hr	14.6 hr	15.0 hr	15.5 hr	16.0 hr	16.5 hr	17.0 hr	17.5 hr
WATER STORAGE	8	7	6	6	5	5	4	4	4
BASIN 6 OUTLET	1	0	0	0	0	0	0	0	0
Total (cfs)	9	7	6	6	5	5	4	4	4

Subarea Description	18.0 hr	19.0 hr	20.0 hr	22.0 hr	26.0 hr
WATER STORAGE	3	3	3	2	0
BASIN 6 OUTLET	0	0	0	0	0
Total (cfs)	3	3	3	2	0

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 04-13-1995 15:12:47
Watershed file: --> CMCWS .WSD
Hydrograph file: --> CMCWS .HYD

CRANDON MINING COMPANY
FOTH AND VAN DYKE 93C049.27
PROPOSED CONDITIONS 4/95
25 YR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
11.0	3	14.8	6
11.1	4	14.9	6
11.2	4	15.0	6
11.3	5	15.1	6
11.4	6	15.2	6
11.5	6	15.3	5
11.6	7	15.4	5
11.7	10	15.5	5
11.8	13	15.6	5
11.9	16	15.7	5
12.0	28	15.8	5
12.1	53	15.9	5
12.2	92	16.0	5
12.3	117	16.1	5
12.4	115	16.2	5
12.5	87	16.3	4
12.6	61	16.4	4
12.7	44	16.5	4
12.8	34	16.6	4
12.9	28	16.7	4
13.0	22	16.8	4
13.1	19	16.9	4
13.2	16	17.0	4
13.3	14	17.1	4
13.4	13	17.2	4
13.5	12	17.3	4
13.6	11	17.4	4
13.7	10	17.5	4
13.8	10	17.6	4
13.9	9	17.7	4
14.0	9	17.8	3
14.1	8	17.9	3
14.2	8	18.0	3
14.3	7	18.1	3
14.4	7	18.2	3
14.5	6	18.3	3
14.6	6	18.4	3

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 04-13-1995 15:12:47
Watershed file: --> CMCWS .WSD
Hydrograph file: --> CMCWS .HYD

CRANDON MINING COMPANY
FOTH AND VAN DYKE 93C049.27
PROPOSED CONDITIONS 4/95
25 YR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
18.6	3	22.4	2
18.7	3	22.5	2
18.8	3	22.6	2
18.9	3	22.7	2
19.0	3	22.8	2
19.1	3	22.9	2
19.2	3	23.0	2
19.3	3	23.1	1
19.4	3	23.2	1
19.5	3	23.3	1
19.6	3	23.4	1
19.7	3	23.5	1
19.8	3	23.6	1
19.9	3	23.7	1
20.0	3	23.8	1
20.1	3	23.9	1
20.2	3	24.0	1
20.3	3	24.1	1
20.4	3	24.2	1
20.5	3	24.3	1
20.6	3	24.4	1
20.7	3	24.5	1
20.8	3	24.6	1
20.9	3	24.7	1
21.0	2	24.8	1
21.1	2	24.9	1
21.2	2	25.0	0
21.3	2	25.1	0
21.4	2	25.2	0
21.5	2	25.3	0
21.6	2	25.4	0
21.7	2	25.5	0
21.8	2	25.6	0
21.9	2	25.7	0
22.0	2	25.8	0
22.1	2	25.9	0
22.2	2		
22.3	2		

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**************************************************************************
*                                                                        *
* CRANDON MINING COMPANY          93C049.27       FOTH & VAN DYKE        *
*       WATER STORAGE BASIN 6                          4/95              *
*                                                                        *
*                                                                        *
*                                                                        *
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Inflow Hydrograph: CMCWS .HYD
Rating Table file: CMCWS .PND

----INITIAL CONDITIONS----
Elevation = 1626.00 ft
Outflow = 0.00 cfs
Storage = 0.00 ac-ft

GIVEN POND DATA			INTERMEDIATE ROUTING COMPUTATIONS	
ELEVATION (ft)	OUTFLOW (cfs)	STORAGE (ac-ft)	2S/t (cfs)	2S/t + O (cfs)
1626.00	0.0	0.000	0.0	0.0
1626.50	0.0	0.006	1.4	1.4
1627.00	0.0	0.014	3.3	3.3
1627.50	0.0	0.024	5.8	5.8
1628.00	0.0	0.038	9.1	9.1
1628.50	0.0	0.055	13.3	13.3
1629.00	0.0	0.077	18.7	18.7
1629.50	0.0	0.293	71.0	71.0
1630.00	0.0	0.519	125.7	125.7
1630.50	0.0	0.755	182.8	182.8
1631.00	0.0	1.002	242.4	242.4
1631.50	0.0	1.258	304.5	304.5
1632.00	0.0	1.526	369.3	369.3
1632.50	0.0	1.804	436.6	436.6
1633.00	0.0	2.094	506.7	506.7
1633.50	0.0	2.395	579.5	579.5
1634.00	0.0	2.707	655.2	655.2
1634.50	0.0	3.032	733.7	733.7
1635.00	0.0	3.368	815.1	815.1
1635.50	0.0	3.717	899.5	899.5
1636.00	0.0	4.078	986.9	986.9
1636.50	0.0	4.452	1077.4	1077.4
1637.00	0.0	4.839	1171.0	1171.0
1637.50	0.0	5.239	1267.8	1267.8
1638.00	0.0	5.652	1367.8	1367.8
1638.50	0.0	6.079	1471.1	1471.1
1639.00	0.0	6.520	1577.8	1577.8
1639.50	0.0	6.974	1687.8	1687.8
1640.00	0.0	7.443	1801.3	1801.3
1640.50	0.0	7.927	1918.3	1918.3
1641.00	0.0	8.425	2038.8	2038.8

GIVEN POND DATA			INTERMEDIATE ROUTING COMPUTATIONS	
ELEVATION (ft)	OUTFLOW (cfs)	STORAGE (ac-ft)	2S/t (cfs)	2S/t + O (cfs)
1641.50	0.0	8.938	2162.9	2162.9
1642.00	0.0	9.466	2290.7	2290.7
1642.50	0.0	10.009	2422.2	2422.2
1643.00	0.0	10.568	2557.5	2557.5
1643.50	0.0	11.143	2696.6	2696.6
1644.00	0.0	11.734	2839.6	2839.6
1644.50	0.0	12.341	2986.4	2986.4
1645.00	0.0	12.964	3137.3	3137.3
1645.50	0.0	13.604	3292.2	3292.2
1646.00	0.0	14.261	3451.2	3451.2
1646.01	0.0	14.274	3454.4	3454.4

Time increment (t) = 0.100 hrs.

Pond File: CMCWS .PND
ow Hydrograph: CMCWS .HYD
...flow Hydrograph: OUT .HYD

INFLOW HYDROGRAPH		ROUTING COMPUTATIONS				
TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
11.000	3.00	-----	0.0	0.0	0.00	1626.00
11.100	4.00	7.0	7.0	7.0	0.00	1627.68
11.200	4.00	8.0	15.0	15.0	0.00	1628.66
11.300	5.00	9.0	24.0	24.0	0.00	1629.05
11.400	6.00	11.0	35.0	35.0	0.00	1629.16
11.500	6.00	12.0	47.0	47.0	0.00	1629.27
11.600	7.00	13.0	60.0	60.0	0.00	1629.39
11.700	10.00	17.0	77.0	77.0	0.00	1629.55
11.800	13.00	23.0	100.0	100.0	0.00	1629.77
11.900	16.00	29.0	129.0	129.0	0.00	1630.03
12.000	28.00	44.0	173.0	173.0	0.00	1630.41
12.100	53.00	81.0	254.0	254.0	0.00	1631.09
12.200	92.00	145.0	399.0	399.0	0.00	1632.22
12.300	117.00	209.0	608.0	608.0	0.00	1633.69
12.400	115.00	232.0	840.0	840.0	0.00	1635.15
12.500	87.00	202.0	1042.0	1042.0	0.00	1636.30
12.600	61.00	148.0	1190.0	1190.0	0.00	1637.10
12.700	44.00	105.0	1295.0	1295.0	0.00	1637.64
12.800	34.00	78.0	1373.0	1373.0	0.00	1638.03
12.900	28.00	62.0	1435.0	1435.0	0.00	1638.33
13.000	22.00	50.0	1485.0	1485.0	0.00	1638.57
13.100	19.00	41.0	1526.0	1526.0	0.00	1638.76
13.200	16.00	35.0	1561.0	1561.0	0.00	1638.92
13.300	14.00	30.0	1591.0	1591.0	0.00	1639.06
13.400	13.00	27.0	1618.0	1618.0	0.00	1639.18
13.500	12.00	25.0	1643.0	1643.0	0.00	1639.30
13.600	11.00	23.0	1666.0	1666.0	0.00	1639.40
13.700	10.00	21.0	1687.0	1687.0	0.00	1639.50
13.800	10.00	20.0	1707.0	1707.0	0.00	1639.58
13.900	9.00	19.0	1726.0	1726.0	0.00	1639.67
14.000	9.00	18.0	1744.0	1744.0	0.00	1639.75
14.100	8.00	17.0	1761.0	1761.0	0.00	1639.82
14.200	8.00	16.0	1777.0	1777.0	0.00	1639.89
14.300	7.00	15.0	1792.0	1792.0	0.00	1639.96
14.400	7.00	14.0	1806.0	1806.0	0.00	1640.02
14.500	6.00	13.0	1819.0	1819.0	0.00	1640.08
14.600	6.00	12.0	1831.0	1831.0	0.00	1640.13
14.700	6.00	12.0	1843.0	1843.0	0.00	1640.18
14.800	6.00	12.0	1855.0	1855.0	0.00	1640.23
14.900	6.00	12.0	1867.0	1867.0	0.00	1640.28
15.000	6.00	12.0	1879.0	1879.0	0.00	1640.33
15.100	6.00	12.0	1891.0	1891.0	0.00	1640.38
15.200	6.00	12.0	1903.0	1903.0	0.00	1640.43
15.300	5.00	11.0	1914.0	1914.0	0.00	1640.48
15.400	5.00	10.0	1924.0	1924.0	0.00	1640.52

Pond File: CMCWS .PND
Inflow Hydrograph: CMCWS .HYD
Outflow Hydrograph: OUT .HYD

INFLOW HYDROGRAPH		ROUTING COMPUTATIONS				
TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
15.500	5.00	10.0	1934.0	1934.0	0.00	1640.57
15.600	5.00	10.0	1944.0	1944.0	0.00	1640.61
15.700	5.00	10.0	1954.0	1954.0	0.00	1640.65
15.800	5.00	10.0	1964.0	1964.0	0.00	1640.69
15.900	5.00	10.0	1974.0	1974.0	0.00	1640.73
16.000	5.00	10.0	1984.0	1984.0	0.00	1640.77
16.100	5.00	10.0	1994.0	1994.0	0.00	1640.81
16.200	5.00	10.0	2004.0	2004.0	0.00	1640.86
16.300	4.00	9.0	2013.0	2013.0	0.00	1640.89
16.400	4.00	8.0	2021.0	2021.0	0.00	1640.93
16.500	4.00	8.0	2029.0	2029.0	0.00	1640.96
16.600	4.00	8.0	2037.0	2037.0	0.00	1640.99
16.700	4.00	8.0	2045.0	2045.0	0.00	1641.02
16.800	4.00	8.0	2053.0	2053.0	0.00	1641.06
16.900	4.00	8.0	2061.0	2061.0	0.00	1641.09
17.000	4.00	8.0	2069.0	2069.0	0.00	1641.12
17.100	4.00	8.0	2077.0	2077.0	0.00	1641.15
17.200	4.00	8.0	2085.0	2085.0	0.00	1641.19
17.300	4.00	8.0	2093.0	2093.0	0.00	1641.22
17.400	4.00	8.0	2101.0	2101.0	0.00	1641.25
17.500	4.00	8.0	2109.0	2109.0	0.00	1641.28
17.600	4.00	8.0	2117.0	2117.0	0.00	1641.31
17.700	4.00	8.0	2125.0	2125.0	0.00	1641.35
17.800	3.00	7.0	2132.0	2132.0	0.00	1641.38
17.900	3.00	6.0	2138.0	2138.0	0.00	1641.40
18.000	3.00	6.0	2144.0	2144.0	0.00	1641.42
18.100	3.00	6.0	2150.0	2150.0	0.00	1641.45
18.200	3.00	6.0	2156.0	2156.0	0.00	1641.47
18.300	3.00	6.0	2162.0	2162.0	0.00	1641.50
18.400	3.00	6.0	2168.0	2168.0	0.00	1641.52
18.500	3.00	6.0	2174.0	2174.0	0.00	1641.54
18.600	3.00	6.0	2180.0	2180.0	0.00	1641.57
18.700	3.00	6.0	2186.0	2186.0	0.00	1641.59
18.800	3.00	6.0	2192.0	2192.0	0.00	1641.61
18.900	3.00	6.0	2198.0	2198.0	0.00	1641.64
19.000	3.00	6.0	2204.0	2204.0	0.00	1641.66
19.100	3.00	6.0	2210.0	2210.0	0.00	1641.68
19.200	3.00	6.0	2216.0	2216.0	0.00	1641.71
19.300	3.00	6.0	2222.0	2222.0	0.00	1641.73
19.400	3.00	6.0	2228.0	2228.0	0.00	1641.75
19.500	3.00	6.0	2234.0	2234.0	0.00	1641.78
19.600	3.00	6.0	2240.0	2240.0	0.00	1641.80
19.700	3.00	6.0	2246.0	2246.0	0.00	1641.82
19.800	3.00	6.0	2252.0	2252.0	0.00	1641.85
19.900	3.00	6.0	2258.0	2258.0	0.00	1641.87
20.000	3.00	6.0	2264.0	2264.0	0.00	1641.90

Pond File: CMCWS .PND
ow Hydrograph: CMCWS .HYD
Outflow Hydrograph: OUT .HYD

INFLOW HYDROGRAPH		ROUTING COMPUTATIONS				
TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
20.100	3.00	6.0	2270.0	2270.0	0.00	1641.92
20.200	3.00	6.0	2276.0	2276.0	0.00	1641.94
20.300	3.00	6.0	2282.0	2282.0	0.00	1641.97
20.400	3.00	6.0	2288.0	2288.0	0.00	1641.99
20.500	3.00	6.0	2294.0	2294.0	0.00	1642.01
20.600	3.00	6.0	2300.0	2300.0	0.00	1642.04
20.700	3.00	6.0	2306.0	2306.0	0.00	1642.06
20.800	3.00	6.0	2312.0	2312.0	0.00	1642.08
20.900	3.00	6.0	2318.0	2318.0	0.00	1642.10
21.000	2.00	5.0	2323.0	2323.0	0.00	1642.12
21.100	2.00	4.0	2327.0	2327.0	0.00	1642.14
21.200	2.00	4.0	2331.0	2331.0	0.00	1642.15
21.300	2.00	4.0	2335.0	2335.0	0.00	1642.17
21.400	2.00	4.0	2339.0	2339.0	0.00	1642.18
21.500	2.00	4.0	2343.0	2343.0	0.00	1642.20
21.600	2.00	4.0	2347.0	2347.0	0.00	1642.21
21.700	2.00	4.0	2351.0	2351.0	0.00	1642.23
21.800	2.00	4.0	2355.0	2355.0	0.00	1642.24
21.900	2.00	4.0	2359.0	2359.0	0.00	1642.26
22.000	2.00	4.0	2363.0	2363.0	0.00	1642.27
22.100	2.00	4.0	2367.0	2367.0	0.00	1642.29
22.200	2.00	4.0	2371.0	2371.0	0.00	1642.31
22.300	2.00	4.0	2375.0	2375.0	0.00	1642.32
22.400	2.00	4.0	2379.0	2379.0	0.00	1642.34
22.500	2.00	4.0	2383.0	2383.0	0.00	1642.35
22.600	2.00	4.0	2387.0	2387.0	0.00	1642.37
22.700	2.00	4.0	2391.0	2391.0	0.00	1642.38
22.800	2.00	4.0	2395.0	2395.0	0.00	1642.40
22.900	2.00	4.0	2399.0	2399.0	0.00	1642.41
23.000	2.00	4.0	2403.0	2403.0	0.00	1642.43
23.100	1.00	3.0	2406.0	2406.0	0.00	1642.44
23.200	1.00	2.0	2408.0	2408.0	0.00	1642.45
23.300	1.00	2.0	2410.0	2410.0	0.00	1642.45
23.400	1.00	2.0	2412.0	2412.0	0.00	1642.46
23.500	1.00	2.0	2414.0	2414.0	0.00	1642.47
23.600	1.00	2.0	2416.0	2416.0	0.00	1642.48
23.700	1.00	2.0	2418.0	2418.0	0.00	1642.48
23.800	1.00	2.0	2420.0	2420.0	0.00	1642.49
23.900	1.00	2.0	2422.0	2422.0	0.00	1642.50
24.000	1.00	2.0	2424.0	2424.0	0.00	1642.51
24.100	1.00	2.0	2426.0	2426.0	0.00	1642.51
24.200	1.00	2.0	2428.0	2428.0	0.00	1642.52
24.300	1.00	2.0	2430.0	2430.0	0.00	1642.53
24.400	1.00	2.0	2432.0	2432.0	0.00	1642.54
24.500	1.00	2.0	2434.0	2434.0	0.00	1642.54
24.600	1.00	2.0	2436.0	2436.0	0.00	1642.55

Pond File: CMCWS .PND
Inflow Hydrograph: CMCWS .HYD
Outflow Hydrograph: OUT .HYD

INFLOW HYDROGRAPH		ROUTING COMPUTATIONS				
TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
24.700	1.00	2.0	2438.0	2438.0	0.00	1642.56
24.800	1.00	2.0	2440.0	2440.0	0.00	1642.57
24.900	1.00	2.0	2442.0	2442.0	0.00	1642.57
25.000	0.00	1.0	2443.0	2443.0	0.00	1642.58
25.100	0.00	0.0	2443.0	2443.0	0.00	1642.58
25.200	0.00	0.0	2443.0	2443.0	0.00	1642.58
25.300	0.00	0.0	2443.0	2443.0	0.00	1642.58
25.400	0.00	0.0	2443.0	2443.0	0.00	1642.58
25.500	0.00	0.0	2443.0	2443.0	0.00	1642.58
25.600	0.00	0.0	2443.0	2443.0	0.00	1642.58
25.700	0.00	0.0	2443.0	2443.0	0.00	1642.58
25.800	0.00	0.0	2443.0	2443.0	0.00	1642.58
25.900	0.00	0.0	2443.0	2443.0	0.00	1642.58

****************** SUMMARY OF ROUTING COMPUTATIONS ******************

Pond File: CMCWS .PND
Inflow Hydrograph: CMCWS .HYD
Outflow Hydrograph: OUT .HYD

Starting Pond W.S. Elevation = 1626.00 ft

***** Summary of Peak Outflow and Peak Elevation *****

Peak Inflow	=	117.00 cfs
Peak Outflow	=	0.00 cfs
Peak Elevation	=	1642.58 ft

***** Summary of Approximate Peak Storage *****

Initial Storage	=	0.00 ac-ft
Peak Storage From Storm	=	10.10 ac-ft
Total Storage in Pond	=	10.10 ac-ft

Warning: Inflow hydrograph truncated on left side.

>>>>>> Warning, peak outflow = last ordinate point. <<<<<<

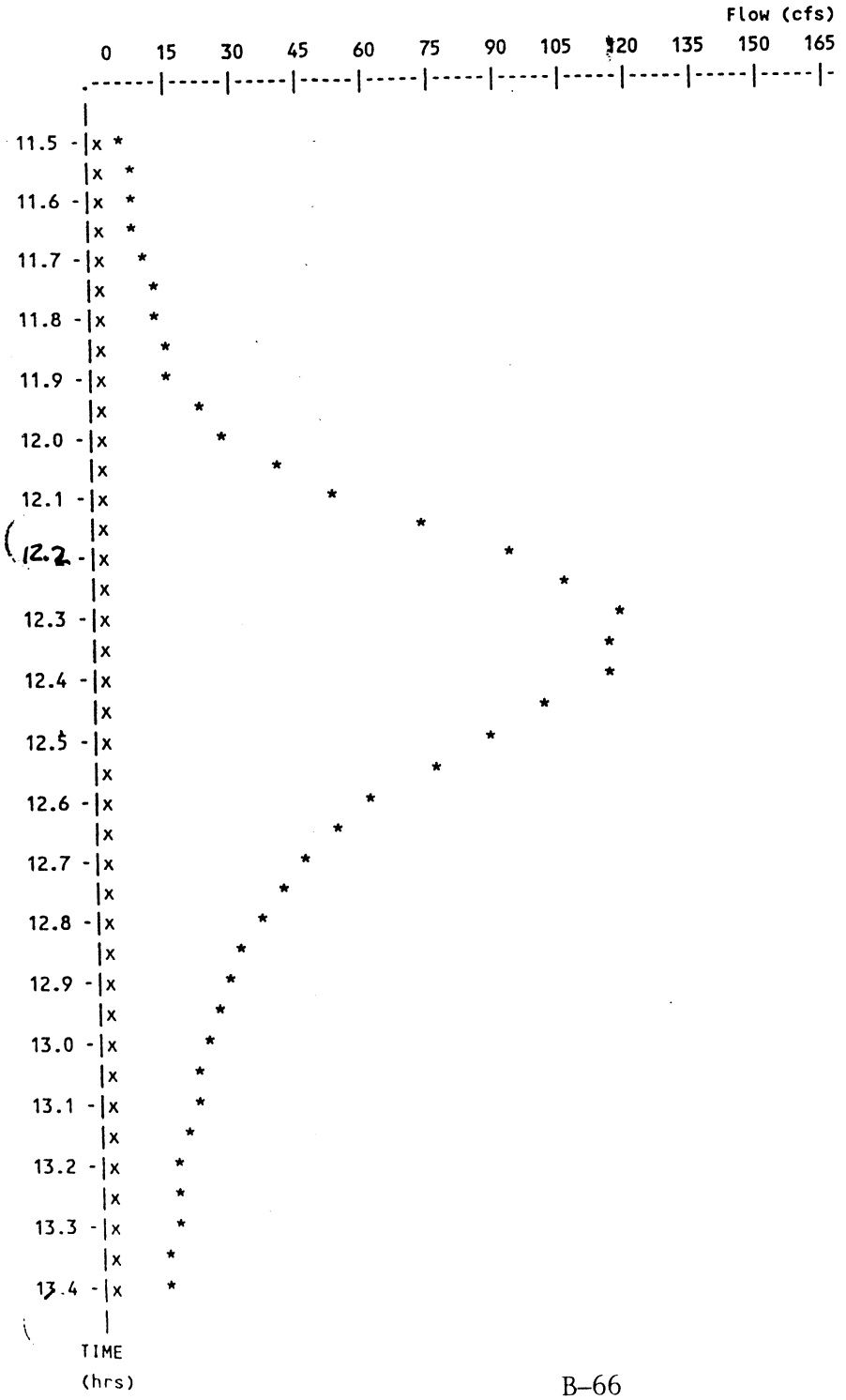
>>>>>> Warning, peak outflow = last ordinate point. <<<<<<

POND-2 Version: 5.16 S/N: 1295130172 Page 8

Pond File: CMCWS .PND
Inflow Hydrograph: CMCWS .HYD
Outflow Hydrograph: OUT .HYD

EXECUTED: 04-25-1995
06:33:24

Peak Inflow = 117.00 cfs
Peak Outflow = 0.00 cfs
Peak Elevation = 1642.58 ft



Appendix C

Crandon Deposit Hanging Wall Sulfide Content Review

MEMORANDUM

EXXON COAL AND MINERALS COMPANY
TECHNICAL DEPARTMENT

July 10, 1996

TO: Mr. D. E. Moe, CMC

FROM: A. J. Erickson, Jr.

SUBJ: Hanging Wall Sulfide Content Review, Crandon Deposit - Updated

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Introduction

The following documents my review of existing geologic logs, proposed development headings as identified on the maps in the April 1996 Redpath mine planning work, and existing analysis of samples from hanging wall formations in areas of proposed early years (first three) development of the Crandon zinc deposit.

Purpose

The purpose is to provide an update of the significance of the generally barren sulfide mineralization that may be encountered in this preproduction work as the mine is developed.

Methodology

The methodology consists of updating eight 1" = 200' scale CMC-detailed geologic cross-sections with both the proposed headings that will be driven in these early years and existing diamond core holes information. Twenty-nine holes were annotated on these sections with the following:

- Estimate sulfide content that was noted during core logging.
- Analytical results (57 analyses) of 1994 ABA samplings. This sampling was designed to provide initial data on the range of sulfide content present in these hanging wall rocks. Note: it must be emphasized that the first sampling was not designed to be representative of hanging wall sulfide content, but was designed to investigate ranges in sulfide content, and in large part, "worst case" material.
- Analytical results (34 analyses) of 1994, "30' Random" samples. These bagged samples consisted of a 3" core sample taken from every 2' of core from four geologic units intersected by the holes. Entire formations were hence samples rigorously at ±2' intervals.
- Analytical results (26 analyses) of 2' core samples taken during 1995. These samples were from drill core which fell within intervals sampled in the 1994 "Random 30 ft." program. The purpose of this program was to look at the variability "within" the intervals represented by the "Random 30 ft." samples.

Table 1, attached, summarizes the data currently being discussed by providing section coordinates, proposed development work, drill holes of significance to the proposed headings, and finally, samples distribution from the formations.

Appendix 1 provides a set of 11, 1" = 400' Redpath level plans showing initial development work, i.e., shafts, ramp, and headings. These level plans have been annotated with the interpreted geology (Skunk Lake, Rice Lake, and Mole Lake Formations) and also with the trace of the eight cross-sections discussed below.

Appendix 2 provides a set of the eight, 1" = 200' cross-sections. These, as indicated above, have had the proposed workings or areas of workings, estimated sulfide content based on a log review, and sulfide sulfur analytical results from the various sampling programs posted to the appropriate drill hole traces. Holes have been color coded for estimated sulfide content and sulfide sulfur analytical results.

> (Note: Analytical data posted were obtained from the Foth and Van Dyke, December 1995, Waste Characterization Update Report which summarizes much of the work done to date on these hanging wall rocks.)

Table 2, attached, provides a conversion of % sulfide sulfur to % pyrite. The calculation assumes that all sulfide sulfur is from pyrite, a conservative assumption. Key values have been highlighted.

Detailed Comments

Overall, what is immediately apparent from review of the sections is the lack of significant thick high sulfide bearing zones in hanging wall rocks associated with the Crandon zinc deposit. Values of estimates are commonly stated as nil to trace, or less than 1% sulfide on the logs and so indicated on the sections. Higher sulfide values have, of course, also been posted. Analytical results from the various ABA programs are commonly <0.1, usually <.01% sulfide sulfur, but at times higher. The only real exceptions are some near surface areas of higher sulfide content, low zinc and copper "stringer" mineralization, in the Skunk Lake Formation. (Lower Mole Lake sulfide is excluded form this discussion as this materials is scheduled for disposal in the TMA.)

As shown on Section 2,278,188E, the top approximately 500' of bed rock shaft sinking of the Main Production Shaft will be in the middle to lower part of the Skunk Lake Formation, generally stratigraphically below a zone of near-surface low grade sulfide mineralization which is north of the proposed shaft. The holes nearest to the proposed shaft, 214 and 74, failed to intersect significant sulfide. Hole 21 contains a zone estimated to contain from 1 to 2% sulfide just above the 1300 level of the proposed shaft although the 1994 ABA "Random 30" sample in this same area indicates the zone contained only about 0.02% sulfide sulfur. (Hole 21 was drilled early in the Crandon program, as logging expertise was being gained.) Hence, it is unlikely that a significant 1 to 2% zone exists. Future shaft pilot hole drilling will provide added data prior to shaft sinking to confirm or deny the existence of this zone.

The area through which the proposed ramp will be driven (shown generally on sections 2,278,319E, 2,278,450E, 2,278,581E, and 2,278,712E) is largely in the low sulfide bearing Rice Lake Formation. Thin, low sulfide, quartz-carbonate veinlets are occasionally identified, but not common in this formation. Zones or horizons of disseminated or bedded pyrite are rare and are all in the 2"- to 6"-thick range. (In the entire 3"/2' 1994 ABA sampling program only three, or perhaps four, thin "massive" horizons, were noted. Nearly 17,000 feet of drillcore were sampled in this program.)

Two holes (73 and 154) have been identified on two sections, 2,278,581E, and 2,278,712E, which show some estimated 1% to 2% sulfide material near the base of the Rice Lake at about the proposed 1300 level. However, the "Random 30'" and 2" variability samples do not confirm the existence of significant sulfide for at least one-third of the zone in hole 73. There is also a suggestion on these sections that an estimated 1% sulfide bearing horizon may exist at depths, 1300' to 1900', in and about the Rice Lake - Mole Lake contact; however, 1) the data is widely spaced and 2) this ramp development will not be done in early years. (See sections 2,278,581E and 2,278,712E.)

The East Vent Shaft shown on section 2,278,843E is entirely in Rice Lake and Upper Mole Lake Formations as it will be collared in the footwall of the Skunk Lake formation. Only rare, thin 1% or <, sporadic sulfide occurrences were noted in logs from holes in this area. One 1994 ABA, 1' sample contained 2.95% sulfide sulfur.

Section Summary

With the exception of the Skunk Lake Formation, and excluding the lower Mole Lake, sulfide identified to date in hanging wall units above the Crandon zinc deposit consist of sporadic very thin cross-cutting low sulfide content quartz-carbonate veins or veinlets, and occasional strata-bound horizons which contain small amounts of disseminated sulfide or very rarely thin, more massive material. As indicated in drill holes, neither of these two types of occurrences show any significant lateral continuity. Occurrences are localized and small and unlikely to contribute a meaningful amount of sulfide material to waste rock generated during early development. This will be further confirmed prior to driving of proposed cross-cuts as the sulfide content will be reevaluated with additional underground drill holes. If present, previously undetected sulfide areas will be identified, the significance determined, and the material handled in an appropriate way.

Significant of Thin Sulfide Occurrences

During mine development, two general types of mine openings will be driven. Ramp, development crosscuts and drifts, (13' x 16') and shafts, nominally 20' to 24' in diameter. Any thin sulfide occurrences encountered during this development will, of course, be identified during face/rib geologic-inspections and mapping. Unless encountered occurrences are significantly thicker and higher in sulfide content than those seen in core to date, these small occurrences will simply be overpowered by the larger amounts of nonsulfide-bearing waste. They will not significantly alter the overall character of the waste rock that is generated.

Several tables are included, Tables 3 - 10, which illustrate the contributory effect of sulfide veins/veinlets, or horizons of varying thickness and sulfide content to "background" sulfide content material generated in drifts or cross-cuts, ramps, or shafts. Tables provided are based on a background grade material of 0.1, 0.2, 0.5, and 0.7% sulfide. The first two values, 0.1 and 0.2, are most likely; 0.5 is perhaps locally present, and 0.7% extreme and not likely to represent typical material. Vein/veinlet or horizon sulfide content on the tables ranges from 0.5% to 100%, while the thickness of the vein/veinlets or horizons ranges from 0.1 inch to 192 inches (16 feet) for headings and 120 inches (12 feet) for shafts. The tables provide a weighted average sulfide content of waste rock generated in a development workings which has background ranges from 0.1 to 0.7% sulfide and intersect veins/veinlets or horizons of varying thickness and sulfide content. (The attached Figure 1 portrays the geometry of the situation for lateral and shaft development.)

Clearly the tables indicate that the thin veinlets typically encountered will never be able to contribute enough sulfide to development headings to increase the weighted average content of waste material much above background. Stratigraphic horizons containing sulfide could be thicker than vein/veinlets seen to date and hence provide an increased amount of sulfide. However, it takes several inches of more massive material to raise the weighted average of horizon and background material to near 1%. As indicated above, the occurrence noted to date of this type material is rare and there is no indication of any significance of lateral continuity of these rare horizons.

Similarly, we also have not seen persistent multi-feet thick horizons containing multi-percent sulfide as the table indicates would need to be present to significantly raise the average grade sulfide content of typical development muck.

It is unlikely that significant sulfide will be encountered; however, contingency plans will be in place to handle any unexpected occurrences in an appropriate method as discussed above.

Finally, shaft pilot hole drilling from surface and initial underground cross-cut drilling combined with routine geologic examination and mapping will allow for identification of any unforeseen sulfide occurrences which then can be directed towards temporary stockpiles as needed.

TABLE - 1

Crandon Mining Company

Hanging Wall Waste Sampling and Data Review

Section No	Stope No	Workings	DDH	1994 ABA Higher S				1994 Random 30'				1995 2' Variability				Comment
				SK	RL	UML	LML	SK	RL	UML	LML	SK	RL	UML	LML	
2277795	57		85			1					1					
			133				1									
2278188	60	Prod Shaft	21		1	1	1		1	1	1					
		and Cross-	44	2		1		2	2	1		5	3			
		cuts	74	1	1											
			98	1	1	1										
			155	10	8											
			160		1	2			2	1		3				
			214													
2278319	62	Ramp	94													
			132				2									
			149		1	1										
			170													
			176			1					1					
2278450	64	Ramp	140							1						Also 23 & 73, in part
2278581	66	Ramp	15						1		1					
			20				1									
			23		1		1	1	2				5			
			73				1			1				3		
			172						2							
2278712	67	Ramp	91				1	2	1							Also 92 in part
			154				1			2						
2278484	69	East	9	4					1							
		Vent Shaft	24		2					1						
			46		1		1		1	2				4		
			92			2		1	1			3				
			143		1		1									
			174													
2279106	72		84													
No.Sections	8	No.Holes	29	5	10	8	10	4	10	8	4	3	2	2	0	
			No. Samples	18	18	10	11	6	14	10	4	11	8	7	0	
			No. Samples				57				34				26	117

SK = Skunk Lake; RL = Rice Lake: UML = Upper Mole Lake; LML = Lower Mole Lake; formations

TABLE - 2

Conversion - % Sulfide Sulfur to % Sulfide (ie Pyrite)

(Assumes pyrite contains 53% sulfur and that all sulfur is in the pyrite)

% Sulfide Sulfur in Sample (Assay)	% Sulfide in Sample (Calculated)
0.01	0.02
0.02	0.04
0.03	0.06
0.04	0.08
0.05	0.09
0.06	0.11
0.07	0.13
0.08	0.15
0.09	0.17
0.10	0.19
0.20	0.38
0.30	0.57
0.40	0.75
0.50	0.94
0.53	1.00
0.60	1.13
0.70	1.32
0.80	1.51
0.90	1.70
1.00	1.89
1.06	2.00
1.10	2.08
1.20	2.26
1.30	2.45
1.40	2.64
1.50	2.83
1.59	3.00
1.60	3.02
1.70	3.21
1.80	3.40
1.90	3.58
2.00	3.77
3.00	5.66
4.00	7.55
5.00	9.43
6.00	11.32
7.00	13.21
8.00	15.09
9.00	16.98
10.0	18.9
15.0	28.3
20.0	37.7
25.0	47.2
30.0	56.6
35.0	66.0
40.0	75.5
45.0	84.9
50.0	94.3
53.0	100.0

TABLE - 3

HEADING WEIGHTED AVERAGE (%) SULFIDE CONTENT - DRIFT OR RAMP

Heading Consists of as stated Background (%) Sulfide Material and Vein/Veinlet or Horizon of as indicated Thickness and Sulfide (%)

Heading = 13 feet x 16 feet or 156 inches x **192** inches Heading Background Sulfide (%) **0.1**

Horizon or Veinlet		Sulfide Content (%) in Horizon or Veinlet(s)																			
Thick-ft.	Thick-in.	0.5	1	2	3	4	5	6	7	8	9	10	20	30	40	50	60	70	80	90	100
<1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
<1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2
<1	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.3
<1	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3
<1	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4
<1	0.6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4
<1	0.7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.4	0.5
<1	0.8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.5
<1	0.9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6
<1	1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6
<1	2	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1
<1	3	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.4	0.6	0.7	0.9	1.0	1.2	1.3	1.5	1.7
<1	4	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.5	0.7	0.9	1.1	1.3	1.6	1.8	2.0	2.2
<1	5	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.6	0.9	1.1	1.4	1.7	1.9	2.2	2.4	2.7
<1	6	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.7	1.0	1.3	1.7	2.0	2.3	2.6	2.9	3.2
<1	7	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.4	0.5	0.8	1.2	1.6	1.9	2.3	2.6	3.0	3.4	3.7
<1	8	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.9	1.3	1.8	2.2	2.6	3.0	3.4	3.8	4.3
<1	9	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	1.0	1.5	2.0	2.4	2.9	3.4	3.8	4.3	4.8
<1	10	0.1	0.1	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	1.1	1.7	2.2	2.7	3.2	3.7	4.3	4.8	5.3
<1	11	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.6	0.6	0.7	1.2	1.8	2.4	3.0	3.5	4.1	4.7	5.3	5.8
1	12	0.1	0.2	0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.7	0.7	1.3	2.0	2.6	3.2	3.8	4.5	5.1	5.7	6.3
2	24	0.2	0.2	0.3	0.5	0.6	0.7	0.8	1.0	1.1	1.2	1.3	2.6	3.8	5.1	6.3	7.6	8.8	10.1	11.3	12.6
3	36	0.2	0.3	0.5	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	3.8	5.7	7.6	9.5	11.3	13.2	15.1	17.0	18.8
4	48	0.2	0.3	0.6	0.8	1.1	1.3	1.6	1.8	2.1	2.3	2.6	5.1	7.6	10.1	12.6	15.1	17.6	20.1	22.6	25.1
5	60	0.2	0.4	0.7	1.0	1.3	1.6	1.9	2.3	2.6	2.9	3.2	6.3	9.4	12.6	15.7	18.8	21.9	25.1	28.2	31.3
6	72	0.3	0.4	0.8	1.2	1.6	1.9	2.3	2.7	3.1	3.4	3.8	7.6	11.3	15.1	18.8	22.6	26.3	30.1	33.8	37.6
7	84	0.3	0.5	0.9	1.4	1.8	2.2	2.7	3.1	3.6	4.0	4.4	8.8	13.2	17.6	21.9	26.3	30.7	35.1	39.4	43.8
8	96	0.3	0.6	1.1	1.6	2.1	2.6	3.1	3.6	4.1	4.6	5.1	10.1	15.1	20.1	25.1	30.1	35.1	40.1	45.1	50.1
9	108	0.3	0.6	1.2	1.7	2.3	2.9	3.4	4.0	4.5	5.1	5.7	11.3	16.9	22.5	28.2	33.8	39.4	45.0	50.7	56.3
10	120	0.4	0.7	1.3	1.9	2.5	3.2	3.8	4.4	5.0	5.7	6.3	12.5	18.8	25.0	31.3	37.5	43.8	50.0	56.3	62.5
11	132	0.4	0.7	1.4	2.1	2.8	3.5	4.2	4.8	5.5	6.2	6.9	13.8	20.7	27.5	34.4	41.3	48.2	55.0	61.9	68.8
12	144	0.4	0.8	1.5	2.3	3.0	3.8	4.5	5.3	6.0	6.8	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0
13	156	0.4	0.8	1.6	2.5	3.3	4.1	4.9	5.7	6.5	7.3	8.1	16.3	24.4	32.5	40.6	48.8	56.9	65.0	73.1	81.3
14	168	0.5	0.9	1.8	2.6	3.5	4.4	5.3	6.1	7.0	7.9	8.8	17.5	26.3	35.0	43.8	52.5	61.3	70.0	78.8	87.5
15	180	0.5	0.9	1.9	2.8	3.8	4.7	5.6	6.6	7.5	8.4	9.4	18.8	28.1	37.5	46.9	56.3	65.6	75.0	84.4	93.8
16	192	0.5	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0

TABLE - 4

HEADING WEIGHTED AVERAGE (%) SULFIDE CONTENT - DRIFT OR RAMP

Heading Consists of as stated Background (%) Sulfide Material and Vein/Veinlet or Horizon of as indicated Thickness and Sulfide (%)

Heading = 13 feet x 16 feet or 156 inches x **192** inches | Heading Background Sulfide (%) **0.2**

Horizon or Veinlet		Sulfide Content (%) in Horizon or Veinlet(s)																		
Thick-ft.	Thick-in.	0.5	1	2	3	4	5	6	7	8	9	10	20	30	40	50	60	70	80	90	100
<1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3
<1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3
<1	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.4
<1	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4
<1	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5
<1	0.6	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.5
<1	0.7	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.5	0.6
<1	0.8	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.6
<1	0.9	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7
<1	1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7
<1	2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2
<1	3	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.5	0.7	0.8	1.0	1.1	1.3	1.4	1.6	1.8
<1	4	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.6	0.8	1.0	1.2	1.4	1.7	1.9	2.1	2.3
<1	5	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.7	1.0	1.2	1.5	1.8	2.0	2.3	2.5	2.8
<1	6	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.8	1.1	1.4	1.8	2.1	2.4	2.7	3.0	3.3
<1	7	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.9	1.3	1.7	2.0	2.4	2.7	3.1	3.5	3.8
<1	8	0.2	0.2	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.6	1.0	1.4	1.9	2.3	2.7	3.1	3.5	3.9	4.4
<1	9	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	1.1	1.6	2.1	2.5	3.0	3.5	3.9	4.4	4.9
<1	10	0.2	0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.6	0.7	0.7	1.2	1.8	2.3	2.8	3.3	3.8	4.4	4.9	5.4
<1	11	0.2	0.2	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.8	1.3	1.9	2.5	3.1	3.6	4.2	4.8	5.3	5.9
1	12	0.2	0.3	0.3	0.4	0.4	0.5	0.6	0.6	0.7	0.8	0.8	1.4	2.1	2.7	3.3	3.9	4.6	5.2	5.8	6.4
2	24	0.2	0.3	0.4	0.6	0.7	0.8	0.9	1.1	1.2	1.3	1.4	2.7	3.9	5.2	6.4	7.7	8.9	10.2	11.4	12.7
3	36	0.3	0.4	0.5	0.7	0.9	1.1	1.3	1.5	1.7	1.9	2.0	3.9	5.8	7.7	9.5	11.4	13.3	15.2	17.0	18.9
4	48	0.3	0.4	0.7	0.9	1.2	1.4	1.7	1.9	2.2	2.4	2.7	5.2	7.7	10.2	12.7	15.2	17.7	20.2	22.7	25.2
5	60	0.3	0.5	0.8	1.1	1.4	1.7	2.0	2.3	2.6	3.0	3.3	6.4	9.5	12.6	15.8	18.9	22.0	25.1	28.3	31.4
6	72	0.3	0.5	0.9	1.3	1.6	2.0	2.4	2.8	3.1	3.5	3.9	7.6	11.4	15.1	18.9	22.6	26.4	30.1	33.9	37.6
7	84	0.3	0.6	1.0	1.4	1.9	2.3	2.7	3.2	3.6	4.1	4.5	8.9	13.2	17.6	22.0	26.4	30.7	35.1	39.5	43.9
8	96	0.4	0.6	1.1	1.6	2.1	2.6	3.1	3.6	4.1	4.6	5.1	10.1	15.1	20.1	25.1	30.1	35.1	40.1	45.1	50.1
9	108	0.4	0.7	1.2	1.8	2.3	2.9	3.5	4.0	4.6	5.2	5.7	11.3	17.0	22.6	28.2	33.8	39.5	45.1	50.7	56.3
10	120	0.4	0.7	1.3	2.0	2.6	3.2	3.8	4.5	5.1	5.7	6.3	12.6	18.8	25.1	31.3	37.6	43.8	50.1	56.3	62.6
11	132	0.4	0.8	1.4	2.1	2.8	3.5	4.2	4.9	5.6	6.3	6.9	13.8	20.7	27.6	34.4	41.3	48.2	55.1	61.9	68.8
12	144	0.4	0.8	1.6	2.3	3.1	3.8	4.6	5.3	6.1	6.8	7.6	15.1	22.6	30.1	37.6	45.1	52.6	60.1	67.6	75.1
13	156	0.4	0.9	1.7	2.5	3.3	4.1	4.9	5.7	6.5	7.4	8.2	16.3	24.4	32.5	40.7	48.8	56.9	65.0	73.2	81.3
14	168	0.5	0.9	1.8	2.7	3.5	4.4	5.3	6.2	7.0	7.9	8.8	17.5	26.3	35.0	43.8	52.5	61.3	70.0	78.8	87.5
15	180	0.5	1.0	1.9	2.8	3.8	4.7	5.6	6.6	7.5	8.5	9.4	18.8	28.1	37.5	46.9	56.3	65.6	75.0	84.4	93.8
16	192	0.5	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0

TABLE - 5

HEADING WEIGHTED AVERAGE (%) SULFIDE CONTENT - DRIFT OR RAMP

Heading Consists of as stated Background (%) Sulfide Material and Vein/Veinlet or Horizon of as indicated Thickness and Sulfide (%)

Heading = 13 feet x 16 feet or 156 inches x **192** inches Heading Background Sulfide (%) **0.5**

Horizon or Veinlet		Sulfide Content (%) in Horizon or Veinlet(s)																			
Thick-ft.	Thick-in.	0.5	1	2	3	4	5	6	7	8	9	10	20	30	40	50	60	70	80	90	100
<1	0.1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6
<1	0.2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6
<1	0.3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.7
<1	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7
<1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.8
<1	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.8	0.8
<1	0.7	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.9
<1	0.8	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.9	0.9
<1	0.9	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	1.0
<1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.7	0.7	0.8	0.8	0.9	0.9	1.0	1.0
<1	2	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5
<1	3	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.8	1.0	1.1	1.3	1.4	1.6	1.7	1.9	2.1
<1	4	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.9	1.1	1.3	1.5	1.7	1.9	2.2	2.4	2.6
<1	5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7	1.0	1.3	1.5	1.8	2.0	2.3	2.6	2.8	3.1
<1	6	0.5	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.7	0.8	0.8	1.1	1.4	1.7	2.0	2.4	2.7	3.0	3.3	3.6
<1	7	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.8	1.2	1.6	1.9	2.3	2.7	3.0	3.4	3.8	4.1
<1	8	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	1.3	1.7	2.1	2.6	3.0	3.4	3.8	4.2	4.6
<1	9	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	0.9	1.4	1.9	2.4	2.8	3.3	3.8	4.2	4.7	5.2
<1	10	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	1.0	1.5	2.0	2.6	3.1	3.6	4.1	4.6	5.2	5.7
<1	11	0.5	0.5	0.6	0.6	0.7	0.8	0.8	0.9	0.9	1.0	1.0	1.6	2.2	2.8	3.3	3.9	4.5	5.1	5.6	6.2
1	12	0.5	0.5	0.6	0.7	0.7	0.8	0.8	0.9	1.0	1.0	1.1	1.7	2.3	3.0	3.6	4.2	4.8	5.5	6.1	6.7
2	24	0.5	0.6	0.7	0.8	0.9	1.1	1.2	1.3	1.4	1.6	1.7	2.9	4.2	5.4	6.7	7.9	9.2	10.4	11.7	12.9
3	36	0.5	0.6	0.8	1.0	1.2	1.3	1.5	1.7	1.9	2.1	2.3	4.2	6.0	7.9	9.8	11.7	13.5	15.4	17.3	19.2
4	48	0.5	0.6	0.9	1.1	1.4	1.6	1.9	2.1	2.4	2.6	2.9	5.4	7.9	10.4	12.9	15.4	17.9	20.4	22.9	25.4
5	60	0.5	0.7	1.0	1.3	1.6	1.9	2.2	2.5	2.8	3.2	3.5	6.6	9.7	12.8	16.0	19.1	22.2	25.3	28.5	31.6
6	72	0.5	0.7	1.1	1.4	1.8	2.2	2.6	2.9	3.3	3.7	4.1	7.8	11.6	15.3	19.1	22.8	26.6	30.3	34.1	37.8
7	84	0.5	0.7	1.2	1.6	2.0	2.5	2.9	3.3	3.8	4.2	4.7	9.0	13.4	17.8	22.2	26.5	30.9	35.3	39.7	44.0
8	96	0.5	0.8	1.3	1.8	2.3	2.8	3.3	3.8	4.3	4.8	5.3	10.3	15.3	20.3	25.3	30.3	35.3	40.3	45.3	50.3
9	108	0.5	0.8	1.3	1.9	2.5	3.0	3.6	4.2	4.7	5.3	5.8	11.5	17.1	22.7	28.3	34.0	39.6	45.2	50.8	56.5
10	120	0.5	0.8	1.4	2.1	2.7	3.3	3.9	4.6	5.2	5.8	6.4	12.7	18.9	25.2	31.4	37.7	43.9	50.2	56.4	62.7
11	132	0.5	0.8	1.5	2.2	2.9	3.6	4.3	5.0	5.7	6.3	7.0	13.9	20.8	27.7	34.5	41.4	48.3	55.2	62.0	68.9
12	144	0.5	0.9	1.6	2.4	3.1	3.9	4.6	5.4	6.1	6.9	7.6	15.1	22.6	30.1	37.6	45.1	52.6	60.1	67.6	75.1
13	156	0.5	0.9	1.7	2.5	3.3	4.2	5.0	5.8	6.6	7.4	8.2	16.3	24.5	32.6	40.7	48.8	57.0	65.1	73.2	81.3
14	168	0.5	0.9	1.8	2.7	3.6	4.4	5.3	6.2	7.1	7.9	8.8	17.6	26.3	35.1	43.8	52.6	61.3	70.1	78.8	87.6
15	180	0.5	1.0	1.9	2.8	3.8	4.7	5.7	6.6	7.5	8.5	9.4	18.8	28.2	37.5	46.9	56.3	65.7	75.0	84.4	93.8
16	192	0.5	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0

TABLE - 6

HEADING WEIGHTED AVERAGE (%) SULFIDE CONTENT - DRIFT OR RAMP

Heading Consists of as stated Background (%) Sulfide Material and Vein/Veinlet or Horizon of as indicated Thickness and Sulfide (%)

Heading = 13 feet x 16 feet or 156 inches x **192** inches Heading Background Sulfide (%) **0.7**

Horizon or Veinlet		Sulfide Content (%) in Horizon or Veinlet(s)																			
Thick-ft.	Thick-in.	0.5	1	2	3	4	5	6	7	8	9	10	20	30	40	50	60	70	80	90	100
<1	0.1	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8
<1	0.2	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8
<1	0.3	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.9
<1	0.4	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.9	0.9	0.9
<1	0.5	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9	1.0
<1	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.9	0.9	0.9	0.9	1.0	1.0
<1	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.9	0.9	1.0	1.0	1.0	1.1
<1	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.9	0.9	0.9	1.0	1.0	1.1	1.1
<1	0.9	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.9	0.9	1.0	1.0	1.1	1.1	1.2
<1	1	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.9	0.9	1.0	1.0	1.1	1.1	1.2	1.2
<1	2	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7
<1	3	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.8	1.0	1.2	1.3	1.5	1.6	1.8	1.9	2.1	2.3
<1	4	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.9	0.9	0.9	1.1	1.3	1.5	1.7	1.9	2.1	2.4	2.6	2.8
<1	5	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9	1.2	1.5	1.7	2.0	2.2	2.5	2.8	3.0	3.3
<1	6	0.7	0.7	0.7	0.8	0.8	0.8	0.9	0.9	0.9	1.0	1.0	1.3	1.6	1.9	2.2	2.6	2.9	3.2	3.5	3.8
<1	7	0.7	0.7	0.7	0.8	0.8	0.9	0.9	0.9	1.0	1.0	1.0	1.4	1.8	2.1	2.5	2.9	3.2	3.6	4.0	4.3
<1	8	0.7	0.7	0.8	0.8	0.8	0.9	0.9	1.0	1.0	1.0	1.1	1.5	1.9	2.3	2.8	3.2	3.6	4.0	4.4	4.8
<1	9	0.7	0.7	0.8	0.8	0.9	0.9	0.9	1.0	1.0	1.1	1.1	1.6	2.1	2.5	3.0	3.5	3.9	4.4	4.9	5.4
<1	10	0.7	0.7	0.8	0.8	0.9	0.9	1.0	1.0	1.1	1.1	1.2	1.7	2.2	2.7	3.3	3.8	4.3	4.8	5.4	5.9
<1	11	0.7	0.7	0.8	0.8	0.9	0.9	1.0	1.1	1.1	1.2	1.2	1.8	2.4	3.0	3.5	4.1	4.7	5.2	5.8	6.4
1	12	0.7	0.7	0.8	0.8	0.9	1.0	1.0	1.1	1.2	1.2	1.3	1.9	2.5	3.2	3.8	4.4	5.0	5.7	6.3	6.9
2	24	0.7	0.7	0.9	1.0	1.1	1.2	1.4	1.5	1.6	1.7	1.9	3.1	4.4	5.6	6.9	8.1	9.4	10.6	11.9	13.1
3	36	0.7	0.8	0.9	1.1	1.3	1.5	1.7	1.9	2.1	2.3	2.4	4.3	6.2	8.1	9.9	11.8	13.7	15.6	17.4	19.3
4	48	0.7	0.8	1.0	1.3	1.5	1.8	2.0	2.3	2.5	2.8	3.0	5.5	8.0	10.5	13.0	15.5	18.0	20.5	23.0	25.5
5	60	0.6	0.8	1.1	1.4	1.7	2.0	2.4	2.7	3.0	3.3	3.6	6.7	9.9	13.0	16.1	19.2	22.4	25.5	28.6	31.7
6	72	0.6	0.8	1.2	1.6	1.9	2.3	2.7	3.1	3.4	3.8	4.2	7.9	11.7	15.4	19.2	22.9	26.7	30.4	34.2	37.9
7	84	0.6	0.8	1.3	1.7	2.1	2.6	3.0	3.5	3.9	4.3	4.8	9.1	13.5	17.9	22.3	26.6	31.0	35.4	39.8	44.1
8	96	0.6	0.9	1.4	1.9	2.4	2.9	3.4	3.9	4.4	4.9	5.4	10.4	15.4	20.4	25.4	30.4	35.4	40.4	45.4	50.4
9	108	0.6	0.9	1.4	2.0	2.6	3.1	3.7	4.2	4.8	5.4	5.9	11.6	17.2	22.8	28.4	34.1	39.7	45.3	50.9	56.6
10	120	0.6	0.9	1.5	2.1	2.8	3.4	4.0	4.6	5.3	5.9	6.5	12.8	19.0	25.3	31.5	37.8	44.0	50.3	56.5	62.8
11	132	0.6	0.9	1.6	2.3	3.0	3.7	4.3	5.0	5.7	6.4	7.1	14.0	20.8	27.7	34.6	41.5	48.3	55.2	62.1	69.0
12	144	0.6	0.9	1.7	2.4	3.2	3.9	4.7	5.4	6.2	6.9	7.7	15.2	22.7	30.2	37.7	45.2	52.7	60.2	67.7	75.2
13	156	0.5	0.9	1.8	2.6	3.4	4.2	5.0	5.8	6.6	7.4	8.3	16.4	24.5	32.6	40.8	48.9	57.0	65.1	73.3	81.4
14	168	0.5	1.0	1.8	2.7	3.6	4.5	5.3	6.2	7.1	8.0	8.8	17.6	26.3	35.1	43.8	52.6	61.3	70.1	78.8	87.6
15	180	0.5	1.0	1.9	2.9	3.8	4.7	5.7	6.6	7.5	8.5	9.4	18.8	28.2	37.5	46.9	56.3	65.7	75.0	84.4	93.8
16	192	0.5	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0

TABLE - 7

HEADING WEIGHTED AVERAGE (%) SULFIDE CONTENT - SHAFT

Shaft Consists of as stated Background (%) Sulfide Material and Vein/Veinlet or Horizon of as indicated Thickness and Sulfide (%)

Shaft pre concrete diameter = 24ft | Area | 65144.22 | sq in | Heading Background Sulfide (%) | 0.1

Horizon or Veinlets				Sulfide Content (%) in Horizon or Veinlet(s)																		
Tk. ft.	Tk.in.	Lgth. in.	Area	0.5	1	2	3	4	5	6	7	8	9	10	20	30	40	50	60	70	80	90	100
<1	0.1	288	29	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
<1	0.2	288	58	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2
<1	0.3	288	86	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2
<1	0.4	288	115	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3
<1	0.5	288	144	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3
<1	0.6	288	173	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4
<1	0.7	288	202	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4
<1	0.8	288	230	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5
<1	0.9	288	259	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.5
<1	1	288	288	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.5
<1	2	288	576	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.4	0.5	0.5	0.6	0.7	0.8	0.9	1.0
<1	3	288	864	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.4	0.5	0.6	0.8	0.9	1.0	1.2	1.3	1.4
<1	4	288	1152	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.5	0.6	0.8	1.0	1.2	1.3	1.5	1.7	1.9
<1	5	288	1440	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.5	0.8	1.0	1.2	1.4	1.6	1.9	2.1	2.3
<1	6	288	1728	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.6	0.9	1.2	1.4	1.7	2.0	2.2	2.5	2.7
<1	7	288	2016	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.7	1.0	1.3	1.6	2.0	2.3	2.6	2.9	3.2
<1	8	288	2304	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.8	1.2	1.5	1.9	2.2	2.6	2.9	3.3	3.6
<1	9	288	2592	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.9	1.3	1.7	2.1	2.5	2.9	3.3	3.7	4.1
<1	10	288	2880	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.4	0.5	0.5	1.0	1.4	1.9	2.3	2.7	3.2	3.6	4.1	4.5
<1	11	288	3168	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	1.1	1.6	2.0	2.5	3.0	3.5	4.0	4.5	5.0
1	12	288	3456	0.1	0.1	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	1.2	1.7	2.2	2.7	3.3	3.8	4.3	4.9	5.4
2	24	288	6912	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	2.2	3.3	4.3	5.4	6.5	7.5	8.6	9.6	10.7
4	48	282	13536	0.2	0.3	0.5	0.7	0.9	1.1	1.3	1.5	1.7	1.9	2.2	4.2	6.3	8.4	10.5	12.5	14.6	16.7	18.8	20.9
6	72	278	20016	0.2	0.4	0.7	1.0	1.3	1.6	1.9	2.2	2.5	2.8	3.1	6.2	9.3	12.4	15.4	18.5	21.6	24.6	27.7	30.8
8	96	270	25920	0.3	0.5	0.9	1.3	1.7	2.0	2.4	2.8	3.2	3.6	4.0	8.0	12.0	16.0	20.0	23.9	27.9	31.9	35.9	39.8
10	120	262	31440	0.3	0.5	1.0	1.5	2.0	2.5	2.9	3.4	3.9	4.4	4.9	9.7	14.5	19.4	24.2	29.0	33.8	38.7	43.5	48.3

TABLE - 8

HEADING WEIGHTED AVERAGE (%) SULFIDE CONTENT - SHAFT

Shaft Consists of as stated Background (%) Sulfide Material and Vein/Veinlet or Horizon of as indicated Thickness and Sulfide (%)

Shaft pre concrete diameter = 24ft | Area | 65144.22 | sq in | Heading Background Sulfide (%) | 0.2

Horizon or Veinlets				Sulfide Content (%) in Horizon or Veinlet(s)																		
Tk. ft.	Tk.in.	Lgth. in.	Area	0.5	1	2	3	4	5	6	7	8	9	10	20	30	40	50	60	70	80	90	100
<1	0.1	288	29	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
<1	0.2	288	58	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3
<1	0.3	288	86	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3
<1	0.4	288	115	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4
<1	0.5	288	144	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4
<1	0.6	288	173	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5
<1	0.7	288	202	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.5
<1	0.8	288	230	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6
<1	0.9	288	259	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.6
<1	1	288	288	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.6
<1	2	288	576	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.4	0.5	0.6	0.6	0.7	0.8	0.9	1.0	1.1
<1	3	288	864	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.5	0.6	0.7	0.9	1.0	1.1	1.3	1.4	1.5
<1	4	288	1152	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.6	0.7	0.9	1.1	1.3	1.4	1.6	1.8	2.0
<1	5	288	1440	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.6	0.9	1.1	1.3	1.5	1.7	2.0	2.2	2.4
<1	6	288	1728	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.7	1.0	1.3	1.5	1.8	2.1	2.3	2.6	2.8
<1	7	288	2016	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.8	1.1	1.4	1.7	2.1	2.4	2.7	3.0	3.3
<1	8	288	2304	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.9	1.3	1.6	2.0	2.3	2.7	3.0	3.4	3.7
<1	9	288	2592	0.2	0.2	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.6	1.0	1.4	1.8	2.2	2.6	3.0	3.4	3.8	4.2
<1	10	288	2880	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.5	0.6	0.6	1.1	1.5	2.0	2.4	2.8	3.3	3.7	4.2	4.6
<1	11	288	3168	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	1.2	1.6	2.1	2.6	3.1	3.6	4.1	4.6	5.1
1	12	288	3456	0.2	0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.6	0.7	0.7	1.3	1.8	2.3	2.8	3.4	3.9	4.4	5.0	5.5
2	24	288	6912	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	2.3	3.4	4.4	5.5	6.5	7.6	8.7	9.7	10.8
4	48	282	13536	0.3	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	4.3	6.4	8.5	10.5	12.6	14.7	16.8	18.9	20.9
6	72	278	20016	0.3	0.5	0.8	1.1	1.4	1.7	2.0	2.3	2.6	2.9	3.2	6.3	9.4	12.4	15.5	18.6	21.6	24.7	27.8	30.9
8	96	270	25920	0.3	0.6	1.0	1.4	1.7	2.1	2.5	2.9	3.3	3.7	4.1	8.1	12.1	16.0	20.0	24.0	28.0	32.0	35.9	39.9
10	120	262	31440	0.3	0.6	1.1	1.6	2.0	2.5	3.0	3.5	4.0	4.4	4.9	9.8	14.6	19.4	24.2	29.1	33.9	38.7	43.5	48.4

TABLE - 9

HEADING WEIGHTED AVERAGE (%) SULFIDE CONTENT - SHAFT

Shaft Consists of as stated Background (%) Sulfide Material and Vein/Veinlet or Horizon of as indicated Thickness and Sulfide (%)

Shaft pre concrete diameter = 24ft	Area	65144.22	sq in									Heading Background Sulfide (%)	0.5

Horizon or Veinlets				Sulfide Content (%) in Horizon or Veinlet(s)																		
Tk. ft.	Tk.in.	Lgth. in.	Area	0.5	1	2	3	4	5	6	7	8	9	10	20	30	40	50	60	70	80	90	100
<1	0.1	288	29	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
<1	0.2	288	58	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6
<1	0.3	288	86	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6
<1	0.4	288	115	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7
<1	0.5	288	144	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7
<1	0.6	288	173	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.8
<1	0.7	288	202	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.8	0.8
<1	0.8	288	230	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.9
<1	0.9	288	259	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.9	0.9
<1	1	288	288	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	0.9
<1	2	288	576	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.8	0.8	0.9	1.0	1.1	1.2	1.3	1.4
<1	3	288	864	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.8	0.9	1.0	1.2	1.3	1.4	1.6	1.7	1.8
<1	4	288	1152	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.8	1.0	1.2	1.4	1.6	1.7	1.9	2.1	2.3
<1	5	288	1440	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.9	1.2	1.4	1.6	1.8	2.0	2.3	2.5	2.7
<1	6	288	1728	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.8	1.0	1.3	1.5	1.8	2.1	2.3	2.6	2.9	3.1
<1	7	288	2016	0.5	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.7	0.8	0.8	1.1	1.4	1.7	2.0	2.3	2.7	3.0	3.3	3.6
<1	8	288	2304	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.8	1.2	1.5	1.9	2.3	2.6	3.0	3.3	3.7	4.0
<1	9	288	2592	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.9	1.3	1.7	2.1	2.5	2.9	3.3	3.7	4.1	4.5
<1	10	288	2880	0.5	0.5	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.9	0.9	1.4	1.8	2.2	2.7	3.1	3.6	4.0	4.5	4.9
<1	11	288	3168	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	1.0	1.4	1.9	2.4	2.9	3.4	3.9	4.4	4.9	5.3
1	12	288	3456	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	1.0	1.0	1.5	2.1	2.6	3.1	3.7	4.2	4.7	5.2	5.8
2	24	288	6912	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	2.6	3.6	4.7	5.8	6.8	7.9	8.9	10.0	11.1
4	48	282	13536	0.5	0.7	0.9	1.1	1.2	1.4	1.6	1.9	2.1	2.3	2.5	4.6	6.6	8.7	10.8	12.9	14.9	17.0	19.1	21.2
6	72	278	20016	0.5	0.8	1.1	1.4	1.6	1.9	2.2	2.5	2.8	3.1	3.4	6.5	9.6	12.6	15.7	18.8	21.9	24.9	28.0	31.1
8	96	270	25920	0.5	0.9	1.3	1.7	1.9	2.3	2.7	3.1	3.5	3.9	4.3	8.3	12.2	16.2	20.2	24.2	28.2	32.1	36.1	40.1
10	120	262	31440	0.5	0.7	1.2	1.7	2.2	2.7	3.2	3.6	4.1	4.6	5.1	9.9	14.7	19.6	24.4	29.2	34.0	38.9	43.7	48.5

TABLE - 10

HEADING WEIGHTED AVERAGE (%) SULFIDE CONTENT - SHAFT

Shaft Consists of as stated Background (%) Sulfide Material and Vein/Veinlet or Horizon of as indicated Thickness and Sulfide (%)

Shaft pre concrete diameter = 24ft	Area	65144.22	sq in									Heading Background Sulfide (%)	0.7

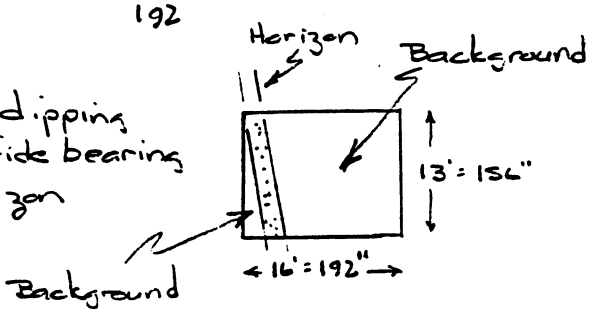
Horizon or Veinlets				Sulfide Content (%) in Horizon or Veinlet(s)																		
Tk. ft.	Tk.in.	Lgth. in.	Area	0.5	1	2	3	4	5	6	7	8	9	10	20	30	40	50	60	70	80	90	100
<1	0.1	288	29	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
<1	0.2	288	58	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8
<1	0.3	288	86	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.8
<1	0.4	288	115	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.9	0.9
<1	0.5	288	144	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9
<1	0.6	288	173	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9	1.0
<1	0.7	288	202	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.9	0.9	0.9	0.9	1.0	1.0
<1	0.8	288	230	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.9	0.9	0.9	1.0	1.0	1.1
<1	0.9	288	259	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.9	0.9	0.9	1.0	1.0	1.1	1.1
<1	1	288	288	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.9	0.9	1.0	1.0	1.1	1.1	1.1
<1	2	288	576	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.9	1.0	1.0	1.1	1.2	1.3	1.4	1.5	1.6
<1	3	288	864	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8	1.0	1.1	1.2	1.4	1.5	1.6	1.8	1.9	2.0
<1	4	288	1152	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.9	1.0	1.2	1.4	1.6	1.7	1.9	2.1	2.3	2.5
<1	5	288	1440	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.9	0.9	0.9	1.1	1.3	1.6	1.8	2.0	2.2	2.5	2.7	2.9
<1	6	288	1728	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9	1.2	1.5	1.7	2.0	2.3	2.5	2.8	3.1	3.3
<1	7	288	2016	0.7	0.7	0.7	0.8	0.8	0.8	0.9	0.9	0.9	1.0	1.0	1.3	1.6	1.9	2.2	2.5	2.8	3.2	3.5	3.8
<1	8	288	2304	0.7	0.7	0.7	0.8	0.8	0.9	0.9	0.9	1.0	1.0	1.0	1.4	1.7	2.1	2.4	2.8	3.2	3.5	3.9	4.2
<1	9	288	2592	0.7	0.7	0.8	0.8	0.8	0.9	0.9	1.0	1.0	1.0	1.1	1.5	1.9	2.3	2.7	3.1	3.5	3.9	4.3	4.7
<1	10	288	2880	0.7	0.7	0.8	0.8	0.8	0.9	0.9	1.0	1.0	1.1	1.1	1.6	2.0	2.4	2.9	3.3	3.8	4.2	4.6	5.1
<1	11	288	3168	0.7	0.7	0.8	0.8	0.9	0.9	1.0	1.0	1.1	1.1	1.2	1.6	2.1	2.6	3.1	3.6	4.1	4.6	5.0	5.5
1	12	288	3456	0.7	0.7	0.8	0.8	0.9	0.9	1.0	1.0	1.1	1.1	1.2	1.7	2.3	2.8	3.3	3.8	4.4	4.9	5.4	6.0
2	24	288	6912	0.7	0.7	0.8	0.9	1.1	1.2	1.3	1.4	1.5	1.6	1.7	2.7	3.8	4.9	5.9	7.0	8.1	9.1	10.2	11.2
4	48	282	13536	0.7	0.9	1.1	1.3	1.4	1.6	1.8	2.0	2.2	2.4	2.6	4.7	6.8	8.9	10.9	13.0	15.1	17.2	19.3	21.3
6	72	278	20016	0.6	1.0	1.3	1.6	1.7	2.0	2.3	2.6	2.9	3.3	3.6	6.6	9.7	12.8	15.8	18.9	22.0	25.1	28.1	31.2
8	96	270	25920	0.6	1.1	1.5	1.9	2.0	2.4	2.8	3.2	3.6	4.0	4.4	8.4	12.4	16.3	20.3	24.3	28.3	32.3	36.2	40.2
10	120	262	31440	0.6	0.8	1.3	1.8	2.3	2.8	3.3	3.7	4.2	4.7	5.2	10.0	14.8	19.7	24.5	29.3	34.1	39.0	43.8	48.6

DRIFT / RAMP — CASE 1

13' VERTICAL 16' HORIZONTAL

156" 192"

80° dipping sulfide bearing horizon



Drift/Ramp total area

13' x 16' = 208ft²

156" x 192" = 29,952in²

TWO ILLUSTRATIONS, CASE 1 & CASE 2

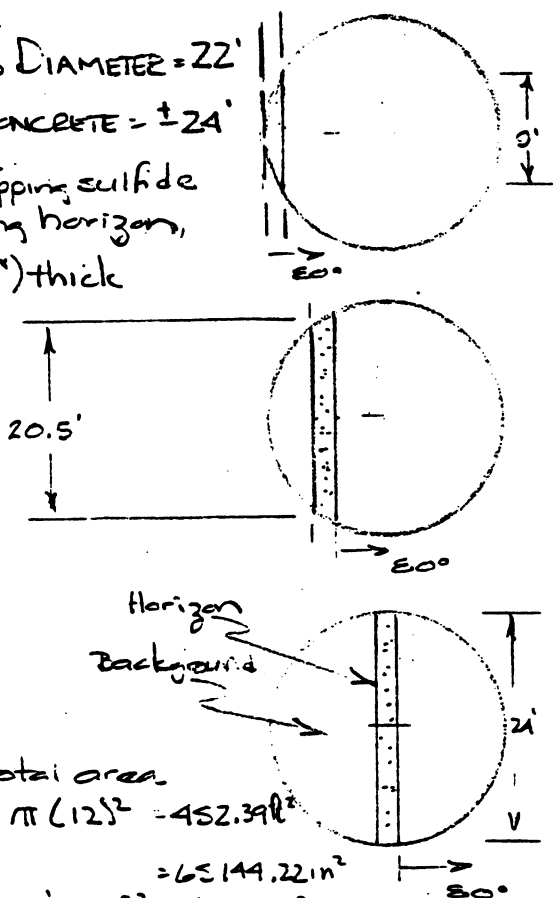
- SHOW GEOMETRY OF A 2' THICK SULFIDE BEARING HORIZON (OR VEIN/VEINLET ZONE) DIPPING AT 80° THROUGH A DRIFT, RAMP OR SHAFT
- TABLES DEVELOPED BY VARYING HORIZON THICKNESS AND/OR SULFIDE CONTENT TO DEMONSTRATE THE RESULTANT WEIGHTED AVERAGE SULFIDE CONTENT OF COMBINED UNITS; - HORIZON + BACKGROUND
- MULTIPLE TABLES SHOW EFFECT OF VARIED BACKGROUNDS
- CALCULATION IGNORED EFFECT OF 80° DIP AS AREA OR VOLUME DIFFERENCE BETWEEN 80° AND 90° NOT SIGNIFICANT
- SHAFT WEIGHTED AVERAGE CALCULATION TREAT AT MIDDLE OF SHAFT WHERE THE EFFECT OF THE HORIZON WOULD BE AT MAXIMUM *

SHAFT — CASE 2

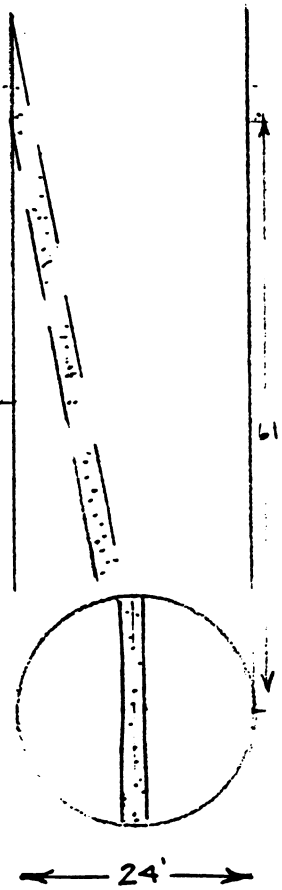
FINISHED DIAMETER = 22'

BEFORE CONCRETE = ±24'

80° dipping sulfide bearing horizon, 2' (24") thick



*Maximum Area



SCALE 1" = 20'

A.J.E Jr
6/16/96

Shaft total area

πr² = π(12)² = 452.39ft²

= 65144.22in²

Horizon: 2' x 24' = 48ft² = 6912in²

APPENDIX - 1

Redpath Level Plans

1" = 400'

500

700

900

1100

1300

1500

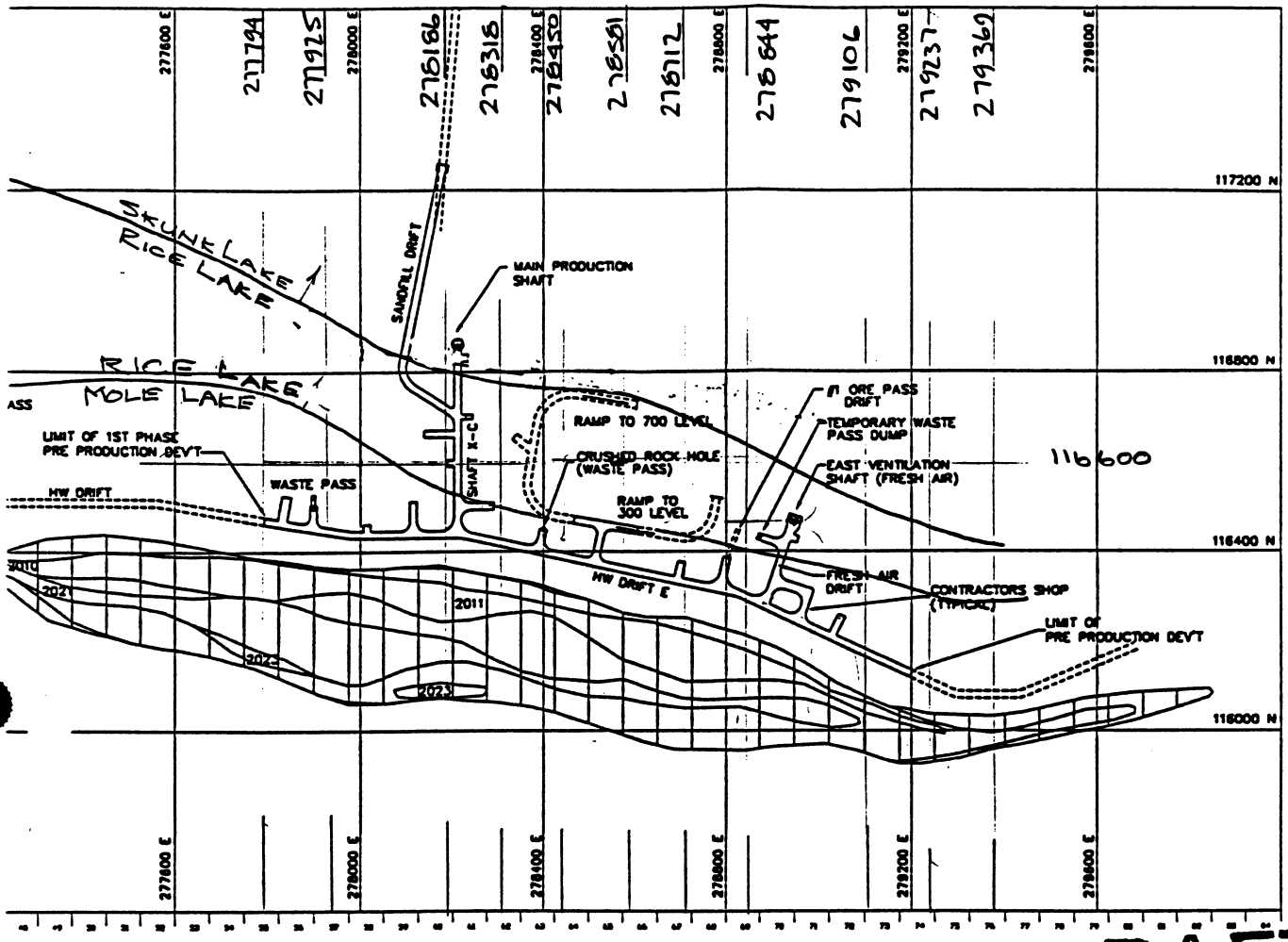
1700

1900

2050

2100

2250



DRAFT

APR 25 1996

LEGEND

PRE-PRODUCTION DEVELOPMENT

FUTURE DEVELOPMENT

NO.	REVISIONS	DATE	BY
4			
3	FOR REFERENCE	24/04/96	SMR
2	FOR REFERENCE	13/02/96	SMR
1	FOR REVIEW	16/01/96	DKS
A	FIRST DRAFT	DEC. 95	SMR

REDPATH McINTOSH ENGINEERING LIMITED
P.O. Box 21043
710 McKeown Avenue
North Bay, Ontario
P1B 9N8
Telephone: 1-705-494-8255
Fax: 1-705-474-2652

CLIENT: CRANDON MINING COMPANY

TITLE: CRANDON PROJECT
500 LEVEL (1150 ELEVATION)
PLAN VIEW

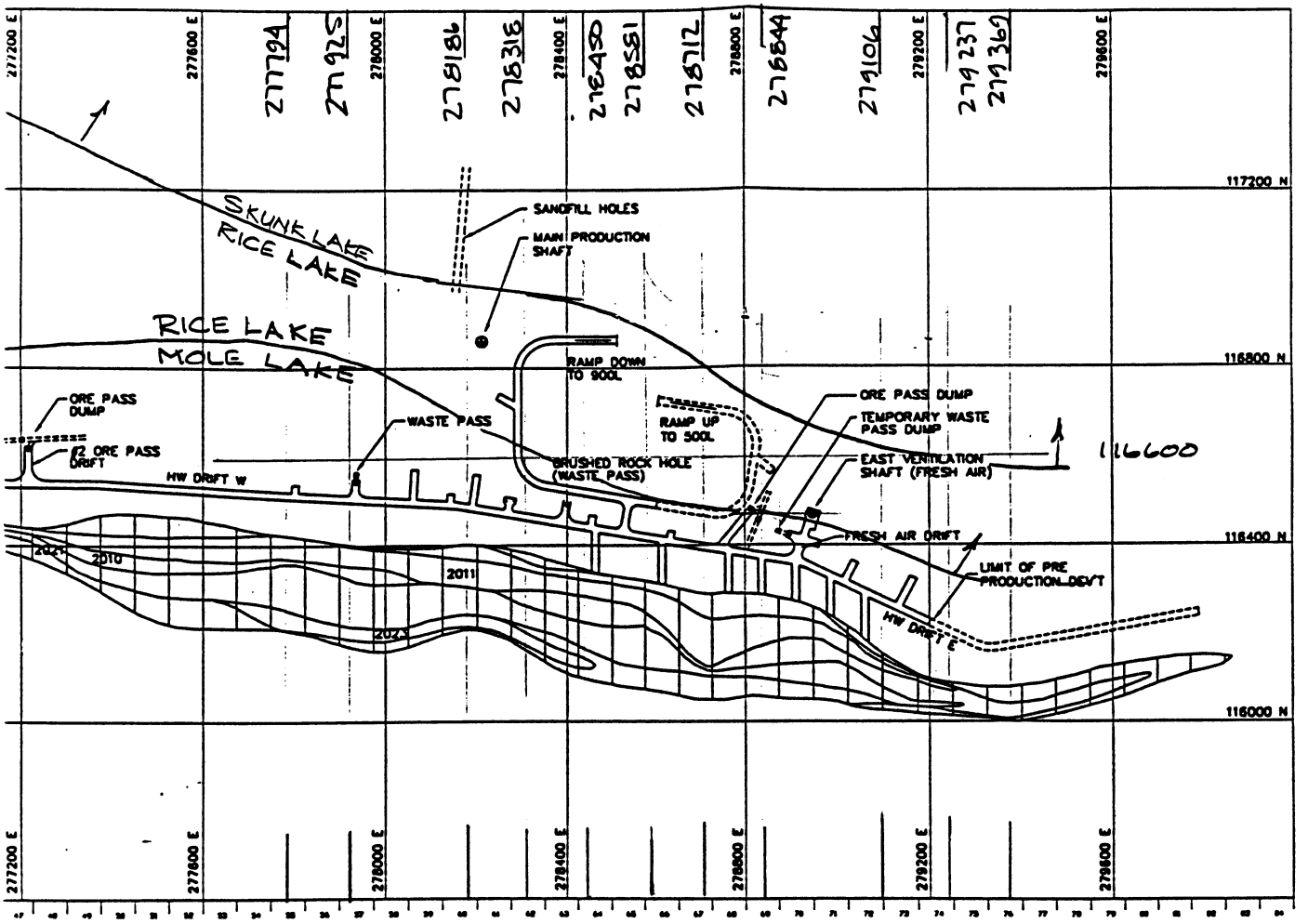
AJEJ- 6/12/96

SCALE: 1"= 400'

DWG. NO.: 6425-0500

REV.: 3

Fig. 21



DRAFT

APR 25 1996

LEGEND

PRE-PRODUCTION DEVELOPMENT

FUTURE DEVELOPMENT

NO.	REVISIONS	DATE	BY
4			
3	FOR REFERENCE	24/04/96	SMR
2	FOR REFERENCE	13/02/96	SMR
1	FOR REVIEW	16/01/96	DKS
A	FIRST DRAFT	DEC.'95	SMR

REDPATH McINTOSH ENGINEERING LIMITED
P.O. Box 21043
710 McKeown Avenue
North Bay, Ontario
P1B 9N8
Telephone: 1-705-494-8255
Fax: 1-705-474-2652

CLIENT: CRANDON MINING COMPANY

TITLE: CRANDON PROJECT
700 LEVEL (950 ELEVATION)
PLAN VIEW

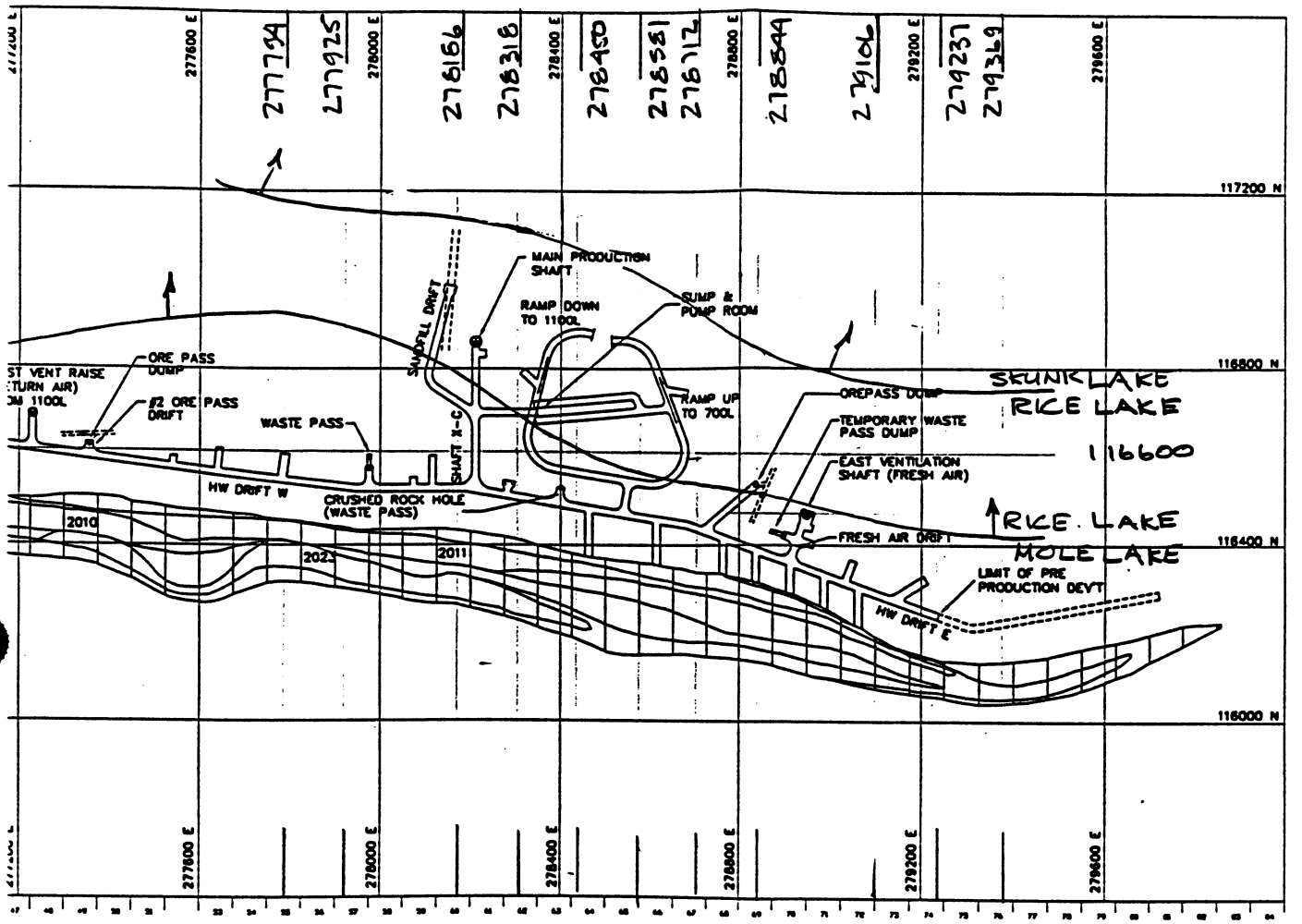
AJE J. 4/12/96

SCALE: 1"=400'

DWG. NO.: 6425-0501

REV.: 3

Fig. 22



DRAFT

APR 25 1996

LEGEND

PRE-PRODUCTION DEVELOPMENT

FUTURE DEVELOPMENT

NO.	REVISIONS	DATE	BY
4			
3	FOR REFERENCE	24/04/96	SMR
2	FOR REFERENCE	13/02/96	SMR
1	FOR REVIEW	16/01/96	DKS
A	FIRST DRAFT	DEC.'95	SMR

REDPATH McINTOSH ENGINEERING LIMITED
P.O. Box 21043
710 McKeown Avenue
North Bay, Ontario
P1B 9N8
Telephone: 1-705-494-8255
Fax: 1-705-474-2652

CLIENT: CRANDON MINING COMPANY

TITLE: CRANDON PROJECT
900 LEVEL (750 ELEVATION)
PLAN VIEW

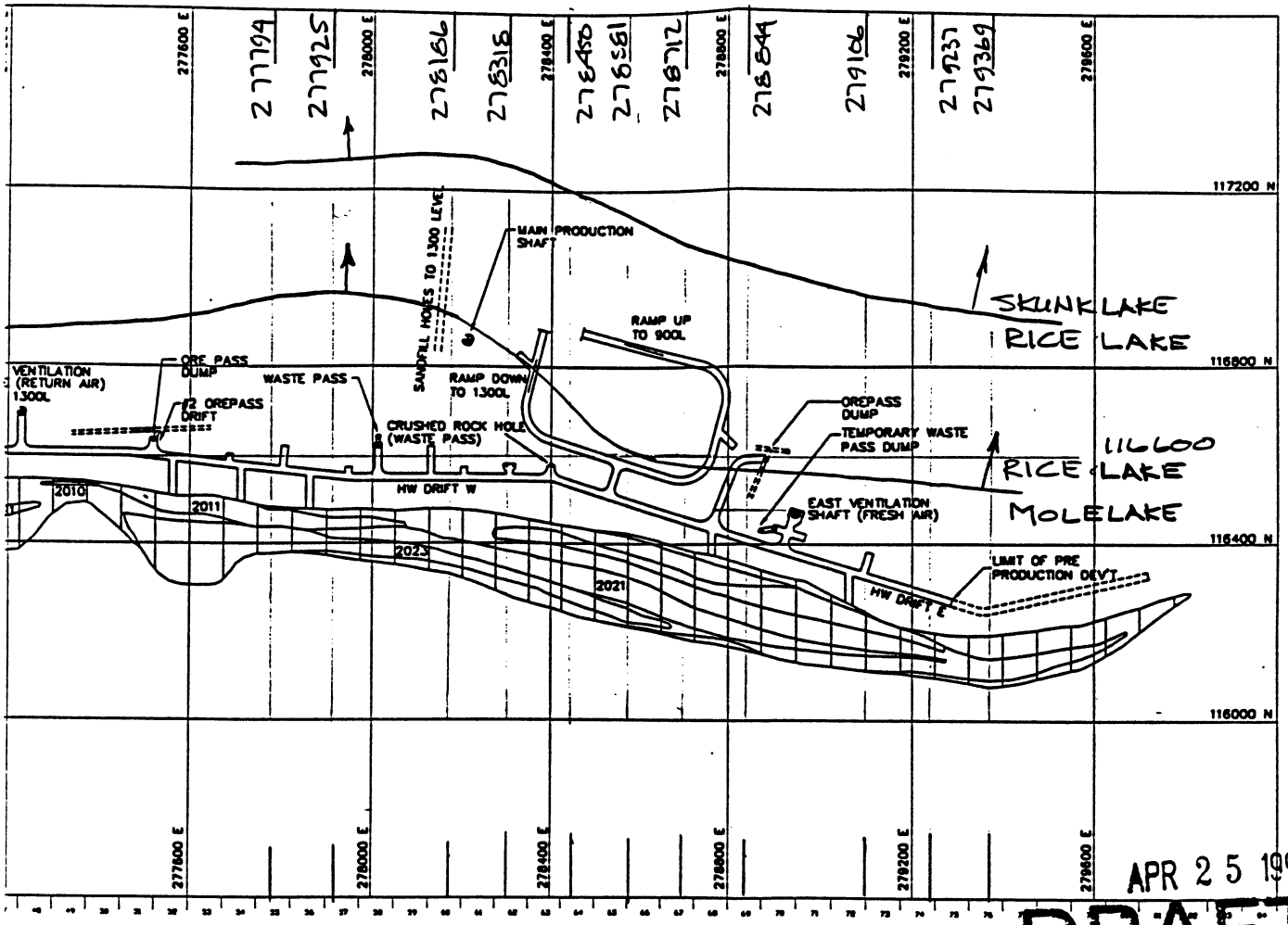
AJEJr 6/12/96

SCALE: 1"=400'

DWG. NO.: 6425-0502

REV.: 3

Fig. 23



APR 25 1996

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LEGEND

PRE-PRODUCTION DEVELOPMENT

FUTURE DEVELOPMENT

NO.	REVISIONS	DATE	BY
4			
3	FOR REFERENCE	24/04/96	SMR
2	FOR REFERENCE	13/02/96	SMR
1	FOR REVIEW	16/01/96	DKS
A	FIRST DRAFT	DEC.'95	SMR

REDPATH McINTOSH ENGINEERING LIMITED
P.O. Box 21043
710 McKeown Avenue
North Bay, Ontario
P1B 9N8
Telephone: 1-705-494-8255
Fax: 1-705-474-2652

CLIENT: CRANDON MINING COMPANY

TITLE: CRANDON PROJECT
1100 LEVEL (550 ELEVATION)
PLAN VIEW

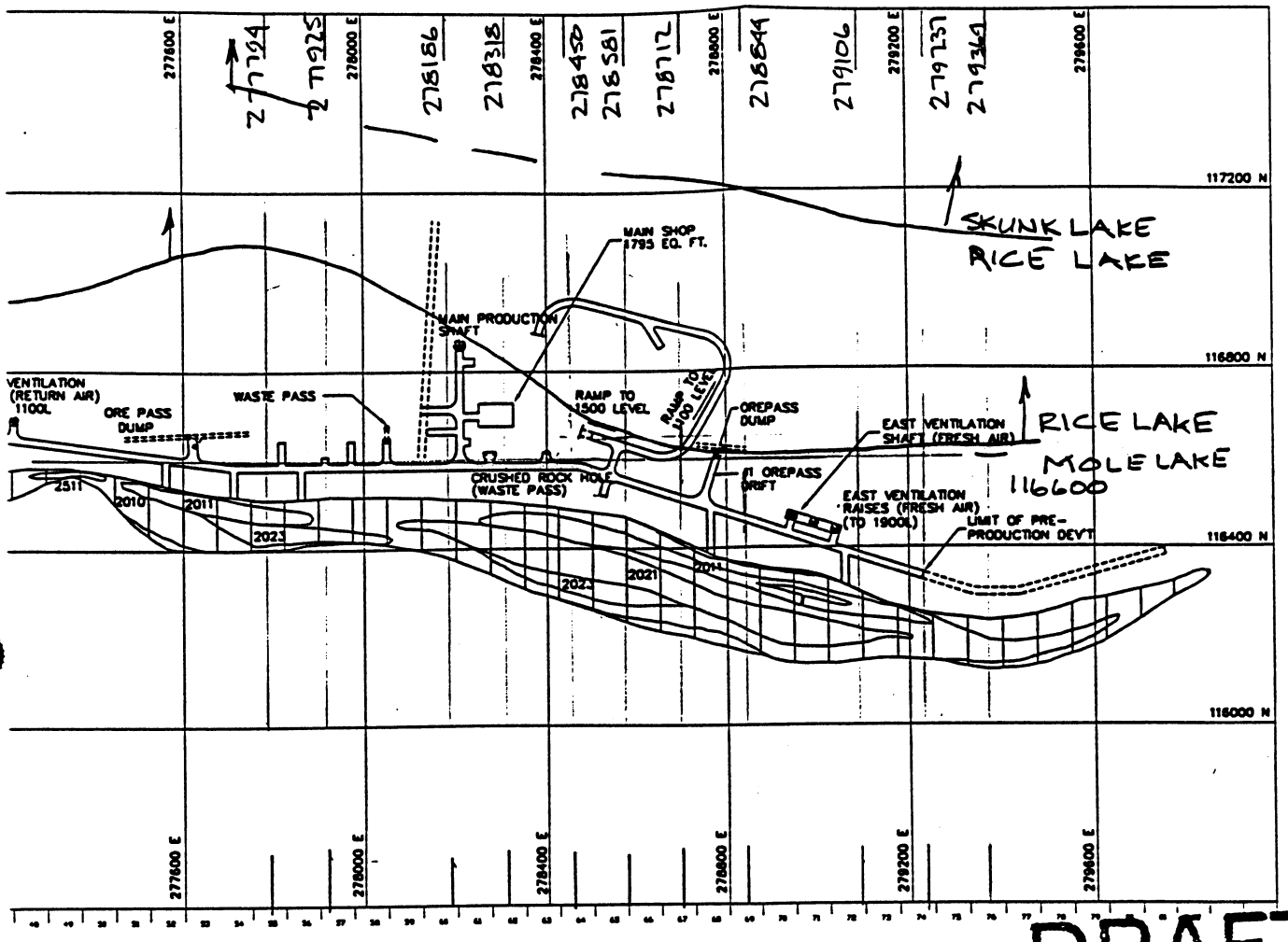
AJEJr 6/12/96

SCALE: 1"=400'

DWG. NO.: 6425-0503

REV.: 3

Fig. 24



DRAFT
APR 25 1996

LEGEND

PRE-PRODUCTION DEVELOPMENT

FUTURE DEVELOPMENT

NO.	REVISIONS	DATE	BY
4			
3	FOR REFERENCE	24/04/96	SMR
2	FOR REFERENCE	13/02/96	SMR
1	FOR REVIEW	16/01/96	DKS
A	FIRST DRAFT	DEC.'95	SMR

REDPATH McINTOSH ENGINEERING LIMITED
P.O. Box 21043
710 McKeown Avenue
North Bay, Ontario
P1B 9N8
Telephone: 1-705-494-8255
Fax: 1-705-474-2652

CLIENT: CRANDON MINING COMPANY

TITLE: CRANDON PROJECT
1300 LEVEL (350 ELEVATION)
PLAN VIEW

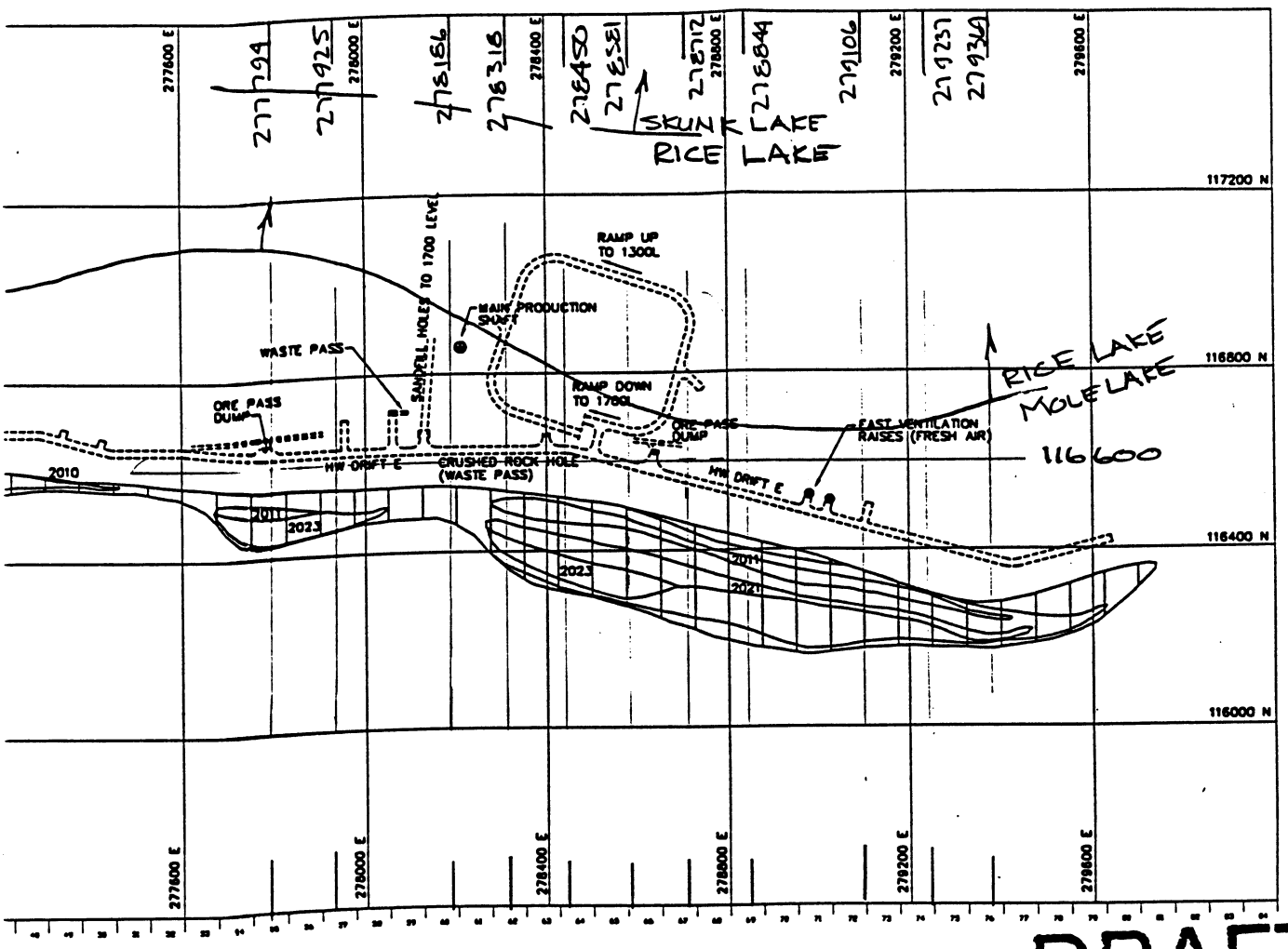
AJES 4/12/96

SCALE: 1"=400'

DWG. NO. 6425-0504

REV. 3

Fig. 25



DRAFT

APR 2 5 1996

NO.	REVISIONS	DATE	BY
4			
3	FOR REFERENCE	24/04/96	SMR
2	FOR REFERENCE	13/02/96	SMR
1	FOR REVIEW	16/01/96	DKS
A	FIRST DRAFT	DEC.'95	SMR

LEGEND

PRE-PRODUCTION DEVELOPMENT

FUTURE DEVELOPMENT

REDPATH McINTOSH ENGINEERING LIMITED
P.O. Box 21043
710 McKeown Avenue
North Bay, Ontario
P1B 9N8
Telephone: 1-705-494-8255
Fax: 1-705-474-2652

CLIENT: CRANDON MINING COMPANY

TITLE: CRANDON PROJECT
1500 LEVEL (150 ELEVATION)
PLAN VIEW

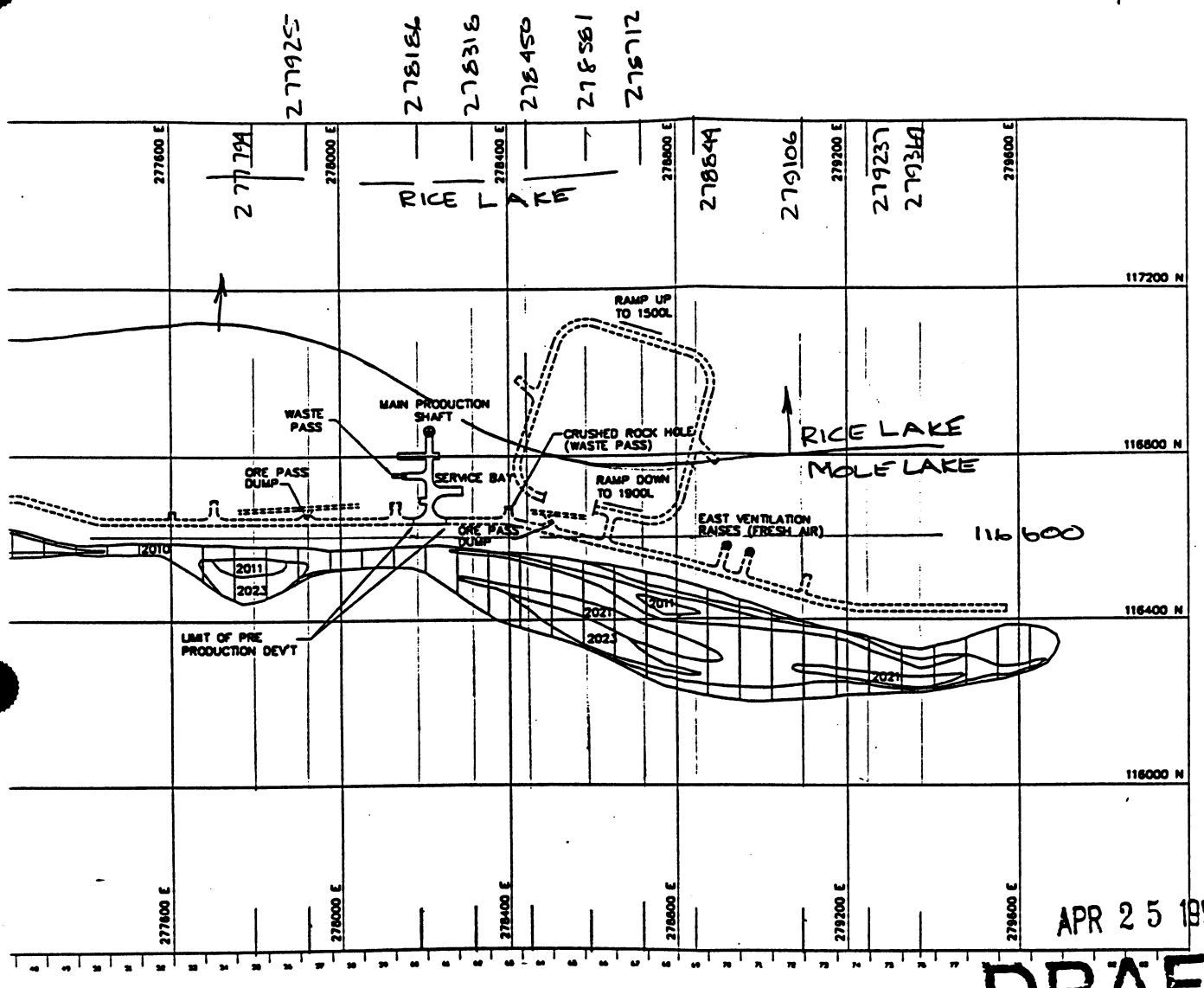
AJE Jr 4/12/96

SCALE: 1"=400'

DWG. NO.: 6425-0505

REV.: 3

Fig. 26



APR 2 5 1996

DRAFT

LEGEND

PRE-PRODUCTION DEVELOPMENT

FUTURE DEVELOPMENT

NO.	REVISIONS	DATE	BY
4			
3	FOR REFERENCE	24/04/96	SMR
2	FOR REFERENCE	13/02/96	SMR
1	FOR REVIEW	16/01/96	DKS
A	FIRST DRAFT	DEC.'95	SMR

REDPATH McINTOSH ENGINEERING LIMITED
P.O. Box 21043
710 McKeown Avenue
North Bay, Ontario
P1B 9N8
Telephone: 1-705-494-8255
Fax: 1-705-474-2652

CLIENT: CRANDON MINING COMPANY

TITLE: CRANDON PROJECT
1700 LEVEL (-50 ELEVATION)
PLAN VIEW

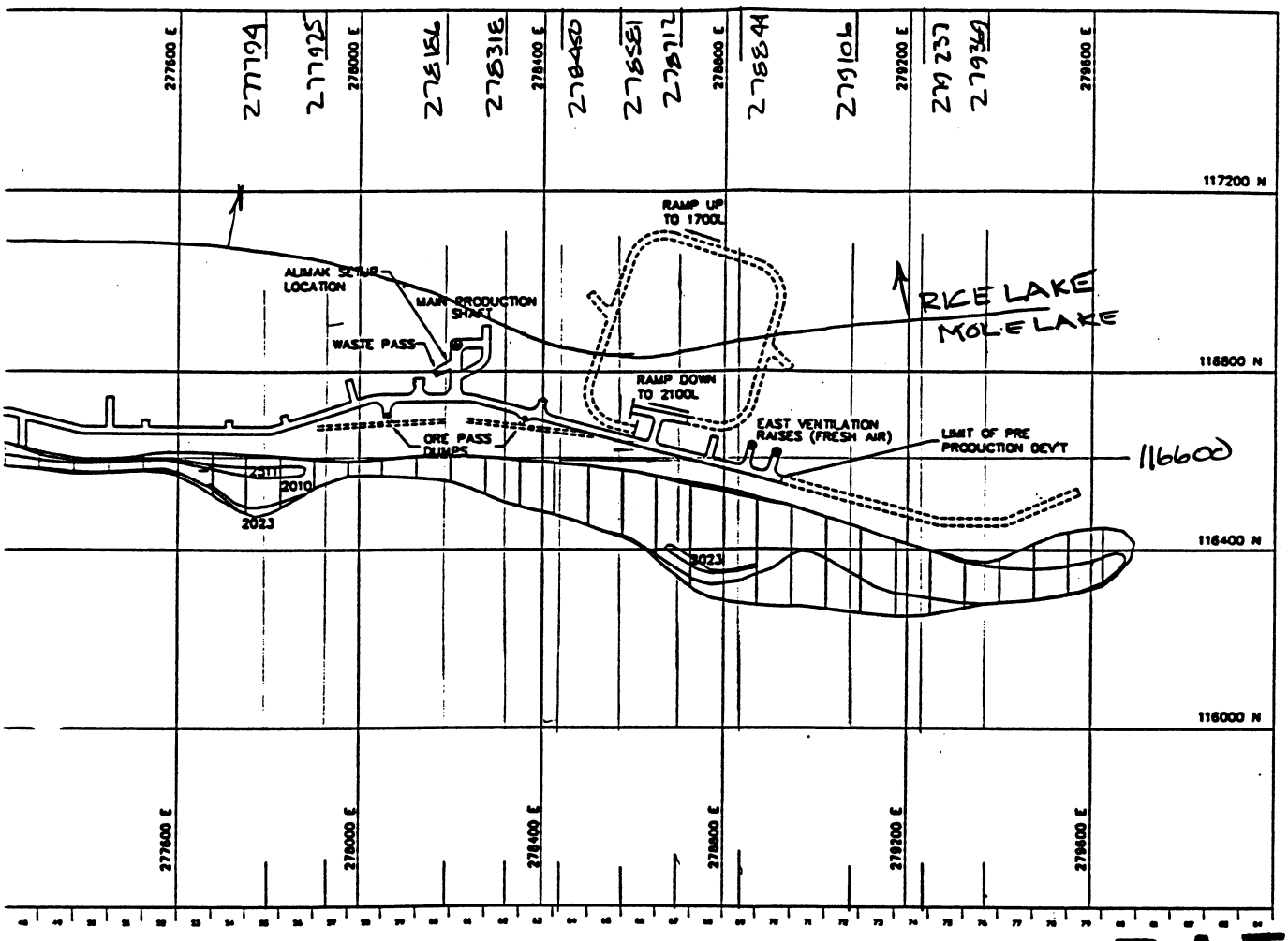
AJEJ- 6/12/96

SCALE: 1"=400'

DWG. NO. 6425-0506

REV. 3

Fig. 27



DRAFT

APR 2 5 1996

NO.	REVISIONS	DATE	BY
4			
3	FOR REFERENCE	24/04/96	SMR
2	FOR REFERENCE	13/02/96	SMR
1	FOR REVIEW	16/01/96	DKS
A	FIRST DRAFT	DEC.'95	SMR

LEGEND

PRE-PRODUCTION DEVELOPMENT

FUTURE DEVELOPMENT

REDPATH McINTOSH ENGINEERING LIMITED
P.O. Box 21043
710 McKeown Avenue
North Bay, Ontario
P1B 9N8
Telephone: 1-705-494-8255
Fax: 1-705-474-2652

CLIENT: CRANDON MINING COMPANY

TITLE: CRANDON PROJECT
1900 LEVEL (-250 ELEVATION)
PLAN VIEW

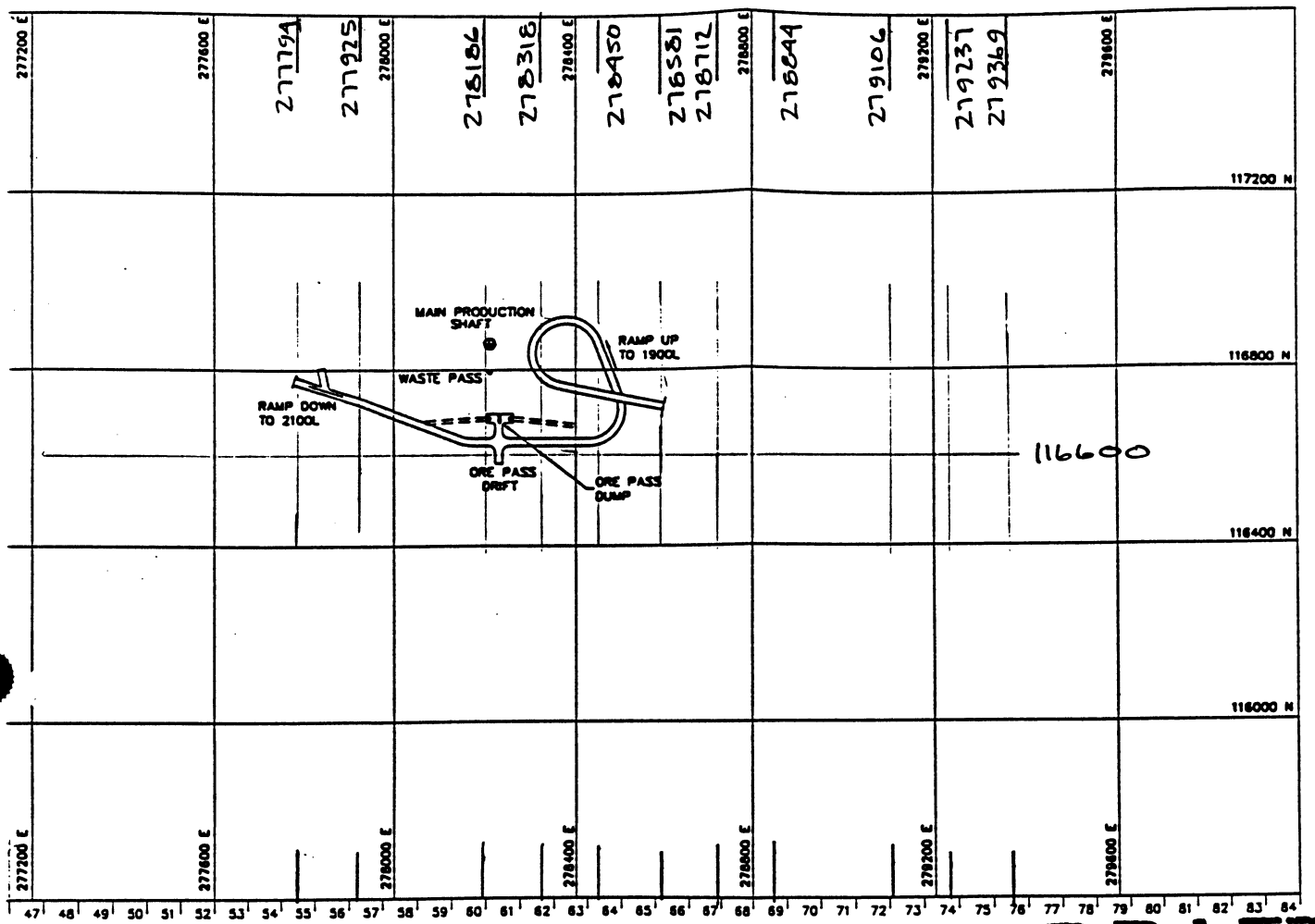
AJE Jr 6/12/96

SCALE: 1"=400'

DWG. NO.: 6425-0507

REV. NO.: 3

Fig. 28



DRAFT

APR 25 1996

NOTE: THIS SHOWS ACCESS TO ORE PASS DUMP ABOVE CRUSHER FOR TRUCK HAUL 2100L AREA

NO.	REVISIONS	DATE	BY
4			
3	FOR REFERENCE	24/04/96	SMR
2	FOR REFERENCE	13/02/96	SMR
1	FOR REVIEW	16/01/96	RS
A	FIRST DRAFT	12/01/96	RS

REDPATH McINTOSH ENGINEERING LIMITED
P.O. Box 21043
710 McKeown Avenue
North Bay, Ontario
P1B 9N8
Telephone: 1-705-494-8255
Fax: 1-705-474-2652

CLIENT: CRANDON MINING COMPANY

TITLE: CRANDON PROJECT
2050 LEVEL (-400 ELEVATION)
PLAN VIEW

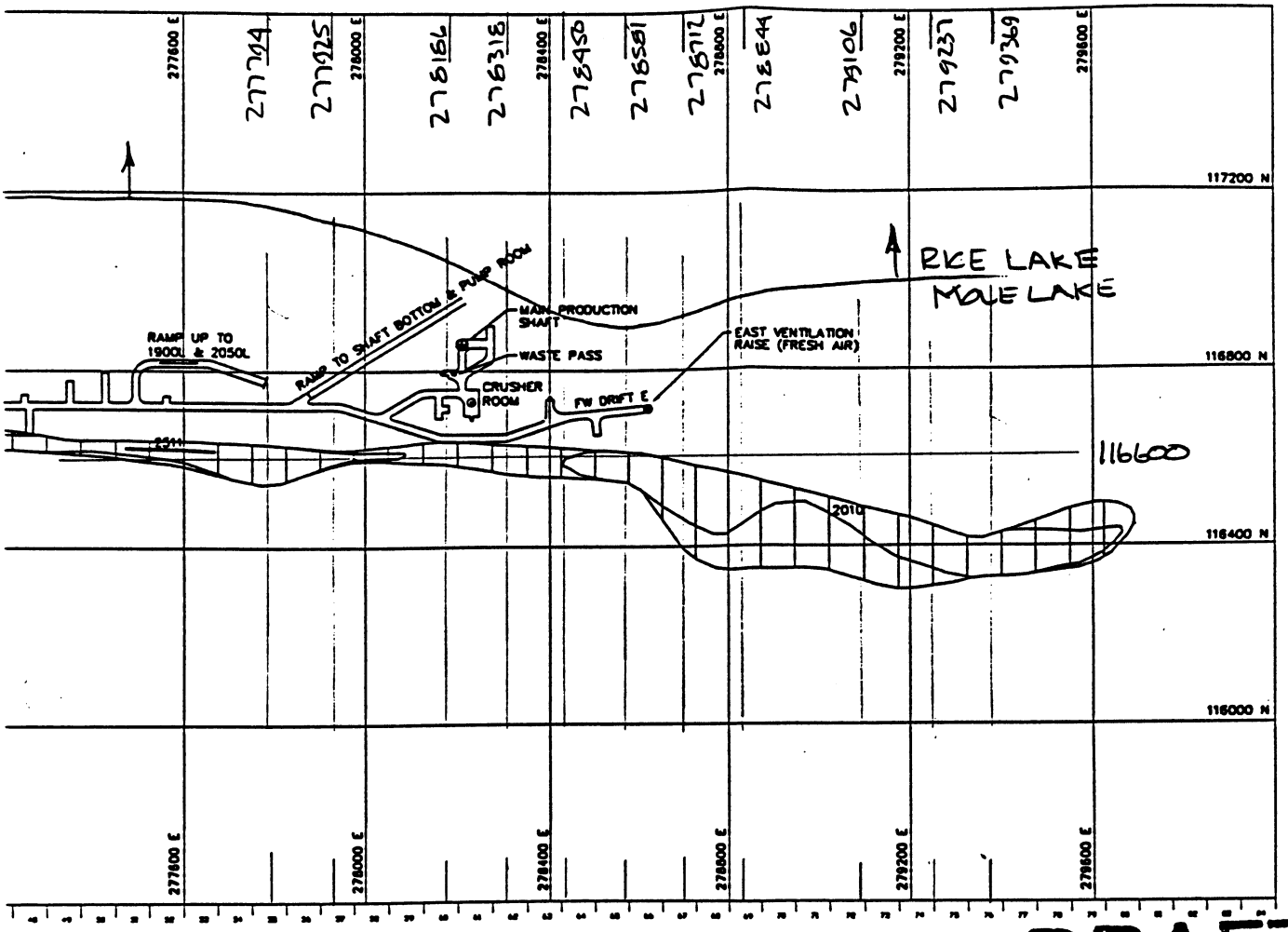
AJE Jr 6/12/96

SCALE: 1"=400'

DWG. NO.: 6425-0509

REV.: 3

Fig. 29



DRAFT

APR 2 5 1996

LEGEND

PRE-PRODUCTION DEVELOPMENT

FUTURE DEVELOPMENT

NO.	REVISIONS	DATE	BY	
4				
3	FOR REFERENCE	24/04/96	SMR	
2	FOR REFERENCE	13/02/96	SMR	
1	FOR REVIEW	16/01/96	DKS	
A	FIRST DRAFT	DEC.'95	SMR	

REDPATH McINTOSH ENGINEERING LIMITED
P.O. Box 21043
710 McKeown Avenue
North Bay, Ontario
P1B 9N8
Telephone: 1-705-494-8255
Fax: 1-705-474-2652

CLIENT: CRANDON MINING COMPANY

TITLE: CRANDON PROJECT
2100 LEVEL (-450 ELEVATION)
PLAN VIEW

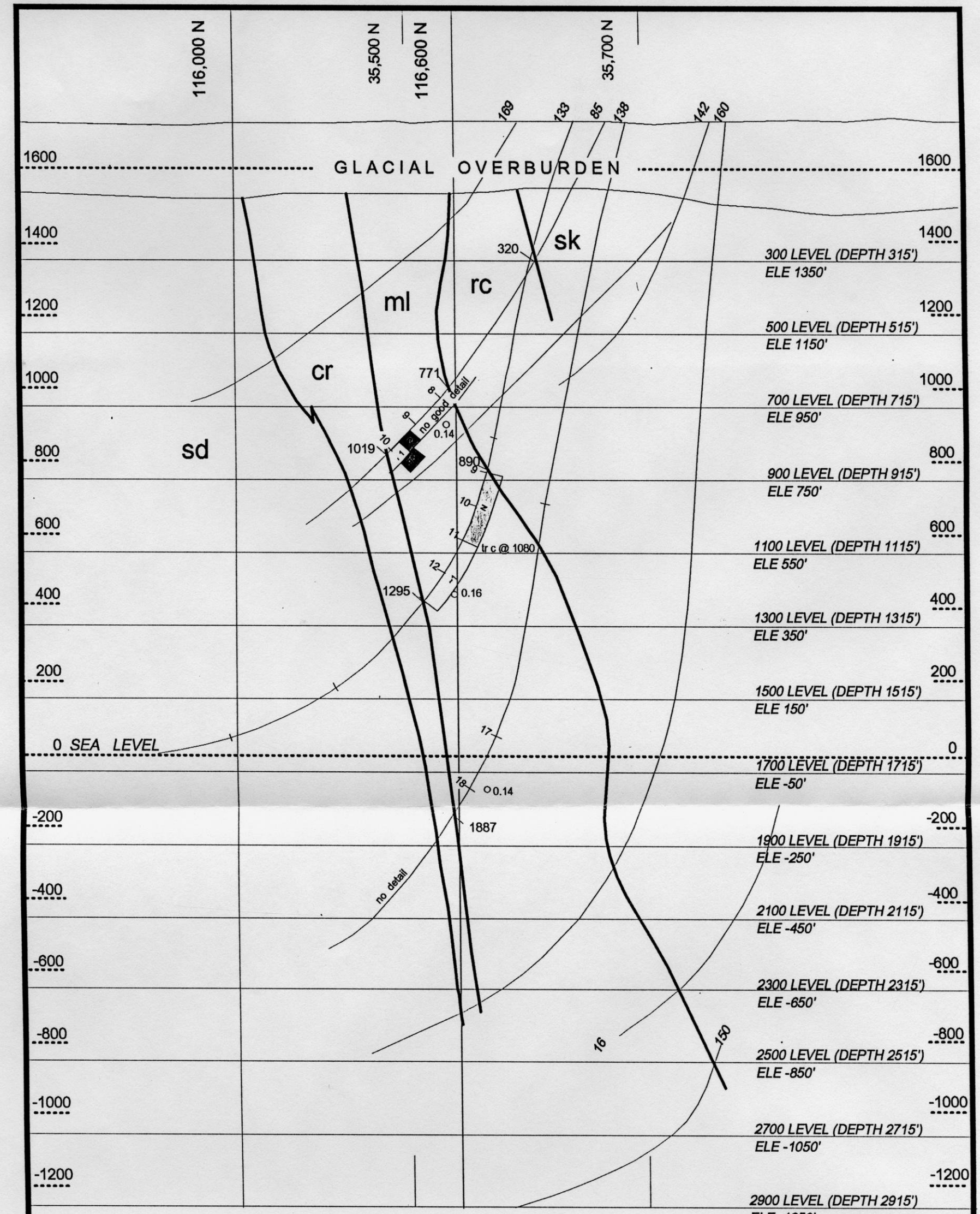
AJEJ- 4/12/96

SCALE: 1"=400'

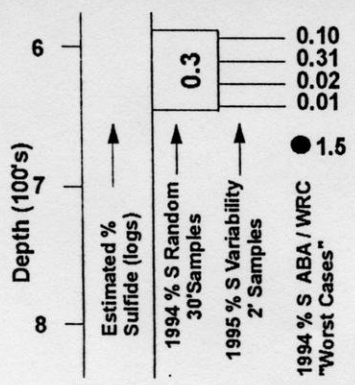
DWG. NO.: 6425-0508

REV.: 3

Fig. 30



dg - DUCK LAKE
ln - LINCOLN
sk - SKUNK LAKE
rc - RICE LAKE
ok - OAK LAKE
ml - MOLE LAKE
cr - CRANDON
sd - SAND LAKE
nh - NASHVILLE



N = Nil
T, Tr = Trace (<0.1)
W = Weak (0.5?)
Numbers = % Total Sulfide
% Sulfur

< = Less Than
≤ = Less Than or Equal
≈ = Approximately

Sulfide Estimate (%)

- N to T
- 0.1 to 0.5
- >0.5 to <1
- 1 to <2
- >2

Sulfur Assay (%)

- 0.01 to 0.1
- 0.1 to <0.53
- 0.53 to 1.06
- >1.06

Crandon Mining Company

CRANDON DEPOSIT

N - S SECTION LOOKING WEST
2,277,925 E

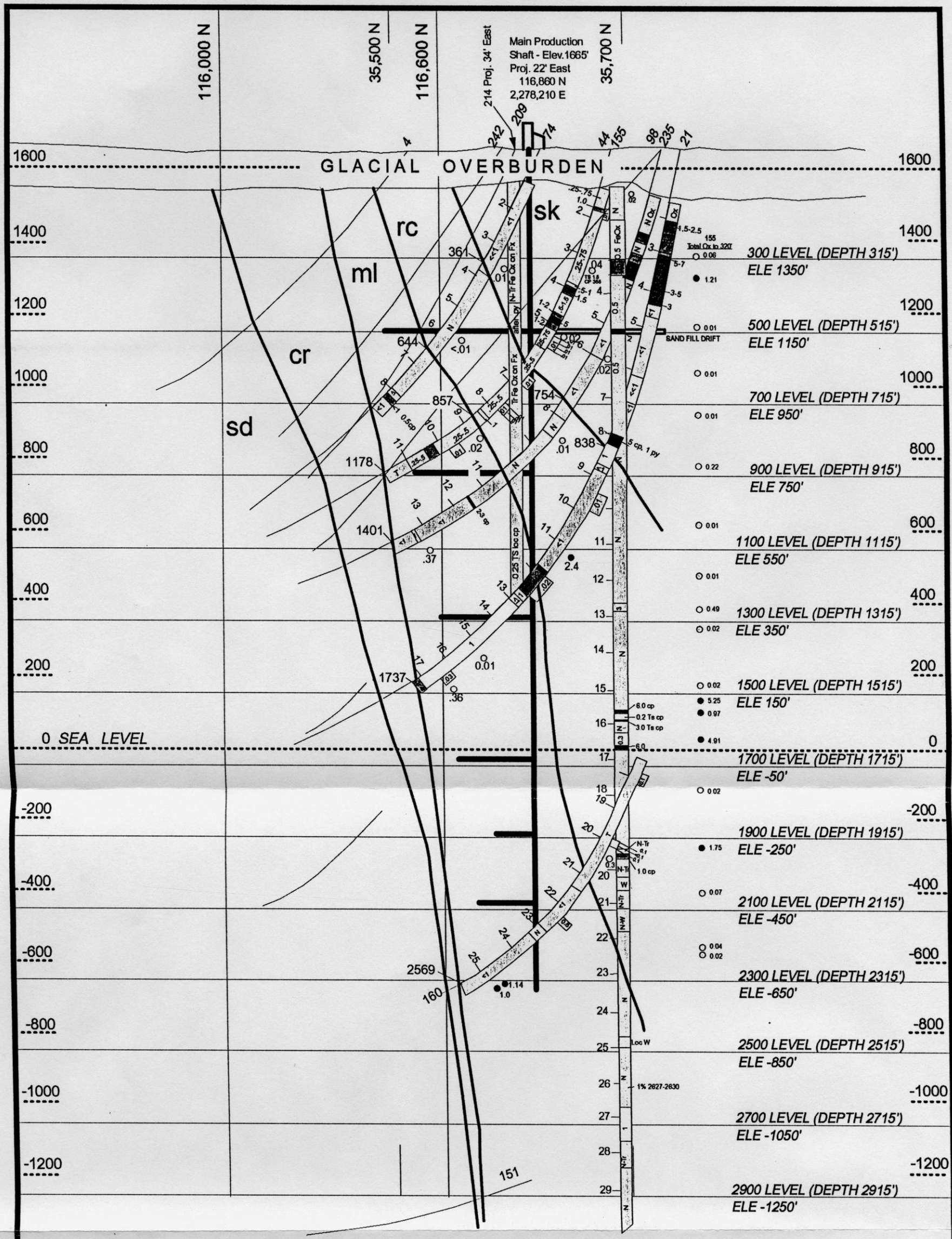
STOPE 57

HANGING WALL SULFIDE CONTENT
SIMPLIFIED GEOLOGY

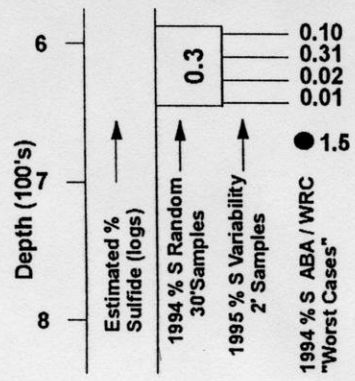
A.J.E.,Jr. / jls - June 1996

0 200' 400'
FEET

2F29593-1



dg - DUCK LAKE
ln - LINCOLN
sk - SKUNK LAKE
rc - RICE LAKE
ok - OAK LAKE
ml - MOLE LAKE
cr - CRANDON
sd - SAND LAKE
nh - NASHVILLE



N = Nil
T, Tr = Trace (<0.1)
W = Weak (0.5?)
Numbers = % Total Sulfide
% Sulfur

< = Less Than
≤ = Less Than or Equal
≈ = Approximately

Sulfide Estimate (%)

- N to T
- 0.1 to 0.5
- >0.5 to <1
- 1 to <2
- >2

Sulfur Assay (%)

- 0.01 to 0.1
- 0.1 to <0.53
- 0.53 to 1.06
- >1.06

Crandon Mining Company

CRANDON DEPOSIT

N - S SECTION LOOKING WEST
2,278,188 E

STOPE 60

HANGING WALL SULFIDE CONTENT
SIMPLIFIED GEOLOGY

A.J.E.,Jr. / jls - June 1996

0 200' 400'
FEET

2F29593-2

116,000 N | 35,500 N | 116,600 N | 35,700 N

GLACIAL OVERBURDEN

sk | ml | rc | cr | sd

AREA INTERSECTED BY RAMP 500 - 2100 WEST SECTION

1600	1600
1400	1400
1200	1200
1000	1000
800	800
600	600
400	400
200	200
0 SEA LEVEL	0
-200	-200
-400	-400
-600	-600
-800	-800
-1000	-1000
-1200	-1200

300 LEVEL (DEPTH 315') ELE 1350'
500 LEVEL (DEPTH 515') ELE 1150'
700 LEVEL (DEPTH 715') ELE 950'
900 LEVEL (DEPTH 915') ELE 750'
1100 LEVEL (DEPTH 1115') ELE 550'
1300 LEVEL (DEPTH 1315') ELE 350'
1500 LEVEL (DEPTH 1515') ELE 150'
1700 LEVEL (DEPTH 1715') ELE -50'
1900 LEVEL (DEPTH 1915') ELE -250'
2100 LEVEL (DEPTH 2115') ELE -450'
2300 LEVEL (DEPTH 2315') ELE -650'
2500 LEVEL (DEPTH 2515') ELE -850'
2700 LEVEL (DEPTH 2715') ELE -1050'
2900 LEVEL (DEPTH 2915') ELE -1250'

dg - DUCK LAKE
ln - LINCOLN
sk - SKUNK LAKE
rc - RICE LAKE
ok - OAK LAKE
ml - MOLE LAKE
cr - CRANDON
sd - SAND LAKE
nh - NASHVILLE

Depth (100's) 6 7 8

Estimated % Sulfide (logs)

1994 % S Random 30'Samples: 0.3

1995 % S Variability 2' Samples: 0.10, 0.31, 0.02, 0.01

1994 % S ABA / WRC "Worst Cases": 1.5

N = Nil
T, Tr = Trace (<0.1)
W = Weak (0.5?)
Numbers = % Total Sulfide / % Sulfur

< = Less Than
≤ = Less Than or Equal
≈ = Approximately

Sulfide Estimate (%)
- N to T
- 0.1 to 0.5
- >0.5 to <1
- 1 to <2
- >2

Sulfur Assay (%)
- 0.01 to 0.1
- 0.1 to <0.53
- 0.53 to 1.06
- >1.06

Crandon Mining Company

CRANDON DEPOSIT

N - S SECTION LOOKING WEST
2,278,319 E

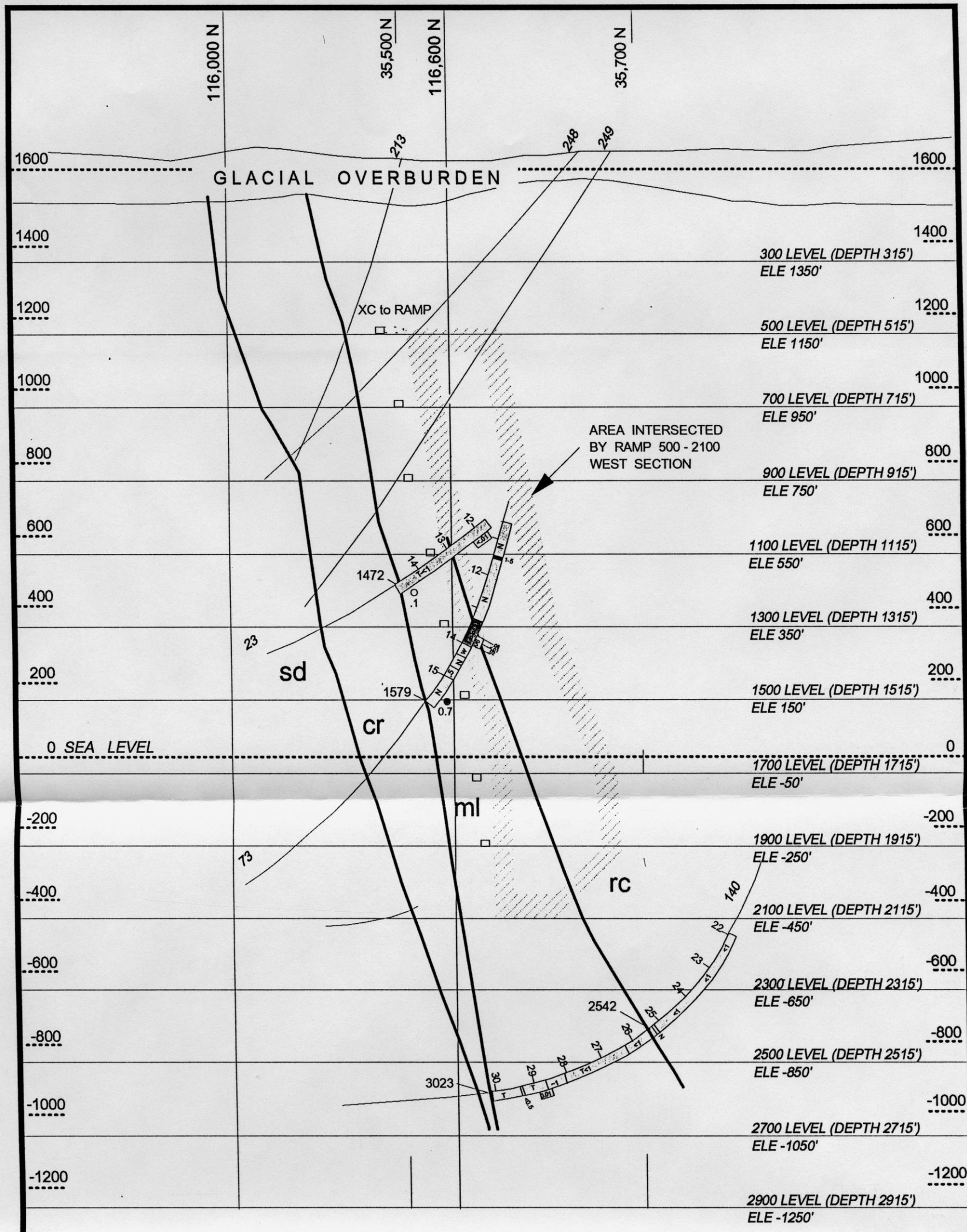
STOPE 62

HANGING WALL SULFIDE CONTENT
SIMPLIFIED GEOLOGY

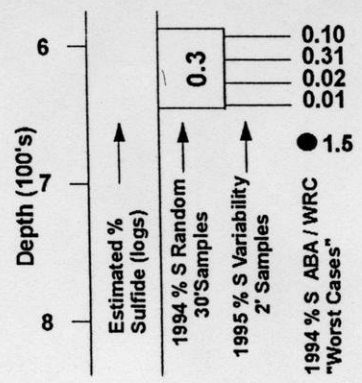
A.J.E.,Jr. / jls - June 1996

0 200' 400'
FEET

2F29593-3



dg - DUCK LAKE
ln - LINCOLN
sk - SKUNK LAKE
rc - RICE LAKE
ok - OAK LAKE
ml - MOLE LAKE
cr - CRANDON
sd - SAND LAKE
nh - NASHVILLE



N = Nil
T, Tr = Trace (<0.1)
W = Weak (0.5?)
Numbers = % Total Sulfide
% Sulfur

< = Less Than
≤ = Less Than or Equal
≈ = Approximately

Sulfide Estimate (%)

- N to T
- 0.1 to 0.5
- >0.5 to <1
- 1 to <2
- >2

Sulfur Assay (%)

- 0.01 to 0.1
- 0.1 to <0.53
- 0.53 to 1.06
- >1.06

Crandon Mining Company

CRANDON DEPOSIT

N - S SECTION LOOKING WEST
2,278,450 E

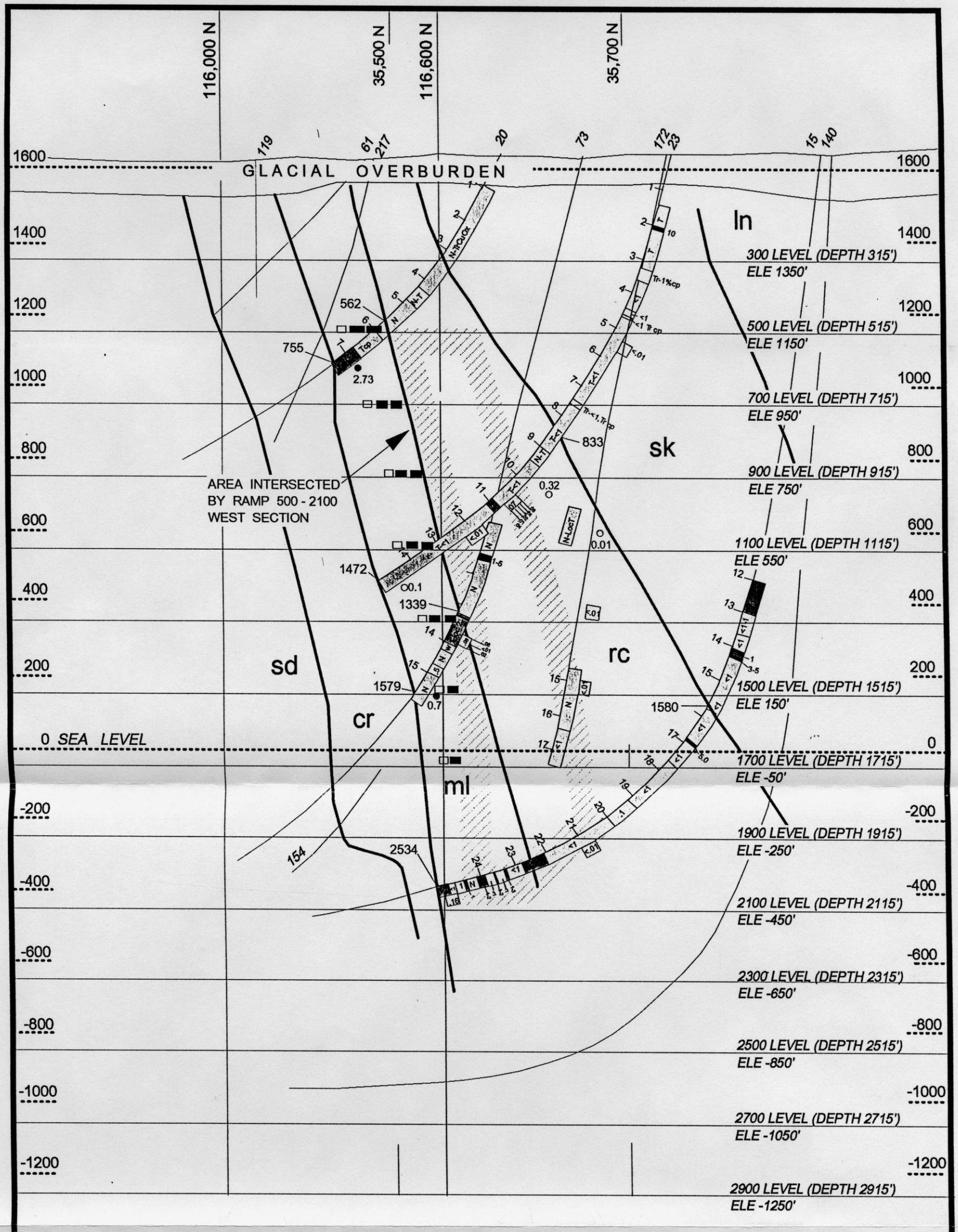
STOPE 64

HANGING WALL SULFIDE CONTENT
SIMPLIFIED GEOLOGY

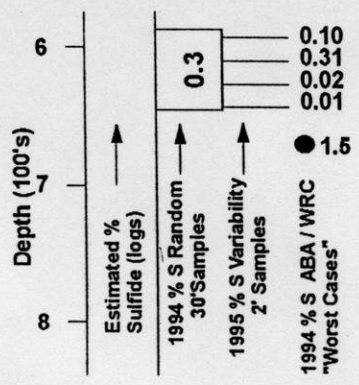
A.J.E.,Jr. / jls - June 1996

0 200' 400'
FEET

2F29593-4



dg - DUCK LAKE
ln - LINCOLN
sk - SKUNK LAKE
rc - RICE LAKE
ok - OAK LAKE
ml - MOLE LAKE
cr - CRANDON
sd - SAND LAKE
nh - NASHVILLE



N = Nil
T, Tr = Trace (<0.1)
W = Weak (0.5?)
Numbers = % Total Sulfide
% Sulfur

< = Less Than
≤ = Less Than or Equal
≈ = Approximately

Sulfide Estimate (%)

- N to T
- 0.1 to 0.5
- >0.5 to <1
- 1 to <2
- >2

Sulfur Assay (%)

- 0.01 to 0.1
- 0.1 to <0.53
- 0.53 to 1.06
- >1.06

Crandon Mining Company

CRANDON DEPOSIT

N - S SECTION LOOKING WEST
2,278,581 E

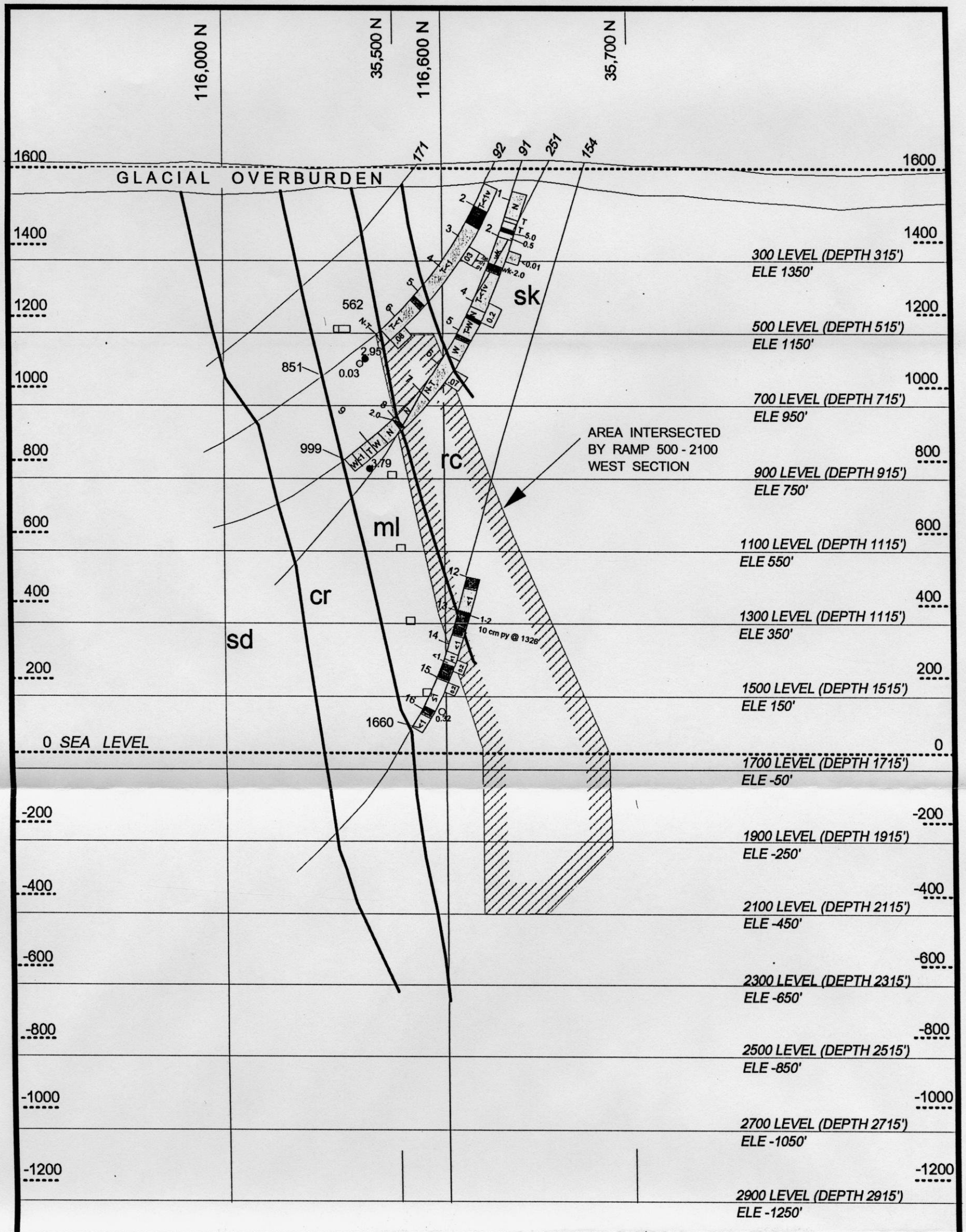
STOPE 66

HANGING WALL SULFIDE CONTENT
SIMPLIFIED GEOLOGY

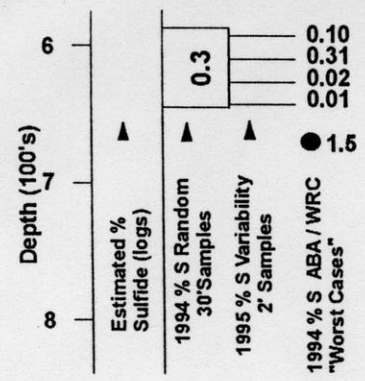
A.J.E.,Jr. / jls - June 1996

0 200' 400'
FEET

2F29593-5



dg - DUCK LAKE
ln - LINCOLN
sk - SKUNK LAKE
rc - RICE LAKE
ok - OAK LAKE
ml - MOLE LAKE
cr - CRANDON
sd - SAND LAKE
nh - NASHVILLE



N = Nil
T, Tr = Trace (<0.1)
W = Weak (0.5?)
Numbers = % Total Sulfide
% Sulfur

< = Less Than
≤ = Less Than or Equal
≅ = Approximately

Sulfide Estimate (%)

- N to T
- 0.1 to 0.5
- >0.5 to <1
- 1 to <2
- >2

Sulfur Assay (%)

- 0.01 to 0.1
- 0.1 to <0.53
- 0.53 to 1.06
- >1.06

Crandon Mining Company

CRANDON DEPOSIT

N - S SECTION LOOKING WEST
2,278,712 E

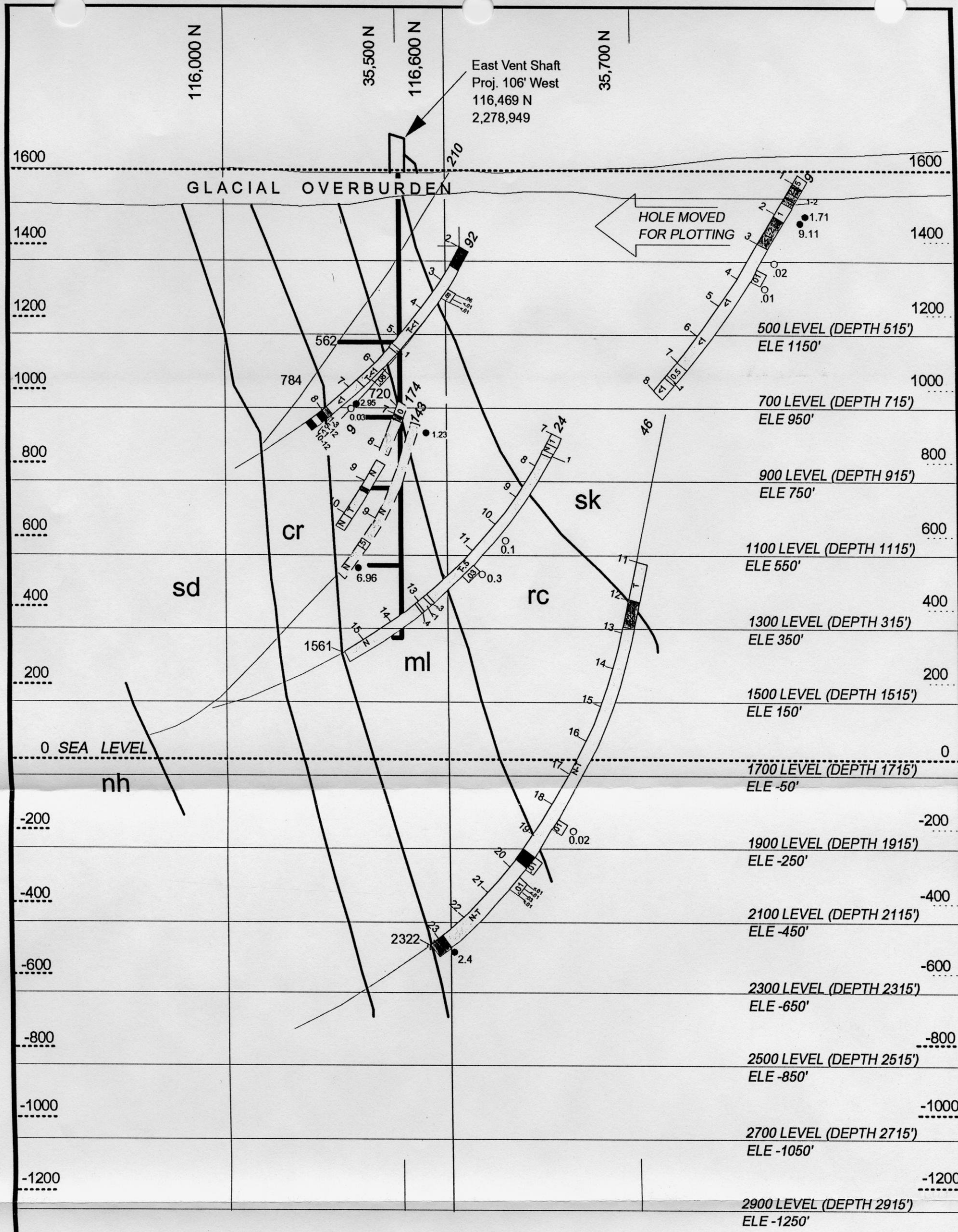
STOPE 67

HANGING WALL SULFIDE CONTENT
SIMPLIFIED GEOLOGY

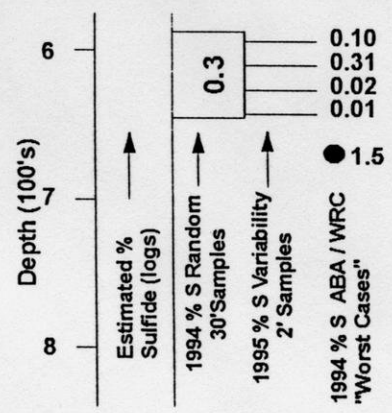
A.J.E.,Jr. / jls - June 1996

0 200' 400'
FEET

2F29593-6



dg - DUCK LAKE
ln - LINCOLN
sk - SKUNK LAKE
rc - RICE LAKE
ok - OAK LAKE
ml - MOLE LAKE
cr - CRANDON
sd - SAND LAKE
nh - NASHVILLE



N = Nil
T, Tr = Trace (<0.1)
W = Weak (0.5?)
Numbers = % Total Sulfide
% Sulfur

< = Less Than
≤ = Less Than or Equal
≈ = Approximately

Sulfide Estimate (%)

- N to T
- 0.1 to 0.5
- >0.5 to <1
- 1 to <2
- >2

Sulfur Assay (%)

- 0.01 to 0.1
- 0.1 to <0.53
- 0.53 to 1.06
- >1.06

Crandon Mining Company

CRANDON DEPOSIT

N - S SECTION LOOKING WEST
2,278,843 E

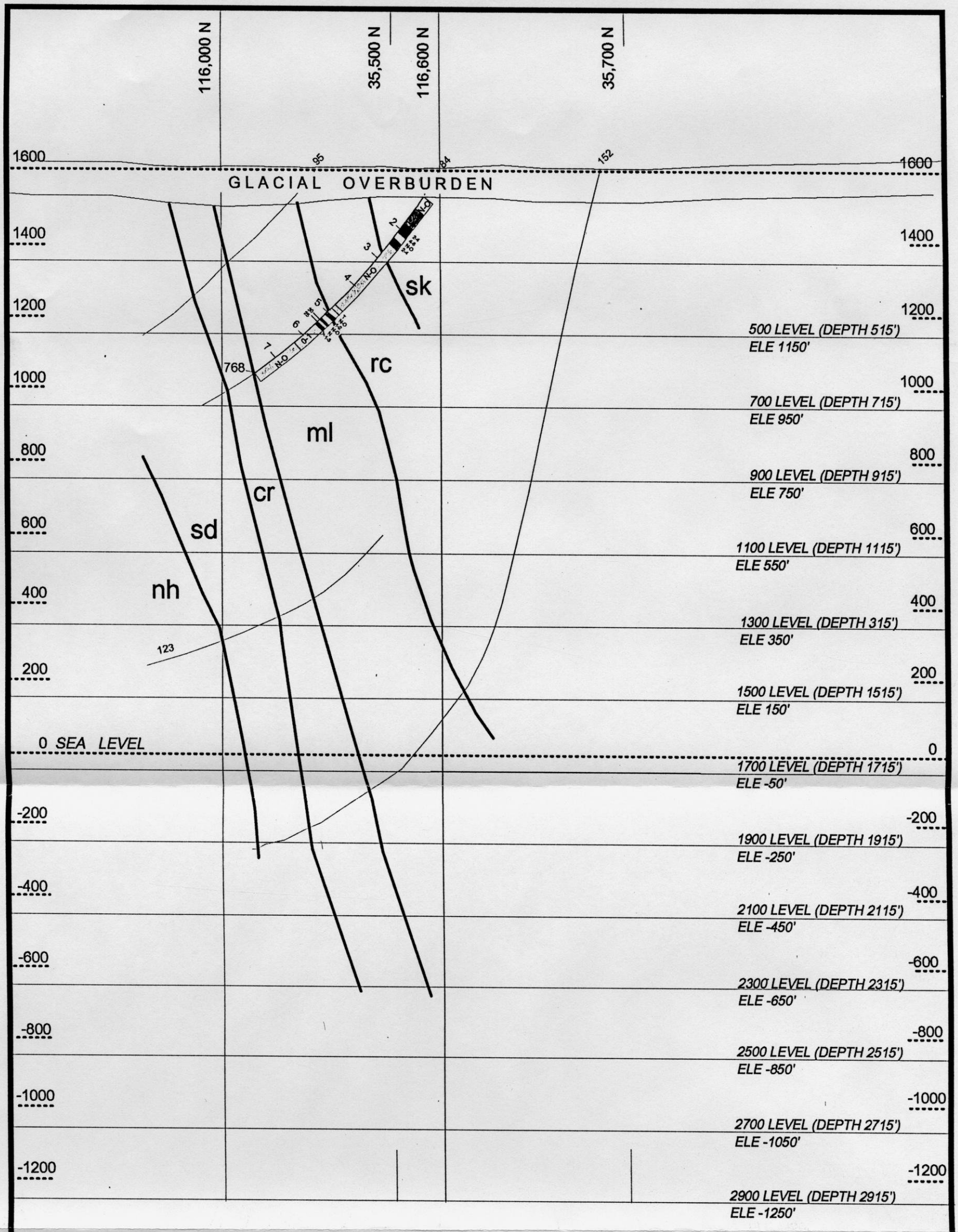
STOPE 69

HANGING WALL SULFIDE CONTENT
SIMPLIFIED GEOLOGY

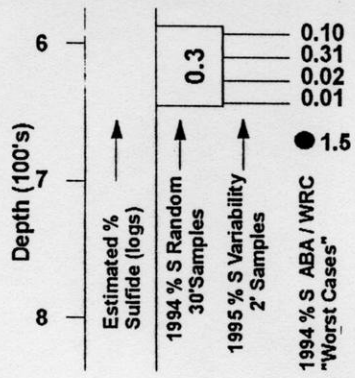
A.J.E.,Jr. / jls - June 1996

0 200' 400'
FEET

2F29593-7



dg - DUCK LAKE
ln - LINCOLN
sk - SKUNK LAKE
rc - RICE LAKE
ok - OAK LAKE
ml - MOLE LAKE
cr - CRANDON
sd - SAND LAKE
nh - NASHVILLE



N = Nil
T, Tr = Trace (<0.1)
W = Weak (0.5?)
Numbers = % Total Sulfide
% Sulfur

< = Less Than
≤ = Less Than or Equal
≅ = Approximately

Sulfide Estimate (%)

- N to T
- 0.1 to 0.5
- >0.5 to <1
- 1 to <2
- >2

Sulfur Assay (%)

- 0.01 to 0.1
- 0.1 to <0.53
- 0.53 to 1.06
- >1.06

Crandon Mining Company

CRANDON DEPOSIT

N - S SECTION LOOKING WEST
2,279,106 E

STOPE 72

HANGING WALL SULFIDE CONTENT
SIMPLIFIED GEOLOGY

A.J.E.,Jr. / jls - June 1996

0 200' 400'
FEET

2F29593-8

116,000 N

35,500 N

116,600 N

35,700 N

East Vent Shaft
Proj. 106' West
116,469 N
2,278,949

1600

GLACIAL OVERBURDEN

1400

1200

1000

800

600

400

200

0 SEA LEVEL

-200

-400

-600

-800

-1000

-1200

sd

cr

nh

sk

rc

ml

562

784

720

1561

2322

HOLE MOVED FOR PLOTTING

500 LEVEL (DEPTH 515')
ELE 1150'

700 LEVEL (DEPTH 715')
ELE 950'

900 LEVEL (DEPTH 915')
ELE 750'

1100 LEVEL (DEPTH 1115')
ELE 550'

1300 LEVEL (DEPTH 315')
ELE 350'

1500 LEVEL (DEPTH 1515')
ELE 150'

1700 LEVEL (DEPTH 1715')
ELE -50'

1900 LEVEL (DEPTH 1915')
ELE -250'

2100 LEVEL (DEPTH 2115')
ELE -450'

2300 LEVEL (DEPTH 2315')
ELE -650'

2500 LEVEL (DEPTH 2515')
ELE -850'

2700 LEVEL (DEPTH 2715')
ELE -1050'

2900 LEVEL (DEPTH 2915')
ELE -1250'

dg - DUCK LAKE
ln - LINCOLN
sk - SKUNK LAKE
rc - RICE LAKE
ok - OAK LAKE
ml - MOLE LAKE
cr - CRANDON
sd - SAND LAKE
nh - NASHVILLE

Depth (100's)

Estimated % Sulfide (logs)

1994 % S Random 30'Samples

1995 % S Variability 2' Samples

1994 % S ABA / WRC "Worst Cases"

N = Nil
T, Tr = Trace (<0.1)
W = Weak (0.5?)
Numbers = % Total Sulfide
% Sulfur

< = Less Than
≤ = Less Than or Equal
≈ = Approximately

Sulfide Estimate (%)

- N to T
- 0.1 to 0.5
- >0.5 to <1
- 1 to <2
- >2

Sulfur Assay (%)

- 0.01 to 0.1
- 0.1 to <0.53
- 0.53 to 1.06
- >1.06

Crandon Mining Company

CRANDON DEPOSIT

N - S SECTION LOOKING WEST
2,278,843 E

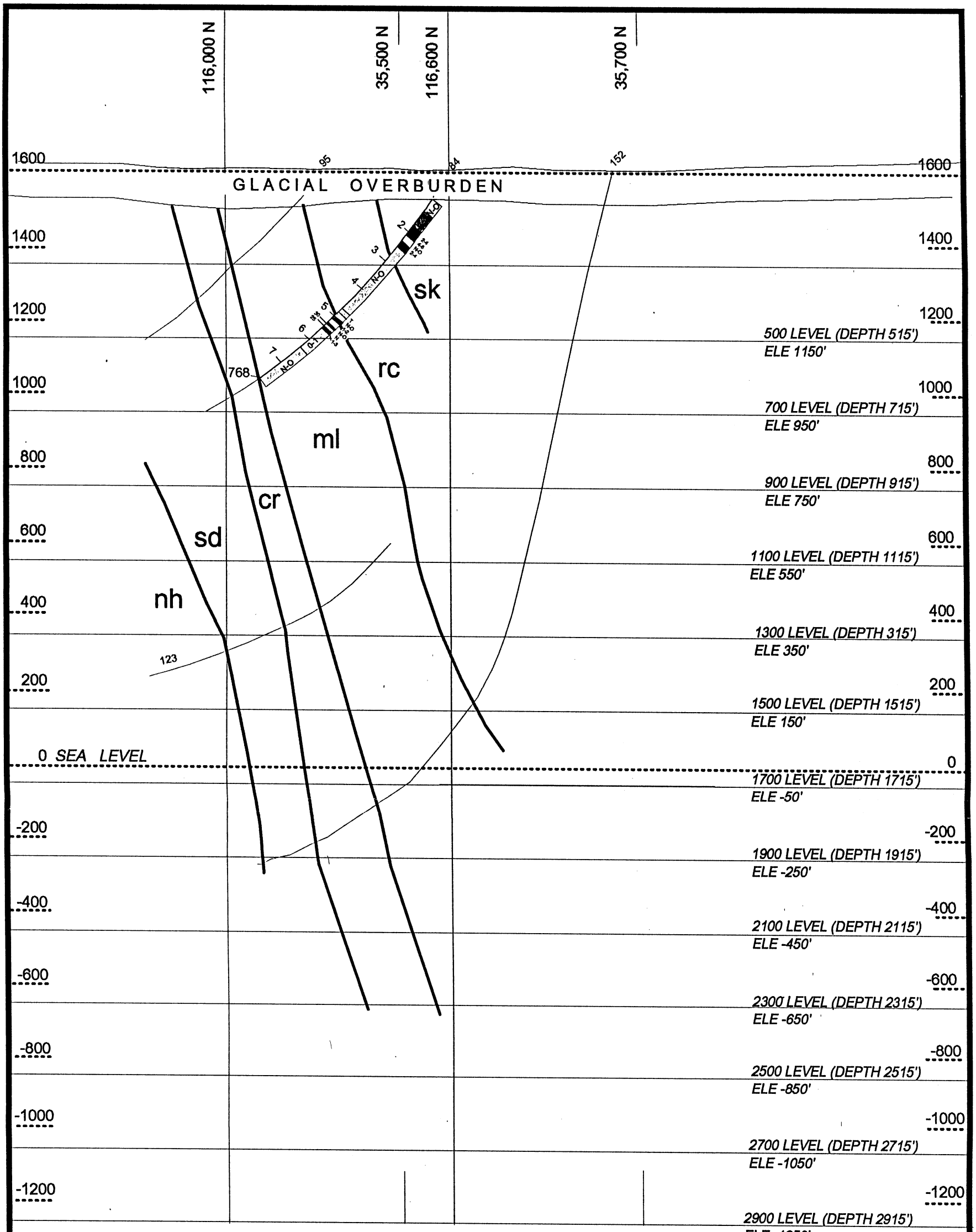
STOPE 69

HANGING WALL SULFIDE CONTENT
SIMPLIFIED GEOLOGY

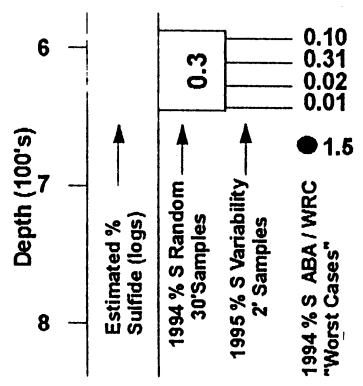
A.J.E.,Jr. / jls - June 1996

0 200' 400'
FEET

2F29593-7



dg - DUCK LAKE
ln - LINCOLN
sk - SKUNK LAKE
rc - RICE LAKE
ok - OAK LAKE
ml - MOLE LAKE
cr - CRANDON
sd - SAND LAKE
nh - NASHVILLE



N = Nil
T, Tr = Trace (<0.1)
W = Weak (0.5?)
Numbers = % Total Sulfide
% Sulfur

< = Less Than
≤ = Less Than or Equal
≈ = Approximately

Sulfide Estimate (%)

- N to T
- 0.1 to 0.5
- >0.5 to <1
- 1 to <2
- >2

Sulfur Assay (%)

- 0.01 to 0.1
- 0.1 to <0.53
- 0.53 to 1.06
- >1.06

Crandon Mining Company

CRANDON DEPOSIT

N - S SECTION LOOKING WEST
2,279,106 E

STOPE 72

HANGING WALL SULFIDE CONTENT
SIMPLIFIED GEOLOGY

A.J.E.,Jr. / jls - June 1996

0 200' 400'
FEET

2F29593-8

>>>>>> Warning, peak outflow = last ordinate point. <<<<<<

POND-2 Version: 5.16 S/N: 1295130172 Page 8

Pond File: CMCWS .PND
Inflow Hydrograph: CMCWS .HYD
Outflow Hydrograph: OUT .HYD

EXECUTED: 04-25-1995
06:33:24

Peak Inflow = 117.00 cfs
Peak Outflow = 0.00 cfs
Peak Elevation = 1642.58 ft

