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Crandon Mining Company

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

February 21, 1996

Mr. Bill Tans
Mr. Christopher Carlson
Mr. Robert Grefe
Wisconsin Department of Natural Resources
101 South Webster Street
P.O. Box 7921
Madison, WI 53707-7921

Dear Mr. Tans, Mr. Carlson, and Mr. Grefe:

Re: Crandon Project - CMC Response to WDNR's January 4, 1996 TMA Completeness Letter

Crandon Mining Company is in the process of developing responses to the comments contained in your January 4, 1996 letter regarding the completeness determination for the Crandon Project's proposed tailings management area feasibility report. At this stage of our work we have completed responses to 28 of the comments raised in your letter. In the interest of providing information to you as it becomes available, we have enclosed the document titled "Addendum No. 1 to the May 1995 Crandon Project Tailings Management Area Feasibility Report/Plan of Operation" which contains responses to the comments referenced above. We anticipate forwarding a second addendum to you during early March 1996 addressing the remaining items in your letter.

If you have any questions regarding the enclosure, please contact me at (715) 365-1450.

Sincerely,

K. W. Collison

Ken W. Collison
Vice President
Crandon Mining Company

KWC:mld2

Enclosure

MLD2\93C049\GBAPP\26595\4000

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Mr. Larry Lynch, Wisconsin Department of Natural Resources
Mr. Dave Siebert, Wisconsin Department of Natural Resources
Mr. Robert Jaeger, U.S. Department of the Interior
Mr. Philip Shopodock, Forest County Potawatomi
Mr. Daniel Santos, Horsley & Witten, Inc.
Mr. Arlyn Ackley, Sokaogon Chippewa Community
Mr. John Teller, Menominee Indian Tribe of Wisconsin
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Mr. Dan Cozza, U.S. Environmental Protection Agency
Dr. John Coleman, University of Wisconsin-Madison
Mr. David Ballman, U.S. Army Corps of Engineers
Mr. Mark Meyers, U.S. Army Corps of Engineers
Mr. Kim Lapakko
Dr. Andy Robertson, A. MacG. Robertson and Associates, Inc.
Mr. Jerry Sevick, Foth & Van Dyke
Mr. Don Moe, Crandon Mining Company

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Crandon Mining Company

7 N. BROWN ST., 3RD FLOOR
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March 15, 1996

Mr. Bill Tans
Mr. Christopher Carlson
Mr. Robert Grefe
Wisconsin Department of Natural Resources
101 South Webster Street
P.O. Box 7921
Madison, WI 53707-7921

Dear Mr. Tans, Mr. Carlson, and Mr. Grefe:

Re: Crandon Project - CMC Response to WDNR's January 4, 1996 TMA Completeness Letter

At the February 21, 1996 meeting between the Wisconsin Department of Natural Resources (WDNR) and U.S. Army Corps of Engineers (USCOE), Crandon Mining Company (CMC) discussed its responses to 28 of the comments contained in the WDNR's January 4, 1996 TMA completeness letter. At the meeting, CMC also distributed "Addendum No. 1 to the May 1995 Crandon Project Tailings Management Area Feasibility Report/Plan of Operation", which contained the responses.

With this letter CMC is submitting "Addendum No. 2 to the May 1995 Crandon Project Tailings Management Area Feasibility Report/Plan of Operation". Addendum No. 2 contains the clarifications and additional information relating to Addendum No. 1 which were requested by the WDNR at the February 22, 1996 meeting as well as responses to the remaining comments contained in the WDNR completeness letter. Addendum No. 2 should be added to the three-ring notebook provided with Addendum No. 1.

Enclosed is an update to Addendum No. 1 to the May 1995 Tailings Management Area Feasibility Report/Plan of Operation. The update has been prepared on behalf of CMC by Foth & Van Dyke and Associates Inc. The update has been provided to the individuals on the carbon copy list to this letter.

Also enclosed is a reference list with information indicating where to insert the revised page in the three ring notebook for the Tailings Management Area Addenda to the Feasibility Report/Plan of Operation previously provided. The list has been prepared to both facilitate insertion of the additional information, and to serve as a log and reference identifying changes made to the document by CMC throughout the permitting process. If subsequent revisions are made, they will be added to the attached list in sequential order and the list will be forwarded with the changes.

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K.W. Collison
Vice President
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Mr. Andy Robertson, A. MacG. Robertson and Associates, Inc.
Mr. Jerry Sevick, Foth & Van Dyke
Mr. Don Moe, Crandon Mining Company

Crandon Project Addendum No. 1 to the Tailings Management Area Feasibility Report/Plan of Operation
Log of Revisions and Additional Information

Entry Number	Date of Revision	Page(s)	Document Section Number	Description
1	03/15/96	10	—	Clarification of geomembrane use.

Addendum No. 1 to the May 1995 Crandon Project Tailings Management Area Feasibility Report/Plan of Operation Crandon Mining Company Responses to Selected Comments Contained in the Wisconsin Department of Natural Resources January 4, 1996 Completeness Determination Letter

Introduction

This document titled "Addendum No. 1 to the May 1995 Crandon Project Tailings Management Area Feasibility Report/Plan of Operation" (Addendum No. 1) has been prepared in response to the Wisconsin Department of Natural Resources (WDNR) completeness determination letter dated January 4, 1996, addressed to Mr. Don Moe, Crandon Mining Company (CMC).

Purpose and Scope

The purpose of this document is to provide information required by NR 182, Wis. Admin. Code, and additional information requested for the following comments listed in the January 4, 1996 WDNR letter.

A) INFORMATION NECESSARY FOR A COMPLETENESS DETERMINATION

Page 2, Comment #4	Page 3, Comment #12	Page 3, Comment #16
Page 2, Comment #5	Page 3, Comment #14	Page 3, Comment #18
Page 2, Comment #9	Page 3, Comment #15	Page 3, Comment #19
Page 2, Comment #11		

B) ADDITIONAL INFORMATION REQUIRED FOR A FEASIBILITY DETERMINATION

Page 4, Comment #7	Page 4, Comment #10	Page 5, Comment #16
Page 4, Comment #8	Page 4, Comment #11	Page 5, Comment #19
Page 4, Comment #9	Page 4, Comment #12	Page 5, Comment #24

C) DESIGN, OPERATIONAL OR PERFORMANCE CONCERNS AND COMMENTS

Page 6, Comment #1	Page 6, Comment #4	Page 6, Comment #7
Page 6, Comment #2	Page 6, Comment #5	Page 6, Comment #9
Page 6, Comment #3	Page 6, Comment #6	Page 6, Comment #11

The remainder of the comments contained in the January 4, 1996 letter will be addressed in a second addendum to the Feasibility Report/Plan of Operation (Feasibility Report) to be forwarded to the WDNR in early March of 1996.

The format used in this document is to first list WDNR's comment and immediately follow it with CMC's response. For clarity, both the comment and response numbers are listed for each item.

A) Information Necessary For a Completeness Determination

Page 2, Comment 4: The regional hydrogeology discussion indicates that there are no bedrock wells within five miles of the site. The Department has provided CMC with information on several bedrock wells within five miles. CMC must provide an updated discussion of the regional hydrogeology to reflect this information. [s. NR 182.08(2)(c)4]

Page 2, Response 4: *Figure 1, prepared based on data provided by the WDNR, shows the approximate location of wells that penetrate the bedrock in the vicinity of the site. Although these wells penetrate the bedrock, the bedrock is generally not considered as an aquifer. Zaporozec and Cotter (1985) note that the metamorphic bedrock in the area is relatively nonproductive yielding small amounts of water, typically less than five gallons per minute (gpm). As such, the wells that penetrate the bedrock usually function to increase storage for the well user or to draw water from shallow fracture networks near the bedrock surface. With the exception of well 19 which is a CMC pump test well, all existing bedrock wells within a 5-mile radius of the tailings management area (TMA) lie outside of or adjacent to the immediate groundwater system boundaries defined by Swamp Creek to the north, Pickerel Creek to the west, Hemlock Creek to the east, and Rolling Stone, Pickerel, and Crane Lakes to the south. Attachment 1 contains information regarding these wells as provided by the WDNR.*

Page 2, Comment 5: The regional water quality discussion does not include the chemistry of the area precipitation. CMC must provide a revised discussion of regional water quality including the available information on dissolved solids, water type, pH, metals content, etc. [s. NR 182.08(2)(c)5]

Page 2, Response 5: *Chemistry data for area precipitation are collected by the National Atmospheric Deposition Program (NADP) near Trout Lake in Vilas County and Popple River in Florence County, both located in northern Wisconsin approximately 52 miles northwest and 36 miles northeast, respectively, from the proposed TMA site. NADP was contacted to acquire the chemistry data for area precipitation. NADP has set up its database in a homepage which is available through the INTERNET. Annual and seasonal chemistry data for area precipitation for the Trout Lake station and the Popple River station were downloaded from the NADP's homepage through the INTERNET and are included in Attachment 2.*

As shown in Attachment 2, the chemistry data include cations such as calcium (Ca), magnesium (Mg), potassium (K), sodium (Na), and ammonium (NH_4); anions such as nitrate (NO_3), chloride (Cl) and sulfate (SO_4); and the intensity parameters conductivity, and pH. Dissolved solids and metals content were not analyzed. The chemistry data are available from 1980 to 1995 for the Trout Lake station and from 1987 to 1995 for the Popple River station.

On an annual basis at the Trout Lake station, ammonium and calcium are the dominant cations, ranging from 0.19 to 0.42 mg/L and from 0.11 to 0.25 mg/L, respectively; whereas, nitrate and sulfate are the dominant anions, ranging from 0.96 to 1.56 mg/L and from 0.84 to 1.85 mg/L, respectively. The field pH of rainwater near Trout Lake ranged from 4.42 to 4.85. At the Popple River station, ammonium and calcium are also the dominant cations, ranging from 0.28 to 0.45 mg/L and from 0.12 to 0.29 mg/L, respectively; whereas sulfate and nitrate are the dominant anions, ranging from 1.13 to 2.01 mg/L and from 1.16 to 1.72 mg/L, respectively. The field pH of rainwater near Popple River ranged from 4.47 to 4.72. Because of the short distance from Crandon to Trout Lake and the Popple River, the chemistry of the project area precipitation is expected to be similar to that measured at the Trout Lake and the Popple River stations.

Page 2, Comment 9: Only one water table map was provided. Some discussion, with or without an additional water table map, must be provided regarding seasonal variation in water table elevations in the vicinity of the TMA. In addition, the contour interval in the legend for the existing water table map, Drawing 4, must be corrected to match the map. [s. NR 182.08(2)(d)7b]

Page 2, Response 9: *Water level hydrographs are provided in Volume VII (Appendix 3.6-8) of the Environmental Impact Report (EIR). As indicated in the hydrographs, seasonal variations in water table elevations were greater in the wells located in recharge areas in the immediate vicinity of the TMA than in discharge areas such as the area near Hemlock Creek. For example, the difference between maximum and minimum water table elevations for wells EX-9BU and G41-G12 (both located in a recharge area) is 7.33 and 4.13 feet, respectively; whereas the difference for EX-7CL and WP-6L (both located in a discharge area) is 0.59 and 0.39 feet, respectively. Although water table elevations varied seasonally, the direction of groundwater flow and the overall hydraulic gradient can be expected to be similar to that shown in Drawing 4.*

An updated Drawing 4R (Groundwater Table Contour Map, October 1984) is included in Attachment 3. The contour interval is corrected to 1 foot to correspond to the map legend. In addition, the 1579 contour was corrected to reflect an inconsistency discovered on the drawing. Section 3.6 of the EIR also includes a high water table map (Figure 3.6-28) from August 1986. This map shows water table elevations in the vicinity of the TMA that are several feet higher than the October 1984 map included here. In addition, a current conditions water table map from June 1995 was provided to the WDNR on August 2, 1995 and will be incorporated into an update of EIR Section 3.6 which will be submitted in the near future.

Page 3, Comment 11: Provide a discussion of the reasoning and logic for site design with respect to traffic routing. Provide an assessment of including two ramps down the interior side slopes of each TMA cell to facilitate construction activities and operational access to the side slopes. Including the ramps in the feasibility design will indicate if the exterior slopes have to be moved outward to accommodate the ramps and necessary volumes. (s. NR 182.08(2)(e)7]

Page 3, Response 11: *The traffic routing at the TMA has been designed to minimize congestion and inconvenience to the users. The vehicular traffic during operations has been described in Section 6.10 of the Feasibility Report (Foth & Van Dyke, 1995a). During construction and operation of the TMA, the main access road and the road on the top of the berms will be used by most of construction and operation traffic. For access inside the cells before the liner is constructed, the slopes along the corners of the cells will be used. Wheel tractor-scrapers and/or off-highway trucks will likely be used to transport construction materials to the TMA cell bottom. The "Caterpillar® Performance Handbook, 2nd Edition" (1991) contains Rimpull-Speed-Gradeability charts for wheel tractor-scrapers and off-highway trucks. Based on these charts, the maximum total effective grade for these vehicles is a 30 percent slope. The slope down the interior corner of a TMA cell is approximately 4.2 to 1 (horizontal to vertical) which is equal to a 24 percent slope. After the liner has been constructed no traffic to the inside of the cells is anticipated. Based on these facts, no ramps down the interior sideslopes are planned. Besides the road on the top of the berm, a perimeter road located at the toe of the TMA berms is also planned. These two roads will be used for monitoring, maintenance, and operational activities.*

Page 3, Comment 12: Provide a discussion of liner intersection with zones of outwash and potential perched aquifers. Include information on how construction methods might differ in areas of outwash versus till. Additionally, describe how perched groundwater systems encountered during construction will be handled. [s. NR 182.08(2)(e)7]

Page 3, Response 12: *The following narrative provides an assessment of the areas of TMA excavation where outwash and potential perched zones could be encountered and also includes conventional construction methods which could be employed to address a perched water table. Also a discussion is provided on construction methods in outwash areas.*

Assessment of Liner Intersection with Outwash Zones

In review of Feasibility Report (Foth & Van Dyke, 1995a) geologic cross sections G"-G‴ (Drawing No. 7), H"-H‴ (Drawing No. 8), and K"-K‴ (Drawing No. 10) it is apparent that coarse grained outwash deposits will likely be encountered in the sidewall during TMA excavation. These coarse grained outwash deposits have been consolidated by the same glacial processes that the late Wisconsinan Till and other soil layers were subjected to. As such, the coarse grained outwash deposits have a very dense structure and are not expected to react differently to excavation than the till soils. Coarse grained outwash deposits may contain coarse gravel and/or boulders which could result in more difficulty in excavation. From a stability standpoint, these over consolidated deposits present no concerns. However, since the outwash deposits are one or more orders of magnitude more permeable than the till, the outwash may be a potential source of perched water that could drain into the excavated area. The discussion which follows provides an assessment of potential perched water systems and describes conventional construction methods which could be used to deal with them.

Assessment of Perched Systems

Perched water conditions could be encountered during excavation. Some could likely be drained as part of the excavation with little or no additional construction measures required to control them. Other perched conditions may drain continually along the TMA cell sideslopes which could potentially lead to softening of subgrade soils and a decrease in the stability of soils below the composite liner.

Perched systems that have the potential to be encountered during the construction of the TMA are of two types:

- *Those associated with either partial or total wetland excavation, or*
- *Those not associated with wetlands and which may be encountered at depth.*

A detailed evaluation of all wetlands in the vicinity of the TMA has been completed as part of the development of an update to Section 3.6 of the project's EIR which will be forwarded to the WDNR shortly. Based on this analysis, it was concluded that no wetlands outside the area of disturbance are connected to perched groundwater systems within the TMA. Therefore construction methods to address this condition are not discussed below.

Contingency Plans for Addressing Perched Water Encountered During Construction

Potential construction measures which could be implemented, if perched water is encountered during excavation of a TMA cell that would adversely affect either construction or a wetland within the area of disturbance, consist of simple sump dewatering, an impervious barrier outside the facility, and interceptor drains. Following is a brief description of how perched water could be dealt with during TMA excavation and construction.

Simple dewatering of a wetland located within the TMA cell under construction can be accomplished by installing a sump and excavating radial ditches which would drain to the sump. The sump would be equipped with a gravel pack and pump. The pump would discharge water to a temporary or

permanent sedimentation pond. The design and construction of this type of system is simple and require only the expertise of the contractor.

Figure 2 shows a typical control measure which could be used when a wetland on the perimeter of the limits of disturbance is to be partially excavated as part of TMA construction. For this scenario, shallow perched water seepage through more permeable soil layers could occur. As shown in Figure 2, an impervious barrier would be installed to limit seepage into the excavated area.

Three types of perched systems not associated with wetlands may be encountered during the excavation for the TMA. These are:

- *A saturated sand lens (or outwash layer) dipping toward the excavation (Figure 3);*
- *A saturated sand lens (or outwash layer) dipping away from the excavation (Figure 4); and*
- *Perched system within the till caused by a layer of lower permeability soil shaped such that it contains or retards water flow (Figure 5).*

The contingency plan to be employed if any of the above types of perched systems is encountered will be governed by the resulting potential impact on construction and the resulting potential impact on long term behavior of the TMA slopes. The contingency plan would only be implemented if an impact on construction or liner stability were anticipated as a result of encountering the perched system.

Relating to construction impacts, if a shallow perched condition along a perimeter berm which will adversely impact construction is encountered within the area to be completely excavated, the contingency action would be similar to the wetland scenario shown on Figure 2. If, on the other hand, the perched water is observed on the final excavation slopes, the construction in this area can be temporarily postponed for a period of several days to allow the perched water to drain. If the water does not dry up during this waiting period, dewatering or plugging methods as shown in Figures 3 and 5 would be employed to allow construction to proceed.

Long-term impacts on the TMA slopes will be dependent on whether the sand lens is dipping towards or away from the excavation slopes. If the lens dips towards the excavation (Figure 3), recharge of the lens in the future would have the potential of causing excess pore water pressures on the TMA liner. On the other hand, a sand lens dipping away from the excavation slope will not cause excess pore water pressure on the TMA liner. A perched system caused by the presence of a lower permeability material within the till may have a slight potential of future recharges exerting hydrostatic forces on the TMA liner. Therefore, the suggested contingency action is as follows:

- *Keep records during excavation of perched systems by geological mapping or other means to ascertain the type of system encountered on the excavation slopes (i.e., sand lens dipping away or towards the excavation, perched system caused by low permeability layer, etc.).*

- *Monitor the flow rate out of the system on the face of the excavation for a period of several days.*

- *For the case of a sand lens dipping away from the slope and where an impact is anticipated, plug the sand lens with a low permeability soil plug (refer to Figure 4).*

- *For the other two cases (refer to Figures 3 and 5), provide a drainage path along the sideslopes towards the base of the excavation to a drain field of adequate capacity constructed below the liner. The design of the drain field can be completed based on the flow rate from the perched system and the hydraulic conductivity of the soils below the TMA base.*

It should be noted that any perched system exposed on the interior walls may not need such remediation if the perched water is permitted to drain.

Page 3, Comment 14: Provide a water budget analysis for normal conditions for the TMA prior to construction (existing conditions). Provide water budget analyses for wet and dry conditions prior to construction, during operations, and post closure, or request an exemption. [s. NR 182.08(2)(f)]

Page 3, Response 14: *Section 6.7 of the Feasibility Report (Foth & Van Dyke, 1995a) contains a detailed description of how the water budget has been prepared for the site using the HELP model (Hydrologic Evaluation of Landfill Performance) which is a more powerful technique than what is intended in NR 182.08(2)(f), Wis. Admin. Code. The intent of NR 182.08(2)(f) is to estimate the "amount and quality of seepage and discharge to surface and groundwater" for three climatological situations depicting dry, wet, and average precipitation.*

The HELP model is a quasi-two dimensional water balance model prepared for the USEPA by Waterway Experiment Station, U.S. Army Corps of Engineers. By performing a water balance analysis on a day-by-day basis for time periods of 100 years, the intent of performing the analyses for the three climatological situations as referenced in NR 182.08(2)(f), Wis. Admin. Code, is satisfied, especially since peak daily values during the period of simulation are used in designs as appropriate.

The HELP model analysis completed for the project has provided the quantity of percolation from the TMA. This data and percolation data for the area outside the TMA footprint (i.e., data from a water balance for the conditions prior to construction) derived as part of the project's regional groundwater flow modeling work are used by GeoTrans, Inc. as inputs into the project's solute transport model. Thus all data required by NR 182.08(2)(f), Wis. Admin. Code, have been developed using methods more accurate than what are implied in the code.

In view of the above, CMC requests that WDNR grant an exemption to those provisions of NR 182.08(2)(f), Wis. Admin. Code, requiring the development of a water balance by the implied simple and much less accurate methods of NR 182.08(2)(f).

Page 3, Comment 15: Provide an analysis of the aesthetic impacts of the proposed facility. [s. NR 182.08(2)(g)]

Page 3, Response 15: *NR 182.08(2)(g) requires that the applicant analyze the impact of the TMA on aesthetics and how such impacts can be minimized. This analysis was performed for the project and is described in detail in Section 4.2.12 of the project's EIR (Foth & Van Dyke, 1995b). A summary of the work and its results follows.*

In 1982, the Sanborn Group, Inc. prepared a visual impact assessment of the proposed project surface facilities including the headframe, tailings pond embankment, and railroad siding. Due to plant design changes, the 1982 assessment was updated in 1985 by Schreiber/Anderson Associates. In 1995, Foth & Van Dyke revisited the 35 viewpoints assessed in the previous survey to determine if potential land use changes have resulted in changes in the aesthetic environment since the previous

assessment was completed. Observation regarding the visual features between each of the viewpoints and the proposed TMA were made and are summarized in Table 3.13-2 of the project's EIR (Foth & Van Dyke, 1995b). In many cases the forests surrounding the proposed facilities have matured and may currently offer greater concealment of these features than that which was previously documented in the 1980s.

The TMA will be constructed in four phases of two stages each. When completed, the TMA will occupy approximately 355 acres and will range from existing grades to a maximum of approximately 100 feet above existing grade. Because of phased construction and closure, full visual impact is not realized until the filling of the facility is nearly complete and final grades are reached. The highest point of the final configuration of the TMA was selected to represent the practical worst case view of the facility. The visual presence or absence of the TMA from the surrounding area is shown in Figure 4.2.12-2 of the EIR (Foth & Van Dyke, 1995b). This figure illustrates that the TMA is visible only in areas adjacent to the outside berm. In other public viewpoints examined, the vegetation (existing 50 to 70 foot high forests) and topography effectively screen the TMA from view. The exterior embankments of the TMA will be topsoiled and seeded, further minimizing the visual impacts of the facility. Since visual impacts do not exist, there is no need to consider further design devices to screen the proposed TMA.

Page 3, Comment 16: Provide an analysis of the TMA embankments with respect to endangerment to human safety, the potential area to be affected in case of failure and any engineering modifications made due to safety considerations. [s. NR 182.08(2)(h)]

Page 3, Response 16: *NR 182.08(2)(h), Wis. Admin. Code requires the applicant to submit data regarding the safety factors of tailings pond embankments. On a case-by-case basis, the factors to be considered are listed below with a description of the information that has been submitted relating to this topic for the Crandon Project.*

1. *Geology of the TMA including type and homogeneity of the foundation.*

   As discussed in Section 6.15.2 of the Feasibility Report (Foth & Van Dyke, 1995a), there are no weak zones in the foundation where potential failure planes may lie. The embankments are also designed on a relatively shallow 3 to 1 (H to V) slope. Therefore a sliding failure along the base or through the foundation is not a possibility.

2. *Materials and methods used for embankment construction.*

   Sections 6.15.1 and 6.15.3 of the Feasibility Report (Foth & Van Dyke, 1995a) describe the materials and methods of embankment construction as they relate to embankment stability. Fairly flat (3 horizontal:1 vertical) till embankments are proposed and the contents of the TMA (tailings deposited in a slurry form with drainage during the operation period) are separated from the embankment by a very efficient hydraulic barrier such that water pressures will not lead to decreased slope stability.

3. *Engineering modifications included in the design.*

   For the type of a tailings disposal facility as proposed for the TMA, this is not an applicable factor. This is more related to tailings dams constructed in valleys.

4. *Physical and chemical characteristics of the waste as deposited and predicted changes through time.*

The expected change in physical characteristics of the waste is the continued consolidation for a length of time following closure of each TMA. This consolidation, which is estimated to occur within one year of the end of deposition, will result in increased strength and decreased flow potential. Projected chemical changes have been described in Section 4 of the Feasibility Report (Foth & Van Dyke, 1995a), but none of these changes have any relevance on the stability of the embankments.

5. *Endangerment to human safety.*

Potential risks of embankment failure are described in Section 4.13.8.2 of the project's Mine Permit Application (Foth & Van Dyke, 1995c). The TMA as designed for the Crandon Project differs from the practice of constructing a tailings dam in a valley to impound a tailings slurry behind it. For the Crandon Project, tailings will be contained in engineered cells and drained from both above and below, thereby transforming the tailings from a slurry to a solid state within a reasonably short time period. The main advantage of this approach is that in the unlikely event of an embankment failure, tailings will not flow out of the TMA. It should be noted that the embankments themselves are designed taking into account potential forces and employing a very conservative safety factor to achieve the stability of the structure at all times, thus eliminating endangerment to human safety. The results of the stability analysis completed for the TMA are presented in Section 6.15.4 of the Feasibility Report (Foth & Van Dyke, 1995a).

6. *Potential area to be affected in case of failure.*

Because of the relatively small amount of liquids in the cells, the potential area to be affected in the unlikely event of an embankment failure will be relatively small, on the order of 200 feet from the facility. Contingency measures to address such an occurrence are described in Section 4.13.8.2 of the project's Mine Permit Application (Foth & Van Dyke, 1995c).

Page 3, Comment 18: Include in the narrative on facility operation what provisions will be made for backup equipment and a summary of contingencies for handling emergency conditions. [ss. NR 182.11(1)(h)-(i)]

Page 3 Response 18: *Provisions to handle a breakdown of critical operating equipment at the TMA are discussed in the following narrative which identifies the type of critical equipment breakdown that can occur and which describes the contingency plan for addressing the conditions, including a list of the backup equipment that will be available.*

Sideslope riser (SSR) pump malfunction.

In the event of a SSR pump malfunction, leachate could not be removed from the TMA cell. The SSR pump is a small submersible pump mounted on a wheeled transporter which can easily be manually removed from the sump by site personnel. Once the pump is removed it can be replaced by a backup pump kept in stock at the mill. Installing the backup pump can be accomplished by site personnel since it involves simple plumbing and electrical hook-ups. Once the backup pump is installed in the sump, leachate pumping can resume.

Decant structure pump malfunction.

If the decant structure pump malfunctions, decant water cannot be removed from the active TMA cell. For this scenario, milling operations may continue and recycled water from the reclaim pond

would continue to be used for processing. In the event that the spare pump is unavailable or repairs to the decant pump take longer than two days, the tailings flow would have to be shut down until the decant pump is brought back on-line. Overtopping of the berms is unlikely since the embankments are designed to contain the 100-year, 24-hour storm taking into account a worst case wave height while allowing for an additional 3 feet of freeboard for wave run up. (refer to Section 6.5.4 of the Feasibility Report [Foth & Van Dyke, 1995a]). A backup pump and/or repair parts will be available from stock kept at the mill. Pump repair can be accomplished by site workers.

If an extended power failure were to occur, the mill would be shut down. If decant water levels were of concern, a portable generator could be used to run the decant pump for the period of time required to lower the water to acceptable levels or until power is restored.

Need for earthwork equipment to maintain operations.

Adverse weather conditions such as heavy rains or snowfalls could result in the need for additional earthwork equipment to make repairs and complete other emergency operations. A grader and front-end loader will be available on-site to meet typical emergency earthwork needs. If additional equipment is required, a local contractor from Crandon or Rhinelander could be contacted to mobilize the needed equipment.

Page 3, Comment 19: Provide a more detailed and comprehensive discussion of the compatibility of all portions of the liner system from the filter layer through the soil layer with the expected waste and leachate characteristics. Include information on the compatibility of the currently available geomembrane/geotextile resins. [ss. NR 182.11(1)(p) and NR 182.08(2)(e)7]

Page 3, Response 19: *Detailed compatibility investigations were completed for the Mine Permit Application and Environmental Impact Report prepared for the Crandon Project by Exxon Minerals Company in the 1980s (D'Appolonia, 1982). These investigations assessed the compatibility of the soils at the site to be used in construction with the tailings and the leachates generated. The compatibility was determined in terms of the effects on permeability, mineralogy, and chemical characteristics. For glacial till, stratified drift, and the bentonite/till admixture, the permeabilities were found to be affected only very slightly. The "column permeability" data was in agreement with the measured field permeabilities. The D'Appolonia study (1982) also showed that there was no change in the mineralogy of the samples except for the formation of gypsum when pH was 3. Also, the tests led to the conclusion that the principal soil minerals were stable in the presence of the permeating leachates.*

A geosynthetic clay liner (GCL) is proposed to be used as the soil component of the composite liner system. The main component of the GCL is a sodium bentonite. Because of the presence of divalent cations in the TMA leachate (e.g., calcium and magnesium), some sodium within the bentonite may be exchanged with divalent ions during the permeation through the GCL. These potential exchange reactions may alter the properties of the GCL depending upon the amount of divalent ion exchange for sodium within the bentonite. Currently available information for the expected TMA leachate and GCL products indicate that it is likely that a sodium bentonite GCL will perform such that liner design parameters are met. Final selection of GCL products typically involve testing performed by the GCL manufacturer at the final design stage of a project to verify that the selected GCL will meet desired specifications. Such testing is planned to be completed at the final TMA design stage which occurs during plan of operation preparation. In the event that the sodium bentonite GCL does not provide characteristics meeting design requirements, contaminant resistant clay can be substituted for sodium bentonite clay in the final specified GCL.

Geotextiles

The geotextiles proposed to be placed above the 24-inch drainage layer will consist of a non-woven, needle punched geotextile with an apparent opening size (AOS) of less than 0.160 mm. The mass per unit area [i.e., ounce per yard (oz/yd)] of the geotextile will vary depending on the manufacturer and will likely be in the 4 to 8 oz/yd range. Polypropylene and polyester are the two most commonly used synthetic fibers, with polypropylene being specified most often primarily due to the lower cost. It is likely that a polypropylene fiber geotextile will be selected for all applications within the TMA.

The compounds and elements which could potentially impact the geotextile include hydrated calcium [gypsum ($CaSO_4 \cdot 2H_2O$)] sulfate and mobile trace metals. Attachment 4 contains a summary table of the 1995 bulk chemical data for the tailings composites from the Crandon Project's Waste Characterization Update Report (Foth & Van Dyke, 1995d). The bulk chemistry data indicates the type and relative proportion of various constituents of the tailings. The data does not define which of the constituents may be mobile and what their concentrations will be. This information is provided in Section 3.5 of the project's EIR (Foth & Van Dyke, 1995b) and in the Waste Characterization Update Report (Foth & Van Dyke, 1995d). The estimated characteristics of the TMA leachate are provided in Table 3 of the October 19, 1995 technical memorandum pertaining to the derivation of the tailings management area source term which is included as Appendix N-2 of the TMA Feasibility Report (Foth & Van Dyke, 1995a).

Attachment 4 also contains a copy of research findings concerning the chemical resistance of polypropylene to various acids, solvents, solutions, etc. The research shows that polypropylene is resistant to acids, moisture, salt solutions, and the metal compounds expected in the leachate and tailings. The findings also show that polypropylene is immune to stress cracking, except in extreme oxidizing environments which will not occur in the TMA cells.

Geomembranes

Section 6.8.1 of the Feasibility Report (Foth & Van Dyke, 1995a) proposed that the geomembrane would be a 60 mil thermoplastic, the specific type of which was not defined. If the TMA were constructed today, a high density polyethylene (HDPE) geomembrane would be selected since polyethylene is the most common geomembrane for waste liners and caps.

Attachment 4 contains a copy of research findings concerning the resistance of polyethylene, specifically HDPE, to chemicals. Upon review of this data, it is apparent that polyethylene is resistant to the chemical groups which could be potentially present in the TMA leachate. Attachment 4 also contains a table reproduced from Koerner (1990) which shows that polyethylene has very good resistance to inorganic acids, heavy metals, and salt which are the chemical groups of concern.

Given the information presented above, the liner and leachate collection system components, consisting of glacial till soils, geotextiles, geomembranes, and GCLs, are all compatible with the expected chemical constituents of the leachate. Therefore, compatibility of the liner system should not be a concern.

B) Additional Information Required for a Feasibility Determination

Page 4, Comment 7: Provide additional discussion of potential dust control measures that could be implemented during extended shutdowns and after cell capacity is reached. Materials and methods of application of those materials over the area of each cell during drying must be covered. Include spray on foams or paper-based products in the discussion.

Page 4, Response 7: *Active tailings cells will largely be covered with a pond of water where decant water will be withdrawn for recycling to the mill. Depending on the cell configuration, the ponds will cover 50 to 75 percent of the cell surface area. As a result, only a small area, 150 to 200 feet, along the perimeter of each cell could be exposed to drying action. Section 6.2.6.4 of the Feasibility Report (Foth & Van Dyke, 1995a) lists operational controls which could be implemented to control tailings dusting during dry, cold weather conditions. The listed operational controls are as follows:*

- *spigot sequencing can be increased to place a veneer of fresh high moisture content tailings over dried areas;*
- *spigots around the cell can be used to direct water which will allow ice to develop on the dried areas; and*
- *other control measures like applying water or a chemical binder to the tailings surface.*

Various chemical binding agents are currently available. Some examples of such agents are discussed below. Manufacturer's literature for the listed products is included in Attachment 5. These products were developed and are typically used to control dust on mine or construction haul roads.

- *ROAD OYL® a resin modified emulsion manufactured from selected fractions of natural tree resins combined with a bonding agent. ROAD OYL® is advertised as a petroleum free, high bond strength binder which can be cold applied. ROAD OYL® is manufactured by Soil Stabilization Products Co., Inc. of Merced, California.*
- *SOILSEAL®, offered by the same manufacturer, is a pure acrylic copolymer used to control dusting, erosion and siltation. SOILSEAL® is reported to be ultraviolet resistant and durable years after application.*
- *DUSTROL™ is also manufactured by Soil Stabilization Products Co., Inc. DUSTROL™ is an organic chemical preparation which reportedly causes soil particles to adhere to each other, forming larger sized particles which resist blowing when dry. DUSTROL™ is typically used as part of a regular watering operation to improve wetting efficiently and reduce the frequency of watering passes.*
- *CFM 400™, a polymer made partially from lignites (paper manufacturing waste products), can be applied wet or dry and reportedly bonds fine particles together to form an erosion resistant surface.*

All of these products can be applied with water trucks, hydroseeders and hand or truck mounted spray bars. A hydroseeder could be effective in applying chemical binders to the dry tailings in a TMA cell since this equipment can spray 250 feet and beyond depending on conditions.

Spray foam products are also available as temporary cover materials. These products have typically been used at municipal solid waste (MSW) sites as an alternative daily cover in lieu of using soil. Typically foam must be applied directly to the waste surface by a wheel or tracked vehicle. However, some products such as Concover® can also be applied with hydroseeders. Concover® makes a number of different products. Information on two foam products available from Concover® are included in Attachment 5. The two products are Concover® "A" Bag, a binding material blended with special clay, biodegradable organic compounds, and fibrous cellulose based material, and Concover® "B" Bag Paper, a binding material blended from recycled paper, wood pulp with water, with a surfactant added. Both of these products are primarily used as MSW daily cover. These products could also be effectively applied to the tailings surface for dust control during temporary shutdowns.

Page 4, Comment 8: Provide information on the probability of needing the proposed riprap causeway for decant water pumping. Describe the potential effects of the causeway, if it is developed, on facility environmental performance and on facility capacity.

Page 4, Response 8: *Section 10.9.5 of the Feasibility Report (Foth & Van Dyke, 1995a) reviewed four alternatives for the TMA reclaim water system. One alternative reviewed was a rock fill central intake consisting of intake tower (manhole) and causeway installed on top of the liner. If implemented, the Type II waste rock would be used as fill and the rock fill access support ramp and manhole would have to be raised as the TMA cell was filled. This alternative was eliminated from consideration and a skid mounted pump with suction intake was selected.*

Page 4, Comment 9: Provide additional discussion of how the production of mining waste is minimized through the design and operation of the mine and mill. Include a brief quantitative comparison of waste generation expected from different mining and processing methods.

Page 4, Response 9: *Mining and metallurgical evaluation programs to optimize design parameters have been developed during the progression of the permitting process. These studies were focused on maximizing recovery of the ore resource by using the best available mining and metallurgical technology while protecting the workforce and the environment. An overview of the results of the studies follows.*

- *Waste production during the mining cycle results from the underground development that provides access to the ore body for the extraction of ore. The cost of mining a ton of waste is approximately equal to the cost of mining a ton of ore and it generates no revenue. It is therefore to CMC's benefit to minimize the amount of waste development and thereby reduce the amount that requires hoisting to the surface and subsequent placement within the TMA.*

- *Prior to the selection of a mining method a number of design parameters were evaluated. They included such areas as:*

    - *geometry of the ore body;*
    - *grade distribution of the deposit;*
    - *rock mechanic properties of the ore zone, hanging wall, and footwall rock;*
    - *planned mining rate;*
    - *alternative mining methods; and*
    - *environmental considerations.*

Based on the evaluation of these factors it was concluded that the blasthole open-stoping technique was the best mining method for most of the Crandon Project ore body. The proposed method is cost-effective, safe, and maximizes the recovery of ore. Backfilling the mined out stope will result in 90 percent ore recovery.

- *The 1986 Mine Permit Application estimated the mine waste rock to be approximately 7.0 million tons during the life of the project while the current mining plan estimates this tonnage to be 1.5 million tons. This reduction is a result of the elimination of the hanging wall drifts and miscellaneous development associated with each mining level. This significantly reduced the amount of waste rock which is to be mined, crushed and hoisted.*

- *CMC will minimize the amount of waste that will be disposed of in the TMA by use of tailings in the backfilling of the mined out voids. Backfilling in the mine reduces the TMA storage requirements by approximately 50 percent.*

Page 4, Comment 10: Provide a discussion of additional below ground tailings disposal. Additional volume would be available for disposal by filling all lower levels and all shafts and raises. Include a discussion of remobilizing tailings from the last TMA cell.

Page 4, Response 10: *At the end of the mining life it may be possible to backfill the shaft and raises, but it would likely be impractical to fill horizontal level development for the following reasons:*

- *In the horizontal development drifts, a series of short bulkheads would be required to be constructed for the containment of fill. This construction method would require a dewatering system to allow for the consolidation of the backfill.*

- *The mine ventilation system would need to be changed to ensure that this work could be done safely.*

- *Only a portion of the horizontal drifts could be filled as safe working room would be required for the dewatering process.*

If CMC were able to fill 50 percent of the mine voids created in waste development headings with tailings, approximately an additional 320,000 cubic yards of fill could be placed. This would result in a reduction of tailings placed in the TMA by about 2 percent. This is deemed to be an insignificant quantity and as the underground openings could only be filled after mining and milling is complete, the tailings would have to be stored in the TMA, remobilized, and pumped back to the mine, where the coarse material would be separated by cyclones and placed underground with the fines returned to the TMA. Physically this would be very difficult, if not impossible, to do. Even if it was feasible, the space in the TMA previously filled with tailings would have to be filled with soil from an outside source in order to achieve the correct slopes for closure.

Page 4, Comment 11: Provide a discussion of proposed lime storage, transport, and mixing procedures for the TMA.

Page 4, Response 11: *All lime storage and mixing equipment will be located at the mill. No such facilities are planned for the TMA. If lime is required for application on an active TMA cell during shut-down it would be mixed in the mill where the following equipment or facilities are available: lime storage areas, mixing tanks, transfer pumps, etc. Lime required at an active TMA cell could be transported by two methods. A lime slurry (milk of lime) could be mixed at the mill and pumped*

through the tailings pipeline and then discharged over the tailings by successive opening and closing of banks of spigots or by spraying with a hand held hose. If a small area is impacted and requires lime treatment the milk of lime could be prepared at the mill and transferred to the TMA by a tanker truck. The impacted area could then be selectively sprayed with lime solution.

Page 4, Comment 12: Resolve inconsistencies between drawings and narrative on filter layer thicknesses. Drawing 29 shows the till layer thickness as 18 inches while the text indicates 24 inches.

Page 4, Response 12: *Section 6.3.1, page 85 of the Feasibility Report (Foth & Van Dyke, 1995a) incorrectly lists a total till layer thickness of 24 inches (i.e., 6 inches of fines from till processing and 18 inches of glacial till) for the base liner system configuration. Drawing 29 correctly shows that the base liner is proposed to consist of a total till layer thickness of 18 inches (i.e., 6 inches of fines from till processing and 12 inches of glacial till).*

Page 5, Comment 16: Provide detailed information on the determination of tailings density. Show data, calculations, and verification procedures for generating density information.

Page 5, Response 16: *Appendix B of the Feasibility Report (Foth & Van Dyke, 1995a) contains the details of a tailings laboratory testing program conducted by Steffen Robertson and Kirsten, Inc. In order to estimate the design densities of the tailings within the TMA cells, column settling, pan evaporation, and one-dimensional consolidation tests were performed on whole tailings and fine tailings (slimes). Since consolidation of the tailings is expected to occur within one year of the end of deposition, the type of density test most representative of field conditions is the consolidation test.*

The resulting dry unit weights for the fine tailings and whole tailings are as follows:

	Dry Unit Weight	
Condition	*Fine Tailings*	*Coarse Tailings*
Consolidation under 30' load	*89 pcf*	*124 pcf*
Consolidation under 60' load	*92 pcf*	*127 pcf*

Each TMA is expected to contain about 80 percent fine tailings and 20 percent whole tailings. Therefore the estimated dry unit weight (average) of tailings in the TMA will be:

$$30' \text{ load} = 0.8(89) + 0.2(124) = 96 \text{ pcf}$$
$$60' \text{ load} = 0.8(92) + 0.2(127) = 99 \text{ pcf}$$

The TMA being 90 feet deep (approximately), the average load is about 45 feet, thus leading to a calculated density of (96 + 99)/2 = 97.5 pcf by linear interpolation. Since the volume of tailings under a relatively smaller load is more, the estimated density was adjusted to a lower value of 97 pcf, which was used for design purposes.

In the HELP model, a variation of densities with depth has been used. This variation is plotted in Figure 6.7-2 of the Feasibility Report (Foth & Van Dyke, 1995a). Three known conditions for this plot are 30' load - 96 pcf, 60' load - 99 pcf, and 0' load - 70 pcf [0.8(65) + 0.2(95) = 71 pcf from column tests]. The plot was made to obtain dry densities of the tailings at different depths.

Page 5, Comment 19: Revise the appropriate portions of the FR that indicate that long-term care begins following final grading and revegetation. The forty-year long-term care period will begin following the issuance of a certificate of completion of reclamation, which cannot be issued until at least four years after the site has been reclaimed according to approved plans and conditions.

Page 5, Response 19: *Section 9.2 (Financial Responsibility for Long-Term Care) of the Feasibility Report (Foth & Van Dyke, 1995a) references Sections 3 and 10 of the Crandon Project Mine Permit Application (MPA) as containing an outline of the long-term care responsibilities. Table 10-1 of the MPA lists the activities required during the long-term care period, their frequency, and the duration of each activity.*

It is understood that the 40-year long-term care period will begin following the issuance by WDNR of a certificate of completion of reclamation, which cannot be issued until at least four years after the site has been reclaimed according to approved plans and conditions.

Page 5, Comment 24: Provide additional discussion on erosion control in the interior of the facility during initial filling. In addition, provide information on how minor sideslope gullying or slumping will be corrected during filling.

Page 5 Response 24: *Section 6.3.5.1 of the Feasibility Report (Foth & Van Dyke, 1995a) contains a discussion of geomembrane and leachate collection system protection during initial TMA cell filling. Section 6.3.5.1 indicates that Type II waste rock varying from 24-inch nominal diameter to 6-inch nominal diameter will be placed over the filter/drainage layers prior to filling with water or tailings. Once the riprap is in place, the cell bottom will be covered with water. The water depth in the cell bottom may vary from less than 1 foot to 17.6 feet or greater in the case of TMA 1 (due to the base grades). The water will be discharged at the bottom of the cell through the spigots around the cell. Each spigot is equipped with a flexible rubber hose which allows them to discharge onto the riprap at the base of the TMA cell. Since the spigot pipes will discharge directly onto a riprapped surface, erosion is not expected to be a problem. Once water spigotting is completed, tailings deposition can begin.*

Tailings will initially be deposited subaqueously around the periphery of the facility until a sufficient beach and a central pond are established around the entire outside of the base of the TMA cell. This deposition will be accomplished by discharging slurry from a discrete continuous panel of spigots selected from the entire set of spigots located around the TMA cell. The discharge "panel" will be moved progressively around the cell by closing spigots at one end of the panel while opening spigots at the other end of the panel. Each spigot consists of a length of flexible pipe which extends from the main ring through a pinch valve to the desired discharge level at the cell base. Once a beach is developed around the entire cell bottom, a water pool will form in the center of the cell bottom. From this point forward, erosion at the cell bottom is not a concern.

Appendix M of the Feasibility Report (Foth & Van Dyke, 1995a) contains erosion estimates developed using the Revised Universal Soil Loss Equations (RUSLE) for the interior berms of the TMA based on a worst case 50 foot height, 3:1 (H to V) slope for bare ground with no vegetative cover. Using RUSLE and assuming a 100 pounds per cubic foot of soil density, the calculation indicates that the bare interior sideslopes will erode at the approximate rate of 1.2 inches per year. Since the average life of each stage of a TMA cell is four years or less, this will translate to about 4.7 inches of erosion or less near the top reaches of a cell. This is acceptable in view of the fact that an 18-inch soil cover protects the geomembrane and that tailings will cover the slope as deposition in the cell proceeds. If significant rill formation occurs (i.e., numerous closely spaced rills) 4 inches

deep or greater, then repair work will be required. These rills can be filled from the TMA access road with a backhoe or filled by hand by site workers using shovels and wheelbarrows. Seeding of interior slopes with grass seed mixes could be considered in the future but is not currently planned or needed.

C) Design, Operational or Performance Concerns and Comments

Page 6, Comment 1: Provide a redesign of the facility extending the drainage layer up the side slopes of each cell at least to the first stage boundary to facilitate leachate drainage and collection.

Page 6, Response 1: *CMC's original TMA design included the collection of leachate from the base of each cell such that the potential for air entry into the tailings through the drainage layer can be minimized. Percolation from the site was estimated under this design condition and a groundwater impact analysis was performed to ascertain if the design meets regulatory requirements. Extending the drainage layer up the sideslopes of each cell as requested by WDNR is not considered necessary by CMC to comply with state and federal environmental guidelines. However, in order to provide redundancy in design and at the same time maintain the goal of minimizing oxygen entry to the base of the tailings, CMC is currently proposing to include a drainage system up to half the height of the first stages in each TMA cell.*

The system as proposed will consist of placing a geocomposite (a geonet with non-woven geotextiles heat bonded to its top and bottom surfaces) on top of the composite liner and then covering the geocomposite with a thermoplastic geomembrane (refer to Figure 6). This geomembrane will be lapped over the composite liner at the base for a length no less than 5 feet. A woven geotextile will be placed over the upper geomembrane. By selecting textured surfaces for the thermoplastic geomembrane on the sideslopes, stability of the drainage system and the protective layers over the liner (consisting of till as originally proposed) will be achieved since the friction angle along all the interfaces in the system (geomembrane to geocomposite to second geomembrane to geotextile to till cover soils) will be much greater than the angle of the sideslopes.

The hydraulic effect of extending the drainage system up to half the height of the first stages in each TMA cell will provide redundancy by reducing the percolation from the site by about 50 percent during operations (from 0.66 in/year to about 0.33 in/year) when most of the total percolation from the site occurs. As a comparison, extending the sand drainage layer up to half the height of the first stages reduces the percolation by the same amount (i.e., 50 percent) during the operation stages. The comparison shows that the proposed drainage concept and a sand drainage layer are equivalent from a hydraulic performance standpoint. The proposed concept is deemed superior to the sand drainage layer since it reduces the potential for air entry along the facility sidewalls.

In order to evaluate the long-term effects of the two different systems of drainage [i.e., i) as currently proposed by CMC, and ii) by extending the drainage layer up to half the height of the first stages as proposed by WDNR] the time for drainage of the tailings to field capacity was examined. By comparing the soil water in the system through time, it was concluded that the soil water content virtually remains constant after 20 years following closure for both systems. This indicates that 20 years after closure, the percolation from the TMA will be governed by the percolation through the final cover. All calculations are included in Attachment 6.

Thus, from the above discussion it can be concluded that:

- *The drainage system as currently proposed by CMC (i.e., up to half the height of the first stage in each cell) will provide redundancy by reducing the percolation from the site during operation and post closure phases.*

- *The system is stable.*

- *Regardless of the extent of the drainage system up the first stage sidewall, for all practical purposes, 20 years after closure percolation is governed by the percolation through the final cover.*

Page 6, Comment 2: Provide an assessment of and/or redesign of the facility using a more conventional "waffle-board" leachate collection pipe layout and associated base grades.

Page 6, Response 2: *Figure 7 provides a plan view of the typical TMA cell leachate collection system (LCS) piping incorporating CMC's redesign of the LCS system to provide additional piping along the base of each cell. The additional LCS piping will provide additional redundancy and a very minor improvement in collection efficiency. Based on HELP model runs on the 130-foot drainage length proposed, CMC estimates that the additional quantity of leachate removed by the added piping will be 0.001847 inches per year during operations and 0.00001 inches per year during post closure.*

Figure 7 shows the system of 4-inch diameter perforated leachate collection pipes that are proposed to be added to the base of each TMA cell at a regular spacing at an approximate 0.5 percent grade toward the 6-inch perforated header pipe at the interior toe of the berm. The typical LCS plan shown is for TMA 1 where an additional perforated leachate header pipe has been added along the southwest facing berm. The liner/LCS "blow-up" on Figure 7 shows that the leachate collection system piping will be bedded within the drainage layer over the geotextile above the geomembrane.

Figure 8 shows a plan and section view of the connection of the 4-inch perforated LCS laterals to the 6-inch perforated LCS header pipe at the toe of the berm. Figure 8 also shows that a 6-inch wye is provided which is stubbed through the protective layers of the composite liner. This will allow for cleaning the 4-inch lines after construction is completed. After the construction cleaning, the wye will be capped and cleaning will be accomplished only in the 6-inch LCS pipe along the berm toe as originally proposed. As in the originally proposed design, cleanouts are provided on both ends of the LCS headers along the berm toe. These 6-inch LCS headers will be cleaned as proposed in the Feasibility Report (Foth & Van Dyke, 1995a).

Attachment 7 provides calculations which show that a 4-inch LCS pipe is properly sized to handle the peak daily flows as determined by the HELP model. The maximum discharge from a 4-inch pipe at 0.5 percent slope is about 80 gpm, the expected peak flow is 5.1 gpm.

Calculations in Attachment 7 show that the maximum 1-foot head on the liner will not be exceeded with pipe installed at the base of the drain layer above the liner. Therefore trenches in the liner are not required to meet the performance requirements.

Page 6, Comment 3: Provide a new liner system design using alternatives to native clay or incorporating at least 3 feet of native clay for the soil component. Use the HELP model to assess different configuration options. If native clay is selected, clay borrow site and transportation impact assessments will be necessary. Additionally, an investigation and testing

program would need to be implemented at all borrow sites to verify the quality and quantity of material available.

Page 6, Comment 4: Provide a new final cover system design using alternatives to native clay or incorporating at least 2 feet of native clay for the soil component. Use the HELP model to assess different configuration options. If native clay is selected, clay borrow site and transportation impact assessments will be necessary. Additionally, an investigation and testing program would need to be implemented at all borrow sites to verify the quality and quantity of material available.

Page 6, Response 3 and 4: *Both Comment 3 and Comment 4 from page 6 are responded to in this single response since the modified liner soil component will be the same for both the composite liner and cap.*

The WDNR has requested that CMC consider an alternative to the use of native clay as the soil component in the TMA composite liner and final cover systems. Based on this request, CMC is currently focusing on using a GCL as the soil component of the composite liner systems overlying a screened till layer. The following narrative provides information on GCLs, including a discussion on the advantages of GCLs when compared with clay liners. In addition, an evaluation of the screened till is provided, including availability and material specifications.

GCL Materials

Geosynthetic clay liners (GCLs) are manufactured liners typically consisting of a bentonite clay component encapsulated in woven or nonwoven geotextiles. The geotextiles are typically held together by needling, stitching or an adhesive. GCLs typically come in roll lengths ranging from 100 to 200 feet and widths ranging from 13 to 17.5 feet.

GCLs have been used for many years as the primary or secondary means of containment for landfills, lagoons, tanks, etc. GCLs have also been used as the primary hydraulic barrier in landfill and other caps or as the clay component in a composite cap.

Available GCL Materials

Following is a general description of available GCL materials. Attachment 8 contains a summary of the properties of Commercially Available GCLs which was reproduced from Geotechnical Fabrics Report, December 1995.

> *BENTOMAT®: BENTOMAT® is manufactured by the Colloid Environmental Technology Company (CETCO), which is a subsidiary of the American Colloid Company. BENTOMAT® consists of VOLCAY® (sodium bentonite) sandwiched and needle punched between two layers of woven or non-woven needle punched geotextiles. Additional details concerning BENTOMAT® can be found on pages 7 through 13, and in Tables 2.2 and 2.3 of the 1993 USEPA report titled "Report of Workshop on Geosynthetic Clay Liners" (USEPA, 1993). Manufacturer's data is included in Attachment 9 for BENTOMAT®.*
>
> *BENTOFIX®: BENTOFIX® is marketed by National Seal Company/Fluid Systems/Columbia Geosystems Ltd. BENTOFIX® consists of a layer of loose granular or powdered bentonite held between two geotextiles by needle punching non-woven fiber through it. Additional details*

concerning BENTOFIX® are found on the same pages of the USEPA report referenced above. Attachment 9 contains technical literature on BENTOFIX®.

GUNDSEAL®: GUNDSEAL® is manufactured by GSE Lining Technology, Inc. GUNDSEAL® is different from the GCLs previously described in that it consists of a layer of bentonite (5 kg/m^2) adhered to a geomembrane. The manufacturer can provide Wyoming sodium bentonite or treated contaminant-resistant bentonite. The geomembrane can be either HDPE or VLDPE with thicknesses ranging from 20 to 80 mils. Additional details concerning GUNDSEAL® can be found on pages 16 through 28 of the USEPA report referenced above. Attachment 9 contains the manufacturers product literature and GUNDSEAL® specifications. GSE Lining Technology also manufactures BENTOLINER® which is similar to BENTOFIX® and BENTOMAT®.

Performance Assessment

Compacted clay liners (CCLs) in conjunction with geomembranes have historically been used for containment, primarily due to the considerable amount of experience gained with CCLs alone or as the soil component of composite liners. GCLs offer an attractive alternative where good quality clay is not available in required quantities. The proposed TMA project is one where the demand for clay, if specified, will be large, with the material unavailable locally.

The evaluation of GCLs and CCLs should focus on GCLs ability to meet the performance objectives of the liner and cover systems. David Daniel, professor of Civil Engineering at the University of Texas at Austin, is one of the leading researchers on the performance and design of both GCLs and CCLs. In Chapter 7 of the "Report of Workshop on Geosynthetic Clay Liners" (USEPA, 1993), Dr. Daniel discusses the equivalency of GCLs and CCLs. Following is a list of advantages of GCLs related to performance, constructibility and other technical issues based on Dr. Daniel's work and the specific site conditions for the TMA.

- *Installation advantages of GCLs (after USEPA, 1993)*

  1. *Installation of GCL is rapid and simple.*
  2. *GCL installation does not require heavy equipment.*
  3. *Inclement weather delays which would typically halt soil liner construction have minimal impacts on GCL installation.*
  4. *GCLs are uniform and consistent since they are manufactured products.*
  5. *GCL material properties related to performance can be determined in the laboratory prior to installation, resulting in the minimization of construction delays related to Quality Assurance and Quality Control (QA/QC) activities.*
  6. *QA/QC is simpler and less costly with GCLs.*
  7. *GCLs are easier to construct on slopes than soil liners.*
  8. *GCLs are not vulnerable to desiccation during installation.*

- *Performance Advantages of GCLs (after USEPA, 1993)*

    1. *Most GCLs can be shown to be equivalent to soil liners with hydraulic conductivities in the 1 x 10^{-7} cm/sec range for steady water flux.*

    2. *GCLs produce less consolidation water than soil liners, which are typically placed wet of their plastic limit.*

    3. *GCLs appear to be superior to soil liners in the ability to withstand freeze/thaw and wet/dry cycles.*

    4. *GCLs maintain low hydraulic conductivity, even when subjected to large differential settlements.*

    5. *GCLs have the capability of self-sealing around certain types of punctures, e.g., penetration by a sharp object.*

    6. *GCLs, when installed with a geomembrane, are equivalent to soil liners with respect to steady solute flux.*

    7. *GCLs can be designed to be stable on slopes.*

- *Advantages of GCLs specific to the site conditions at the TMA include:*

    1. *Use of a GCL will eliminate the need for a large off-site borrow area for native clay.*

    2. *Use of a GCL reduces the environmental implications related to a soil borrow area.*

    3. *Use of a GCL eliminates concerns regarding soil component desiccation due to drying (USEPA, 1993 p.89).*

    4. *Use of a GCL eliminates concerns regarding soil component desiccation due to freeze-thaw (USEPA, 1993 p.89).*

Alternative to Clay for Soil Component for Composite Liner

As an alternative to the one foot of native clay soil proposed in the Feasibility Report (Foth & Van Dyke, 1995a) CMC is proposing the following for the soil component of the composite liner:

- *Geosynthetic clay liner (GCL) ~ 10 mm thick.*
- *P40 till layer - minimum 1-foot thick.*

The 1-foot, P40 till layer is proposed as a grading layer for the GCL. The primary purpose of this layer is to provide a stable, uniform, smooth surface which is free from coarse gravel and cobbles which could potentially puncture or tear the GCL. GCLs are fabricated with the bentonite sandwiched between two layers of geotextiles to prevent the movement of bentonite particles from the GCL liner. The P40 till layer provides redundancy in the prevention of soil particle movement because of its well-graded nature and fine particle size. GCLs have been approved by the WDNR for liner and caps on industrial landfills in areas of the state where clay is scarce, difficult to obtain, uneconomical, or environmentally less desirable as is the case for the TMA. Past approved GCL

installations had no requirement for a backup soil liner, only that the subgrade be prepared such that the GCL could be installed without danger of puncturing or tearing during construction.

Table 1 provides a comparison of GCLs to native clay. The table also provides information regarding the characteristics of the proposed P40 till material. In reviewing Table 1 it is apparent that, as the soil component of a geocomposite liner, a GCL provides a number of advantages over a CCL including:

- *GCL construction is rapid and simple;*
- *Heavy equipment is not required to install a GCL;*
- *A GCL can probably better withstand freeze/thaw and wet/dry cycles than CCLs;*
- *Quality assurance is simpler with GCLs;*
- *Because GCLs are manufactured, material concerns regarding the potential inconsistency of materials from borrow sites is eliminated;*
- *GCLs have a lower hydraulic conductivity than CCLs; and*
- *GCLs are not vulnerable to desecration damage during construction.*

Liner hydraulic equivalency

As part of the evaluation to determine if a GCL is appropriate for use in the TMA design it is necessary to determine whether the composite liner consisting of a geomembrane overlying the GCL is hydraulically equivalent to the originally proposed composite liner. Hydraulic equivalency is achieved if the flow through the modified liner (with GCL) has the same or lower rate under an arbitrarily selected head of one foot (the maximum head on the liner in general will be less than this value) compared to the liner originally proposed (geomembrane overlying a clay layer of 1-foot thickness and hydraulic conductivity of 10^{-7} cm/sec). To address hydraulic equivalency, flows through three liner configurations were calculated as listed below.

GCL with k = $3x10^{-9}$ cm/sec (design value)
1-foot thick clay with k = $1x10^{-7}$ cm/sec
3-foot thick clay with k = $1x10^{-7}$ cm/sec

The calculations are provided in Attachment 10. The results show that the composite liner with a GCL backing has a smaller flow rate at least by a factor of 2.6 when compared with the other systems. Therefore, the geomembrane/GCL composite is hydraulically equivalent to the geomembrane/clay liner system originally proposed.

Availability of suitable on-site till

To achieve the design base grades within the TMA, soil will be excavated and berms constructed within the TMA footprint. Most of the soil excavated will consist of the Late Wisconsinan Till (LWT) with the remainder consisting of coarse grained outwash deposits. It is estimated that approximately 8,900,000 cubic yards of LWT will be excavated during construction of the TMA (see Attachment 11 for calculations).

Table 1

Comparison of a GCL to a Native Clay Liner

Characteristics	Comments on Advantages or Characteristics		
	Native Clay Liner	Geosynthetic Clay Liner (GCL)	P40 Material (-¾-inch Till)
Materials	Native Clay Soil. Available from commercial off-site sources approximately 40 miles from the TMA site.	Bentonite Clay, Adhesives and/or Geotextile. Available from many suppliers, though only two manufacture a suitable GCL.	Native Till Soils screened on-site to remove material larger than ¾-inch. Available from TMA excavation.
Thickness	1 foot or greater. Relatively insensitive to puncture or to small imperfections in any one-lift.	Approximately 10 mm (~0.4 inch). Insensitive to puncture because of self healing properties and low hydraulic conductivity.	1 foot or greater. Relatively insensitive to puncture or to small imperfections in any one-lift.
Hydraulic Conductivity	10^{-7} to 10^{-8} cm/sec. Low hydraulic conductivity possible with typical liner quality clays.	10^{-8} to 10^{-10} cm/sec. Lowest hydraulic conductivity of soil liners.	10^{-4} to 10^{-5} cm/sec. Hydraulic conductivities will depend on the percent passing the number 200 sieve which varies in the till.
Physical/Mechanical Properties			
• Freeze-Thaw	Moderate Resistance. Potential for negative impacts.	Resistant. Little negative impact.	Moderate Resistance. Potential for negative impacts.
• Wet/Dry Cycles	Little Resistance. Rewetting may result in partial recovery of the original hydraulic conductivity. May lose moisture on slopes with black membrane.	Resistant. Bentonite is self healing.	Little Resistance. Rewetting may result in partial recovery of original permeability.
• Slope Stability	Stable on 3:1 (H to V) slopes or less.	Stable with proper design. Construction QA important.	Stable on 3:1 (H to V) slopes or less.
• Puncture Resistance	Resistant. Unlikely to be punctured through entire thickness.	Resistant. Capable of self healing around punctures.	Resistant. Unlikely to be punctured through entire thickness.
• Attenuation	Higher capacity to absorb inorganics.	Thickness limits absorptive capacity.	Absorptive capacity dependent on till fines properties, e.g., percent clay size particles.

Table 1 *(Continued)*

Characteristics	Comments on Advantages or Characteristics		
	Native Clay Liner	Geosynthetic Clay Liner (GCL)	P40 Material (-¾-inch Till)
Construction			
• Subgrade Condition	Not Impacted. Construction with heavy equipment and multiple lift thickness. Moisture in the subbase not a critical concern.	Sensitive. <¾-inch till base where cobbles and stones are removed so that the GCL is not compromised. Not suitable for wet subbase.	Not Impacted. Construction with heavy equipment and multiple lift thickness. Moisture in the subbase not a critical concern.
• Ease of Placement	Easy with heavy equipment. Construction can be delayed by inclement weather.	Very Easy. Can be rapidly deployed with light construction equipment even in adverse weather conditions.	Easy with heavy equipment. Construction can be delayed by inclement weather.
• Speed of Construction	Moderate. Heavy equipment and good construction coordination required.	Fast. Rapid deployment possible with light equipment.	Moderate. Heavy equipment and good construction coordination required.
• Weather Constraints	Possible. Adverse weather conditions could delay construction.	Few. Can be installed if necessary in adverse weather conditions other than precipitation.	Possible. Adverse weather conditions could delay construction.
• Availability of Materials	Available from off-site commercial borrow source within 40 miles of the TMA site.	Available from mainly two manufacturers, but no problem with prior orders.	Till material available on-site within TMA footprint.
• Quality Assurance (QA) and Quality Control (QC)	Requires extensive QA/QC to demonstrate compliance with specifications.	Manufactured product which requires little QA/QC on-site. Construction QA critical for stability.	Requires extensive QA/QC to demonstrate compliance with specifications.
Contact Between Geomembrane and Soil Component of Liner	Great effort required to obtain smooth surface for geomembrane.	Best possible contact.	Great effort required for obtaining smooth surface for geomembrane.
Environmental Issues	Off-site Borrow Source. Off-site impact from borrow site development and trucking.	Manufactured Materials. Little environmental impact from obtaining materials and constructing.	On-site Materials. Impacts from on-site borrow area activities.

Prepared by: REM
Checked by: JWS

The excavated LWT will be the source of material for the drainage layers and till blanket layers proposed for the TMA. Sieving of the LWT will be performed to achieve the required gradations and quantities for the various layers. Calculations show that the 8,900,000 cubic yards of LWT will provide enough material for the drainage layers and till blanket layers. Calculations also show there will be enough fines (minus #40 sieve) available to also produce the proposed 1-foot thick P40 till layer for the base liner and final cover system. Table 2 summarizes the calculations that looked at "average" till gradations as well as the "coarse" and "fine" gradations that bracket the LWT gradations for soil volumes generated during the manufacture of the drainage layer.

Table 2

Till Soil Volume Availability

Layer	Required Volume	Available Using Average LWT Gradation Curve	Available Using Coarse LWT Gradation Curve	Available Using Fine LWT Gradation Curve
Drainage Layer (½" to #40 sieve)	675,000	675,000	675,000	675,000
Fine Till Layer (finer than #40 sieve)	78,300	78,300	78,300	78,300
P40 Till Layers[1] (finer than #40 sieve)	746,000	1,021,000	596, 900	2,959,200

Note: All values in cubic yards.
[1]Liner and final cover.

Prepared by: JBH1
Checked by: NXP

This analysis shows that during the production of the drainage layer, enough fines are produced to supply the needs of the fine till layer and the P40 till layer using the average LWT gradation curve and the fine LWT gradation curve. Enough fines are produced during the production of the drainage layer using the coarse LWT gradation curve to supply 80 percent of the P40 till layer. Processing approximately 150,000 cubic yards of additional LWT will provide the remaining 20 percent. Therefore, there is sufficient LWT on-site to manufacture the drainage layers, fine till layer, and the P40 till layer regardless of which gradation curve (fine, average, or coarse) predominates at the site.

Analysis of the gradations for the LWT that will be excavated during TMA construction show that the material will be generally well graded with coefficient of uniformity (Cu) values varying from 9 to 90 with some greater than 400. Minus #200 (P200) sieve percentages range from 18 to 35 percent.

Analysis of the gradations of the amended (screened) LWT (finer than the #40 sieve) show Cu values ranging from 33 to greater than 200. Minus #200 sieve percentages range from 7 to 54 percent. Estimates of permeability based on D_{10} size range from $2x10^{-5}$ cm/sec to less than $1x10^{-6}$ cm/sec. Actual permeability tests performed on soils with similar soil gradation curves located in site wetlands (refer to EIR Appendix 3.5-28) show permeabilities of $1x10^{-6}$ cm/sec to $1.8x10^{-6}$ cm/sec.

<u>Specifications for the GCL/P40 Till Layer</u>

The GCL will consist of granular bentonite sandwiched between two layers of geotextiles. The geotextile will function to prevent the displacement of bentonite by fluids passing through the GCL

(i.e., piping). The well graded nature of the P40 till material underlying the GCL along with the relatively high percentage of P200 material (approximately 27 to 54) will act to serve as an additional filter for the bentonite component of the GCL. Therefore, piping of bentonite from the GCL is very unlikely.

The proposed material to be used for the grading layer below the GCL of the TMA base and cover composite liners is LWT that is screened through the #40 sieve during generation of the drainage layer material (½" to #40 sieve). This P40 sieve material is generally well graded fine sand and silt with clay. This material is readily compactible in 6-inch lifts. Compaction can be performed by standard equipment such as rubber tired rollers or vibratory smooth drum rollers. Although this material is sensitive to moisture content, the material can be readily dried if too wet and wetted if too dry without long time delays, using conventional means.

Based on the LWT soil gradation analysis in Attachment 11, the following specifications for the P40 till layer properties are suggested:

Soil Properties:

The soil shall consist of sieved LWT with the following characteristics:

P40 sieve (percent fines by weight)	=	*100 percent*
P200 (percent fines by weight)	≥	*18 percent (min)*
Cu values	>	*6 (min)*

The soil shall be placed in 6-inch lifts and compacted to 95 percent of the maximum dry density as determined by the Modified Proctor Test (ASTM D 1557) using rubber tired or vibratory smooth drum rollers.

Page 6, Comment 5: Provide an assessment of alternative final cover shapes and orientations.

Page 6, Response 5: *This topic was discussed at both the November 29, 1995 and January 11, 1996 meetings with WDNR. At the later meeting WDNR indicated that the work currently included in the Feasibility Report (Foth & Van Dyke, 1995a) should provide sufficient data to address this issue.*

Page 6, Comment 6: Provide an assessment of the devices/systems available for monitoring liner and final cover performance.

Page 6, Response 6: *Completing an assessment of devices/systems available for monitoring liner and final cover performance was initially discussed at a TMA meeting on November 29, 1995. This meeting was attended by representatives of CMC, WDNR, Foth & Van Dyke, and other interested parties. During this meeting, Mr. Christopher Carlson (WDNR, hydrogeologist) requested that CMC identify and evaluate methodologies for monitoring to determine if applicable technologies are available to assess the effectiveness of the TMA liner and final cover. The purpose of such monitoring would be to assess the need to modify the design of or construction techniques for subsequent liner or final cover placement. Methodologies identified at that meeting for consideration were: full basin lysimeters, suction lysimeters, electrical resistivity, neutron logging, gypsum soil moisture blocks, etc. WDNR indicated that CMC should not discount a given monitoring method from potential use because it has a relatively short life span since such a system could provide data to use in construction of subsequent cells.*

The discussion which follows is an overview of an evaluation of available monitoring systems to determine if techniques are applicable to assess the effectiveness and performance of TMA liner and final cover construction. The goal of such a monitoring effort would be to collect information which

could, if deemed appropriate, be used to modify the design or construction techniques used for subsequent liner or final cover placement.

Monitoring the performance of a liner or final cover can be performed by one of the following methods:

- *Monitoring the groundwater.*
- *Monitoring the vadose zone.*
- *Monitoring the constructed elements prior to commissioning or some time afterwards.*

Groundwater monitoring, which is included as part of the project's monitoring plan, provides a mid- to long-term assessment of system performance and therefore does not meet the goal of providing short-term information that can be used to assess if modifications to TMA design or construction techniques are needed for subsequent liner or final cover placement. Therefore, the following discussion will focus on monitoring of the vadose zone and monitoring of constructed elements.

Vadose Zone Monitoring

An ideal monitoring system to assess liner or cover system performance should provide the following information:

- *The location of leaks, if present.*
- *Time and duration of occurrence.*
- *Quantity and rate of leakage.*
- *Quality of leakage (at the point of exit from the liner and when entering groundwater).*

In addition, the response time of the monitoring system should be reasonably quick.

A review of information on available instrumentation and techniques for performance monitoring shows that, often, several devices may have to be deployed simultaneously in order to collect data for all monitoring needs discussed above.

Monitoring the vadose zone (the unsaturated zone between the liner and the groundwater table) could provide some of the information identified for an ideal monitoring system. The literature identifies two approaches for vadose zone monitoring (Bagchi, 1994).

- *Direct Leakage Monitors: Installation of instrumentation that can collect leachate percolation, identify liner defects or areas of concentrated leachate percolation.*

- *Indirect Leakage Monitors: Installation of instruments that can detect changes in moisture content, changes in chemical concentration, and changes in electrical conductivity.*

Direct Leakage Monitors

Three types or methods of direct leakage monitoring are available. These are:

- *Suction lysimeters;*
- *Basin lysimeters;*
- *Use of sensing electrodes below the liner.*

Bagchi (1994) describes suction lysimeters as follows:

> ***Suction Lysimeter.*** *Suction lysimeters should be installed below the liner area. To protect these lysimeters during landfill construction and operation, they should be installed several feet below the subbase grade. These lysimeters do not function very well if the moisture content of the vadose zone is extremely low.*
>
> *Three different designs for suction lysimeters are available: vacuum operated, vacuum-pressure operated, and vacuum-pressure samplers with check valves (Everett, 1981). These have been used (in nonlandfill projects) for a number of years, both in laboratory and field studies (Parizek and Lane, 1970; Apgar and Langmuir, 1971; Johnson and Cartwright, 1980). Suction lysimeters may provide valuable information if installed and operated properly. Typically a series of suction lysimeters are installed at several depths in the same or immediately adjacent bore holes. A typical suction lysimeter is shown in Figure [9].*

Suction lysimeters have several limitations which make them impractical for use as a vadose zone monitoring device for a TMA cell. Some of the limitations are:

- *Suction lysimeters are capable of only sampling a very small area (several square feet). The TMA cells are very large (33 acres and greater).*
- *Suction lysimeters must be placed directly below a hole or imperfection in the geomembrane to be able to sample percolation through the liner. This is unlikely given the fact that defects will be few and their locations cannot be anticipated with any precision.*
- *Suction lysimeters have a limited service life.*
- *Contact between the lysimeter and soils is difficult to maintain in coarse textured soils such as glacial tills and coarse outwash deposits in the TMA subbase grade. (Everett, et al., 1984)*

Bagchi (1994) describes basin (collection) lysimeters as follows:

> ***Collection Lysimeter.*** *These are also called basin type lysimeters. These have been used successfully in many landfills (Kmet and Lindorff, 1983). The lysimeter is to be constructed in the field. Figure [10] shows a collection lysimeter design. The exfiltrate collected can be monitored for rate of leakage and quality. The basin should be sufficiently large so that it collects an adequate volume of sample necessary for determining the quality of leachate. Usually 2 liters of leachate is necessary for analytical work. . . .*
>
> *The transfer pipe drains to a standpipe from which the leachate is withdrawn, either by pump or manually, on a regular basis. The standpipe should be sized in such a way that it can hold leakage in between withdrawals. The standpipe should be large enough so that it can be cleaned occasionally.*
>
> *The leachate head in the standpipe should be monitored more frequently (the suggested interval is 15 days) for the first 2 years initially. Leachate must be removed whenever the level reaches 15 cm (6 in.) below the invert of the transfer pipe. The*

frequency of head monitoring in the standpipe and withdrawal may be reduced when a stabilized leakage rate is observed for at least 2 subsequent years. The transfer pipe should be cleaned periodically (the suggested frequency is once every 2 years).

Collection lysimeters are most effective in sampling facilities with soil liners where percolation through the liner typically is at a relative constant rate across the constructed liner. Since soil liners are typically constructed to specifications with a reasonable amount of construction QA/QC, lysimeters can be useful in predicting the quantity and quality of percolation through the liner. Lysimeters are not suitable for a composite lined facility since in order for them to collect percolation from the facility the lysimeters would have to be located below a hole or defect in the geomembrane. This is unlikely to occur since the location of potential liner leaks are unknown at the time the lysimeter is constructed which is prior to geomembrane deployment and construction.

Lee and Jones-Lee (1993) proposed the use of a basin lysimeter that would underlie the full landfill area. This approach results in a double liner system where the lower liner and the leak detection system above it will serve the purpose of monitoring. Although this method is effective in detecting percolation through the liner, the duration of the leak is not easily detected. In addition, a full basin lysimeter would not provide any insight to the location of a leak and would double the cost of lining the TMA cells.

Installation of a grid of sensing electrodes below the geomembrane has been described by Nosko and Andrezal (1993). This electrode grid is designed to last for 50 years and can be used both for direct leak detection (better accuracy for a closely spaced grid) and indirect leak detection by measuring the electrical resistivity of the ground.

A grid of sensing electrodes was reviewed as a potential method of sampling the unsaturated zone below the TMA. This method is limited in its applicability to the TMA due to the size of the TMA and the need to have close grid spacing to achieve desired sensitivity. In addition, this method does not provide any information on the chemical characteristics of the moisture being measured, so increases in resistance could be attributable to moisture moving from constructed soil layers.

Indirect Leakage Monitors

Bagchi (1994) describes indirect leakage monitors as follows:

> *Many researchers are attempting to develop new instruments or to adapt an existing instrument for landfill leakage detection purposes (Davis et al., 1984; Maser and Kaelin, 1986; Hwang, 1987; Burton, 1987; Daniel et al., 1981; Christel et al., 1985; Everett et al., 1982; Phene et al., 1971a,b; Thiel et al., 1963; Wilson, 1981, 1982, 1983). In most cases indirect leakage monitors were tested in an experimental setup or a conceptual use was discussed.*
>
> *The indirect monitors can be subdivided into two groups: (1) instruments that detect changes in moisture content of the vadose zone, and (2) instruments that detect a change in the chemical concentration (salinity in most cases) in the vadose zone. These monitors detect changes of moisture content or chemical concentration in the vadose zone but not the quality at any particular time. Since some leakage is expected through a clay-lined landfill these monitors will provide information at the initial stage when changes are taking place. But after several years, when steady state is reached in the vadose zone, most of these monitors will probably fail to provide any valuable information. However, for landfills that are designed for zero or negligible*

leakage (double lined or landfills lined with synthetic membrane), use of these types of monitors may provide valuable information if a serious leak develops. . . . In general, indirect monitors are not used for routine landfill monitoring but it appears that some of these monitors have potential for future use.

Everett (1993) states that

The most promising of the indirect vadose zone monitoring techniques is called neutron moderation. Neutron moderation has been shown to be one of the most accurate and precise indirect predictors of soil moisture distribution. As a result, neutron moderation is rapidly gaining acceptance as a real-time, minimal cost indirect technique for measuring dissolved contaminant migration in the vadose zone.

Everett (1993) describes the method as follows:

Principle of the neutron moderation method

The principle of neutron moderation depends on two properties related to the introduction of neutrons with matter: scattering and capture (Gardner, 1965). High-energy neutrons emitted from a radioactive source may be slowed down or thermalized by collisions with atomic nuclei. The statistical probability for such thermalization depends on the scattering 'cross-section' of various nuclei. The scattering cross-section of hydrogen causes a greater thermalizing affect on fast neutrons than many elements commonly found in soils. This forms the basis for detecting the concentration of water in soil (van Bavel, 1963). The second property of interest in the neutron moderation method is capture of slow neutrons by elements present in the soil with the release of other nuclear properties or energy. Cadmium and boron have extremely large capture cross-sections compared with hydrogen. The property of energy released during capture serves as a means of detecting the concentration of slow neutrons.

In operation, when a source of fast neutrons is lowered into a soil through a suitable well or casing, a cloud of thermalized neutrons is established (Gardner, 1965). This cloud reflects the moderating effect of scattering cross-sections of nuclei in the soil mass on fast neutrons. If a suitable calibration is made to isolate the moderating effects of soil nuclei other than hydrogen, changes in the volume of the thermalized cloud will reflect changes in water content. In general, the wetter the soil, the smaller the volume of thermalized neutrons. A detector that relies on capture of thermalized neutrons is used in conjunction with suitable electronic circuitry to measure the water volume.

Instrumentation used to measure the water content of neutron moderation requires three principal components:

1. *a source of fast neutrons. . .;*
2. *a detector of slow neutrons. . .; and*
3. *an instrument [Figure 11] to determine the count rate from the detection equipment.*

Field implementation

Access tubes for neutron moisture logging may be constructed of seamless steel, aluminum, or PVC [Figure 11]. In addition, access tubes can either use closed or perforated casing. Although the use of PVC casing slightly dampens the signal, more than sufficient thermalized neutrons can be detected to measure soil moisture over all ranges of concern (Keller et al., 1989). . . .

With respect to landfills and contamination sites, the neutron moderation access tubes can either be installed vertically, on an angle, or horizontally beneath landfill cell expansion areas. Since neutron moderation operates over the range between zero matric potential (water saturation) and 90 bars of soil water tension, the neutron probe can be utilized under all conditions. Although the neutron probe was originally designed to measure indirectly soil moisture distribution, recent patents have expanded the application of neutron moderation to include soil gas analysis. In effect, patents held by Toxic Technology, Inc. of Costa Mesa, California utilize a perforated hydroprobe access casing wherein the neutron probe identifies the location of the contamination. Subsequently, a soil gas sample is taken adjacent to the depth identified by the neutron probe and analyzed using a field GC to confirm the presence of volatile organic contaminants. This approach is particularly attractive because the neutron probe is used as a least-cost screening tool, wherein confirmation of dissolved organic contamination can be obtained through soil gas analysis. Clearly, therefore, the installation of neutron probe access tubes below landfill liner sumps, beneath V-shaped landfill cells, or through any depth associated with contamination sites, provide a very accurate, and precise method of measuring not only soil moisture migration, but also dissolved contaminant transport.

The limitations of neutron moisture logging make it very difficult to use as part of a vadose monitoring system for the TMA. This conclusion is based on the following:

- *The logging device is typically installed in a stainless steel, aluminum, or PVC casing. The casing must have a tight fit to the borehole which may be very difficult in the tight, gravelly and cobbly tills in and around the TMA.*

- *In general, non-uniform soil conditions reduce the reliability of this method (Gairon and Hudas, 1973, as contained in Everett, 1993).*

- *Drilling mud is not recommended for installation of the casing. It is very difficult to install casing in the TMA area without drilling mud.*

- *The neutron method is used mainly to determine changes in volumetric water content of materials in the vadose zone. It provides no information on quality or quantity of percolation through the liner.*

- *An inordinate amount of time would be involved in lowering the tube down the hole while taking readings for deep soil wells such as those which would be required at the TMA.*

- *Many deep cased boreholes would be required to effectively monitor the TMA.*

- *The device must be calibrated at the surface with barrels of on-site soils from various depths.*

Bagchi (1994) describes other indirect leakage monitors as follows:

Gamma Ray Attenuation Probes. *These are used for detecting changes in moisture content (Schmugge et al., 1980). The degree of attenuation of gamma rays depends on the bulk density and water content of the medium. Two different methods are available: transmission and scattering. In the transmission method, two wells are installed at a known distance. A single well is used in the scattering method. The method is usually limited to shallow depth because of difficulties in installing parallel wells.*

Electrical Resistance Blocks. *[Includes gypsum moisture blocks.] These also measure changes in water content. Electrode blocks embedded in porous material are installed in the soil. The electrical properties of the blocks change with the changing water content of the vadose zone (Schmugge et al., 1980). The water content is calculated from calibration curves after determining changes in the electrical properties of the blocks.*

Thermocouple Psychrometers. *These meters are used to detect changes in moisture content. The meter relies on cooling the thermocouple junction by the peltier effect (Merill and Rawlins, 1972). Two types of meters are available: wet bulb and dew point. The dew point method is more accurate (Wilson, 1981). The relationship between soil water potential and relative humidity is used in reading the water content of the medium.*

Tensiometers. *Tensiometers have been used for many years by soil scientists to measure the matric potential of soil. (Richards and Gardner, 1936; Marthaler et al., 1983). Tensiometers measure the negative pressure (capillary pressure) that exists in unsaturated soil. . . .*

Heat Dissipation Sensors. *These units also can monitor water content by measuring the rate of heat dissipation from the block to the surrounding soil. Calibration curves relating matric potential and temperature difference for the on-site soil need to be developed in the laboratory.*

Electrical Probes. *These probes can be used to determine the salinity of the vadose zone. Four probes are installed in an array (Wenner array) so that conductivity of the soil can be measured (Rhoades, 1979; Rhoades and Van Schilfgaarde, 1976). A calibration curve relating conductivity and soil salinity is used for predicting soil salinity.*

Salinity Sensors. *As the name indicates, these sensors can be used to monitor soil salinity. Electrodes attached to a porous ceramic cup are installed in the soil (Oster and Ingualson, 1967). Calibration curves relating specific conductance and salinity are used to interpret readings.*

Soil Gas Probes. *The probes monitor volatile organic compounds (VOC) in the soil. The gas probe consists of a galvanized pipe that can be driven into the ground easily. . . . The gas may be analyzed in situ using a portable gas chromatograph or tested in a laboratory after absorbing it in charcoal (Silka, 1988; Daniel and Kurtovich, 1987).*

Wave Sensing Devices. *Use of both seismic and acoustic wave propagation properties for leak detection in experimental setup has been reported in the literature (Maser and Kaelin, 1986; Davis et al., 1984). In the seismic wave technique, the difference in*

travel time of Rayleigh waves between the source and geophones is used to detect leaks. In the acoustic emission monitoring (AEM) technique, sound waves generated by flowing water from a leak are utilized in leak detection.

Time Domain Reflectrometry (TDR). *This technique is based on the difference in dielectric properties of water and soil. TDR measures wide-frequency bandwidth and short-pulse length that are sensitive to the high-frequency electrical properties of the material (Davis et al., 1984). TDR is reported to be insensitive to soil type, density, temperature, and pore liquid quality but is sensitive to changes in the water content of soil (Topp et al., 1980).*

Because of the limitation to shallow depths, gamma ray attenuation probes are not considered a practical application for the TMA cells. Gypsum blocks do not perform well in sandy, coarse soils such as the TMA tills because of the problem of getting a good contact with these soils and, therefore, have limited application. Psychrometers are most useful in measuring water potential in dry soils, (i.e., desert-like conditions) and are not suitable for monitoring at the proposed TMA cells.

The other methods described above are examples of the available technology for estimating the capacity of a given volume of vadose zone underlying a source to store water (i.e., percolation from a lined facility). Most require precise installation with no disturbance after installation. This requirement makes these methods impractical since the TMA cells have considerable depth and activities related to construction of the liners and leachate collection systems will be ongoing after instrumentation of the vadose zone. In addition, access to take readings from instruments such as those described is difficult and, should failure occur, repair would be impractical. As a result, these methods are not practical for monitoring the TMA cells.

Monitoring the Constructed Elements

Groundwater monitoring and monitoring of the vadose zone are time-tested methods that will not effectively meet the TMA liner and final cover performance monitoring goal described above. Even an expensive full basin lysimeter system will not provide all the information an ideal performance monitoring system should provide. For example, the location of a leak will only be very roughly defined, if at all. Additional instrumentation such as a grid of electrodes may be necessary to obtain this data. Also, the rate of leakage from the facility as a whole may be approximated by frequent monitoring, but if there are multiple leaks, the leaks from these cannot be separately identified. Since the proposed liner and final cover for the TMA consist of a geomembrane component, the leaks will be a result of isolated membrane/seam defects. This contrasts with the leakage through a clay liner which typically will be uniformly distributed throughout the liner area. Further, almost all types of sub-liner and sub-final cover monitoring devices will be required to have cables or pipes leading to them. These accesses are a source of poor foundation conditions which could cause the liner or final cover to be compromised.

In view of the above discussion, it appears that the key to reducing leakage from a composite liner is to achieve a good quality membrane at the time of installation. Besides a top class quality assurance program during installation, a post-installation leak location survey could aid in determining whether the design conditions are actually met by the construction process before the facility is commissioned. Leak location surveys are typically accomplished using the principles of electrical continuity.

The electrical leak location method works by impressing a voltage across the geomembrane liner and detecting areas where electrical current flows through discontinuities in the geomembrane. Discontinuities are located by systematically scanning the material covering the liner for areas of high

electrical potential caused by electrical current flowing through the discontinuity. Leak Location Services, Inc. of San Antonio, Texas, (Leak Location Services, 1994) have reported the capability of detecting 0.006 square centimeter leaks in liners covered with water and 0.06 square centimeter leaks in liners covered with up to 2 feet of soil.

Based on information provided by Leak Location Services Inc., to survey a liner, an electrical conduction path through a leak in the liner to the soil sub-grade or leak detection layer must be established. To do this the soil needs sufficient moisture to allow for electrical contact with the leak. If necessary, this can be achieved by wetting the soil after placement of the HDPE liner and allowing the water to percolate to the liner surface. The electrical measurements are then conducted on the moist soil. In completing the test, the protective soil cover placed on the primary liner should not contact earth ground at the perimeter of the lined area. This can be prevented by leaving an area of liner material temporarily exposed at the top of the sideslope or along the edge of the liner.

Since a geomembrane liner has protective soil covering the liner, point-by-point electrical potential measurements are made. The measurements are made on the soil surface using special electrodes. The potential data is recorded in a portable data acquisition logger and then down-loaded to a portable computer for processing and data analysis. The survey is conducted by making potential measurements along survey lines spaced at regular intervals across the bottom floor area of the landfill. The potential measurements are typically made with a dipole electrode separation of 2 feet on survey lines spaced 2 feet apart. Therefore, data is collected on a 2-foot grid pattern. When a suspect area is indicated in the processed data, manual measurements are taken to further localize the leak.

After a careful review of the concept of post-installation leak location surveys, CMC has determined that the leak location survey method is suitable for use to complete such surveys in a manner that will achieve the goal of determining the effectiveness of TMA liner and final cover construction. The advantages of the leak location survey method are as follows:

- *No permanent monitoring facilities are required to be installed above or below the liner system, which could affect liner integrity.*
- *Monitoring can be done immediately after the drainage blanket/till layer is placed over the geomembrane. Therefore, in the unlikely event that major liner breaches are located, they can be repaired before the TMA cell is placed in operation or before the remaining portion of the final cover is placed.*
- *The system can be used to monitor the final cover system periodically during the post-closure period to assess the continuity of the geomembrane.*
- *The system can evaluate each square foot of large portions of the lined area allowing the application of statistics to assess the effectiveness of liner and final cover construction.*
- *Since the system provides immediate results, the data obtained from the monitoring program can be used to adjust, if needed, the design, construction, or quality assurance programs used on subsequent liner installation for the project.*

The major disadvantages of the system are that it does not provide the opportunity to collect samples of percolated water nor allow the determination of the rate of percolation. Also, the system can only be used on double geomembrane lined systems if the void between the liners is filled with water. Based on the advantages of the system and an understanding of the goal established for this element

of the project's overall monitoring program, CMC has concluded that the leak location survey has an application to the Crandon Project. Therefore, CMC proposes that the leak location survey be added to the project's monitoring program as follows.

In order to verify that the project's quality assurance goals have been met during geomembrane installation, the base liner and final cover system for each TMA cell will be monitored using the leak location survey method after drainage blanket/till blanket placement to determine if the number of pinholes and/or defects is consistent with the numbers used in the HELP model analysis to verify that the performance of the TMA will meet groundwater standards. The use of the leak location survey coupled with the planned groundwater monitoring program will provide an initial monitoring of the liner and final cover construction and mid- to long-term monitoring of liner and final cover performance.

A statistical sampling plan will be used to determine if the number of pinholes/defects in the constructed liner or final cover is consistent with the analyses completed as part of the facility design. Statistical sampling will allow this determination to be made without monitoring the entire liner, while achieving a high degree of confidence (95 percent) in the decisions that are made.

The method proposed for use is based on sequential test statistics. This method involves randomly collecting samples until enough information has been gathered to make statistically meaningful predictions. The method is flexible in that the amount of sampling required varies depending upon the distance of the sample values from the decision threshold.

For the HELP model simulations, the pinhole and defect size was established, based on information from the literature and the HELP model users manual, as 0.1 centimeter and 1.0 centimeter, respectively. Since the area to be monitored using the leak location survey method will be covered by geotextile and the drainage/till blanket, it will not be easy to differentiate between a pinhole or defect. Since the size of a defect in the HELP model analysis is larger than a pinhole and more defects were included in the analysis than pinholes by a ratio of 4 to 1, the statistical monitoring program to be implemented by CMC will use four defects per acre as the lower threshold value for comparison purposes.

The groundwater impact analysis conducted by CMC used the predicted percolation rates from the HELP model and established that with the TMA design as proposed in the Feasibility Report (Foth & Van Dyke, 1995a), the estimated groundwater standards are met at the compliance boundary. Following this point, based on comments from WDNR, CMC has proposed to introduce redundancy in the liner/leachate collection system design by providing a drainage system up to half of the height of the first stages in each cell. This redundancy results in decreasing the percolation from the TMA by 50 percent. The concentrations at the compliance boundary will also be reduced by the same amount resulting in an additional factor of safety of at least 2 with respect to groundwater standards. This means that even if the number of defects on the liner were to be twice those used in the HELP model simulations, the resulting doubled percolation will not cause groundwater standards exceedances. Thus, as an upper threshold value for defects, eight per acre may be acceptable. However, CMC proposes to use a conservative approach of six defects per acre as the upper threshold for statistical sampling purposes.

The test procedure will begin by randomly selecting 1-acre segments of the constructed liner for monitoring. The total lined area will be segmented with gridlines 209 feet apart. The resulting 1-acre segments will be numbered sequentially. A random number generator will then be used to identify liner segments for monitoring. The first random number generated will correspond to the first liner segment to be tested, the second random number to the second liner segment, and so on. A

minimum of three plots will be tested for each TMA cell before the integrity of the liner is accepted. The total number of plots to be tested will be a function of the number of defects encountered on the tested segments.

In order to determine the number of 1-acre segments to test, it is necessary to prepare a plot depicting decision boundaries for use in the field. This plot is shown in Figure 12. The derivation of the decision boundaries illustrated in Figure 12 is given in Attachment 12. After monitoring each 1-acre segment of the liner, the cumulative number of defects found will be tabulated and plotted on the chart in Figure 12.

Two possible decisions could be made based on the results of the monitoring of each of the first two 1-acre segments as follows:

1. *Continue sampling.*

2. *Discontinue random sampling and test entire liner. Upon completion of testing the entire liner, if the average number of pinholes/defects for the entire liner is four or less liner integrity is accepted. If the average number of pinholes/defects is between four and six the liner integrity is accepted and improved quality assurance will be employed for future liner construction. If the average number of pinholes/defects is greater than six, noted pinholes/defects will be repaired and improved quality assurance will be employed for future liner construction.*

Once three or more but less than 16 liner segments are tested, three possible decisions could be made as follows:

1. *Discontinue sampling and accept liner integrity.*

2. *Continue sampling.*

3. *Discontinue random sampling and test entire liner. Upon completion of testing the entire liner, if the average number of pinholes/defects for the entire liner is four or less liner integrity is accepted. If the average number of pinholes/defects is between four and six the liner integrity is accepted and improved quality assurance will be employed for future liner construction. If the average number of pinholes/defects is greater than six, noted pinholes/defects will be repaired and improved quality assurance will be employed for future liner construction.*

If sampling continues beyond 16 liner segments, four decisions could be made as follows:

1. *Discontinue sampling and accept liner integrity.*

2. *Continue sampling.*

3. *Discontinue sampling, accept liner integrity and use improved quality assurance for future liner construction.*

4. *Discontinue random sampling and test entire liner. Upon completion of testing the entire liner, if the average number of pinholes/defects for the entire liner is four or less liner integrity is accepted. If the average number of pinholes/defects is between four and six the liner integrity is accepted and improved quality assurance will be employed for future liner*

construction. If the average number of pinholes/defects is greater than six, noted pinholes/defects will be repaired and improved quality assurance will be employed for future liner construction.

A simulation of the sampling process was performed using a Poisson random number generator. Three simulations were completed: one each generating a series of random numbers based on an average of three, five, and seven defects per acre, respectively. The simulations are illustrated in Figure 13.

In the simulation, based on a series of random numbers generated with an average of three defects per acre, the cumulative defects passed below the lower decision boundary with the 11th sample. Therefore, it would be correctly concluded that the true average number of defects per acre was less than or equal to four, and liner integrity would be accepted. In the second simulation, based on a series of random numbers generated with an average of five defects per acre, the cumulative defects passed the boundary indicating the true average is greater than four but less than or equal to six after 17 samples. Therefore, the liner integrity would be accepted and quality assurance procedures would be adjusted before construction of the following liner. In the last simulation, based on a series of random numbers generated with an average of seven defects per acre, the cumulative defects passed the upper boundary after 28 samples. At this point, random sampling of the liner would cease and the entire liner would be tested.

In conclusion, the simulation shows that the sequential test achieves the desired quality assurance goal. Based on the simulation, the appropriate decisions would be made to reject liner integrity when the true mean number of pinholes/defects per acre was six or more. The test also successfully determined the integrity of the liner was acceptable when the true mean number of pinholes/defects per acre was four or less. Therefore, the proposed statistical method will maintain quality assurance objectives while potentially reducing the need to test the entire liner.

Page 6, Comment 7: Provide a detailed discussion of the decision process for the final shape and physical location of the proposed TMA from the perspective of minimizing overall environmental impacts.

Page 6, Response 7: *This topic has been addressed through an update to Section 10 of the TMA Feasibility Report (Foth & Van Dyke, 1995a) issued in February 1996.*

Page 6, Comment 9: Provide the water balance model and code used to assess impacts from the TMA on specific wetlands.

Page 6, Response 9: *This topic was addressed in a January 17, 1996 letter addressed to Mr. Christopher Carlson of WDNR.*

Page 6, Comment 11: Provide an update to EIR Appendix 4.2-5 Table 4, taking into account the changes that occur to the drainage basin due to capping of the TMA.

Page 6, Response 11: *This topic has been addressed through an update to Appendix 4.2-5 of the project's EIR (Foth & Van Dyke, 1995b) which was issued in February 1996.*

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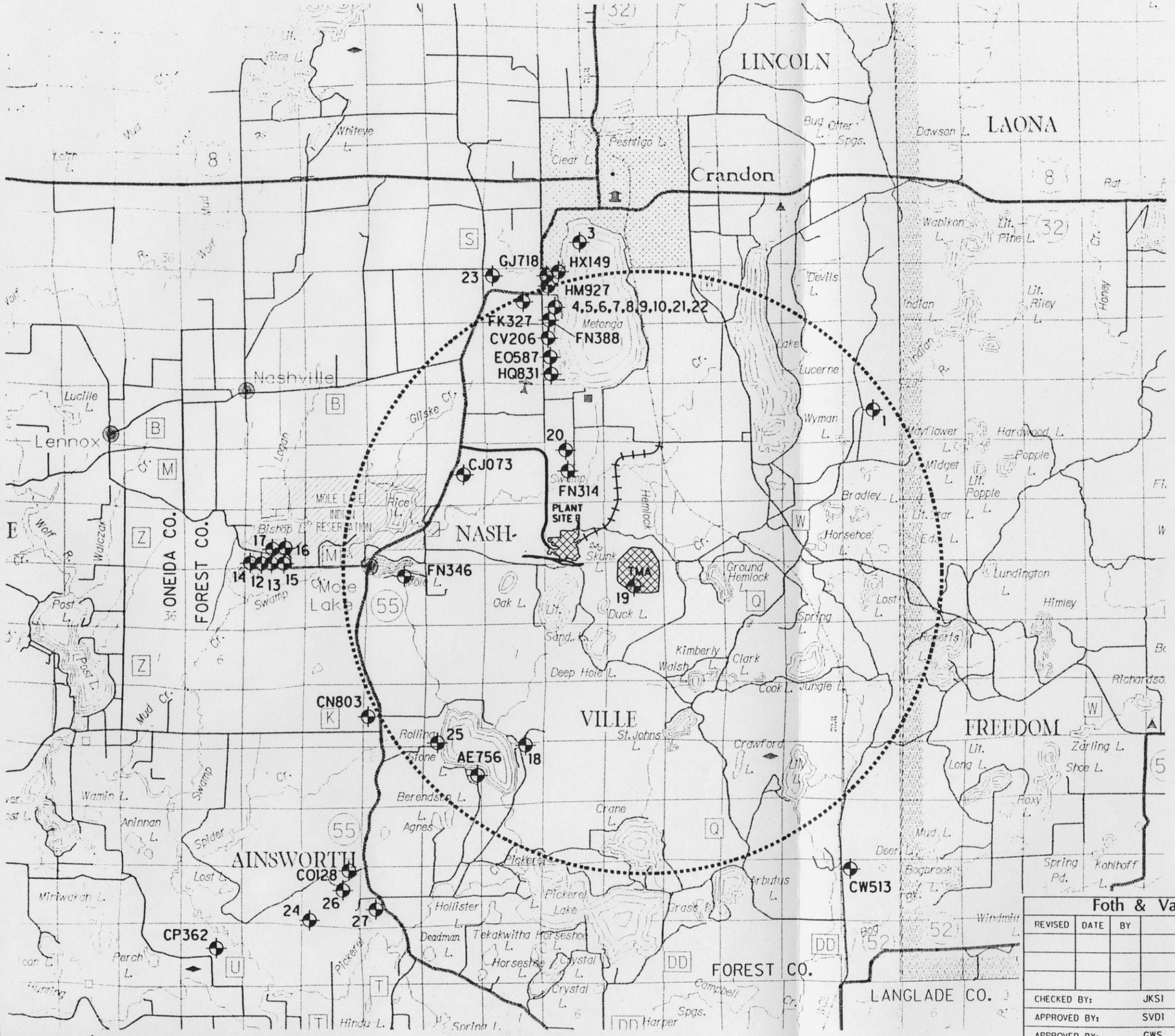
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Figures for Addendum No. 1 to the May 1995 Crandon Project Tailings Management Area Feasibility Report/Plan of Operation



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
- Zarling L. LAKES
- STREAMS
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- 5 MILE RADIUS AROUND TMA
- 24 APPROXIMATE BEDROCK WELL LOCATION AND IDENTIFICATION BASED ON WDNR DATA. CONSTRUCTED PRIOR TO 1988.
- FN314 APPROXIMATE BEDROCK WELL LOCATION AND IDENTIFICATION BASED ON WDNR DATA. CONSTRUCTED AFTER 1988.

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.

Foth & Van Dyke

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APPROVED BY:	GWS	DATE: FEB. '96

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FIGURE 1
LOCATION OF BEDROCK WELLS IN SITE VICINITY

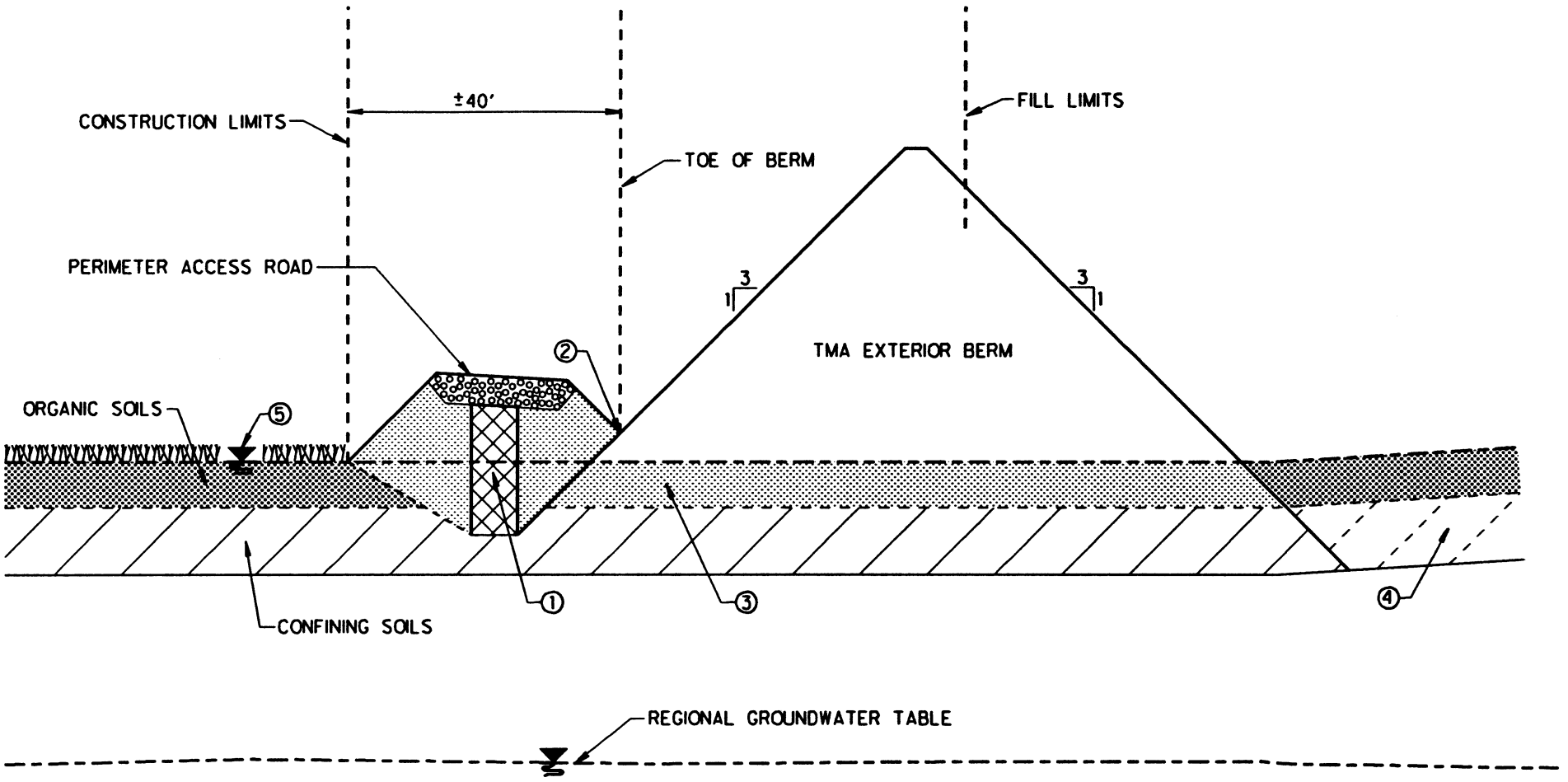
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Prepared By: Foth & Van Dyke | By: JRB2

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NOTES

① PROVIDE LOW PERMEABILITY CUT-OFF WALL BETWEEN EXTERIOR WETLAND AND TMA EXCAVATION AS REQUIRED TO CONTROL SEEPAGE.

② PERIMETER DITCH DISCHARGING TO A TEMPORARY OR PERMANENT SEDIMENTATION POND.

③ EXCAVATE AND STOCKPILE ORGANIC SOIL AND REPLACE WITH COMPACTED CLEAN EARTH FILL.

④ WETLANDS SOILS INTERIOR TO TMA CELL TO BE REMOVED DURING TMA EXCAVATION.

⑤ PERCHED WETLAND WATER TABLE.

TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

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APPROVED BY:	GWS	DATE: FEB. '96

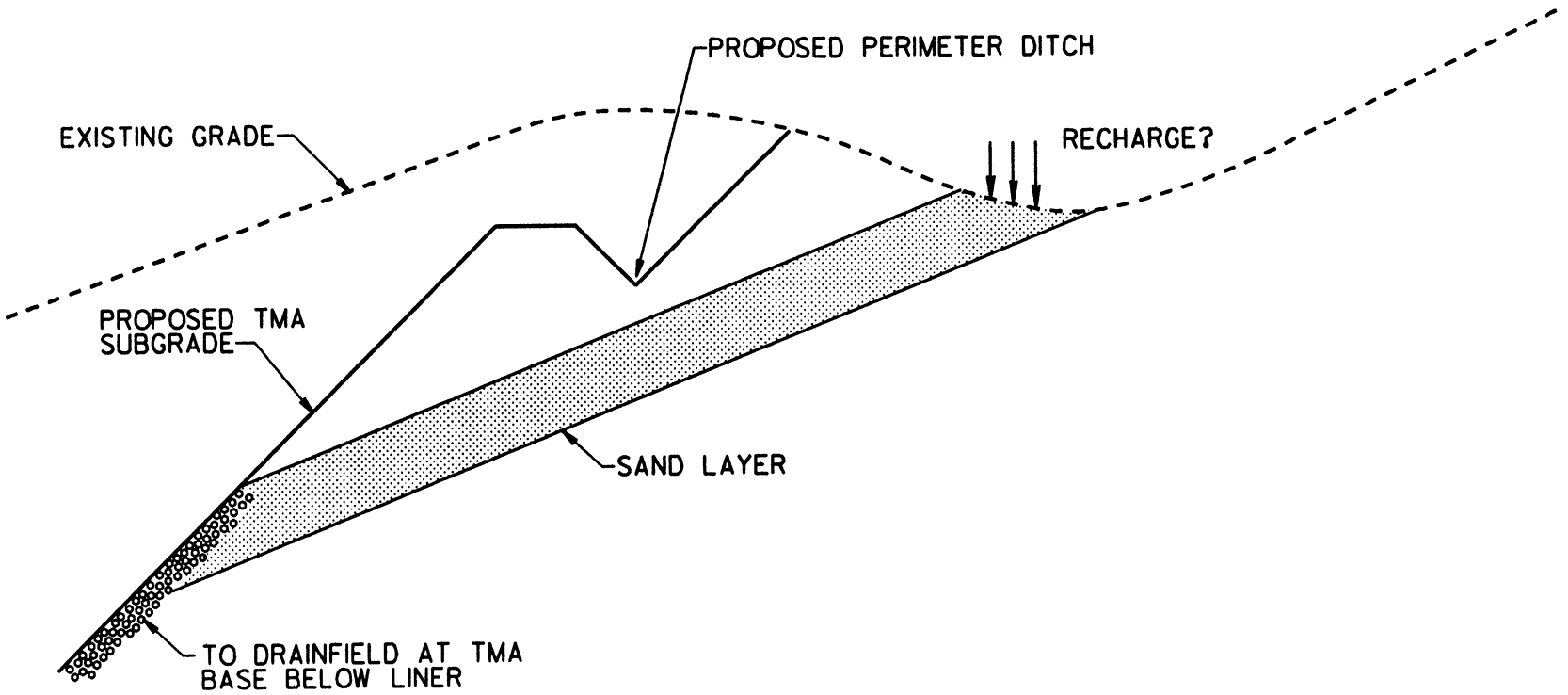
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FIGURE 2
TYPICAL CONTROL MEASURES
FOR EXTERIOR WETLANDS

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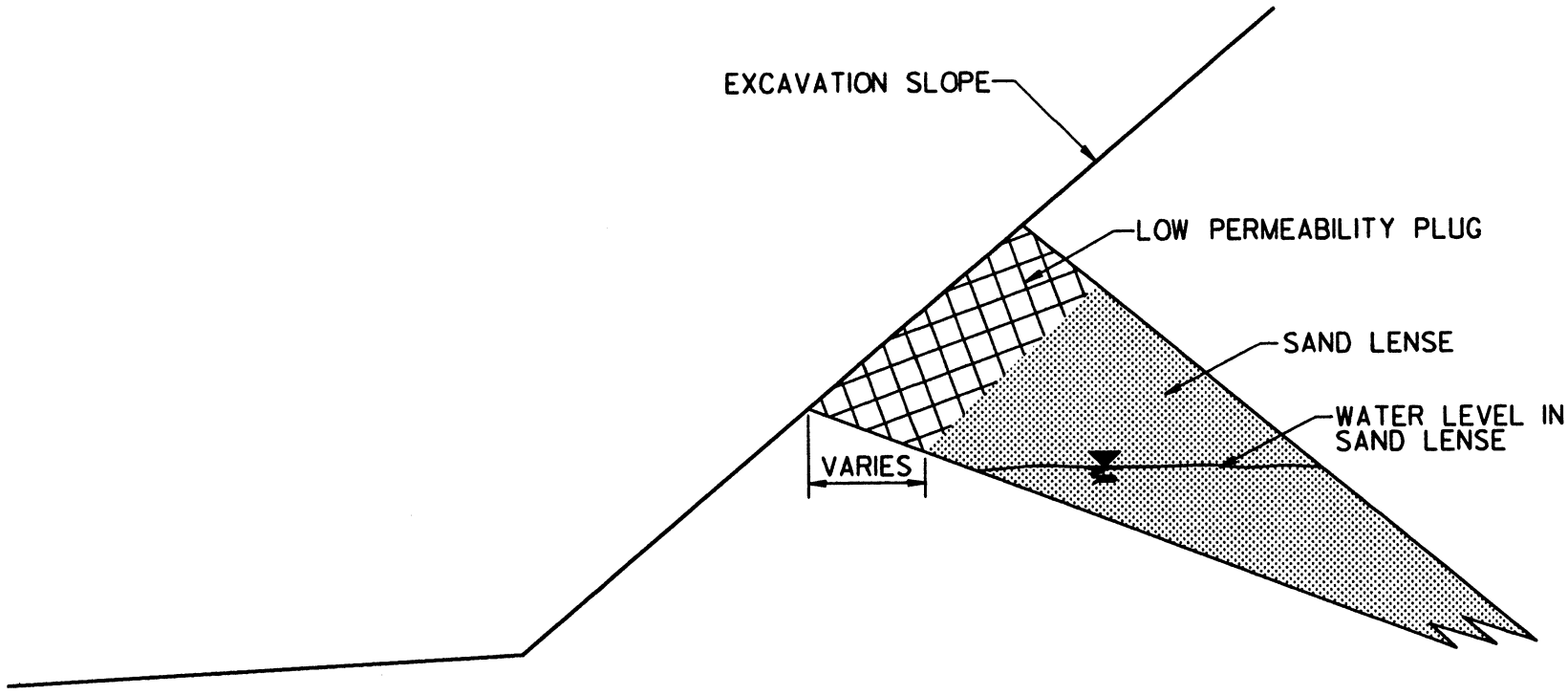
FIGURE 3

TYPICAL SAND LAYER PLUGGING

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REGIONAL GROUNDWATER TABLE

TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

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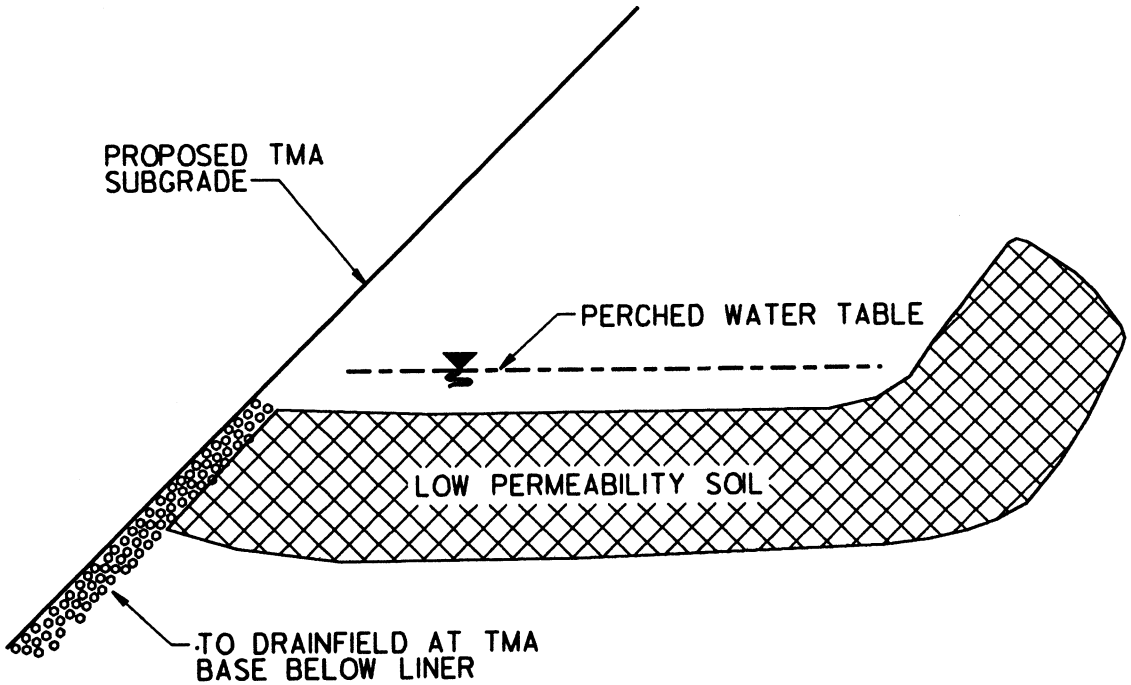
FIGURE 4

TYPICAL SAND LENSE PLUGGING

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APPROVED BY:	GWS	DATE: FEB. '96

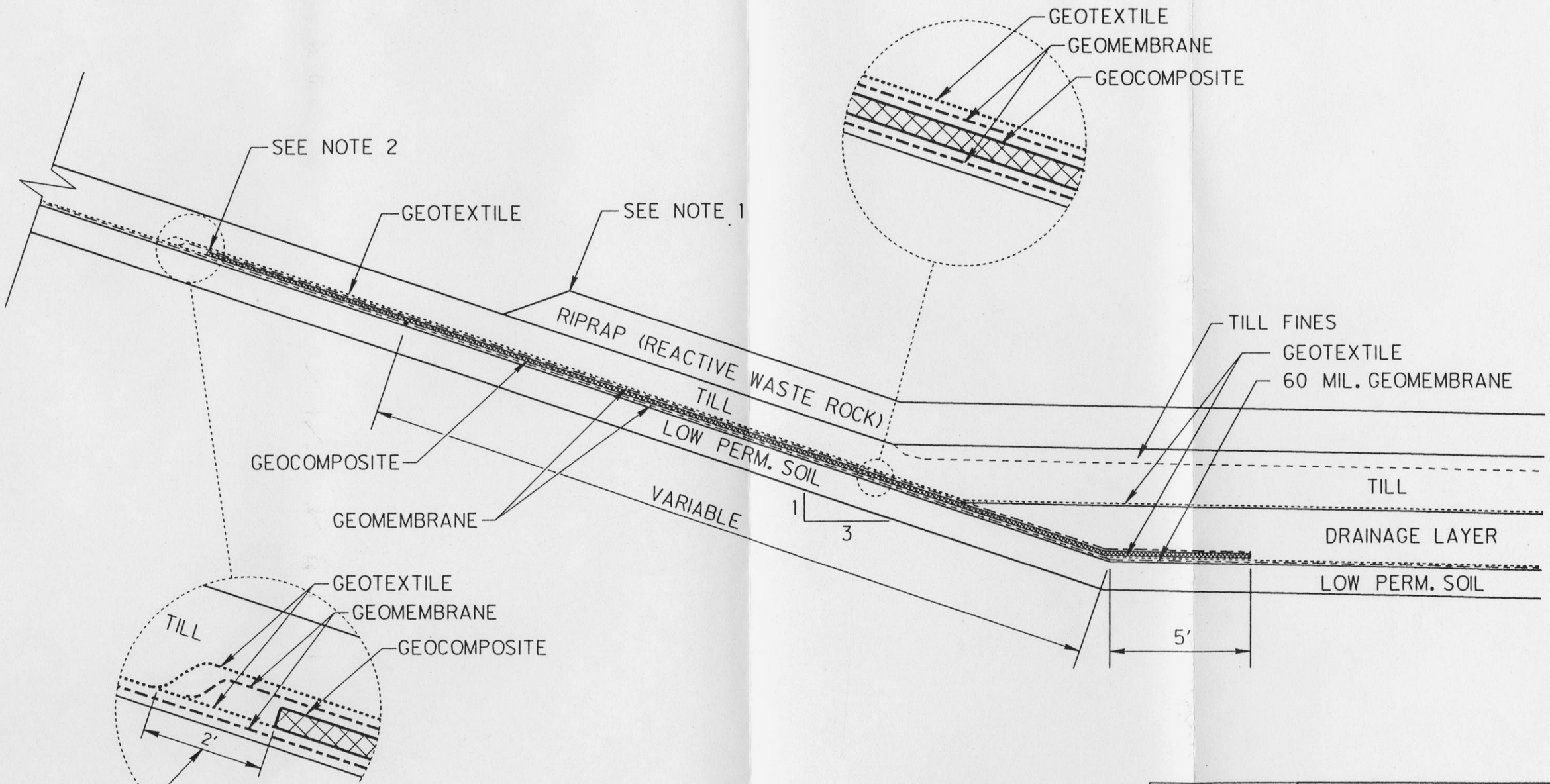
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FIGURE 5

TYPICAL PERCHED DRAINAGE SYSTEM

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Prepared By:	Foth & Van Dyke	By:	JRB2

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NOTES:

1. RIPRAP TO EXTEND TO A MAXIMUM OF APPROXIMATELY 10' FROM THE BASE.
2. SIDE WALL DRAINAGE LAYER TO EXTEND UP TO THE MID-HEIGHT OF INITIAL STAGES.

TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

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FIGURE 6

SIDEWALL DRAINAGE LAYER DETAIL

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2,283,000 E

2,284,000 E

2,285,000 E

115,000 N

114,000 N

MANHOLE

REGLAIM PIPE AT PERIMETER BERM

PROPOSED RECLAIM PIPE

PROPOSED SUMP

SEE DETAIL FIGURE 13

0.5% (TYP.)

260' (TYP.)

PROPOSED PERFORATED LEACHATE COLLECTION PIPE SEE DETAIL THIS FIGURE

PROPOSED DECANT STRUCTURE

1675.0

1707.0

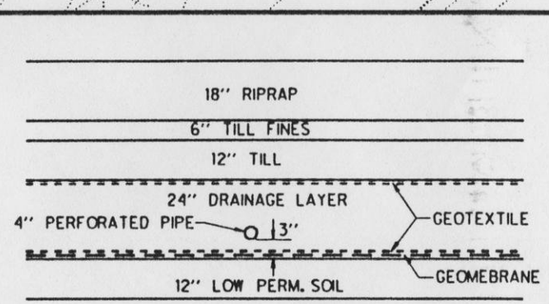
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LEGEND

- EXISTING ROAD
- 1675 — EXISTING CONTOUR
- x 1692.0 — SPOT ELEVATION
- 1725 — PROPOSED CONTOUR (BASE GRADE)
- 3:1 — PROPOSED SLOPE RATIO (TYP.)
- 2% — PROPOSED SLOPE (TYP.)
- PROPOSED RECLAIM PIPE
- PROPOSED LEACHATE PIPE
- PROPOSED PERFORATED LEACHATE COLLECTION PIPE
- PROPOSED DECANT STRUCTURE
- PROPOSED VALVE
- PROPOSED SIDE SLOPE RISER
- PROPOSED CLEANOUT RISER
- PROPOSED SUMP 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 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).



TYPICAL CROSS SECTION DETAIL

TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

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APPROVED BY:	NXP	DATE: FEB. '96
APPROVED BY:	GWS	DATE: FEB. '96

Crandon Mining Company

FIGURE 7

TYPICAL REDESIGNED LEACHATE COLLECTION SYSTEM

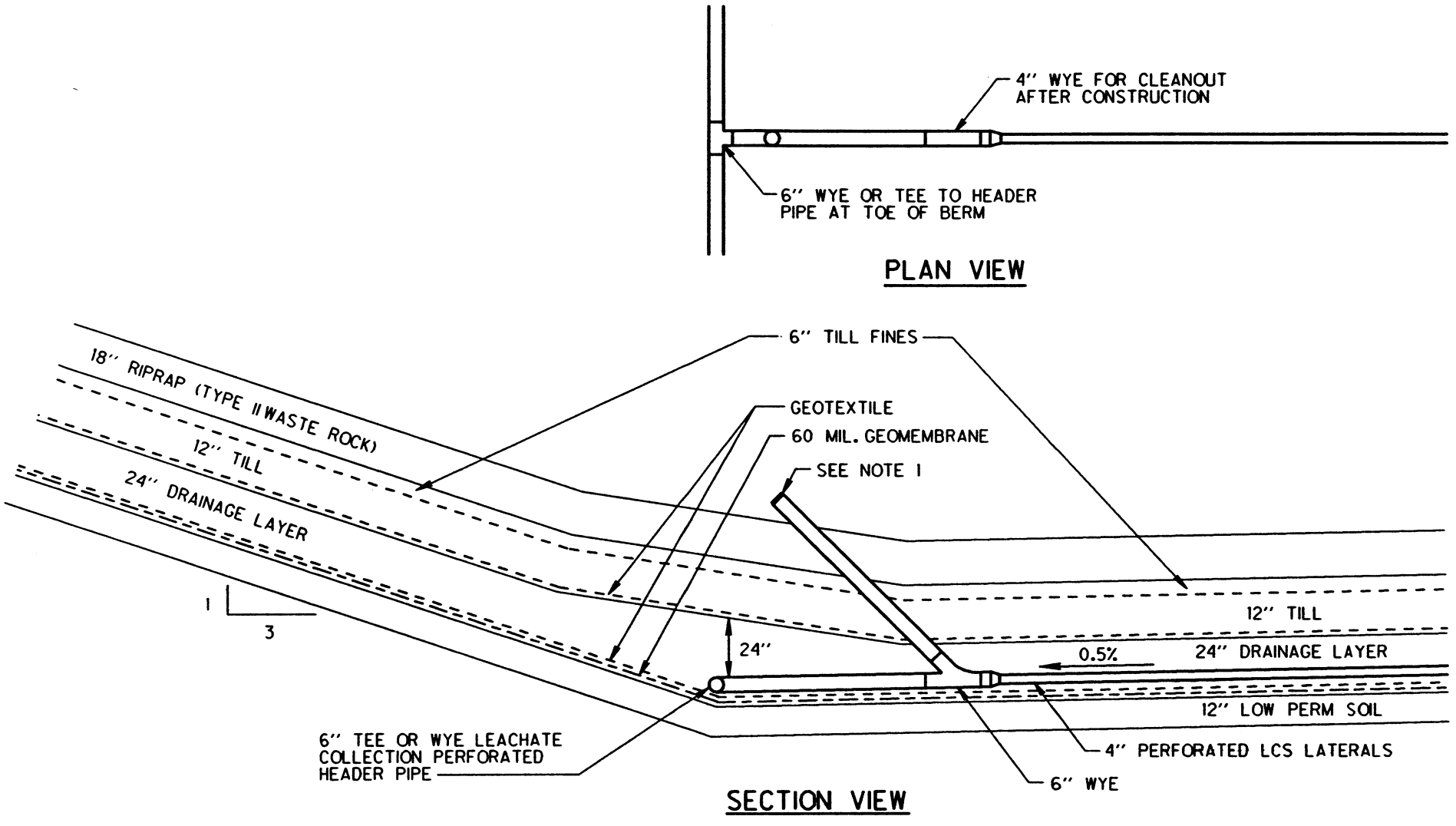
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Prepared By: Foth & Van Dyke | By: JRB2

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NOTE:

1. 6" PIPE STUBBED OUT FOR TEMPORARY CLEANOUT FOR PIPE CLEANING AFTER CONSTRUCTION IS COMPLETE. CAP AFTER CLEANING.

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

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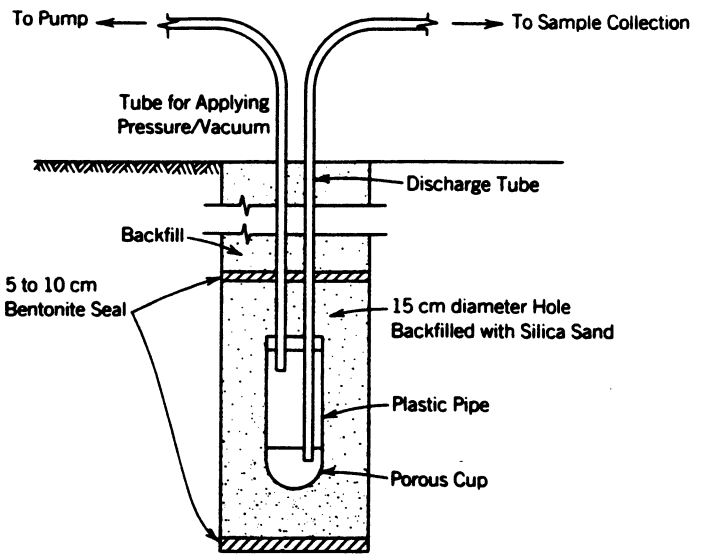
Crandon Mining Company

FIGURE 8

TYPICAL DETAIL FOR LEACHATE COLLECTION SYSTEM LATERAL

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SOURCE: BAGCHI, A. 1994. DESIGN CONSTRUCTION AND MONITORING OF LANDFILLS.

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

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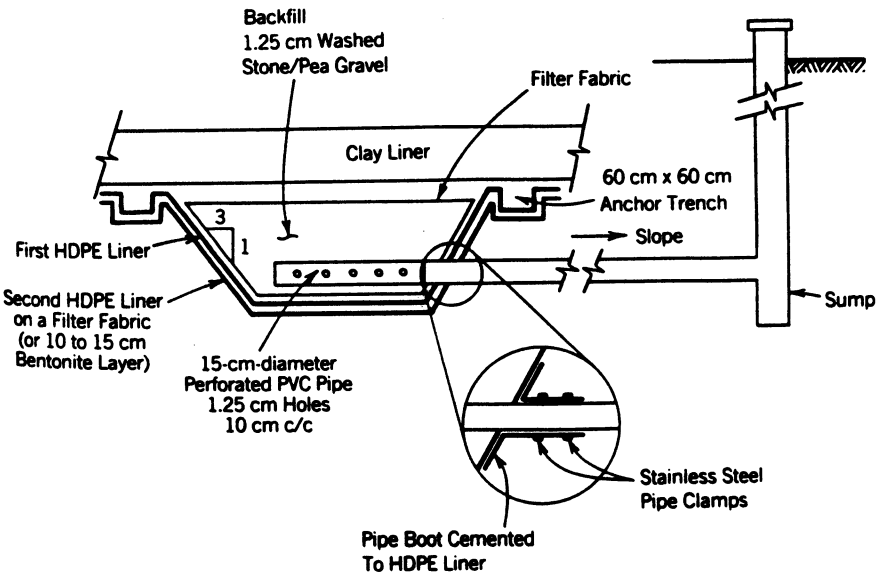
FIGURE 9
SUCTION LYSIMETER

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SOURCE: BAGCHI, A. 1994. DESIGN CONSTRUCTION AND MONITORING OF LANDFILLS.

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: FEB. '96
APPROVED BY:	NXP	DATE: FEB. '96
APPROVED BY:	GWS	DATE: FEB. '96

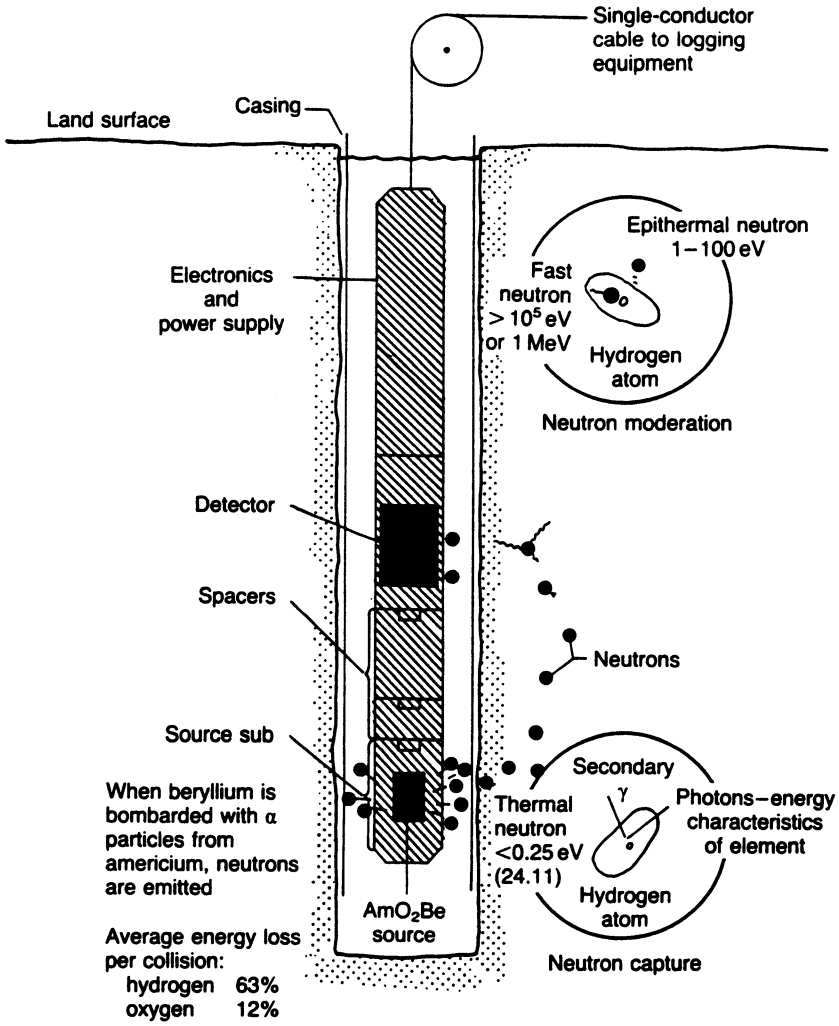
Crandon Mining Company

FIGURE 10
COLLECTION LYSIMETER

Scale:	NOT TO SCALE	Date:	FEBRUARY 1996
Prepared By:	Foth & Van Dyke	By:	JRB2

c:\cadwork\4c54f6.dgn

93C049



SOURCE: EVERETT, L. G., WILSON, L.G. AND HOYLMAN, E. W. 1984, VADOSE ZONE MONITORING FOR HAZARDOUS WASTE SITES.

TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: FEB. '96
APPROVED BY:	NXP	DATE: FEB. '96
APPROVED BY:	GWS	DATE: FEB. '96

Crandon Mining Company

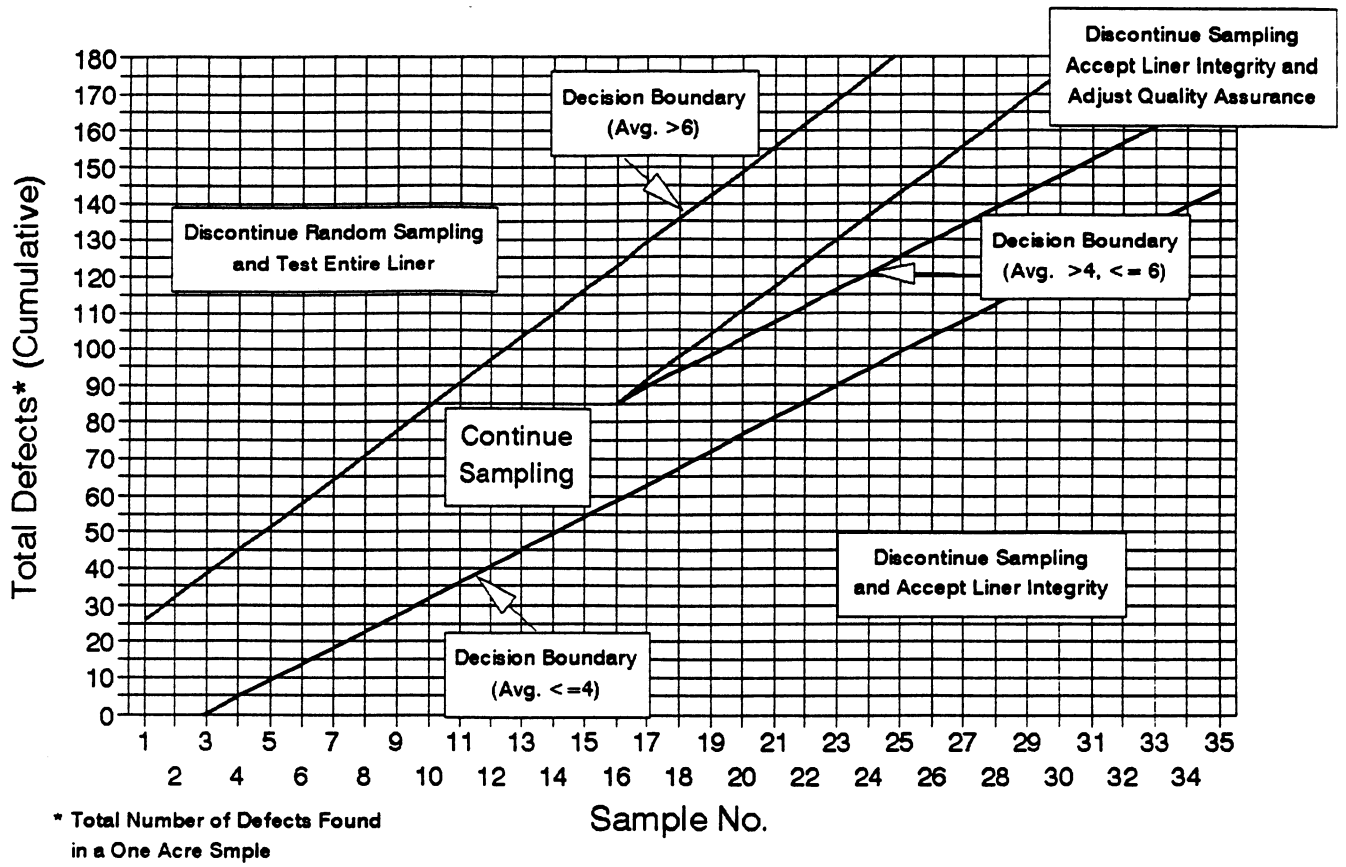
FIGURE 11

EQUIPMENT AND PRINCIPLES OF NEUTRON MOISTURE LOGGING

Scale: NOT TO SCALE	Date: FEBRUARY 1996	
Prepared By: Foth & Van Dyke		By: JRB2

c:\cadwork\4c54f6.dgn

93C049



* Total Number of Defects Found
in a One Acre Smple

Foth & Van Dyke				
REVISED	DATE	BY	DESCRIPTION	
CHECKED BY:	JKSI			DATE: FEB. '96
APPROVED BY:	NXP			DATE: FEB. '96
APPROVED BY:	GWS			DATE: FEB. '96

Crandon Mining Company

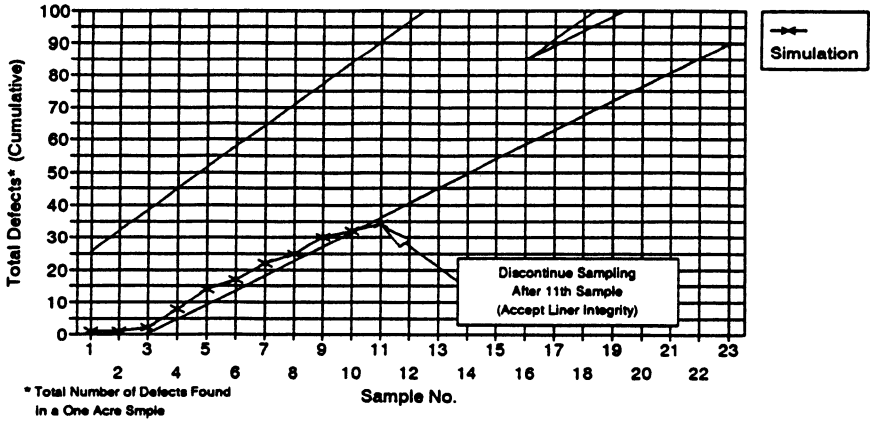
FIGURE 12
GEOMEMBRANE LINER
SEQUENTIAL TEST - DEFECTS

Scale:	NOT TO SCALE	Date:	FEBRUARY 1996
Prepared By:	Foth & Van Dyke	By:	JRB2

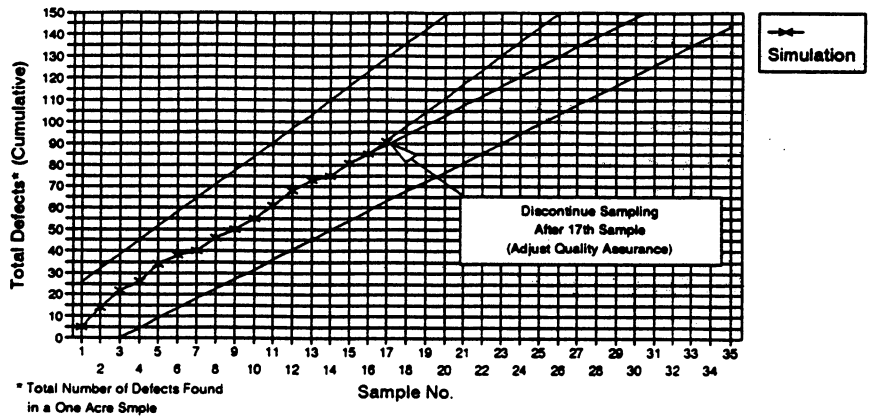
c:\cadwork\4c54f6.dgn

93C049

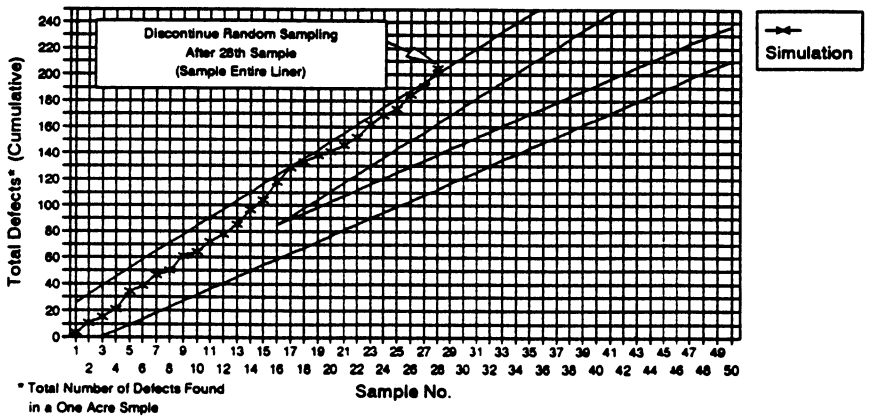
Geomembrane Liner Sampling Simulation
Average Defects/Acre = 3



Geomembrane Liner Sampling Simulation
Average Defects/Acre = 5



Geomembrane Liner Sampling Simulation
Average Defects/Acre = 7



Foth & Van Dyke			
REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: FEB. '96
APPROVED BY:	NXP	DATE: FEB. '96
APPROVED BY:	GWS	DATE: FEB. '96

Crandon Mining Company

FIGURE 13

GEOMEMBRANE LINER
SAMPLING SIMULATION - AVERAGE DEFECTS

Scale:	NOT TO SCALE	Date:	FEBRUARY 1996
Prepared By:	Foth & Van Dyke	By:	JRB2

c:\cadwork\4c54f6.dgn

93C049

Attachment 1

Bedrock Well Construction Information

BEST COPY AVAILABLE

WI_UNIQUE_WELL_NO:	AE756
OWNER_NAME:	HARP KANE
WELL_COMPLETE_DATE:	4/09/90
WELL_STREET_ADDRESS:	WALLEYE RD
QQ_SECTION:	NE
Q_SECTION:	NE
SURVEY_SECTION:	23
SURVEY_TOWNSHIP:	34
SURVEY_RANGE:	12
RANGE_DIR:	E
CLS_DIAMETER_AMOUNT1:	6
CLS_DIAMETER_AMOUNT2:	
CLS_DIAMETER_AMOUNT3:	
CLS_DIAMETER_AMOUNT4:	
CLS_FROM_AMOUNT1:	0
CLS_FROM_AMOUNT2:	
CLS_TO_AMOUNT1:	126
CLS_TO_AMOUNT2:	0
WELL_DEPTH:	277
STATIC_WTR_DEPTH_AMOUNT:	20
PUMP_WTR_LEVEL_BELOW_AMT:	265
PUMPING_GALS_AMOUNT:	2
PUMPING_HRS_TIME:	024.00

Granite 126'-277

WI_UNIQUE_WELL_NO:	CJ073
OWNER_NAME:	BOB TORGESON
WELL_COMPLETE_DATE:	6/26/89
WELL_STREET_ADDRESS:	SHERMAN LN
QQ_SECTION:	NW
Q_SECTION:	SE
SURVEY_SECTION:	23
SURVEY_TOWNSHIP:	35
SURVEY_RANGE:	12
RANGE_DIR:	E
CLS_DIAMETER_AMOUNT1:	6
CLS_DIAMETER_AMOUNT2:	
CLS_DIAMETER_AMOUNT3:	
CLS_DIAMETER_AMOUNT4:	
CLS_FROM_AMOUNT1:	0
CLS_FROM_AMOUNT2:	
CLS_TO_AMOUNT1:	73
CLS_TO_AMOUNT2:	0
WELL_DEPTH:	165
STATIC_WTR_DEPTH_AMOUNT:	45
PUMP_WTR_LEVEL_BELOW_AMT:	120
PUMPING_GALS_AMOUNT:	3
PUMPING_HRS_TIME:	024.00

Granite 73'-165'

WI_UNIQUE_WELL_NO:	CN803
OWNER_NAME:	GERALD SCHALINSKI
WELL_COMPLETE_DATE:	6/28/90
WELL_STREET_ADDRESS:	HWY 55
QQ_SECTION:	SW
Q_SECTION:	NW
SURVEY_SECTION:	10
SURVEY_TOWNSHIP:	34
SURVEY_RANGE:	12
RANGE_DIR:	E
CLS_DIAMETER_AMOUNT1:	6
CLS_DIAMETER_AMOUNT2:	
CLS_DIAMETER_AMOUNT3:	
CLS_DIAMETER_AMOUNT4:	
CLS_FROM_AMOUNT1:	0
CLS_FROM_AMOUNT2:	
CLS_TO_AMOUNT1:	95
CLS_TO_AMOUNT2:	0
WELL_DEPTH:	265
STATIC_WTR_DEPTH_AMOUNT:	61
PUMP_WTR_LEVEL_BELOW_AMT:	100
PUMPING_GALS_AMOUNT:	7
PUMPING_HRS_TIME:	002.00

Granite
95'-265'

WI_UNIQUE_WELL_NO:	CO128
OWNER_NAME:	LOUIS MICHIEL
WELL_COMPLETE_DATE:	4/27/90
WELL_STREET_ADDRESS:	LOST LAKE RD
QQ_SECTION:	NE
Q_SECTION:	NE
SURVEY_SECTION:	28
SURVEY_TOWNSHIP:	34
SURVEY_RANGE:	12
RANGE_DIR:	E
CLS_DIAMETER_AMOUNT1:	6
CLS_DIAMETER_AMOUNT2:	
CLS_DIAMETER_AMOUNT3:	
CLS_DIAMETER_AMOUNT4:	
CLS_FROM_AMOUNT1:	0
CLS_FROM_AMOUNT2:	
CLS_TO_AMOUNT1:	0
CLS_TO_AMOUNT2:	41
WELL_DEPTH:	260
STATIC_WTR_DEPTH_AMOUNT:	22
PUMP_WTR_LEVEL_BELOW_AMT:	250
PUMPING_GALS_AMOUNT:	1
PUMPING_HRS_TIME:	024.00

Granite
28'-260'

WI_UNIQUE_WELL_NO:	CP362
OWNER_NAME:	CLIFF MCGINNIS
WELL_COMPLETE_DATE:	3/13/90
WELL_STREET_ADDRESS:	
QQ_SECTION:	SE
Q_SECTION:	NE
SURVEY_SECTION:	31
SURVEY_TOWNSHIP:	34
SURVEY_RANGE:	12
RANGE_DIR:	E
CLS_DIAMETER_AMOUNT1:	5
CLS_DIAMETER_AMOUNT2:	
CLS_DIAMETER_AMOUNT3:	
CLS_DIAMETER_AMOUNT4:	
CLS_FROM_AMOUNT1:	0
CLS_FROM_AMOUNT2:	
CLS_TO_AMOUNT1:	0
CLS_TO_AMOUNT2:	70
WELL_DEPTH:	70
STATIC_WTR_DEPTH_AMOUNT:	14
PUMP_WTR_LEVEL_BELOW_AMT:	64
PUMPING_GALS_AMOUNT:	6
PUMPING_HRS_TIME:	1.50

Granite 69-70'

WI_UNIQUE_WELL_NO:	CV206
OWNER_NAME:	HAROLD CARTER
WELL_COMPLETE_DATE:	7/22/89
WELL_STREET_ADDRESS:	SMITH LANE
QQ_SECTION:	NW
Q_SECTION:	NW
SURVEY_SECTION:	7
SURVEY_TOWNSHIP:	35
SURVEY_RANGE:	13
RANGE_DIR:	E
CLS_DIAMETER_AMOUNT1:	6
CLS_DIAMETER_AMOUNT2:	
CLS_DIAMETER_AMOUNT3:	
CLS_DIAMETER_AMOUNT4:	
CLS_FROM_AMOUNT1:	0
CLS_FROM_AMOUNT2:	
CLS_TO_AMOUNT1:	77
CLS_TO_AMOUNT2:	0
WELL_DEPTH:	261
STATIC_WTR_DEPTH_AMOUNT:	6
PUMP_WTR_LEVEL_BELOW_AMT:	255
PUMPING_GALS_AMOUNT:	3
PUMPING_HRS_TIME:	002.00

Granite 72-261

WI_UNIQUE_WELL_NO:	CW513
OWNER_NAME:	DAN WALLACE
WELL_COMPLETE_DATE:	6/25/90
WELL_STREET_ADDRESS:	WOODLAWN RD
QQ_SECTION:	NW
Q_SECTION:	NW
SURVEY_SECTION:	25
SURVEY_TOWNSHIP:	34
SURVEY_RANGE:	13
RANGE_DIR:	E
CLS_DIAMETER_AMOUNT1:	6
CLS_DIAMETER_AMOUNT2:	
CLS_DIAMETER_AMOUNT3:	
CLS_DIAMETER_AMOUNT4:	
CLS_FROM_AMOUNT1:	0
CLS_FROM_AMOUNT2:	
CLS_TO_AMOUNT1:	0
CLS_TO_AMOUNT2:	68
WELL_DEPTH:	117
STATIC_WTR_DEPTH_AMOUNT:	15
PUMP_WTR_LEVEL_BELOW_AMT:	50
PUMPING_GALS_AMOUNT:	2
PUMPING_HRS_TIME:	004.00

Granite 67'-117'

WI_UNIQUE_WELL_NO:	EO587
OWNER_NAME:	JAMES BERGE
WELL_COMPLETE_DATE:	6/10/92
WELL_STREET_ADDRESS:	AIRPORT RD
QQ_SECTION:	SW
Q_SECTION:	NW
SURVEY_SECTION:	7
SURVEY_TOWNSHIP:	35
SURVEY_RANGE:	13
RANGE_DIR:	E
CLS_DIAMETER_AMOUNT1:	6
CLS_DIAMETER_AMOUNT2:	
CLS_DIAMETER_AMOUNT3:	
CLS_DIAMETER_AMOUNT4:	
CLS_FROM_AMOUNT1:	0
CLS_FROM_AMOUNT2:	
CLS_TO_AMOUNT1:	0
CLS_TO_AMOUNT2:	90
WELL_DEPTH:	220
STATIC_WTR_DEPTH_AMOUNT:	3
PUMP_WTR_LEVEL_BELOW_AMT:	200
PUMPING_GALS_AMOUNT:	2
PUMPING_HRS_TIME:	002.00

Granite 57'-220'

'I_UNIQUE_WELL_NO:	FK327
WNER_NAME:	KIRK SCHALLOCK
ELL_COMPLETE_DATE:	8/18/92
ELL_STREET_ADDRESS:	CTY HWY 55
Q_SECTION:	SW
_SECTION:	NE
URVEY_SECTION:	1
URVEY_TOWNSHIP:	35
URVEY_RANGE:	12
ANGE_DIR:	E
LS_DIAMETER_AMOUNT1:	6
LS_DIAMETER_AMOUNT2:	
LS_DIAMETER_AMOUNT3:	
LS_DIAMETER_AMOUNT4:	
LS_FROM_AMOUNT1:	0
LS_FROM_AMOUNT2:	
LS_TO_AMOUNT1:	0
LS_TO_AMOUNT2:	74
WELL_DEPTH:	75
STATIC_WTR_DEPTH_AMOUNT:	25
PUMP_WTR_LEVEL_BELOW_AMT:	67
PUMPING_GALS_AMOUNT:	7
PUMPING_HRS_TIME:	004.00

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Granite
71-75'

WI_UNIQUE_WELL_NO:	FN314
OWNER_NAME:	JOAN HIGGINS
WELL_COMPLETE_DATE:	9/09/92
WELL_STREET_ADDRESS:	SWAMPY LN
QQ_SECTION:	SE
Q_SECTION:	NW
SURVEY_SECTION:	19
SURVEY_TOWNSHIP:	35
SURVEY_RANGE:	13
RANGE_DIR:	E
CLS_DIAMETER_AMOUNT1:	6
CLS_DIAMETER_AMOUNT2:	
CLS_DIAMETER_AMOUNT3:	
CLS_DIAMETER_AMOUNT4:	
CLS_FROM_AMOUNT1:	0
CLS_FROM_AMOUNT2:	
CLS_TO_AMOUNT1:	0
CLS_TO_AMOUNT2:	78
WELL_DEPTH:	201
STATIC_WTR_DEPTH_AMOUNT:	48
PUMP_WTR_LEVEL_BELOW_AMT:	195
PUMPING_GALS_AMOUNT:	2
PUMPING_HRS_TIME:	002.00

Granite
78-201

WI_UNIQUE_WELL_NO:	FN346
OWNER_NAME:	SPRUCE CORPORATION INC
WELL_COMPLETE_DATE:	11/04/92
WELL_STREET_ADDRESS:	MOLE LAKE RD
QQ_SECTION:	NW
Q_SECTION:	NE
SURVEY_SECTION:	34
SURVEY_TOWNSHIP:	35
SURVEY_RANGE:	12
RANGE_DIR:	E
CLS_DIAMETER_AMOUNT1:	6
CLS_DIAMETER_AMOUNT2:	
CLS_DIAMETER_AMOUNT3:	
CLS_DIAMETER_AMOUNT4:	
CLS_FROM_AMOUNT1:	0
CLS_FROM_AMOUNT2:	
CLS_TO_AMOUNT1:	0
CLS_TO_AMOUNT2:	145
WELL_DEPTH:	242
STATIC_WTR_DEPTH_AMOUNT:	10
PUMP_WTR_LEVEL_BELOW_AMT:	235
PUMPING_GALS_AMOUNT:	1
PUMPING_HRS_TIME:	002.00

Granite
145 - 242

WI_UNIQUE_WELL_NO:	FN388
OWNER_NAME:	DEBRA KELLER
WELL_COMPLETE_DATE:	2/26/93
WELL_STREET_ADDRESS:	AIRPORT RD
QQ_SECTION:	SW
Q_SECTION:	SW
SURVEY_SECTION:	6
SURVEY_TOWNSHIP:	35
SURVEY_RANGE:	13
RANGE_DIR:	E
CLS_DIAMETER_AMOUNT1:	6
CLS_DIAMETER_AMOUNT2:	
CLS_DIAMETER_AMOUNT3:	
CLS_DIAMETER_AMOUNT4:	
CLS_FROM_AMOUNT1:	0
CLS_FROM_AMOUNT2:	
CLS_TO_AMOUNT1:	0
CLS_TO_AMOUNT2:	62
WELL_DEPTH:	101
STATIC_WTR_DEPTH_AMOUNT:	30
PUMP_WTR_LEVEL_BELOW_AMT:	85
PUMPING_GALS_AMOUNT:	7
PUMPING_HRS_TIME:	002.00

Granite
62 - 101

WI_UNIQUE_WELL_NO:	GJ718
OWNER_NAME:	CHARLES ROLAND
WELL_COMPLETE_DATE:	5/28/93
WELL_STREET_ADDRESS:	STRAWBERRY BLUTT RD
QQ_SECTION:	NE
Q_SECTION:	NW
SURVEY_SECTION:	6
SURVEY_TOWNSHIP:	35
SURVEY_RANGE:	13
RANGE_DIR:	E
CLS_DIAMETER_AMOUNT1:	6
CLS_DIAMETER_AMOUNT2:	
CLS_DIAMETER_AMOUNT3:	
CLS_DIAMETER_AMOUNT4:	
CLS_FROM_AMOUNT1:	0
CLS_FROM_AMOUNT2:	
CLS_TO_AMOUNT1:	0
CLS_TO_AMOUNT2:	83
WELL_DEPTH:	330
STATIC_WTR_DEPTH_AMOUNT:	8
PUMP_WTR_LEVEL_BELOW_AMT:	65
PUMPING_GALS_AMOUNT:	5
PUMPING_HRS_TIME:	002.00

Granite 83'-330'

WI_UNIQUE_WELL_NO:	HM927
OWNER_NAME:	SCHMIDT, SHAWN
WELL_COMPLETE_DATE:	6/01/94
WELL_STREET_ADDRESS:	NEMEC RD
QQ_SECTION:	SW
Q_SECTION:	NW
SURVEY_SECTION:	6
SURVEY_TOWNSHIP:	35
SURVEY_RANGE:	13
RANGE_DIR:	E
CLS_DIAMETER_AMOUNT1:	6
CLS_DIAMETER_AMOUNT2:	
CLS_DIAMETER_AMOUNT3:	
CLS_DIAMETER_AMOUNT4:	
CLS_FROM_AMOUNT1:	0
CLS_FROM_AMOUNT2:	
CLS_TO_AMOUNT1:	0
CLS_TO_AMOUNT2:	41
WELL_DEPTH:	121
STATIC_WTR_DEPTH_AMOUNT:	3
PUMP_WTR_LEVEL_BELOW_AMT:	105
PUMPING_GALS_AMOUNT:	6
PUMPING_HRS_TIME:	003.00

Granite 40'-121'

WI_UNIQUE_WELL_NO:	HQ831
OWNER_NAME:	SAMZ, BENEDICT
WELL_COMPLETE_DATE:	9/03/94
WELL_STREET_ADDRESS:	SMITH LN
QQ_SECTION:	SW
Q_SECTION:	SW
SURVEY_SECTION:	6
SURVEY_TOWNSHIP:	35
SURVEY_RANGE:	13
RANGE_DIR:	E
CLS_DIAMETER_AMOUNT1:	6
CLS_DIAMETER_AMOUNT2:	
CLS_DIAMETER_AMOUNT3:	
CLS_DIAMETER_AMOUNT4:	
CLS_FROM_AMOUNT1:	0
CLS_FROM_AMOUNT2:	
CLS_TO_AMOUNT1:	0
CLS_TO_AMOUNT2:	60
WELL_DEPTH:	102
STATIC_WTR_DEPTH_AMOUNT:	12
PUMP_WTR_LEVEL_BELOW_AMT:	80
PUMPING_GALS_AMOUNT:	3
PUMPING_HRS_TIME:	024.00

Granite 60' - 102

WI_UNIQUE_WELL_NO:	HX149
OWNER_NAME:	FARENBACK, MARK
WELL_COMPLETE_DATE:	11/01/94
WELL_STREET_ADDRESS:	STRAWBERRY BLUFF LN
QQ_SECTION:	NW
Q_SECTION:	NW
SURVEY_SECTION:	6
SURVEY_TOWNSHIP:	35
SURVEY_RANGE:	13
RANGE_DIR:	E
CLS_DIAMETER_AMOUNT1:	6
CLS_DIAMETER_AMOUNT2:	
CLS_DIAMETER_AMOUNT3:	
CLS_DIAMETER_AMOUNT4:	
CLS_FROM_AMOUNT1:	0
CLS_FROM_AMOUNT2:	
CLS_TO_AMOUNT1:	65
CLS_TO_AMOUNT2:	0
WELL_DEPTH:	185
STATIC_WTR_DEPTH_AMOUNT:	20
PUMP_WTR_LEVEL_BELOW_AMT:	165
PUMPING_GALS_AMOUNT:	3
PUMPING_HRS_TIME:	002.00

Granite 65' - 185'

FR-41C-3
Wel 6

WELL CONSTRUCTOR'S REPORT TO WISCONSIN STATE BOARD OF HEALTH

See Instructions on Reverse Side

RECEIVED
MAR 27 1964
SANITARY ENGINEERING

1. County Forest — Town ☒ / Village ☐ / City ☐ Lincoln (Check one and give name)

2. Location SEC. 13 T.35N. R.13E. (Name of street and number of premise or Section, Town and Range numbers)

3. Owner ☒ or Agent ☐ RICHARD CRAM (Name of individual, partnership or firm)

4. Mail Address CRANDON, Wis. (Complete address required)

5. From well to nearest: Building 5 ft; sewer ____ ft; drain ____ ft; septic tank 75 ft; dry well or filter bed 90 ft; abandoned well ____ ft.

6. Well is intended to supply water for: Household

7. DRILLHOLE:

Dia. (in.)	From (ft.)	To (ft.)	Dia. (in.)	From (ft.)	To (ft.)
5	0	71			

8. CASING AND LINER PIPE OR CURBING:

Dia. (in.)	Kind and Weight	From (ft.)	To (ft.)
5	Steel St.	0	48

9. GROUT:

Kind	From (ft.)	To (ft.)
None		

10. FORMATIONS:

Kind	From (ft.)	To (ft.)
Sand	0	40
Sand & Clay		
Caving	40	48
Rock	48	71

Construction of the well was completed on: Dec 31 19 63

The well is terminated 10 inches ☒ above, below ☐ the permanent ground surface.

Was the well disinfected upon completion? Yes ✓ No ____

Was the well sealed watertight upon completion? Yes ✓ No ____

11. MISCELLANEOUS DATA:

Yield test: 5 Hrs. at 3 GPM.

Depth from surface to water-level: 28 ft.

Water-level when pumping: 70 ft.

Water sample was sent to the state laboratory at: Jan 2 to Madison 19 64 (City)

Signature David Behan, Registered Well Driller — Rhinelander, Wis. (Complete Mail Address)

Please do not write in space below

Rec'd ____ No ____

Ans'd ____

Interpretation ____

	10 ml	10 ml	10 ml	10 ml	10 ml
Gas—24 hrs.					
48 hrs.					
Confirm					
B. Coli					

Examiner ____

ELL CONSTRUCTOR'S REPORT

91–6

WHITE COPY – DIVISION'S COPY
GREEN COPY – DRILLER'S COPY
YELLOW COPY – OWNER'S COPY

STATE OF WISCONSIN
DEPARTMENT OF NATURAL RESOURCES
Box 450
Madison, Wisconsin 53701

COUNTY: Forest

CHECK ONE: ☑ Town ☐ Village ☐ City

NAME: Crandon

LOCATION (Number and Street or ¼ section, section, township and range. Also give subdivision name, lot and block numbers when available.)
LOT 2 S 7 - 35 - 13

OWNER AT TIME OF DRILLING
GEORGE HUEBNER

OWNER'S COMPLETE MAIL ADDRESS
CRANDON WIS.

Distance in feet from well to nearest: (Record answer in appropriate block)	BUILDING	SANITARY SEWER C. I.	SANITARY SEWER TILE	FLOOR DRAIN C. I.	FLOOR DRAIN TILE	FOUNDATION DRAIN SEWER CONNECTED	FOUNDATION DRAIN INDEPENDENT	WASTE WATER DR. C. I.	WASTE WATER DR. TILE
	6	40		NONE		NONE		40	

REAR WATER DRAIN C. I.	REAR WATER DRAIN TILE	SEPTIC TANK	PRIVY	SEEPAGE PIT	ABSORPTION FIELD	BARN	SILO	ABANDONED WELL	SINK HOLE
		65	-	—	90	-	-		-

WATER POLLUTION SOURCES (Give description such as dump, quarry, drainage well, stream, pond, lake, etc.)

Well is intended to supply water for:
HOME

DRILLHOLE

Dia. (in.)	From (ft.)	To (ft.)	Dia. (in.)	From (ft.)	To (ft.)
6	Surface	172			

CASING, LINER, CURBING, AND SCREEN

Dia. (in.)	Kind and Weight	From (ft.)	To (ft.)
6	NEW BLACK STEEL	Surface	153'
	19.45# T & C		
6	SOFT GRAY ROCK	153	172'

GROUT OR OTHER SEALING MATERIAL

Kind	From (ft.)	To (ft.)
NONE	Surface	

10. FORMATIONS

Kind	From (ft.)	To (ft.)
MUCK	Surface	15
GRAVEL	15	35
RED CLAY	35	50
GRAY CLAY	50	150
SOFT GRAY ROCK	150	172

Well construction completed on Aug 4, 19

Well is terminated 9 inches ☑ above ☐ below final grade

Well disinfected upon completion ☑ Yes ☐

Well sealed watertight upon completion ☑ Yes ☐

MISCELLANEOUS DATA

Yield test: 24 Hrs. at 2 GPM

Depth from surface to normal water level 2 ft.

Depth to water level when pumping 120 ft.

Water sample sent to ST MARYS HOSPITAL RHINELANDER laboratory on: Aug. 11, 19

Your opinion concerning other pollution hazards, information concerning difficulties encountered, and data relating to nea
wells, screens, seals, type of casing joints, method of finishing the well, amount of cement used in grouting, blasting, s
surface pumprooms, access pits, etc., should be given on reverse side.

SIGNATURE
Robert D. Behm Registered Well Driller

COMPLETE MAIL ADDRESS
Route 3
Rhinelander, Wis 54501

Please do not write in space below

UNIFORM TEST RESULT	GAS — 24 HRS.	GAS — 48 HRS.	CONFIRMED	REMARKS

Rev. 11–68

2

WELL CONSTRUCTOR'S REPORT

FORM 3300-15

FEB 10 1975

JAN 6 1976

NOTE
WHITE COPY – DIVISION'S COPY
GREEN COPY – DRILLER'S COPY
YELLOW COPY – OWNER'S COPY

STATE OF WISCONSIN
DEPARTMENT OF NATURAL RESOUR
Box 450
Madison, Wisconsin 53701

1. COUNTY: Forest

CHECK ONE: [XX] Town [ ] Village [ ] City

NAME: Nashville

2. LOCATION – ¼ Section | Section: 6 | Township: T35N | Range: 13E

3. OWNER AT TIME OF DRILLING: Marvin Kazor

ADDRESS: 1412 West Kemps Ave.

OR – Grid or street no. | Street name

AND – If available subdivision name, lot & block no.: Gov. Lot 3

POST OFFICE: Appleton, Wisconsin

4. Distance in feet from well to nearest: (Record answer in appropriate block)

BUILDING	SANITARY SEWER C. I.	SANITARY SEWER TILE	FLOOR DRAIN C. I.	FLOOR DRAIN TILE	FOUNDATION DRAIN SEWER CONNECTED	FOUNDATION DRAIN INDEPENDENT	WASTE WATER C. I.	WASTE WATER TI
none		none						

CLEAR WATER DRAIN C. I.	CLEAR WATER DRAIN TILE	SEPTIC TANK	PRIVY	SEEPAGE PIT	ABSORPTION FIELD	BARN	SILO	ABANDONED WELL	SINK HOLE
		none			none				

5. OTHER POLLUTION SOURCES (Give description such as dump, quarry, drainage well, stream, pond, lake, etc.): lake 100 ft.

6. Well is intended to supply water for: Future cottage

7. DRILLHOLE

Dia. (in.)	From (ft.)	To (ft.)	Dia. (in.)	From (ft.)	To (ft.)
6	Surface	126			

8. CASING, LINER, CURBING, AND SCREEN

Dia. (in.)	Kind and Weight	From (ft.)	To (ft.)
6	New Steel T&C 19:45 lbs	Surface	52

9. FORMATIONS

Kind	From (ft.)	To
sand & loose clay	Surface	29
heavy clay	29	52
solid rock Granite	52	1

10. GROUT OR OTHER SEALING MATERIAL

Kind	From (ft.)	To (ft.)
	Surface	

11. TYPE OF DRILLING MACHINE USED

[XX] Cable Tool [ ] Direct Rotary [ ] Reverse Rota
[ ] Rotary – air w/drilling mud [ ] Rotary – hammer with drilling mud & air [ ] Jetting with [ ] Air [ ] W

Well construction completed on 3/ 7/ 74 19

12. MISCELLANEOUS DATA

Yield test: 2 Hrs. at 4 GPM

Well is terminated 10 inches [XX] above [ ] below final g

Depth from surface to normal water level 6 ft.

Well disinfected upon completion [XX] Yes [ ]

Depth to water level when pumping 115 ft.

Well sealed watertight upon completion [XX] Yes [ ]

Water sample sent to ~~Wisc~~ Wis. Dept. of Water Res. to be sent when pump is installed laboratory on: 6/16 19

Your opinion concerning other pollution hazards, information concerning difficulties encountered, and data relating to nearby wells, screens, type of casing joints, method of finishing the well, amount of cement used in grouting, blasting, sub-surface pumprooms, access pits, etc., shc given on reverse side.

SIGNATURE: William Sinkler
Registered Well Driller

COMPLETE MAIL ADDRESS: Harshaw, WI. 54529

Please do not write in space below

COLIFORM TEST RESULT	GAS – 24 HRS.	GAS – 48 HRS.	CONFIRMED	REMARKS

REV. 3-71

WELL CONSTRUCTOR'S REPORT
FORM 3300-15

SEP 8 1975

NOTE
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GREEN COPY – DRILLER'S COPY
YELLOW COPY – OWNER'S COPY

STATE OF WISCONSIN
DEPARTMENT OF NATURAL RESOURC
Box 450
Madison, Wisconsin 53701

1. COUNTY: FOREST

CHECK ONE: ☑ Town ☐ Village ☐ City NAME: LINCOLN

2. LOCATION – ¼ Section: SWNW | Section: 6 | Township: 35N | Range: 13E

3. OWNER AT TIME OF DRILLING: MARVIN JANZ

OR – Grid or street no. | Street name

ADDRESS

AND – If available subdivision name, lot & block no.

POST OFFICE: CRANDON, WIS.

4. Distance in feet from well to nearest: (Record answer in appropriate block)

BUILDING	SANITARY SEWER C. I.	SANITARY SEWER TILE	FLOOR DRAIN C. I.	FLOOR DRAIN TILE	FOUNDATION DRAIN SEWER CONNECTED	FOUNDATION DRAIN INDEPENDENT	WASTE WATER C. I.	WASTE WATER T
8	not in				–	–	–	–

CLEAR WATER DRAIN C. I.	CLEAR WATER DRAIN TILE	SEPTIC TANK	PRIVY	SEEPAGE PIT	ABSORPTION FIELD	BARN	SILO	ABANDONED WELL	SINK HOLE
–	–	not in			–				–

OTHER POLLUTION SOURCES (Give description such as dump, quarry, drainage well, stream, pond, lake, etc.)
– LAKE METONGA

5. Well is intended to supply water for:
NEW HOME

6. DRILLHOLE

Dia. (in.)	From (ft.)	To (ft.)	Dia. (in.)	From (ft.)	To (ft.)
10	Surface	20			
5	20	232			

7. CASING, LINER, CURBING, AND SCREEN

Dia. (in.)	Kind and Weight	From (ft.)	To (ft.)
5	NEW BLACK STEEL PE 14.81 #	Surface	190
4	NEW BLACK STEEL 10.89 #	85	232

8. GROUT OR OTHER SEALING MATERIAL

Kind	From (ft.)	To (ft.)
CLAY	Surface	20

9. FORMATIONS

Kind	From (ft.)	To
GRAVEL FILL	Surface	6
MUD	6	24
RED CLAY	24	85
ROCK & CLAY LAYERS	85	23
GRANITE	232	

10. TYPE OF DRILLING MACHINE USED
☑ Cable Tool ☐ Direct Rotary ☐ Reverse Rotar
☐ Rotary – air w/drilling mud ☐ Rotary – hammer with drilling mud & air ☐ Jetting with ☐ Air ☐ W

Well construction completed on 8-22 19 7

11. MISCELLANEOUS DATA
Yield test: 24 Hrs. at 2½ GPM

Well is terminated 12 inches ☑ above ☐ below final gr

Depth from surface to normal water level 1 ft.

Well disinfected upon completion ☑ Yes ☐

Depth to water level when pumping 100 ft.

Well sealed watertight upon completion ☑ Yes ☐

Water sample sent to MADISON laboratory on: 8-22 19

Your opinion concerning other pollution hazards, information concerning difficulties encountered, and data relating to nearby wells, screens, type of casing joints, method of finishing the well, amount of cement used in grouting, blasting, sub-surface pumprooms, access pits, etc., sho given on reverse side. — (OVER)

SIGNATURE: Robert L. Rehm Registered Well Driller

COMPLETE MAIL ADDRESS: RT 3 Rhinelander, Wis 54501

Please do not write in space below

COLIFORM TEST RESULT	GAS – 24 HRS.	GAS – 48 HRS.	CONFIRMED	REMARKS

REV. 3-71

I could not get 6" pipe at time of drilling so upper pipe is 5". Liner used to keep lower hole open through clay layers. 4" pipe slotted from 190 to 200 ft.

85 – 110	soft rock
110 – 118	hard rock (white rock)
118 – 122	clay & rock
122 – 130	rock
130 – 160	red clay & rock
160 – 170	mixed clay
170 – 192	brown clay
192 – 205	blue clay & rock (water at 195')
205 – 210	red clay & rock
210 – 227	blue clay & rock
227 – 228	red clay
228 – 229	blue clay
229 – 232	rock
232 –	granite rock

5

State of Wisconsin
Department of Natural Resources
Box 7921
Madison, Wisconsin 53707

JUN 28 1977

NOTE:
White Copy – Division's Copy
Green Copy – Driller's Copy
Yellow Copy – Owner's Copy

WELL CONSTRUCTOR'S REPORT

Form 3300–15 Rev. 12-76

1. COUNTY: Forest
CHECK (✓) ONE: ☒ Town ☐ Village ☐ City
Name: Lincoln

2. LOCATION: ¼ Section: SESW | Section: 6 | Township: 35N | Range: 13E
OR – Grid or Street No. | Street Name
AND – If available subdivision name, lot & block No.

3. NAME ☒ OWNER ☐ AGENT AT TIME OF DRILLING CHECK (✓) O: Otto Nemec
ADDRESS: R.F.D. 1
POST OFFICE: Crandon, Wisc.

4. Distance in feet from well to nearest: (Record answer in appropriate block)

Building	Sanitary Bldg. Drain C.I.	Sanitary Bldg. Drain Other	Sanitary Bldg. Sewer C.I.	Sanitary Bldg. Sewer Other	Floor Drain Connected To: C.I. Sewer	Floor Drain Connected To: Other Sewer	Storm Bldg. Drain C.I.	Storm Bldg. Drain Other	Storm Bldg. C.I.	Storm Bldg. Oth
FIRST CONSTRUCTION ON LOT										

Street Sewer San.	Street Sewer Storm	Other Sewers C.I.	Other Sewers Other	Foundation Drain Connected to: Sewer / Clearwater Or.	Foundation Drain Connected to: Sewage Sump / Clearwater Sump	Sewage Sump C.I.	Sewage Sump Other	Clearwater Sump	Septic Tank	Holding Tank	Sewage Absorption Unit: Seepage Pit / Seepage Bed / Seepage Trench

Privy	Pet Waste Pit	Pit: Nonconforming Existing: Well / Pump / Tank	Subsurface Pumproom Nonconforming Existing	Barn Gutter	Animal Barn Pen	Animal Yard	Silo With Pit	Glass Lined Storage Facility	Silo w/o Pit	Earthen Silage Storage Trench Or Pit

Temporary Manure Stack	Watertight Liquid Manure Tank	Solid Manure Storage Structure	Subsurface Gasoline or Oil Tank	Waste Pond or Land Disposal Unit (Specify Type)	Other (Give Description)

5. Well is intended to supply water for: Campground

6. DRILLHOLE

Dia. (in.)	From (ft.)	To (ft.)	Dia. (in.)	From (ft.)	To (ft.)
6	Surface	122			

7. CASING, LINER, CURBING AND SCREEN

Dia. (in.)	Material, Weight, Specification & Method of Assembly	From (ft.)	To (ft.)
6	New Black Steel 19.45# T&C A53 US Steel	Surface	57

8. GROUT OR OTHER SEALING MATERIAL

Kind	From (ft.)	To (ft.)
None	Surface	

9. FORMATIONS

Kind	From (ft.)	To (ft.
Sand Caving	Surface	24
Hard Pan & Boulders	24	57
Soft Red Granite	57	122
Water Enters 75&95		

10. TYPE OF DRILLING MACHINE USED
☐ Cable Tool ☒ Rotary-hammer w/drilling mud & air ☐ Jetting with
☐ Rotary-air w/drilling mud ☐ Rotary-hammer & air ☐ Air ☐ Water
☐ Rotary-w/drilling mud ☐ Reverse Rotary

Well construction completed on 6/3/77 19___

11. MISCELLANEOUS DATA
Yield Test: 2 Hrs. at 1 GPM
Depth from surface to normal water level 28 Ft.
Depth of water level when pumping 115 Ft. Stabilized ☒ Yes ☐ No

Well is terminated 12 inches ☒ above ☐ below final grade
Well disinfected upon completion ☒ Yes ☐ No
Well sealed watertight upon completion ☒ Yes ☐ No

Water sample sent to St Mary's Hospital laboratory on 6/6/77 19___

Your opinion concerning other pollution hazards, information concerning difficulties encountered, and data relating to nearby wells, screens, seals, method o finishing the well, amount of cement used in grouting, blasting, etc., should be given on reverse side.

Signature: [signature] Registered Well Driller

Complete Mail Addres: RHINELANDER WELL DRILLING,
680 COUNTRY DRIVE
RHINELANDER, WISCONSIN 54501

VELL CONSTRUCTOR'S REPORT
ORM 3300-15

6

BEST COPY AVAILABLE

NOTE
WHITE COPY – DIVISION'S COPY
GREEN COPY – DRILLER'S COPY
YELLOW COPY – OWNER'S COPY

STATE OF WISCONSIN
DEPARTMENT OF NATURAL RESOURCE
Box 450
Madison, Wisconsin 53701

COUNTY	CHECK ONE	NAME
Forest	☒ Town ☐ Village ☐ City	Lincoln

LOCATION – ¼ Section	Section	Township	Range	OWNER AT TIME OF DRILLING
NE of SW¼	6	35N	13E	Otto Nemec

R – Grid or street no.	Street name	ADDRESS

ND – If available subdivision name, lot & block no.	POST OFFICE
	Crandon, Wis. 54520

Distance in feet from well to nearest: (Record answer in appropriate block)	BUILDING	SANITARY SEWER C.I.	SANITARY SEWER TILE	FLOOR DRAIN C.I.	FLOOR DRAIN TILE	FOUNDATION DRAIN SEWER CONNECTED	FOUNDATION DRAIN INDEPENDENT	WASTE WATER DR C.I.	WASTE WATER DR TIL

LEAR WATER DRAIN C.I.	LEAR WATER DRAIN TILE	SEPTIC TANK	PRIVY	SEEPAGE PIT	ABSORPTION FIELD	BARN	SILO	ABANDONED WELL	SINK HOLE
				first construction					

THER POLLUTION SOURCES (Give description such as dump, quarry, drainage well, stream, pond, lake, etc.)
none

Well is intended to supply water for:
trailer court

DRILLHOLE

Dia. (in.)	From (ft.)	To (ft.)	Dia. (in.)	From (ft.)	To (ft.)
6	Surface	77			

CASING, LINER, CURBING, AND SCREEN

Dia. (in.)	Kind and Weight	From (ft.)	To (ft.)
6 new	blk steel 18.42#/ft	Surface	67
	T&C		

9. FORMATIONS

Kind	From (ft.)	To (ft.)
sand & clay	Surface	27
clay	27	67
brown granite	67	77
water enters 75'		

GROUT OR OTHER SEALING MATERIAL

Kind	From (ft.)	To (ft.)
	Surface	

10. TYPE OF DRILLING MACHINE USED

☒ Cable Tool ☐ Direct Rotary ☐ Reverse Rotary
☐ Rotary – air w/drilling mud ☐ Rotary – hammer with drilling mud & air ☐ Jetting with ☐ Air ☐ Wa

Well construction completed on July 29 19 7

1. MISCELLANEOUS DATA

ield test: 2 Hrs. at 5 GPM

Well is terminated 12 inches ☒ above ☐ below final gr

epth from surface to normal water level 24 ft.

Well disinfected upon completion ☒ Yes ☐

epth to water level when pumping 61 ft.

Well sealed watertight upon completion ☒ Yes ☐

ater sample sent to Madison Lab laboratory on: July 29 19

our opinion concerning other pollution hazards, information concerning difficulties encountered, and data relating to nearby wells, screens, s
pe of casing joints, method of finishing the well, amount of cement used in grouting, blasting, sub-surface pumprooms, access pits, etc., sho
given on reverse side.

GNATURE [signature]
Registered Well Driller

COMPLETE MAIL ADDRESS
680 Country Drive
Rhinelander, Wis. 54501

Please do not write in space below

OLIFORM TEST RESULT	GAS – 24 HRS.	GAS – 48 HRS.	CONFIRMED	REMARKS

EV. 3–71

F 7

ELL CONSTRUCTOR'S REPORT

ORM 3300-15

MAY 14 1974

NOTE
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GREEN COPY – DRILLER'S COPY
YELLOW COPY – OWNER'S COPY

STATE OF WISCONSIN
DEPARTMENT OF NATURAL RESOURCES
Box 450
Madison, Wisconsin 53701

COUNTY: Forest

CHECK ONE: ☑ Town ☐ Village ☐ City

NAME: Lincoln

LOCATION – ¼ Section: SE | SE | Section: 6 | Township: 35 | Range: 13E

3. OWNER AT TIME OF DRILLING: Edward J. Pasarwicz

R – Grid or street no. | Street name

ADDRESS: 169 E. Cedar St.

ND – If available subdivision name, lot & block no.: Crist Lot 1 E 2

POST OFFICE: Pulaski, Wisconsin

Distance in feet from well to nearest:
(Record answer in appropriate block)

BUILDING	SANITARY SEWER C. I.	SANITARY SEWER TILE	FLOOR DRAIN C. I.	FLOOR DRAIN TILE	FOUNDATION DRAIN SEWER CONNECTED	FOUNDATION DRAIN INDEPENDENT	WASTE WATER DR. C. I.	WASTE WATER DR. TILE

CLEAR WATER DRAIN C. I.	CLEAR WATER DRAIN TILE	SEPTIC TANK	PRIVY	SEEPAGE PIT	ABSORPTION FIELD	BARN	SILO	ABANDONED WELL	SINK HOLE

OTHER POLLUTION SOURCES (Give description such as dump, quarry, drainage well, stream, pond, lake, etc.): None

. Well is intended to supply water for: Cottage

. DRILLHOLE

Dia. (in.)	From (ft.)	To (ft.)	Dia. (in.)	From (ft.)	To (ft.)
6	Surface	104½			

. CASING, LINER, CURBING, AND SCREEN

Dia. (in.)	Kind and Weight	From (ft.)	To (ft.)
6	New Steel pipe	Surface	59
	19.18 T and C		

9. FORMATIONS

Kind	From (ft.)	To (ft.)
Sand and Stones	Surface	5
Granite	59	10

3. GROUT OR OTHER SEALING MATERIAL

Kind	From (ft.)	To (ft.)
	Surface	1

10. TYPE OF DRILLING MACHINE USED

☑ Cable Tool ☐ Direct Rotary ☐ Reverse Rota
☐ Rotary – air w/drilling mud ☐ Rotary – hammer with drilling mud & air ☐ Jetting with ☐ Air ☐

Well construction completed on 10/28 19 7

11. MISCELLANEOUS DATA

Yield test: 10 Hrs. at 5 GPM

Well is terminated 12 inches ☑ above ☐ below final

Depth from surface to normal water level 14 ft.

Well disinfected upon completion ☑ Yes ☐

Depth to water level when pumping 60 ft.

Well sealed watertight upon completion ☑ Yes ☐

Water sample sent to State Lab. of Hygiene Madison, Wisc. laboratory on: 5-5 19

Your opinion concerning other pollution hazards, information concerning difficulties encountered, and data relating to nearby wells, screens type of casing joints, method of finishing the well, amount of cement used in grouting, blasting, sub-surface pumprooms, access pits, etc., sh be given on reverse side.

SIGNATURE: Bernard Yarusso Registered Well Driller

COMPLETE MAIL ADDRESS: R.R2 Hillett, Wisconsin 54124

Please do not write in space below

COLIFORM TEST RESULT	GAS – 24 HRS.	GAS – 48 HRS.	CONFIRMED	REMARKS

REV 3-71

WELL CONSTRUCTOR'S REPORT

FORM 3300-15

NOTE
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GREEN COPY – DRILLER'S COPY
YELLOW COPY – OWNER'S COPY

AUG 22 19[illegible]

STATE OF WISCONSIN
DEPARTMENT OF NATURAL RESOURCES
Box 450
Madison, Wisconsin 53701

1. COUNTY	CHECK ONE	NAME
Forest	☒ Town ☐ Village ☐ City	Lincoln

2. LOCATION – ¼ Section	Section	Township	Range	3. OWNER AT TIME OF DRILLING
SW-NW	6	35N	13E	Gene Shank

ER – Grid or street no.	Street name	ADDRESS
		Rt. 1

ND – If available subdivision name, lot & block no.	POST OFFICE
	Antigo, Wis.

4. Distance in feet from well to nearest: (Record answer in appropriate block)	BUILDING	SANITARY SEWER C. I.	SANITARY SEWER TILE	FLOOR DRAIN C. I.	FLOOR DRAIN TILE	FOUNDATION DRAIN SEWER CONNECTED	FOUNDATION DRAIN INDEPENDENT	WASTE WATER D. C. I.	WASTE WATER D. TILE
	6'								

CLEAR WATER DRAIN C. I.	CLEAR WATER DRAIN TILE	SEPTIC TANK	PRIVY	SEEPAGE PIT	ABSORPTION FIELD	BARN	SILO	ABANDONED WELL	SINK HOLE
		45			70				

OTHER POLLUTION SOURCES (Give description such as dump, quarry, drainage well, stream, pond, lake, etc.)

5. Well is intended to supply water for:
Dwelling

6. DRILLHOLE

Dia. (in.)	From (ft.)	To (ft.)	Dia. (in.)	From (ft.)	To (ft.)
6	Surface	50			

7. CASING, LINER, CURBING, AND SCREEN

Dia. (in.)	Kind and Weight	From (ft.)	To (ft.)
6	New Black Steel 19.45# per/ft T & C	Surface	45

9. FORMATIONS

Kind	From (ft.)	To
Gravel & Clay (caving)	Surface	30
Hard Pan	30	45
Brown Granite	45	50
Water Enters At 44'		

8. GROUT OR OTHER SEALING MATERIAL

Kind	From (ft.)	To (ft.)
None	Surface	

10. TYPE OF DRILLING MACHINE USED

☒ Cable Tool ☐ Direct Rotary ☐ Reverse Rotar
☐ Rotary – air w/drilling mud ☐ Rotary – hammer with drilling mud & air ☐ Jetting with ☐ Air ☐ W

11. MISCELLANEOUS DATA

Yield test: 1½ Hrs. at 4 GPM

Depth from surface to normal water level 11 ft.

Depth to water level when pumping 45 ft.

Well construction completed on June 18, 19 7-

Well is terminated 12 inches ☒ above ☐ below final g

Well disinfected upon completion ☒ Yes ☐

Well sealed watertight upon completion ☒ Yes ☐

Water sample sent to Madison, Wis. laboratory on: June 19, 19,

Your opinion concerning other pollution hazards, information concerning difficulties encountered, and data relating to nearby wells, screens, type of casing joints, method of finishing the well, amount of cement used in grouting, blasting, sub-surface pumprooms, access pits, etc., shc e given on reverse side.

SIGNATURE
Robert Weber Registered Well Driller

COMPLETE ADDRESS OF WELL DRILLING FIRM
RHINELANDER WELL DRILLING, INC.
680 COUNTRY DRIVE
RHINELANDER, WISCONSIN 54501

Please do not write in space below

COLIFORM TEST RESULT	GAS – 24 HRS.	GAS – 48 HRS.	CONFIRMED	REMARKS

REV. 3-71

FR-425-U

State of Wisconsin
Department of Natural Resources
Box 450
Madison, Wisconsin 53701

JUN 3 1976

NOTE:
White Copy – Division's Copy
Green Copy – Driller's Copy
Yellow Copy – Owner's Copy

WELL CONSTRUCTOR'S REPORT
Form 3300-15
Rev. 10-75

1. COUNTY: Forest
CHECK (✓) ONE: ☑ Town ☐ Village ☐ City
Name: Lincoln

2. LOCATION: ¼ Section: SW NW | Section: 6 | Township: 35N | Range: 13E
OR – Grid or Street No. | Street Name
AND – If available subdivision name, lot & block No.

3. NAME ☑ OWNER ☐ AGENT AT TIME OF DRILLING CHECK (✓) ON
Glen McClure
ADDRESS: 1163 Dousman
POST OFFICE: Green Bay, Wisc.

4. Distance in feet from well to nearest: (Record answer in appropriate block)

Building	Sanitary Bldg. Drain		Sanitary Bldg. Sewer		Floor Drain Connected To:		Storm Bldg. Drain		Storm Bldg. S	
	C.I.	Other	C.I.	Other	C.I. Sewer	Other Sewer	C.I.	Other	C.I.	Othe
6										

Street Sewer		Other Sewers		Foundation Drain Connected to:		Sewage Sump		Clearwater Sump	Septic Tank	Holding Tank	Sewage Absorption Unit	
San.	Storm	C.I.	Other	Sewer	Sewage Sump	C.I.	Other		40		Seepage Pit	
				Clearwater Dr.	Clearwater Sump						Seepage Bed	50
											Seepage Trench	

Privy	Pet Waste Pit	Pit: Nonconforming Existing	Subsurface Pumproom Nonconforming Existing	Barn Gutter	Animal Barn Pen	Animal Yard	Silo With Pit	Glass Lined Storage Facility	Silo w/o Pit	Earthen Silage Storage Trench Or Pit
		Well								
		Pump								
		Tank								

Temporary Manure Stack	Watertight Liquid Manure Tank	Solid Manure Storage Structure	Subsurface Gasoline or Oil Tank	Waste Pond or Land Disposal Unit (Specify Type)	Other (Give Description)

5. Well is intended to supply water for: Dwelling

6. DRILLHOLE

Dia. (in.)	From (ft.)	To (ft.)	Dia. (in.)	From (ft.)	To (ft.)
6	Surface	161			

7. CASING, LINER, CURBING AND SCREEN

Dia. (in.)	Material, Weight, Specification & Method of Assembly	From (ft.)	To (ft.)
6	New Black Steel 19.45# T&C A53 US Steel	Surface	61

8. GROUT OR OTHER SEALING MATERIAL

Kind	From (ft.)	To (ft.)
None	Surface	

9. FORMATIONS

Kind	From (ft.)	To (ft.)
Sand & Clay caving	Surface	25
Gravel & Clay	25	61
Black Quartzite Granite	61	161
Water Enters 155-161		

10. TYPE OF DRILLING MACHINE USED

☐ Cable Tool
☒ Rotary-air w/drilling mud
☐ Rotary-w/drilling mud
☐ Rotary-hammer w/drilling mud & air
☐ Rotary-hammer & air
☐ Reverse Rotary
☐ Jetting with Air ☐ Water

Well construction completed on 5/20/76 19

11. MISCELLANEOUS DATA

Yield Test: 2 Hrs. at 30 GPH GPM

Depth from surface to normal water level 10 Ft.

Depth of water level when pumping 155 Ft. Stabilized ☒ Yes ☐ No

Well is terminated 24 inches ☒ above ☐ below final grade

Well disinfected upon completion ☒ Yes ☐ No

Well sealed watertight upon completion ☒ Yes ☐ No

Water sample sent to St Mary's Hospital laboratory on 5/21/76 19

Your opinion concerning other pollution hazards, information concerning difficulties encountered, and data relating to nearby wells, screens, seals, method of finishing the well, amount of cement used in grouting, blasting, etc., should be given on reverse side.

Signature: [signature]
Registered Well Driller

Complete Mail Address: RHINELANDER WELL DRILLING, INC.
600 COUNTRY DRIVE
RHINELANDER, WISCONSIN 54501

WELL CONSTRUCTOR'S REPORT

FORM 3300–15

10

NOTE
WHITE COPY – DIVISION'S COPY
GREEN COPY – DRILLER'S COPY
YELLOW COPY – OWNER'S COPY

STATE OF WISCONSIN
DEPARTMENT OF NATURAL RESOURCES
Box 450
Madison, Wisconsin 53701

COUNTY	CHECK ONE	NAME
Forest	☒ Town ☐ Village ☐ City	Lincoln

LOCATION – ¼ Section	Section	Township	Range
NW–NW¼	6	35N	~~x~~13E

3. OWNER AT TIME OF DRILLING: Otto Nemec

R – Grid or street no. | Street name

ADDRESS: Route 1,

ND – If available subdivision name, lot & block no.

POST OFFICE: Crandon, Wis. 54520

Distance in feet from well to nearest: (Record answer in appropriate block)	BUILDING	SANITARY SEWER C. I.	SANITARY SEWER TILE	FLOOR DRAIN C. I.	FLOOR DRAIN TILE	FOUNDATION DRAIN SEWER CONNECTED	FOUNDATION DRAIN INDEPENDENT	WASTE WATER DR. C. I.	WASTE WATER DR. TILE
	20								

EAR WATER DRAIN C. I.	EAR WATER DRAIN TILE	SEPTIC TANK	PRIVY	SEEPAGE PIT	ABSORPTION FIELD	BARN	SILO	ABANDONED WELL	SINK HOLE
		None							

THER POLLUTION SOURCES (Give description such as dump, quarry, drainage well, stream, pond, lake, etc.)

. Well is intended to supply water for: Mobil Home

. DRILLHOLE

Dia. (in.)	From (ft.)	To (ft.)	Dia. (in.)	From (ft.)	To (ft.)
6	Surface	90			

. CASING, LINER, CURBING, AND SCREEN

Dia. (in.)	Kind and Weight	From (ft.)	To (ft.)
6	New Black Steel 19.45# pr/ft T & C	Surface	50

9. FORMATIONS

Kind	From (ft.)	To
Sand & Gravel	Surface	25
Hard Pan & Boulders	25	50
Highly Crevised Red & Black Granite	50	90
Water enters 70 to 90 feet.		

. GROUT OR OTHER SEALING MATERIAL

Kind	From (ft.)	To (ft.)
None	Surface	

10. TYPE OF DRILLING MACHINE USED

☐ Cable Tool ☐ Direct Rotary ☐ Reverse Rotary
☐ Rotary – air w/drilling mud ☒ Rotary – hammer with drilling mud & air ☐ Jetting with ☐ Air ☐ W

Well construction completed on July 29, 1973 19

1. MISCELLANEOUS DATA

ield test: 14 Hrs. at 7 GPM

epth from surface to normal water level 12 ft.

epth to water level when pumping 85 ft.

Well is terminated ~~x~~ 12 inches ☒ above ☐ below final gr

Well disinfected upon completion ☒ Yes ☐

Well sealed watertight upon completion ☒ Yes ☐

/ater sample sent to St. Mary's Hospital laboratory on: July 28, 1973 19

our opinion concerning other pollution hazards, information concerning difficulties encountered, and data relating to nearby wells, screens, : pe of casing joints, method of finishing the well, amount of cement used in grouting, blasting, sub-surface pumprooms, access pits, etc., sho e given on reverse side.

IGNATURE

Bradley W. Asty Registered Well Driller

COMPLETE MAILADDRESS: RHINELANDER WELL DRILLING, INC.
630 COUNTRY DRIVE
RHINELANDER, WISCONSIN 54501

Please do not write in space below

OLIFORM TEST RESULT	GAS – 24 HRS.	GAS – 48 HRS.	CONFIRMED	REMARKS

EV. 3–71

Well # 1 FR-196-U

State of Wisconsin
Department of Natural Resources
Box 7921
Madison, Wisconsin 53707

NOTE:
White Copy – Division's Copy
Green Copy – Driller's Copy
Yellow Copy – Owner's Copy

WELL CONSTRUCTOR'S REPORT
Form 3300-15 Rev. 12-76

COUNTY: Forest

CHECK (✓) ONE: ☒ Town ☐ Village ☐ City

Name: Nashiville

LOCATION: ¼ Section: SE SW | Section: 28 | Township: 35N | Range: 12E

OR – Grid or Street No. | Street Name

AND – If available subdivision name, lot & block No.

3. NAME ☒ OWNER ☐ AGENT AT TIME OF DRILLING CHECK (✓) ONE: James Devine

ADDRESS: Mole Lake, Wisc.

POST OFFICE

Distance in feet from well to nearest: (Record answer in appropriate block)	Building	Sanitary Bldg. Drain C.I.	Sanitary Bldg. Drain Other	Sanitary Bldg. Sewer C.I.	Sanitary Bldg. Sewer Other	Floor Drain Connected To: C.I. Sewer	Floor Drain Connected To: Other Sewer	Storm Bldg. Drain C.I.	Storm Bldg. Drain Other	Storm Bldg. Sewer C.I.	Storm Bldg. Sewer Other
	6										

Street Sewer	Other Sewers		Foundation Drain Connected to:		Sewage Sump		Clearwater Sump	Septic Tank	Holding Tank	Sewage Absorption Unit	
n.	Storm	C.I.	Other	Sewer	Sewage Sump	C.I.	Other		40		Seepage Pit
				Clearwater Dr.	Clearwater Sump						Seepage Bed 55
											Seepage Trench

vy	Pet Waste Pit	Pit: Nonconforming Existing	Subsurface Pumproom Nonconforming Existing	Barn Gutter	Animal Barn Pen	Animal Yard	Silo With Pit	Glass Lined Storage Facility	Silo w/o Pit	Earthen Silage Storage Trench Or Pit
		Well								
		Pump								
		Tank								

mporary anure ack	Watertight Liquid Manure Tank	Solid Manure Storage Structure	Subsurface Gasoline or Oil Tank	Waste Pond or Land Disposal Unit (Specify Type)	Other (Give Description)

Well is intended to supply water for: Dwelling

DRILLHOLE

Dia. (in.)	From (ft.)	To (ft.)	Dia. (in.)	From (ft.)	To (ft.)
10	Surface	25	6	25	59

CASING, LINER, CURBING AND SCREEN

Dia. (in.)	Material, Weight, Specification & Method of Assembly	From (ft.)	To (ft.)
6 New	Black Steel 19.45# T&C A53 US Steel	Surface	53
6	20-slot Stainless Well Screen	53	59

GROUT OR OTHER SEALING MATERIAL

Kind	From (ft.)	To (ft.)
Neat Cement	Surface	25

9. FORMATIONS

Kind	From (ft.)	To (ft.)
Sand Caving	Surface	24
Sand & Clay Mud	24	53
Dirty Sand & Gravel	53	59
Grey Clay	59	90
Soft Granite (No Water)	90	120

10. TYPE OF DRILLING MACHINE USED

☐ Cable Tool
☐ Rotary-air w/drilling mud
☐ Rotary-w/drilling mud
☐ Rotary-hammer w/drilling mud & air
☒ Rotary-hammer & air
☐ Reverse Rotary
☐ Jetting with Air ☐ Water

Well construction completed on 8/3/77 19

Well is terminated 12 inches ☒ above ☐ below final grade

Well disinfected upon completion ☒ Yes ☐ No

Well sealed watertight upon completion ☒ Yes ☐ No

11. MISCELLANEOUS DATA

Yield Test: 8 Hrs. at 8 GPM

Depth from surface to normal water level 19 Ft.

Depth of water level when pumping 48 Ft. Stabilized ☒ Yes ☐ No

Water sample sent to St Marys Hospital laboratory on 8/11/77 19

Your opinion concerning other pollution hazards, information concerning difficulties encountered, and data relating to nearby wells, screens, seals, method of finishing the well, amount of cement used in grouting, blasting, etc., should be given on reverse side.

Signature

Registered Well Driller

Complete Mail Address
660 COUNTRY DRIVE
RHINELANDER, WISCONSIN 54501

FR-152-U

ELL CONSTRUCTOR'S REPORT

ORM 3300-15

CORRECTED REPORT

NOTE

WHITE COPY – DIVISION'S COPY
GREEN COPY – DRILLER'S COPY
YELLOW COPY – OWNER'S COPY

STATE OF WISCONSIN
DEPARTMENT OF NATURAL RESOURCE
Box 450
Madison, Wisconsin 53701

12 AUG 30 1974

COUNTY	CHECK ONE	NAME
Forest	☒ Town ☐ Village ☐ City	Nashville

LOCATION – ¼ Section	Section	Township	Range	3. OWNER AT TIME OF DRILLING
SE-SW	29	35N	12E	Mrs. Warren Ryan

Grid or street no.	Street name	ADDRESS
		W. 215 N. 10075 Hickory Dr.

(D) If available subdivision name, lot & block no. — POST OFFICE: Colgate, Wis.

Distance in feet from well to nearest: (Record answer in appropriate block)	BUILDING	SANITARY SEWER C. I.	SANITARY SEWER TILE	FLOOR DRAIN C. I.	FLOOR DRAIN TILE	FOUNDATION DRAIN SEWER CONNECTED	FOUNDATION DRAIN INDEPENDENT	WASTE WATER DR. C. I.	WASTE WATER DR. TILE
	10								

REAR WATER DRAIN C. I.	REAR WATER DRAIN TILE	SEPTIC TANK	PRIVY	SEEPAGE PIT	ABSORPTION FIELD	BARN	SILO	ABANDONED WELL	SINK HOLE
		None			None				

OTHER POLLUTION SOURCES (Give description such as dump, quarry, drainage well, stream, pond, lake, etc.)

Well is intended to supply water for: Dwelling

DRILLHOLE

Dia. (in.)	From (ft.)	To (ft.)	Dia. (in.)	From (ft.)	To (ft.)
8	Surface	34			
6	34	83			

CASING, LINER, CURBING, AND SCREEN

Dia. (in.)	Kind and Weight	From (ft.)	To (ft.)
6	New Black Steel 19.18# per/ft	Surface	34
	P.E.		

9. FORMATIONS

Kind	From (ft.)	To (ft.)
Gravel & Clay (Caving)	Surface	25
Granite	25	83
Water enters 68'		

GROUT OR OTHER SEALING MATERIAL

Kind	From (ft.)	To (ft.)
Neat Cement	Surface	34

10. TYPE OF DRILLING MACHINE USED

☐ Cable Tool ☐ Direct Rotary ☐ Reverse Rotary
☐ Rotary – air w/drilling mud ☒ Rotary – hammer with drilling mud & air ☐ Jetting with ☐ Air ☐ Wa

Well construction completed on 5/29/ 19 74

MISCELLANEOUS DATA

eld test: 3 Hrs. at 30 GPH ~~GPM~~

pth from surface to normal water level 8 ft.

pth to water level when pumping 76 ft.

Well is terminated 8 inches ☒ above ☐ below final gra

Well disinfected upon completion ☒ Yes ☐

Well sealed watertight upon completion ☒ Yes ☐

ter sample sent to St. Mary's Hospital laboratory on: June 3, 197-

ur opinion concerning other pollution hazards, information concerning difficulties encountered, and data relating to nearby wells, screens, se e of casing joints, method of finishing the well, amount of cement used in grouting, blasting, sub-surface pumprooms, access pits, etc., shou given on reverse side.

GNATURE

Registered Well Driller

COMP RHINELANDER WELL DRILLING, INC.
680 COUNTRY DRIVE
RHINELANDER, WISCONSIN 54501

Please do not write in space below

LIFORM TEST RESULT	GAS – 24 HRS.	GAS – 48 HRS.	CONFIRMED	REMARKS
V. 3-71 * Corrected Report sent in after telephone Conversation.				

WELL CONSTRUCTOR'S REPORT

FORM 3300-15

13

NOTE AUG 22 1974

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YELLOW COPY – OWNER'S COPY

SEP 19 1974 FR-154

STATE OF WISCONSIN
DEPARTMENT OF NATURAL RESOURCES
Box 450
Madison, Wisconsin 53701

COUNTY	CHECK ONE	NAME
Forest	☒ Town ☐ Village ☐ City	Nashville

LOCATION – ¼ Section	Section	Township	Range
SE-SW	29	35N	12E

– Grid or street no. | Street name

3. OWNER AT TIME OF DRILLING: Floyd K. Howard

ADDRESS: 3803 N. 100th. St.

D – If available subdivision name, lot & block no.

POST OFFICE: Milwaukee, Wis.

Distance in feet from well to nearest: (Record answer in appropriate block)

BUILDING	SANITARY SEWER C. I.	SANITARY SEWER TILE	FLOOR DRAIN C. I.	FLOOR DRAIN TILE	FOUNDATION DRAIN SEWER CONNECTED	FOUNDATION DRAIN INDEPENDENT	WASTE WATER DRAIN C. I.	WASTE WATER DRAIN TILE

REAR WATER DRAIN C. I.	REAR WATER DRAIN TILE	SEPTIC TANK	PRIVY	SEEPAGE PIT	ABSORPTION FIELD	BARN	SILO	ABANDONED WELL	SINK HOLE
				1st. Const.					

OTHER POLLUTION SOURCES (Give description such as dump, quarry, drainage well, stream, pond, lake, etc.)

Well is intended to supply water for: Dwelling

DRILLHOLE

Dia. (in.)	From (ft.)	To (ft.)	Dia. (in.)	From (ft.)	To (ft.)
8	Surface	54			
6"	~~#~~54	63			

CASING, LINER, CURBING, AND SCREEN

Dia. (in.)	Kind and Weight	From (ft.)	To (ft.)
6"	New Black Steel 18.97# per/ft PE	Surface	54
	Open Bottom		

9. FORMATIONS

Kind	From (ft.)	To (ft.)
Gravel & Clay (Caving)	Surface	54
Granite	54	63

GROUT OR OTHER SEALING MATERIAL

Kind	From (ft.)	To (ft.)
Neat Cement	Surface	54

10. TYPE OF DRILLING MACHINE USED

☐ Cable Tool ☐ Direct Rotary ☐ Reverse Rotary
☐ Rotary – air w/drilling mud ☒ Rotary – hammer with drilling mud & air ☐ Jetting with ☐ Air ☐ Wa

Well construction completed on May 29, 1974

Well is terminated 10 inches ☒ above ☐ below final gr

Well disinfected upon completion ☒ Yes ☐

Well sealed watertight upon completion ☒ Yes ☐

MISCELLANEOUS DATA

Yield test: 2 Hrs. at 6 GPM

Depth from surface to normal water level 14 ft.

Depth to water level when pumping 55 ft.

Water sample sent to Madison, Wis. laboratory on: June 3, 197

Your opinion concerning other pollution hazards, information concerning difficulties encountered, and data relating to nearby wells, screens, s- pe of casing joints, method of finishing the well, amount of cement used in grouting, blasting, sub-surface pumprooms, access pits, etc., sho given on reverse side.

SIGNATURE: Robert W. Peterson Registered Well Driller

COMPLETE ADDRESS OF WELL DRILLING FIRM:
~~RHINELANDER WELL DRILLING, INC.~~
680 COUNTRY DRIVE
RHINELANDER, WISCONSIN 54501

Please do not write in space below

COLIFORM TEST RESULT	GAS – 24 HRS.	GAS – 48 HRS.	CONFIRMED	REMARKS

FORM 3-71

WELL CONSTRUCTOR'S REPORT
FORM 3300-15

JUN 20 1974

JUL 11 19

FR-153-U

14

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NOTE
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GREEN COPY – DRILLER'S COPY
YELLOW COPY – OWNER'S COPY

STATE OF WISCONSIN
DEPARTMENT OF NATURAL RESOUR(
Box 450
Madison, Wisconsin 53701

1. COUNTY: Forest

CHECK ONE: [X] Town [ ] Village [ ] City

NAME: Nashville

2. LOCATION – ¼ Section: SE-SW | Section: 29 | Township: 35N | Range: 12E

OR – Grid or street no. | Street name

AND – If available subdivision name, lot & block no.

3. OWNER AT TIME OF DRILLING: Richard Pitts

ADDRESS: Route 1,

POST OFFICE: Crandon, Wis,

4. Distance in feet from well to nearest: (Record answer in appropriate block)

BUILDING	SANITARY SEWER C. I.	SANITARY SEWER TILE	FLOOR DRAIN C. I.	FLOOR DRAIN TILE	FOUNDATION DRAIN SEWER CONNECTED	FOUNDATION DRAIN INDEPENDENT	WASTE WATER C. I.	WASTE WATER T

CLEAR WATER DRAIN C. I.	CLEAR WATER DRAIN TILE	SEPTIC TANK	PRIVY	SEEPAGE PIT	ABSORPTION FIELD	BARN	SILO	ABANDONED WELL	SINK HOLE
				FIRST CONSTRUCTION					

OTHER POLLUTION SOURCES (Give description such as dump, quarry, drainage well, stream, pond, lake, etc.)

5. Well is intended to supply water for: Dwelling

6. DRILLHOLE

Dia. (in.)	From (ft.)	To (ft.)	Dia. (in.)	From (ft.)	To (ft.)
8"	Surface	32			
6	32	143			

7. CASING, LINER, CURBING, AND SCREEN

Dia. (in.)	Kind and Weight	From (ft.)	To (ft.)
6"	New Black Steel 18.97# pr/ft P.E.	Surface	32

8. GROUT OR OTHER SEALING MATERIAL

Kind	From (ft.)	To (ft.)
Neat Cement	Surface	32

9. FORMATIONS

Kind	From (ft.)	To
Gravel & Clay-Caving	Surface	22
Granite	22	143

Water enters 97'

10. TYPE OF DRILLING MACHINE USED

[ ] Cable Tool [ ] Direct Rotary [ ] Reverse Rota
[ ] Rotary – air w/drilling mud [X] Rotary – hammer with drilling mud & air [ ] Jetting with [ ] Air [ ]

Well construction completed on May 29, 1974 19

11. MISCELLANEOUS DATA

Yield test: 2 Hrs. at 15 GPH

Well is terminated 8 inches [X] above [ ] below final g

Depth from surface to normal water level 12 ft.

Well disinfected upon completion [X] Yes [ ]

Depth to water level when pumping 135 ft.

Well sealed watertight upon completion [X] Yes [ ]

Water sample sent to St. Mary's Hospital laboratory on: 6/1 19

Your opinion concerning other pollution hazards, information concerning difficulties encountered, and data relating to nearby wells, screens, ype of casing joints, method of finishing the well, amount of cement used in grouting, blasting, sub-surface pumprooms, access pits, etc., sh e given on reverse side.

SIGNATURE: Robert Webster Registered Well Driller

COMPLETE MAILING ADDRESS
RHINELANDER WELL DRILLING, INC.
680 COUNTRY DRIVE
RHINELANDER, WISCONSIN 54501

Please do not write in space below

COLIFORM TEST RESULT	GAS – 24 HRS.	GAS – 48 HRS.	CONFIRMED	REMARKS

REV. 3-71

L CONSTRUCTOR'S REPORT 15 DEPARTMENT OF RESOURCE DEVELOPMENT Wel

COUNTY: FOREST | CHECK ONE: ☑ Town ☐ Village ☐ City | NAME: NASHVILLE

LOCATION (Number and Street or ¼ section, section, township and range. Also give subdivision name, lot and block numbers when available.)
SE ¼ SEC. 29 T 35 N R 12 E

OWNER AT TIME OF DRILLING
Verna P. Danil

OWNER'S COMPLETE MAIL ADDRESS
RR 1 Box 371 B Crandon, Wis.

Distance in feet from well to nearest: (Record answer in appropriate block)

BUILDING	SANITARY SEWER C. I.	SANITARY SEWER TILE	FLOOR DRAIN C. I.	FLOOR DRAIN TILE	FOUNDATION DRAIN SEWER CONNECTED	FOUNDATION DRAIN INDEPENDENT	WASTE WATER DRA C. I.	WASTE WATER DRA TILE
7						☑		

AR WATER DRAIN C. I.	AR WATER DRAIN TILE	SEPTIC TANK	PRIVY	SEEPAGE PIT	ABSORPTION FIELD	BARN	SILO	ABANDONED WELL	SINK HOLE
		60		80					

ER POLLUTION SOURCES (Give description such as dump, quarry, drainage well, stream, pond, lake, etc.)

Well is intended to supply water for: home

DRILLHOLE

a. (in.)	From (ft.)	To (ft.)	Dia. (in.)	From (ft.)	To (ft.)
6	Surface	61			

CASING, LINER, CURBING, AND SCREEN

a. (in.)	Kind and Weight	From (ft.)	To (ft.)
6	NEW T&C Black steel 19.45	Surface	36
	Granite	36	61

GROUT OR OTHER SEALING MATERIAL

Kind	From (ft.)	To (ft.)
none	Surface	

10. FORMATIONS

Kind	From (ft.)	To (ft.)
Sand	Surface	14
Red clay caving	14	36
Granite	36	61

Well construction completed on 4-7 19 (

Well is terminated 12 inches ☑ above ☐ below final grac

Well disinfected upon completion ☑ Yes ☐

Well sealed watertight upon completion ☑ Yes ☐

MISCELLANEOUS DATA

id test: 4 Hrs. at 18 GPM

pth from surface to normal water level 7 ft.

pth to water level when pumping 45 ft.

ater sample sent to Madison laboratory on: 4-10 19(

ur opinion concerning other pollution hazards, information concerning difficulties encountered, and data relating to nea ells, screens, seals, type of casing joints, method of finishing the well, amount of cement used in grouting, blasting, s rface pumprooms, access pits, etc., should be given on reverse side.

NATURE Daniel Behm
RDB Registered Well Driller

COMPLETE MAIL ADDRESS
R. 2 Rhinelander, Wis.

Please do not write in space below

LIFORM TEST RESULT	GAS — 24 HRS.	GAS — 48 HRS.	CONFIRMED	REMARKS

State of Wisconsin
Department of Natural Resources
Box 7921
Madison, Wisconsin 53707

JUN 30 1977

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NOTE:
White Copy - Division's Copy
Green Copy - Driller's Copy
Yellow Copy - Owner's Copy

WELL CONSTRUCTOR'S REPORT

Form 3300-15 Rev. 12-76

1. COUNTY: FOREST
CHECK (✓) ONE: ☑ Town ☐ Village ☐ City
Name: NASHVILLE

2. LOCATION: ¼ Section: SE | Section: 29 | Township: 35N | Range: 12E
OR - Grid or Street No. | Street Name:
AND - If available subdivision name, lot & block No.

3. NAME ☑ OWNER ☐ AGENT AT TIME OF DRILLING CHECK (✓) ONE
CHARLES W. PUPP
ADDRESS: RT. 2 181 HIGHVIEW DR.
POST OFFICE: CEDARBURG WIS

4. Distance in feet from well: Nearest (Record answer in appropriate block).

Building	Sanitary Bldg. Drain C.I.	Sanitary Bldg. Drain Other	Sanitary Bldg. Sewer C.I.	Sanitary Bldg. Sewer Other	Floor Drain Connected To: C.I. Sewer	Floor Drain Connected To: Other Sewer	Storm Bldg. Drain C.I.	Storm Bldg. Drain Other	Storm Bldg. Se C.I.	Storm Bldg. Se Other
35			60							

Street Sewer San.	Street Sewer Storm	Other Sewers C.I.	Other Sewers Other	Foundation Drain Connected to: Sewer	Foundation Drain Connected to: Sewage Sump	Foundation Drain Connected to: Clearwater Dr.	Foundation Drain Connected to: Clearwater Sump	Sewage Sump C.I.	Sewage Sump Other	Clearwater Sump	Septic Tank	Holding Tank	Sewage Absorption Unit
											75		Seepage Pit Seepage Bed 75 Seepage Trench

Privy	Pet Waste Pit	Pit: Nonconforming Existing	Subsurface Pumproom Nonconforming Existing	Barn Gutter	Animal Barn Pen	Animal Yard	Silo With Pit	Glass Lined Storage Facility	Silo w/o Pit	Earthen Silage Storage Trench Or Pit
		Well Pump Tank								

Temporary Manure Stack	Watertight Liquid Manure Tank	Solid Manure Storage Structure	Subsurface Gasoline or Oil Tank	Waste Pond or Land Disposal Unit (Specify Type)	Other (Give Description)

5. Well is intended to supply water for: COTTAGE

6. DRILLHOLE

Dia. (in.)	From (ft.)	To (ft.)	Dia. (in.)	From (ft.)	To (ft.)
6	Surface	122			

7. CASING, LINER, CURBING AND SCREEN

Dia. (in.)	Material, Weight, Specification & Method of Assembly	From (ft.)	To (ft.)
6	NEW BLK STEEL 19.45 #/FT .280" RECESSED COUPLINGS NKK A53	Surface	116

8. GROUT OR OTHER SEALING MATERIAL

Kind	From (ft.)	To (ft.)
	Surface	

9. FORMATIONS

Kind	From (ft.)	To (ft.)
SAND + GRAVEL	Surface	55
CLAY	55	102
HARD PAN	102	116
GRANITE	116	122

10. TYPE OF DRILLING MACHINE USED
☑ Cable Tool ☐ Rotary-air w/drilling mud ☐ Rotary-w/drilling mud ☐ Rotary-hammer w/drilling mud & air ☐ Rotary-hammer & air ☐ Reverse Rotary ☐ Jetting with Air ☐ Water

Well construction completed on JUNE 22 1977

11. MISCELLANEOUS DATA
Yield Test: / Hrs. at 9 GPM
Depth from surface to normal water level 26 Ft.
Depth of water level when pumping 105 Ft. Stabilized ☑ Yes ☐ No

Well is terminated 12 inches ☑ above ☐ below final grade
Well disinfected upon completion ☑ Yes ☐ No
Well sealed watertight upon completion ☑ Yes ☐ No

Water sample sent to MADISON laboratory on JUNE 23 1977

Your opinion concerning other pollution hazards, information concerning difficulties encountered, and data relating to nearby wells, screens, seals, method of finishing the well, amount of cement used in grouting, blasting, etc., should be given on reverse side.

Signature: Philip Koepsel Registered Well Driller
Complete Mail Address: BOX 1 PITTSOX. WIS.

JUN 20 1974

FR-155-U

WELL CONSTRUCTOR'S REPORT
FORM 3300-15

BEST COPY AVAILABLE

NOTE
WHITE COPY – DIVISION'S COPY
GREEN COPY – DRILLER'S COPY
YELLOW COPY – OWNER'S COPY

STATE OF WISCONSIN
DEPARTMENT OF NATURAL RESOUF
Box 450
Madison, Wisconsin 53701

1. COUNTY: Forest

CHECK ONE: [X] Town [ ] Village [ ] City

NAME: Nashville

2. LOCATION – ¼ Section: NW-SE | Section: 29 | Township: 35N | Range: 12E

OR – Grid or street no. | Street name:

AND – If available subdivision name, lot & block no.:

3. OWNER AT TIME OF DRILLING: Raymond Masiakowski

ADDRESS: 3454 So. 20th. St.

POST OFFICE: Milwaukee, Wis.

4. Distance in feet from well to nearest: (Record answer in appropriate block)

BUILDING	SANITARY SEWER C. I.	SANITARY SEWER TILE	FLOOR DRAIN C. I.	FLOOR DRAIN TILE	FOUNDATION DRAIN SEWER CONNECTED	FOUNDATION DRAIN INDEPENDENT	WASTE WATER C. I.
20							

CLEAR WATER DRAIN C. I.	CLEAR WATER DRAIN TILE	SEPTIC TANK	PRIVY	SEEPAGE PIT	ABSORPTION FIELD	BARN	SILO	ABANDONED WELL	SINK HOLE
			80						

OTHER POLLUTION SOURCES (Give description such as dump, quarry, drainage well, stream, pond, lake, etc.)

5. Well is intended to supply water for: Dwelling

6. DRILLHOLE

Dia. (in.)	From (ft.)	To (ft.)	Dia. (in.)	From (ft.)	To (ft.)
6	Surface	60			

7. CASING, LINER, CURBING, AND SCREEN

Dia. (in.)	Kind and Weight	From (ft.)	To (ft.)
6"	New Black Steel 19.45# per/ft T & C	Surface	42

9. FORMATIONS

Kind	From (ft.)	T
Sand & Clay (Caving)	Surface	2
Clay	26	4
Crevised Granite	42	6
Water Enters 44-60'		

8. GROUT OR OTHER SEALING MATERIAL

Kind	From (ft.)	To (ft.)
None	Surface	

10. TYPE OF DRILLING MACHINE USED

[ ] Cable Tool [ ] Direct Rotary [ ] Reverse Ro
[ ] Rotary – air w/drilling mud [X] Rotary – hammer with drilling mud & air [ ] Jetting with Air [ ]

Well construction completed on: May 21, 197

11. MISCELLANEOUS DATA

Yield test: 2 Hrs. at 6 GPM

Well is terminated 8 inches [X] above [ ] below final

Depth from surface to normal water level: 6 ft.

Well disinfected upon completion [X] Yes [ ]

Depth to water level when pumping: 55 ft.

Well sealed watertight upon completion [X] Yes [ ]

Water sample sent to ### Madison, Wis. laboratory on: May 22, 1

Your opinion concerning other pollution hazards, information concerning difficulties encountered, and data relating to nearby wells, screen type of casing joints, method of finishing the well, amount of cement used in grouting, blasting, sub-surface pumprooms, access pits, etc., s be given on reverse side.

SIGNATURE: Robert Webster Registered Well Driller

COMPLETE WITH ADDRESS:
RHINELANDER WELL DRILLING, INC.
680 COUNTRY DRIVE
RHINELANDER, WISCONSIN 54501

Please do not write in space below

COLIFORM TEST RESULT	GAS – 24 HRS.	GAS – 48 HRS.	CONFIRMED	REMARKS

REV. 3-71

FEB 18 1976

LA-E

ELL CONSTRUCTOR'S REPORT

ORM 3300-15

Jan 29 1976

NOTE
WHITE COPY – DIVISION'S COPY
GREEN COPY – DRILLER'S COPY
YELLOW COPY – OWNER'S COPY

STATE OF WISCONSIN
DEPARTMENT OF NATURAL RESOURCES
Box 450
Madison, Wisconsin 53701

COUNTY: Langlade

CHECK ONE: [X] Town [ ] Village [ ] City

NAME: Ainsworth

LOCATION – ¼ Section: NW-NE | Section: 13 | Township: 34N | Range: 12E

3. OWNER AT TIME OF DRILLING: Anton Schriendl

– Grid or street no. | Street name

ADDRESS: Pearson, Wisc.

D – If available subdivision name, lot & block no.

POST OFFICE

Distance in feet from well to nearest: (Record answer in appropriate block)	BUILDING	SANITARY SEWER C. I.	SANITARY SEWER TILE	FLOOR DRAIN C. I.	FLOOR DRAIN TILE	FOUNDATION DRAIN SEWER CONNECTED	FOUNDATION DRAIN INDEPENDENT	WASTE WATER DR C. I.	WASTE WATER DR TIL
	6'	30'							

EAR WATER DRAIN C. I.	EAR WATER DRAIN TILE	SEPTIC TANK	PRIVY	SEEPAGE PIT	ABSORPTION FIELD	BARN	SILO	ABANDONED WELL	SINK HOLE
		55'			70'				

THER POLLUTION SOURCES (Give description such as dump, quarry, drainage well, stream, pond, lake, etc.)

Well is intended to supply water for: Dwelling

DRILLHOLE

Dia. (in.)	From (ft.)	To (ft.)	Dia. (in.)	From (ft.)	To (ft.)
6	Surface	163			

CASING, LINER, CURBING, AND SCREEN

Dia. (in.)	Kind and Weight	From (ft.)	To (ft.)
6	New Black Steel 19.45# T.&C. A53 US Steel	Surface	43

9. FORMATIONS

Kind	From (ft.)	To
Caving Sand & Clay	Surface	43
Black Quaritzite Granite	43	163
Water Enters	95'	

GROUT OR OTHER SEALING MATERIAL

Kind	From (ft.)	To (ft.)
None	Surface	

10. TYPE OF DRILLING MACHINE USED

[ ] Cable Tool [ ] Direct Rotary [ ] Reverse Rotar
[ ] Rotary – air w/drilling mud [X] Rotary – hammer with drilling mud & air [ ] Jetting with [ ] Air [ ] W

Well construction completed on 5/14/ 1975

Well is terminated 8 inches [X] above [ ] below final g

Well disinfected upon completion [X] Yes [ ]

Well sealed watertight upon completion [X] Yes [ ]

1. MISCELLANEOUS DATA

Field test: 24 Hrs. at 1½ GPM

epth from surface to normal water level 6 ft.

epth to water level when pumping 150 ft.

ater sample sent to St. Marys Hospital laboratory on: 1/17/76 19

our opinion concerning other pollution hazards, information concerning difficulties encountered, and data relating to nearby wells, screens, pe of casing joints, method of finishing the well, amount of cement used in grouting, blasting, sub-surface pumprooms, access pits, etc., sho given on reverse side.

GNATURE

Registered Well Driller

COMPLETE MAIL ADDRESS
RHINELANDER WELL DRILLING, INC.
680 COUNTRY DRIVE
RHINELANDER, WISCONSIN 54501

Please do not write in space below

OLIFORM TEST RESULT	GAS – 24 HRS.	GAS – 48 HRS.	CONFIRMED	REMARKS

EV 3-71

Fr-5

State of Wisconsin
Department of Natural Resources
Box 7921
Madison, Wisconsin 53707

NOTE:
White Copy - Division's Copy
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Yellow Copy - Owner's Copy

WELL CONSTRUCTOR'S REPORT
Form 3300-15 Rev. 12-76

19 ... 3 1980.

1. COUNTY: Forest
CHECK (✓) ONE: ☒ Town ☐ Village ☐ City
Name: Lincoln

2. LOCATION: ¼ Section: SE¼ of NW¼ Section: 32 Township: 35 Range: 13E
OR - Grid or Street No. Street Name: NEAR CENTER OF S½ of N½ of Section 32
AND - If available subdivision name, lot & block No.

3. NAME ☒ OWNER ☐ AGENT AT TIME OF DRILLING CHECK (✓ ONE)
Exxon Minerals Co., U.S.A. WELL #1
ADDRESS
655 Washington Street PERMAN. WELL
POST OFFICE
Rhinelander, WI 54501 #46401

4. Distance in feet from well to nearest: (Record answer in appropriate block)

Building	Sanitary Bldg. Drain C.I.	Sanitary Bldg. Drain Other	Sanitary Bldg. Sewer C.I.	Sanitary Bldg. Sewer Other	Floor Drain Connected To: C.I. Sewer	Floor Drain Connected To: Other Sewer	Storm Bldg. Drain C.I.	Storm Bldg. Drain Other	Storm Bldg. S C.I.	Storm Bldg. S Other
-	-	-	-	-	-	-	-	-	-	-

Street Sewer San.	Street Sewer Storm	Other Sewers C.I.	Other Sewers Other	Foundation Drain Connected to: Sewer / Clearwater Or.	Sewage Sump / Clearwater Sump	Sewage Sump C.I.	Sewage Sump Other	Clearwater Sump	Septic Tank	Holding Tank	Sewage Absorption Unit: Seepage Pit / Seepage Bed / Seepage Trench
-	-	-	-	/ /	/ /	-	-	-	-	-	/ / /

Privy	Pet Waste Pit	Pit: Nonconforming Existing: Well / Pump / Tank	Subsurface Pump or nom Nonconforming Existing	Barn Gutter	Animal Barn Pen	Animal Yard	Silo With Pit	Glass Lined Storage Facility	Silo w/o Pit	Earthen Silage Storage Trench Or Pit
-	-	/ / /	-	-	-	-	-	-	-	-

Temporary Manure Stack	Watertight Liquid Manure Tank	Solid Manure Storage Structure	Subsurface Gasoline or Oil Tank	Waste Pond or Land Disposal Unit (Specify Type)	Other (Give Description)
-	-	-	-	-	None FOREST Co. INDUST. #1

5. Well is intended to supply water for:
Pump Test & Supply Well

6. DRILLHOLE

Dia. (in.)	From (ft.)	To (ft.)	Dia. (in.)	From (ft.)	To (ft.)
23	Surface	110	17	110	340

7. CASING, LINER, CURBING AND SCREEN

Dia. (in.)	Material, Weight, Specification & Method of Assembly	From (ft.)	To (ft.)
18	70.59# new black P.E. casing steel. ASTMA-53 Grade B. Mfg. LaBarge, Inc.	Surface	110
12	49.56# new black P.E. casing steel ASTM A-53 Grade B. Mfg. LaBarge, Inc.	surface	to 152
12	S.S. Well Screen	152	258'3"
12	Casing (Same as Above	258'3"	301'5"
12	S.S. Well Screen	301'5"	321'9"
12	Casing (Same as Above)	321'9"	340'

8. GROUT OR OTHER SEALING MATERIAL

Kind	From (ft.)	To (ft.)
Pressure Cement Grout between 23 hole & 18" casing	from Surface	to 110'
Gravel Pack between 12" casing & screen & 17" hole & 18" casing.	Surface	to 340'

9. FORMATIONS

Kind	From (ft.)	To (ft.
See samples sent to: Geological & Natural History Survey 1815 University Avenue University of Wisconsin Madison, WI 53706	Surface	

SEE ATTACHED SHEET FOR GEOLOGIC LOG OF WELL

APPROVAL DATE: APRIL 29, 1980

FILE LOCATION: CRANDON

CC: To STATE GEOLOGIST

10. TYPE OF DRILLING MACHINE USED
☐ Cable Tool ☐ Rotary-air w/drilling mud ☒ Rotary-w/drilling mud ☐ Rotary-hammer w/drilling mud & air ☐ Rotary-hammer & air ☒ Reverse Rotary ☐ Jetting with Air Water

11. MISCELLANEOUS DATA
Yield Test: 3 weeks Hrs. at 1430 GPM
Depth from surface to normal water level 110' Ft.
Depth of water level when pumping 1180' Ft. Stabilized ☒ Yes ☐ No
Water sample sent to 4 Spec. Cap. = 20.4 gpm/ft. State took care of. laboratory on 19

Well construction completed on June 13, 19 80
Well is terminated 36" inches ☒ above ☐ below final grade
Well disinfected upon completion ☒ Yes ☐ No
Well sealed watertight upon completion ☒ Yes ☐ No

Your opinion concerning other pollution hazards, information concerning difficulties encountered, and data relating to nearby wells, screens, seals, method of finishing the well, amount of cement used in grouting, blasting, etc., should be given on reverse side.

Signature: Alan Lang
Registered Well Driller

Complete Mail Address: Alan Lang Well & Pump, Inc.
7514 Stettin Drive, Wausau, WI 54401

Fr-56

ALAN LANG WELL & PUMP INC.

OCT 6

7514 STETTIN DRIVE - WAUSAU, WI 54401
715/842-4906 845-7084

driller's descrip

October 2, 1980

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

Attention: Eric Imhof
Subject: Exxon Well description.

0-2½	Loose brown, silty, fine to medium sand
2½' - 32	Fine & coarse gravel & cobbles
32 - 64	Fine & coarse sand & gravel, silt, cobbles & few boulders
64 - 82½	Dense brown, fine sand & silt, also traces of coarse gravel & sand
82½ - 89	Very dense gray brown, medium to coarse sand, some fine to med. gravel, trace of silt
89 - 100	Very dense, green-black to dark brown organic silt, some clay, trace fine gr
100 - 107½	Very dense, brown, fine to coarse gravelly, fine to coarse sand, trace of s
107½ - 115	Very dense, brown, fine to coarse gravel & fine to coarse sand, trace of si to frequent cobbles
115 - 125	Very dense, red-brown, silty, fine to coarse sand, some fine to coarse grav trace of clay to fine to coarse sand, some silt, trace to some fine to coar gravel, occasional frequent cobbles.
125 - 165	Very dense, red-brown, silty, fine to coarse sand, some fine to coarse grav trace clay to fine to coarse sand, some silt, trace to some fine & coarse gravel, occasional to frequent cobbles
165 - 186	Very dense, red-brown to brown, fine to coarse sand, some silt, trace to so fine gravel, trace clay, frequent cobbles.
186 - 192½	Very dense, red-brown to brown fine to coarse sand, some silt, trace to som fine gravel, trace clay, frequent cobbles
192½ - 202	Gravel & cobbles
202 - 218	Very dense, brown, fine to coarse sand to fine sand, trace silt, (fineness increasing with depth).

Fr-5

ALAN LANG WELL & PUMP INC.

driller's desc

7514 STETTIN DRIVE - WAUSAU, WI 54401
715/842-4996 845-3084

218' - 237½	Very dense, brown, fine to coarse sand to fine sand, trace silt
237½' - 241	Very dense, fine sandy silt
241 - 247½	Very dense, brown, silty fine sand, trace of clay.
247½ - 252½	Very dense, brown fine sandy silt
252½ - 266½	Very dense, brown to red-brown silty fine to coarse sand, trace fine gravel, trace clay to fine to coarse gravelly fine to coarse sand, some silt, occasional to frequent cobbles & boulders.
266½ - 300	Very dense, brown to red-brown, silty fine to coarse sand, trace fine gravel, trace clay to fine to coarse gravelly fine to coarse sand, some silt, occasional to frequent cobbles & boulders.
300 - 307½	Very dense, brown to red-brown, silty fine to coarse sand, trace fine gra trace clay to fine to coarse gravelly fine to coarse sand, some silt, occasional to frequent cobbles & boulders
307½ - 315	Very dense, brown silt, some fine sand to fine to coarse sand & silt, trac fine gravel
315 - 340	Red-brown and green, highly weathered to weathered metavolcanic TUFF.

I hope that this will help you and if you have any more questions, please call us.
715-848-1312

Thank You,
ALAN LANG WELL & PUMP, INC.

Alan F. Lang,
Corporate President

State of Wisconsin
Department of Natural Resources
Private Water Supply
Box 7921
Madison, Wisconsin 53707

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WELL CONSTRUCTOR'S REPORT

Form 3300–15 Rev. 2-79

JUL 6 1981

1. COUNTY ~~SE NW~~ Forest | CHECK (✓) ONE: ☒ Town ☐ Village ☐ City | Name Lincoln

2. LOCATION | ¼ Section or Gov't. Lot: SE NW | Section: 19 | Township: 35N | Range: 13E

3. NAME ☒ OWNER ☐ AGENT AT TIME OF DRILLING CHECK (✓): Mr. Conrad Schodorf

OR – Grid or Street No. | Street or Road Name

ADDRESS: 831 De Pere St.

AND – If available subdivision name, lot & block No.

POST OFFICE: Menasha, Misc. ZIP CODE: 54952

4. Distance in feet from well to nearest: (Record answer in appropriate block)

Building	Sanitary Bldg. Drain	Sanitary Bldg. Sewer	Floor Drain Connected To:	Storm Bldg. Drain	Storm Bldg
TEST Construction ON LOT	C.I. Other	Other	C.I. Sewer / Other Sewer	C.I. / Other	C.I. / O:

Street Sewer: San.	Storm	Other Sewers: C.I.	Other	Foundation Drain Connected to: Sewer / Clearwater Or.	Sewage Sump / Clearwater Sump	Sewage Sump: C.I.	Other	Clearwater Sump	Septic Tank	Holding Tank	Sewage Absorption Unit: ☐ Seepage Pit ☐ Seepage Bed ☐ Seepage Trench	Manure Hopp Retention or Pnuematic Ta

Privy	Pet Waste Pit	Pit: Nonconforming Existing: ☐ Well ☐ Pump ☐ Tank	Subsurface Pumproom Nonconforming Existing	Barn Gutter	Animal Barn Pen	Animal Yard	Silo With Pit	Glass Lined Storage Facility	Silo w/o Pit	Earthen Silage Storage Trench Or Pit	Earthen Manure

Temporary Manure Stack or Platform	Watertight Liquid Manure Tank or Basin	Manure Pressure Pipe	Subsurface Gasoline or Oil Tank	Waste Pond or Land Disposal Unit (Specify Type)	Manure Storage Basin: ☐ Concrete Floor Only ☐ Concrete Floor and Partial Concrete Walls	Other (Describe)

5. Well is intended to supply water for: Dwelling

6. DRILLHOLE

Dia. (in.)	From (ft.)	To (ft.)	Dia. (in.)	From (ft.)	To (ft.)
6	Surface	102			

7. CASING, LINER, CURBING AND SCREEN

Dia. (in.)	Material, Weight, Specification Mfg. & Method of Assembly	From (ft.)	To (ft.)
6	New Black Steel 19.00# SE 453 US Steel	Surface	74

8. GROUT OR OTHER SEALING MATERIAL

Kind	From (ft.)	To (ft.)
None	Surface	

9. FORMATIONS

Kind	From (ft.)	To (ft.)
Caving Clay & Gravel	Surface	1.3
Sand & Clay Mud	1.3	71
Gravel & Clay	71	74
Highly Fractured Granite	74	102

10. TYPE OF DRILLING MACHINE USED

☐ Cable Tool
☐ Rotary-air w/drilling mud
☐ Rotary-w/drilling mud
☒ Rotary-hammer w/drilling mud & air
☐ Rotary-hammer & air
☐ Reverse Rotary
☐ Jetting with: ☐ Air ☐ Water

Well construction completed on 6/29/81 19__

11. MISCELLANEOUS DATA

Yield Test: 2 Hrs. at 10 GPM

Depth from surface to normal water level 28 Ft.

Depth of water level when pumping 70 Ft. Stabilized ☒ Yes ☐ No

Well is terminated 12 inches ☒ above ☐ below final grade

Well disinfected upon completion ☒ Yes ☐ No

Well sealed watertight upon completion ☒ Yes ☐ No

Water sample sent to Madison laboratory on 6/29/81 19__

Your opinion concerning other pollution hazards, information concerning difficulties encountered, and data relating to nearby wells, screens, seals, method finishing the well, amount of cement used in grouting, blasting, etc., should be given on reverse side.

Signature

Registered Well Driller

Business Name and Address: RHINELANDER WELL DRILLING, INC.
680 COUNTRY DRIVE
RHINELANDER, WISCONSIN 54501

State of Wisconsin
Department of Natural Resources
Private Water Supply
Box 7921
Madison, Wisconsin 53707

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WELL CONSTRUCTOR'S REPORT

Form 3300–15 Rev. 2-79

JUN 14 1982

1. COUNTY: Forest
CHECK (✓) ONE: ☒ Town ☐ Village ☐ City Name: Lincoln

2. LOCATION: ¼ Section or Gov't. Lot: Govt. lot 2 | Section: 6 | Township: 35N | Range: I3E
OR – Grid or Street No. | Street or Road Name:
AND – If available subdivision name, lot & block No.:

3. NAME ☒ OWNER ☐ AGENT AT TIME OF DRILLING CHECK (✓): Stan Hayes
ADDRESS: 936 Hillcrest
POST OFFICE: Horicon Wis. ZIP CODE: 53032

4. Distance in feet from well to nearest: (Record answer in appropriate block)

Building	Sanitary Bldg. Drain C.I.	Sanitary Bldg. Drain Other	Sanitary Bldg. Sewer C.I.	Sanitary Bldg. Sewer Other	Floor Drain Connected To: C.I. Sewer	Other Sewer	Storm Bldg. Drain C.I.	Storm Bldg. Drain Other	Storm Bldg. C.I.
8									

Street Sewer: San. | Storm | C.I. | Other
Other Sewers: C.I. | Other
Foundation Drain Connected to: Sewer | Sewage Sump | Clearwater Dr. | Clearwater Sump
Sewage Sump: C.I. | Other
Clearwater Sump
Septic Tank: 60
Holding Tank
Sewage Absorption Unit: ☐ Seepage Pit ☒ Seepage Bed 70 ☐ Seepage Trench
Manure Hoc Retention o Pnuematic T

Privy | Pet Waste Pit
Pit: Nonconforming Existing: Well | Pump | Tank
Subsurface Pumproom: Nonconforming Existing
Barn Gutter | Animal Barn Pen | Animal Yard | Silo With Pit | Glass Lined Storage Facility | Silo w/o Pit | Earthen Silage Storage Trench Or Pit | Earthe Manur

Temporary Manure Stack or Platform | Watertight Liquid Manure Tank or Basin | Manure Pressure Pipe | Subsurface Gasoline or Oil Tank | Waste Pond or Land Disposal Unit (Specify Type)
☐ Manure Storage Basin ☐ Concrete Floor Only ☐ Concrete Floor and Partial Concrete Walls
Other (Describe)

5. Well is intended to supply water for: Dwelling

6. DRILLHOLE

Dia. (in.)	From (ft.)	To (ft.)	Dia. (in.)	From (ft.)	To (ft.)
6	Surface	202			

7. CASING, LINER, CURBING AND SCREEN

Dia. (in.)	Material, Weight, Specification Mfg. & Method of Assembly	From (ft.)	To (ft.)
6	6I½ ft PE A53 US steel I9.00# new black	Surface	6I½

8. GROUT OR OTHER SEALING MATERIAL

Kind	From (ft.)	To (ft.)
None	Surface	

9. FORMATIONS

Kind	From (ft.)	To
clay and gravel (caving)	Surface	47
Decomposed granite	47	60
black and red granite	60	202

10. TYPE OF DRILLING MACHINE USED
☐ Cable Tool ☐ Rotary-air w/drilling mud ☐ Rotary-w/drilling mud ☐ Rotary-hammer w/drilling mud & air ☒ Rotary-hammer & air ☐ Reverse Rotary ☐ Jetting with ☐ Air ☐ Water

Well construction completed on 5-24-82 19

11. MISCELLANEOUS DATA
Yield Test: I Hrs. at 25 GPM
Depth from surface to normal water level 15 Ft.
Depth of water level when pumping 200 Ft. Stabilized ☒ Yes ☐ No

Well is terminated 12 inches ☒ above ☐ below final grade
Well disinfected upon completion ☒ Yes ☐ No
Well sealed watertight upon completion ☒ Yes ☐ No

Water sample sent to WA Dison laboratory on 5-24-82 19

Your opinion concerning other pollution hazards, information concerning difficulties encountered, and data relating to nearby wells, screens, seals, method finishing the well, amount of cement used in grouting, blasting, etc., should be given on reverse side.

Signature: Burt Webster
Registered Well Driller

Business Name and Complete Mailing Address:
RHINELANDER WELL DRILLING, INC.
680 COUNTRY DRIVE
RHINELANDER, WISCONSIN 54501

[redacted]

Box 7921
Madison, Wisconsin 53707

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WELL CONSTRUCTOR'S REPORT
Form 3300-15 Rev. 2-79

JAN 19 1981

1. COUNTY: Forest
CHECK (✓) ONE: ☒ Town ☐ Village ☐ City
Name: Lincoln

2. LOCATION: ¼ Section or Gov't. Lot: Govt. Lot-2 | Section: 6 | Township: 35N | Range: 13E
OR – Grid or Street No. | Street or Road Name
AND – If available subdivision name, lot & block No.

3. NAME ☒ OWNER ☐ AGENT AT TIME OF DRILLING CHECK (✓): Mr. & Mrs. Al Torborg
ADDRESS: Clintonville, Wisc. 54929
POST OFFICE | ZIP CODE

4. Distance in feet from well to nearest: (Record answer in appropriate block)

Building	Sanitary Bldg. Drain C.I.	Sanitary Bldg. Drain Other	Sanitary Bldg. Sewer C.I.	Sanitary Bldg. Sewer Other	Floor Drain Connected To: C.I. Sewer	Floor Drain Connected To: Other Sewer	Storm Bldg. Drain C.I.	Storm Bldg. Drain Other	Storm Bldg. C.I.	Storm Bldg. C
10										

Street Sewer San.	Street Sewer Storm	Other Sewers C.I.	Other Sewers Other	Foundation Drain Connected to: Sewer	Foundation Drain Connected to: Sewage Sump	Sewage Sump C.I.	Sewage Sump Other	Clearwater Sump	Septic Tank	Holding Tank	Sewage Absorption Unit	Manure Hold Retention or Pneumatic T.
				Clearwater Dr.	Clearwater Sump				40		Seepage Pit Seepage Bed 50 Seepage Trench	

Privy	Pet Waste Pit	Pit: Nonconforming Existing	Subsurface Pumproom Nonconforming Existing	Barn Gutter	Animal Barn Pen	Animal Yard	Silo With Pit	Glass Lined Storage Facility	Silo w/o Pit	Earthen Silage Storage Trench Or Pit	Earthen Manure
		Well Pump Tank									

Temporary Manure Stack or Platform	Watertight Liquid Manure Tank or Basin	Manure Pressure Pipe	Subsurface Gasoline or Oil Tank	Waste Pond or Land Disposal Unit (Specify Type)	Manure Storage Basin Concrete Floor Only Concrete Floor and Partial Concrete Walls	Other (Describe)

5. Well is intended to supply water for: Dwelling

6. DRILLHOLE

Dia. (in.)	From (ft.)	To (ft.)	Dia. (in.)	From (ft.)	To (ft.)
6	Surface	150			

7. CASING, LINER, CURBING AND SCREEN

Dia. (in.)	Material, Weight, Specification Mfg. & Method of Assembly	From (ft.)	To (ft.)
6	New Black Steel 19.00# PE A53 US Steel	Surface	40

8. GROUT OR OTHER SEALING MATERIAL

Kind	From (ft.)	To (ft.)
None	Surface	

9. FORMATIONS

Kind	From (ft.)	To (ft.)
Caving Gravel & Clay	Surface	40
Red Granite	40	150
Water Enters 40-41ft		

10. TYPE OF DRILLING MACHINE USED
☐ Cable Tool ☐ Rotary-hammer w/drilling mud & air ☐ Jetting with
☐ Rotary-air w/drilling mud ☒ Rotary-hammer & air ☐ Air ☐ Water
☐ Rotary-w/drilling mud ☐ Reverse Rotary

Well construction completed on 12/12/80 19__

11. MISCELLANEOUS DATA
Yield Test: 6 Hrs. at 40gph GPM
Depth from surface to normal water level 13 Ft.
Depth of water level when pumping 150 Ft. Stabilized ☒ Yes ☐ No

Well is terminated 18 inches ☒ above ☐ below final grade
Well disinfected upon completion ☒ Yes ☐ No
Well sealed watertight upon completion ☒ Yes ☐ No

Water sample sent to Madison laboratory on 12/12/80 19__

Your opinion concerning other pollution hazards, information concerning difficulties encountered, and data relating to nearby wells, screens, seals, method of finishing the well, amount of cement used in grouting, blasting, etc., should be given on reverse side.

Signature: [signature]
Registered Well Driller

Business Name and Complete Mailing Address:
RHINELANDER WELL DRILLING, IN
660 COUNTRY DRIVE
RHINELANDER, WISCONSIN 54501

State of Wisconsin
Department of Natural Resources
Private Water Supply
Box 7921
Madison, Wisconsin 53707

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WELL CONSTRUCTOR'S REPORT
Form 3300-15 Rev. 5-85

OCT 13 1986

1. COUNTY: Forest
CHECK (✓) ONE: ☑ Town ☐ Village ☐ City
Name: Nashville

¼ Section or Gov't. Lot | Section | Township | Range
2. LOCATION: NW NW | 1 | 35N | 12E ✓

OR – Grid or Street No. Street or Road Name

AND – If available subdivision name, lot & block No.

3. NAME ☒ OWNER ☐ AGENT AT TIME OF DRILLING CHECK (✓): Douglas Hayes
ADDRESS: Route 1, Box 471
POST OFFICE: Crandon, Wis.
ZIP CODE: 54520

4. Distance in feet from well to nearest: (Record answer in appropriate block)

Building	Sanitary Bldg. Drain		Sanitary Bldg. Sewer		Floor Drain Connected To:		Storm Bldg. Drain		Storm Bldg.
	C.I.	Other	C.I.	Other	C.I. Sewer	Other Sewer	C.I.	Other	C.I.	O:
8'										

Street Sewer			Other Sewers		Foundation Drain Connected to:			Sewage Sump		Clearwater Sump	Septic Tank	Holding Tank	Sewage Absorption Unit	Manure Hood Retention or Pneumatic Tar
San.	Storm	C.I.	Other		Sewer	Sewage Sump	C.I.	Other					Seepage Pit	
					Clearwater Dr.	Clearwater Sump					1st		Seepage Bed 1st	
													Seepage Trench	

Privy	Pet Waste Pit	Pit: Nonconforming Existing	Subsurface Pumproom	Barn Gutter	Animal Barn Pen	Animal Yard	Silo With Pit	Glass Lined Storage Facility	Silo w/o Pit	Earthen Silage Storage Trench Or Pit	Earthen Manure
		Well	Nonconforming Existing								
		Pump									
		Tank									

Temporary Manure Stack or Platform	Watertight Liquid Manure Tank or Basin	Manure Pressure Pipe	Subsurface Gasoline or Oil Tank	Waste Pond or Land Disposal Unit (Specify Type)	Manure Storage Basin	Other (Describe)
					Concrete Floor Only	
					Concrete Floor and Partial Concrete Walls	

5. Well is intended to supply water for: Dwelling

6. DRILLHOLE

Dia. (in.)	From (ft.)	To (ft.)	Dia. (in.)	From (ft.)	To (ft.)
6	Surface	122			

7. CASING, LINER, CURBING AND SCREEN

Dia. (in.)	Material, Weight, Specification Mfg. & Method of Assembly	From (ft.)	To (ft.)
6	Black iron pipe PE 18.97 lbs/ft. US Steel	Surface	56

8. GROUT OR OTHER SEALING MATERIAL

Kind	From (ft.)	To (ft.)
	Surface	

9. FORMATIONS

Kind	From (ft.)	To (ft.)
Caving Sand	Surface	26
Gravel & Clay	26	56
Granite	56	122

10. TYPE OF DRILLING MACHINE USED
☐ Cable Tool ☐ Rotary-air w/drilling mud ☐ Rotary-w/drilling mud
☐ Rotary-hammer w/drilling mud & air ☒ Rotary-hammer & air ☐ Reverse Rotary
☐ Jetting with ☐ Air ☐ Water

11. MISCELLANEOUS DATA
Yield Test: 1 Hrs. at 3 GPM
Depth from surface to normal water level 20 Ft.
Depth of water level when pumping 117 Ft. Stabilized ☒ Yes ☐ No

Well construction completed on Sept. 3 1986
Well is terminated 12 inches ☒ above ☐ below final grade
Well disinfected upon completion ☒ Yes ☐ No
Well sealed watertight upon completion ☒ Yes ☐ No

Water sample sent to Marathon Co. laboratory on Sept. 5 1986

Your opinion concerning other pollution hazards, information concerning difficulties encountered, and data relating to nearby wells, screens, seals, method of finishing the well, amount of cement used in grouting, blasting, etc., should be given on reverse side.

Signature of Registered Well Driller

Business Name and Complete Mailing Address
RHINELANDER WELL DRILLING, INC.
680 COUNTRY DRIVE
RHINELANDER, WISCONSIN 54501

State of Wisconsin
Department of Natural Resources
Private Water Supply
Box 7921
Madison, Wisconsin 53707

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NOTE:
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WELL CONSTRUCTOR'S REPORT
Form 3300-15 Rev. 2-79

JUL 7 1983

1. COUNTY: Langlade
CHECK (✓) ONE: ☒ Town ☐ Village ☐ City
Name: Ainsworth

2. LOCATION: ¼ Section or Gov't. Lot: SW | Section: 28 | Township: 34N | Range: 12E
OR – Grid or Street No. | Street or Road Name: Forest Rd.
AND – If available subdivision name, lot & block No.

3. NAME ☑ OWNER ☐ AGENT AT TIME OF DRILLING CHECK (✓ O
Don West
ADDRESS
POST OFFICE: PEARSON
ZIP CODE

4. Distance in feet from well to nearest: (Record answer in appropriate block)

Building	Sanitary Bldg. Drain		Sanitary Bldg. Sewer		Floor Drain Connected To:		Storm Bldg. Drain		Storm Bldg.	
	C.I.	Other	C.I.	Other	C.I. Sewer	Other Sewer	C.I.	Other	C.I.	Ot
10										

Street Sewer		Other Sewers		Foundation Drain Connected to:		Sewage Sump		Clearwater Sump	Septic Tank	Holding Tank	Sewage Absorption Unit	Manure Hopp Retention or Pneumatic Ta.
San.	Storm	C.I.	Other	Sewer	Sewage Sump	C.I.	Other		68		Seepage Pit	
				Clearwater Dr.	Clearwater Sump						Seepage Bed 70	
											Seepage Trench	

Privy	Pet Waste Pit	Pit: Nonconforming Existing	Subsurface Pumproom Nonconforming Existing	Barn Gutter	Animal Barn Pen	Animal Yard	Silo With Pit	Glass Lined Storage Facility	Silo w/o Pit	Earthen Silage Storage Trench Or Pit	Earthen Manure
		Well									
		Pump									
		Tank									

Temporary Manure Stack or Platform	Watertight Liquid Manure Tank or Basin	Manure Pressure Pipe	Subsurface Gasoline or Oil Tank	Waste Pond or Land Disposal Unit (Specify Type)	Manure Storage Basin / Concrete Floor Only / Concrete Floor and Partial Concrete Walls	Other (Describe)

5. Well is intended to supply water for: Private home.

6. DRILLHOLE

Dia. (in.)	From (ft.)	To (ft.)	Dia. (in.)	From (ft.)	To (ft.)
9	Surface	54	6	54	165

7. CASING, LINER, CURBING AND SCREEN

Dia. (in.)	Material, Weight, Specification Mfg. & Method of Assembly	From (ft.)	To (ft.)
6	Astm A120 18.97	Surface	54
	Union Steel Welded		

8. GROUT OR OTHER SEALING MATERIAL

Kind	From (ft.)	To (ft.)
drilling mud	Surface	54

9. FORMATIONS

Kind	From (ft.)	To (ft.)
dirty sand	Surface	30
Stones + clay	30	54
Granit Rock	54	165
Blue + Black		

10. TYPE OF DRILLING MACHINE USED

☐ Cable Tool ☒ Rotary-hammer w/drilling mud & air ☐ Jetting with
☐ Rotary-air w/drilling mud ☐ Rotary-hammer & air ☐ Air ☐ Water
☐ Rotary-w/drilling mud ☐ Reverse Rotary

Well construction completed on 6-29 1983

11. MISCELLANEOUS DATA

Yield Test: 1 Hrs. at 1½ GPM
Depth from surface to normal water level 15 Ft.
Depth of water level when pumping 70 Ft. Stabilized ☒ Yes ☐ No

Well is terminated 20 inches ☒ above ☐ below final grade
Well disinfected upon completion ☒ Yes ☐ No
Well sealed watertight upon completion ☒ Yes ☐ No

Water sample sent to Clintonville Water No 72 laboratory on 6-29 1983

Your opinion concerning other pollution hazards, information concerning difficulties encountered, and data relating to nearby wells, screens, seals, method c finishing the well, amount of cement used in grouting, blasting, etc., should be given on reverse side.

Signature: Don Dillenburg
Registered Well Driller

Business Name and Complete Mailing Address: SHAWANO Well Drilling Rt 3

State of Wisconsin
Department of Natural Resources
Private Water Supply
Box 7921
Madison, Wisconsin 53707

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NOTE:
White Copy – Division's Copy
Green Copy – Driller's Copy
Yellow Copy – Owner's Copy

WELL CONSTRUCTOR'S REPORT
Form 3300–15 Rev. 2-79

JUL 6 1981

1. COUNTY: Langlade
CHECK (✓) ONE: ☒ Town ☐ Village ☐ City
Name: Hainsworth

2. LOCATION: ¼ Section or Gov't. Lot: SW SW | Section: 11 | Township: 34N | Range: 12E
OR – Grid or Street No. | Street or Road Name:
AND – If available subdivision name, lot & block No.:

3. NAME ☒ OWNER ☐ AGENT AT TIME OF DRILLING CHECK (✓) ONE
Mr. & Mrs. Howard Sublitz
ADDRESS: 6611 N 78th St.
POST OFFICE: Milwaukee, Wisc. ZIP CODE: 53200

4. Distance in feet from well to nearest: (Record answer in appropriate block)

Building	Sanitary Bldg. Drain		Sanitary Bldg. Sewer		Floor Drain Connected To:		Storm Bldg. Drain		Storm Bldg.	
	C.I.	Other	C.I.	Other	C.I. Sewer	Other Sewer	C.I.	Other	C.I.	Other
6										

Street Sewer		Other Sewers		Foundation Drain Connected to:		Sewage Sump		Clearwater Sump	Septic Tank	Holding Tank	Sewage Absorption Unit	Manure Hopper Retention or Pneumatic Tank
San.	Storm	C.I.	Other	Sewer	Sewage Sump	C.I.	Other				Seepage Pit	
				Clearwater Dr.	Clearwater Sump						Seepage Bed 60	
									45		Seepage Trench	

Privy	Pet Waste Pit	Pit: Nonconforming Existing	Subsurface Pumproom Nonconforming Existing	Barn Gutter	Animal Barn Pen	Animal Yard	Silo With Pit:	Glass Lined Storage Facility	Silo w/o Pit	Earthen Silage Storage Trench Or Pit	Earthen Manure
		Well									
		Pump									
		Tank									

Temporary Manure Stack or Platform	Watertight Liquid Manure Tank or Basin	Manure Pressure Pipe	Subsurface Gasoline or Oil Tank	Waste Pond or Land Disposal Unit (Specify Type)	Manure Storage Basin	Other (Describe)
					Concrete Floor Only	
					Concrete Floor and Partial Concrete Walls	

5. Well is intended to supply water for: Dwelling

6. DRILLHOLE

Dia. (in.)	From (ft.)	To (ft.)	Dia. (in.)	From (ft.)	To (ft.)
6	Surface	114			

7. CASING, LINER, CURBING AND SCREEN
Material, Weight, Specification Mfg. & Method of Assembly

Dia. (in.)		From (ft.)	To (ft.)
6	New Black Steel 19.00# PE A53 US Steel	Surface	40

8. GROUT OR OTHER SEALING MATERIAL

Kind	From (ft.)	To (ft.)
None	Surface	

9. FORMATIONS

Kind	From (ft.)	To (ft.)
Caving Gravel & Clay	Surface	40
Black Granite	40	114
Water Enters 43 45gpm		

10. TYPE OF DRILLING MACHINE USED
☐ Cable Tool ☐ Rotary-air w/drilling mud ☐ Rotary-w/drilling mud ☐ Rotary-hammer w/drilling mud & air ☒ Rotary-hammer & air ☐ Reverse Rotary ☐ Jetting with ☐ Air ☐ Water

11. MISCELLANEOUS DATA
Yield Test: 1 Hrs. at 90gph GPM
Depth from surface to normal water level 8 Ft.
Depth of water level when pumping 110 Ft. Stabilized ☒ Yes ☐ No

Well construction completed on 6/12/81 19
Well is terminated 8 inches ☒ above ☐ below final grade
Well disinfected upon completion ☒ Yes ☐ No
Well sealed watertight upon completion ☒ Yes ☐ No

Water sample sent to Madison laboratory on 6/12/81 19

Your opinion concerning other pollution hazards, information concerning difficulties encountered, and data relating to nearby wells, screens, seals, method of finishing the well, amount of cement used in grouting, blasting, etc., should be given on reverse side.

Signature: Brad Webster
Registered Well Driller

Business Name and Complete Mailing Address:
RHINELANDER WELL DRILLING, INC.
680 COUNTRY DRIVE
RHINELANDER, WISCONSIN 54501

State of Wisconsin
Department of Natural Resources
Box 7921
Madison, Wisconsin 53707

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NOTE:
White Copy - Division's Copy
Green Copy - Driller's Copy
Yellow Copy - Owner's Copy

MAY 25 1978 LA-967

WELL CONSTRUCTOR'S REPORT

Form 3300-15 Rev. 12-76

MAY 25 1978

1. COUNTY: Langlade

CHECK (✓) ONE: ☑ Town ☐ Village ☐ City

Name: Ainsworth

2. LOCATION: ¼ Section: SE NE; Section: 28; Township: 34N; Range: 12E

OR - Grid or Street No.: ; Street Name:

AND - If available subdivision name, lot & block No.:

3. NAME ☑ OWNER ☐ AGENT AT TIME OF DRILLING CHECK (✓ O

Mr. Vernon Tomlin

ADDRESS: 2137 W. College D27

POST OFFICE: Milwaukee, Wisc. 53221

4. Distance in feet from well to nearest: (Record answer in appropriate block)

Building	Sanitary Bldg. Drain		Sanitary Bldg. Sewer		Floor Drain Connected To:		Storm Bldg. Drain		Storm Bldg.	
	C.I.	Other	C.I.	Other	C.I. Sewer	Other Sewer	C.I.	Other	C.I.	Oth
6										

Street Sewer		Other Sewers		Foundation Drain Connected to:		Sewage Sump		Clearwater Sump	Septic Tank	Holding Tank	Sewage Absorption Unit	
San.	Storm	C.I.	Other	Sewer	Sewage Sump	C.I.	Other				Seepage Pit	
				Clearwater Or.	Clearwater Sump				40		Seepage Bed	60
											Seepage Trench	

Privy	Pet Waste Pit	Pit: Nonconforming Existing	Subsurface Pumproom Nonconforming Existing	Barn Gutter	Animal Barn Pen	Animal Yard	Silo With Pit	Glass Lined Storage Facility	Silo w/o Pit	Earthen Silage Storage Trench Or Pit
		Well								
		Pump								
		Tank								

Temporary Manure Stack	Watertight Liquid Manure Tank	Solid Manure Storage Structure	Subsurface Gasoline or Oil Tank	Waste Pond or Land Disposal Unit (Specify Type)	Other (Give Description)

5. Well is intended to supply water for: Dwelling

6. DRILLHOLE

Dia. (in.)	From (ft.)	To (ft.)	Dia. (in.)	From (ft.)	To (ft.)
6	Surface	182			

7. CASING, LINER, CURBING AND SCREEN

Dia. (in.)	Material, Weight, Specification & Method of Assembly	From (ft.)	To (ft.)
6	New Black Steel 19.45# T&C A53 US Steel	Surface	1.5

8. GROUT OR OTHER SEALING MATERIAL

Kind	From (ft.)	To (ft.)
None	Surface	

9. FORMATIONS

Kind	From (ft.)	To (ft.
Caving Gravel & Clay	Surface	1.5
Hard Black Granite	1.5	182
Water Enters 170ft		

10. TYPE OF DRILLING MACHINE USED

☐ Cable Tool ☑ Rotary-hammer w/drilling mud & air ☐ Jetting with
☐ Rotary-air w/drilling mud ☐ Rotary-hammer & air ☐ Air ☐ Water
☐ Rotary-w/drilling mud ☐ Reverse Rotary

11. MISCELLANEOUS DATA

Yield Test: 10 Hrs. at 15gph GPM

Depth from surface to normal water level: 20 Ft.

Depth of water level when pumping: 175 Ft. Stabilized ☑ Yes ☐ No

Water sample sent to: St Mary's Hospital

Well construction completed on: ☒ 5/12/78 19___

Well is terminated: 12 inches ☑ above ☐ below final grade

Well disinfected upon completion ☑ Yes ☐ No

Well sealed watertight upon completion ☑ Yes ☐ No

laboratory on: 5/12/78 19___

Your opinion concerning other pollution hazards, information concerning difficulties encountered, and data relating to nearby wells, screens, seals, method of finishing the well, amount of cement used in grouting, blasting, etc., should be given on reverse side.

Signature: Robert Webster Registered Well Driller

Complete Mail Address: RHINELANDER WELL DRILLING, IN
630 COUNTRY DRIVE
RHINELANDER, WISCONSIN 54501

[redacted] 7921
Madison, Wisconsin 53707

NOTE:
White Copy – Division's Copy
Green Copy – Driller's Copy
Yellow Copy – Owner's Copy

WELL CONSTRUCTOR'S REPORT
Form 3300–15 Rev. 2-7[illegible]

DEC 3 1980

27

1. COUNTY: LANGLADE
CHECK (✓) ONE: ☑ Town ☐ Village ☐ City
Name: PERSON IAINSL[illegible]

2. LOCATION: ¼ Section or Gov't. Lot: NW¼ SW¼ | Section: 27 | Township: 34N. | Range: 12E.
OR – Grid or Street No. | Street or Road Name:
AND – If available subdivision name, lot & block No.

3. NAME ☑ OWNER ☐ AGENT AT TIME OF DRILLING CHECK [illegible]: MICHAEL ZUNAC
ADDRESS: 4345 CONTENATAL DR.
POST OFFICE: BROOKFIELD, WI. ZIP CODE: 53005

4. Distance in feet from well to nearest: (Record answer in appropriate block)

Building	Sanitary Bldg. Drain C.I.	Sanitary Bldg. Drain Other	Sanitary Bldg. Sewer C.I.	Sanitary Bldg. Sewer Other	Floor Drain Connected To: C.I. Sewer	Other Sewer	Storm Bldg. Drain C.I.	Storm Bldg. Drain Other	Storm Bl C.I.
8			12	Mc Septic [illegible]			[illegible]	[illegible]	

Street Sewer San.	Street Sewer Storm	Other Sewers C.I.	Other Sewers Other	Foundation Drain Connected to: Sewer	Foundation Drain Connected to: Sewage Sump	Sewage Sump C.I.	Sewage Sump Other	Clearwater Sump	Septic Tank	Holding Tank	Sewage Absorption Unit: Seepage Pit	Seepage Bed	Seepage Trench	Absorption Retention or Pnuematic
				Clearwater Dr.	Clearwater Sump									

Privy	Pet Waste Pit	Pit: Nonconforming Existing: Well	Pump	Tank	Subsurface Pump Room Nonconforming Existing	Barn Gutter	Animal Barn Pen	Animal Yard	Silo With Pit	Glass Lined Storage Facility	Silo w/o Pit	Earthen Silage Storage Trench Or Pit	Earth Manu

Temporary Manure Stack or Platform	Watertight Liquid Manure Tank or Basin	Manure Pressure Pipe	Subsurface Gasoline or Oil Tank	Waste Pond or Land Disposal Unit (Specify Type)	Manure Storage Basin: Concrete Floor Only	Concrete Floor and Partial Concrete Walls	Other (Describe)

5. Well is intended to supply water for: Home

6. DRILLHOLE

Dia. (in.)	From (ft.)	To (ft.)	Dia. (in.)	From (ft.)	To (ft.)
6	Surface	76			

7. CASING, LINER, CURBING AND SCREEN
Material, Weight, Specification

Dia. (in.)	Mfg. & Method of Assembly	From (ft.)	To (ft.)
6	New Steel T&C 19:45	Surface	40
	Granite	40	76
	ASTM A-53		
	Inter-Lake		

8. GROUT OR OTHER SEALING MATERIAL

Kind	From (ft.)	To (ft.)
	Surface	

9. FORMATIONS

Kind	From (ft.)	To
Soil & Sand	Surface	26
Lime Clay	26	40
Granite	40	76

10. TYPE OF DRILLING MACHINE USED

☐ Cable Tool
☐ Rotary-air w/drilling mud
☐ Rotary-w/drilling mud
☐ Rotary-hammer w/drilling mud & air
☑ Rotary-hammer & air
☐ Reverse Rotary
☐ Jetting wi
☐ Air
☐ Wat

Well construction completed on 6-6 19

11. MISCELLANEOUS DATA

Yield Test: 1 Hrs. at 5 GPM
Well is terminated 8 inches ☑ above ☐ below final grade
Depth from surface to normal water level 20 Ft.
Well disinfected upon completion ☑ Yes ☐ No
Depth of water level when pumping 60 Ft. Stabilized ☒ Yes ☒ No
Well sealed watertight upon completion ☑ Yes ☐ No
Water sample sent to Wis Lab of Hygiene laboratory on 6/6 19

Your opinion concerning other pollution hazards, information concerning difficulties encountered, and data relating to nearby wells, screens, seals, methc finishing the well, amount of cement used in grouting, blasting, etc., should be given on reverse side.

Signature: William Middleton
Registered Well Driller

Business Name and Complete Mailing Address: Hartland Wis

Attachment 2

National Atmospheric Deposition Program (NADP) Rainwater Chemistry Data: Trout Lake (Vilas County) and Popple River (Florence County)

TROUT LAKE

NATIONAL ATMOSPHERIC DEPOSITION PROGRAM/NATIONAL TRENDS NETWORK

PRECIPITATION-WEIGHTED MEANS
(Reported in Milligrams/Liter)
Printed: 960201

CAL code	Summ. Per.	Year	Data Completeness Criteria ..... Percent 1	2	3	4	Laboratory Means ..... mg/L ..... Ca	Mg	K	Na	NH4	NO3	Cl	SO4	pH	uS/cm Cond.	Field Means pH	uS/cm Cond.	Ratio c/a (lab)	....Totals .... mL Svol	cm Ppt	% Ppt Rep.by F Chem.	Valid Samp. L	F	Days	Dates
WI36	ann	1980	94.2	94.2	99.8	92.9	0.25	0.036	0.027	0.106	0.41	1.56	0.15	1.80	4.65	15.9	--	--	0.99	44559.3	73.49	0.0	43	0	343	800122 801230
WI36	fal	1980	92.3	100.0	99.8	92.6	0.24	0.037	0.020	0.027	0.42	1.63	0.14	1.84	4.65	16.2	--	--	0.91	12778.1	23.27	0.0	12	0	91	800902 801202
WI36	win	1980	46.2	46.2	100.0	--	0.24	0.034	0.046	0.090	0.34	2.24	0.25	1.31	4.61	15.8	--	--	0.90	248.4	0.37	0.0	5	0	42	800122 800304
WI36	spr	1980	84.6	100.0	99.3	96.5	0.41	0.056	0.035	0.163	0.72	2.40	0.17	3.42	4.32	28.4	--	--	1.05	6826.1	10.43	0.0	9	0	91	800304 800603
WI36	sum	1980	100.0	100.0	100.0	94.0	0.20	0.030	0.028	0.142	0.33	1.26	0.14	1.38	4.79	12.4	--	--	1.02	23754.0	37.24	0.0	13	0	91	800603 800902
WI36	ann	1981	86.3	100.0	74.0	91.8	0.22	0.049	0.029	0.057	0.33	1.23	0.10	1.77	4.71	16.3	--	--	0.95	31306.4	72.55	0.0	39	0	364	801230 811229
WI36	fal	1981	76.9	100.0	96.3	94.5	0.24	0.052	0.020	0.075	0.29	1.17	0.07	2.23	4.54	18.2	--	--	0.96	8475.7	13.74	0.0	8	0	91	810901 811201
WI36	win	1981	76.9	100.0	88.3	70.2	0.13	0.019	0.016	0.034	0.34	1.78	0.16	1.17	4.62	17.6	--	--	0.90	3654.3	8.69	0.0	9	0	91	801202 810303
WI36	spr	1981	100.0	100.0	100.0	93.3	0.27	0.042	0.035	0.037	0.38	1.17	0.08	1.78	4.85	15.3	--	--	0.94	12391.3	19.23	0.0	12	0	91	810303 810602
WI36	sum	1981	83.5	100.0	43.2	108.8	0.20	0.062	0.037	0.058	0.33	0.00	0.12	1.63	4.84	14.4	--	--	0.96	6988.5	30.61	0.0	10	0	91	810602 810901
WI36	ann	1982	85.2	100.0	79.9	90.2	0.21	0.038	0.026	0.038	0.38	1.23	0.08	1.85	4.67	15.9	--	--	0.96	48275.1	104.31	0.0	42	0	371	811229 830104
WI36	fal	1982	84.6	100.0	75.2	92.8	0.18	0.022	0.020	0.032	0.35	0.99	0.08	1.63	4.76	13.0	--	--	0.94	12854.1	33.21	0.0	10	0	91	820831 821130
WI36	win	1982	92.3	100.0	99.4	53.3	0.18	0.094	0.019	0.170	0.09	1.95	0.16	1.11	4.63	15.7	--	--	0.90	2971.7	8.26	0.0	12	0	91	811201 820302
WI36	spr	1982	100.0	100.0	100.0	88.7	0.25	0.041	0.032	0.028	0.53	1.45	0.07	2.56	4.53	20.8	--	--	0.98	18334.6	30.45	0.0	13	0	91	820302 820601
WI36	sum	1982	69.2	100.0	68.4	101.3	0.20	0.040	0.027	0.021	0.31	1.03	0.05	1.41	4.87	13.1	--	--	0.97	13109.9	27.89	0.0	8	0	91	820601 820831
WI36	ann	1983	82.7	100.0	84.3	95.4	0.19	0.036	0.026	0.049	0.27	1.12	0.09	1.57	4.65	15.1	--	--	0.99	45779.1	83.70	0.0	40	0	364	830104 840103
WI36	fal	1983	92.3	100.0	99.4	97.1	0.14	0.019	0.014	0.031	0.14	0.81	0.08	1.05	4.79	10.7	--	--	0.91	20813.6	31.75	0.0	11	0	91	830830 831129
WI36	win	1983	47.3	100.0	28.8	86.2	0.12	0.019	0.015	0.138	0.27	1.18	0.09	0.94	4.88	9.6	--	--	1.03	2162.9	12.82	0.0	6	0	91	821130 830301
WI36	spr	1983	100.0	100.0	100.0	95.4	0.20	0.033	0.017	0.061	0.30	1.38	0.06	2.01	4.50	19.1	--	--	0.98	10012.6	15.39	0.0	13	0	91	830301 830531
WI36	sum	1983	76.9	100.0	72.0	97.4	0.28	0.062	0.046	0.037	0.49	1.41	0.10	2.19	4.56	20.0	--	--	1.07	13063.2	27.47	0.0	9	0	91	830531 830830
WI36	ann	1984	87.1	100.0	86.3	92.6	0.23	0.038	0.029	0.057	0.34	1.07	0.09	1.44	4.84	11.9	--	--	1.03	41516.4	80.10	0.0	39	0	365	840103 850102
WI36	fal	1984	92.3	100.0	99.0	97.7	0.14	0.024	0.017	0.041	0.23	0.87	0.07	1.23	4.72	11.5	--	--	1.02	12263.0	20.08	0.0	11	0	91	840904 841204
WI36	win	1984	76.9	100.0	63.1	61.2	0.12	0.042	0.047	0.141	0.06	0.94	0.15	0.62	5.03	8.2	--	--	0.91	2588.0	8.88	0.0	9	0	91	831129 840228
WI36	spr	1984	85.7	100.0	99.1	88.4	0.42	0.048	0.031	0.064	0.35	1.23	0.08	1.59	4.92	12.5	--	--	1.09	7358.6	14.10	0.0	9	0	91	840228 840529
WI36	sum	1984	78.6	100.0	79.9	95.7	0.23	0.040	0.035	0.035	0.47	1.17	0.09	1.66	4.86	12.5	--	--	1.02	18329.6	35.33	0.0	11	0	98	840529 840904
WI36	ann	1985	78.7	100.0	78.1	88.2	0.22	0.039	0.019	0.036	0.32	1.09	0.07	1.39	4.81	12.5	--	--	1.02	46717.1	103.31	0.0	41	0	362	850102 851230
WI36	fal	1985	69.2	100.0	74.0	84.0	0.08	0.019	0.006	0.013	0.05	0.62	0.02	0.89	4.72	10.5	--	--	0.96	16990.1	36.85	0.0	9	0	91	850903 851203
WI36	win	1985	91.7	100.0	97.5	67.6	0.13	0.052	0.027	0.154	0.19	1.14	0.14	0.88	4.87	10.4	--	--	1.03	4475.7	10.01	0.0	11	0	84	841204 850226
WI36	spr	1985	71.4	100.0	70.3	88.6	0.41	0.066	0.027	0.042	0.67	1.46	0.10	1.77	5.47	11.6	--	--	1.09	10460.8	31.00	0.0	10	0	98	850226 850604
WI36	sum	1985	76.9	100.0	86.6	97.9	0.25	0.038	0.027	0.042	0.33	1.20	0.08	1.78	4.68	15.6	--	--	0.97	16445.4	28.58	0.0	10	0	91	850604 850903
WI36	ann	1986	90.4	100.0	92.5	94.6	0.14	0.023	0.014	0.039	0.19	1.01	0.05	1.29	4.76	12.2	--	--	0.87	42938.6	75.43	0.0	44	0	365	851230 861230
WI36	fal	1986	84.6	100.0	98.9	89.5	0.07	0.013	0.009	0.040	0.14	0.80	0.03	1.23	4.70	12.3	--	--	0.87	14365.3	23.15	0.0	11	0	91	860902 861202
WI36	win	1986	100.0	100.0	100.0	78.9	0.14	0.021	0.012	0.042	0.21	1.40	0.09	0.75	4.66	12.9	--	--	1.09	3699.7	6.83	0.0	12	0	92	851203 860305
WI36	spr	1986	84.4	100.0	97.3	96.9	0.22	0.030	0.018	0.038	0.38	1.33	0.06	1.68	4.69	14.7	--	--	0.98	7881.1	12.27	0.0	10	0	90	860305 860603
WI36	sum	1986	92.3	100.0	85.2	100.3	0.16	0.030	0.017	0.031	0.17	0.98	0.06	1.28	4.85	11.2	--	--	0.81	17469.2	34.06	0.0	12	0	91	860603 860902
WI36	ann	1987	94.2	100.0	90.1	94.9	0.19	0.034	0.019	0.065	0.29	1.28	0.13	1.59	4.71	13.6	4.64	15.0	0.89	39678.2	68.20	87.7	45	38	364	861230 871229
WI36	fal	1987	92.3	100.0	99.9	95.0	0.16	0.027	0.013	0.073	0.22	0.92	0.06	1.41	4.70	12.7	4.60	14.6	0.99	13515.7	20.84	96.2	12	11	91	870901 871201
WI36	win	1987	100.0	100.0	100.0	71.1	0.14	0.023	0.016	0.114	0.21	2.18	0.58	2.05	4.84	10.2	4.80	11.3	0.43	2550.0	5.31	77.0	10	6	91	861202 870303
WI36	spr	1987	92.3	100.0	97.4	94.4	0.31	0.062	0.036	0.062	0.50	1.59	0.12	1.87	4.80	14.8	4.73	16.5	1.00	8478.5	13.59	93.3	11	7	91	870303 870602
WI36	sum	1987	84.6	100.0	73.6	103.3	0.21	0.033	0.018	0.065	0.30	1.29	0.10	1.69	4.65	15.4	4.59	16.4	0.94	12463.3	24.16	73.6	11	11	91	870602 870901
WI36	ann	1988	96.2	100.0	99.1	92.3	0.23	0.034	0.014	0.058	0.23	1.25	0.08	1.36	4.81	11.9	4.70	13.3	0.98	44223.0	73.83	96.8	48	43	371	871230 880103
WI36	fal	1988	100.0	100.0	100.0	92.1	0.10	0.015	0.008	0.048	0.16	0.92	0.05	1.12	4.76	10.6	4.70	11.8	0.89	16767.2	26.75	100.0	13	13	91	880830 881129
WI36	win	1988	92.3	100.0	99.1	73.1	0.07	0.010	0.004	0.045	0.03	1.06	0.06	0.56	4.67	10.9	4.65	11.1	0.96	4200.6	8.53	96.4	12	9	91	871201 880301
WI36	spr	1988	84.6	100.0	94.8	92.8	0.47	0.071	0.035	0.088	0.53	2.05	0.12	2.54	4.68	18.5	4.43	24.6	0.94	6449.4	10.80	81.4	10	7	91	880301 880531
WI36	sum	1988	100.0	100.0	100.0	102.2	0.28	0.043	0.015	0.058	0.21	1.27	0.08	1.32	4.94	11.0	4.84	11.8	0.87	19044.2	27.54	100.0	13	13	91	880531 880830
WI36	ann	1989	92.3	100.0	88.8	87.4	0.17	0.031	0.029	0.064	0.42	1.30	0.11	1.42	4.82	12.8	4.67	15.1	0.99	31488.0	58.52	72.0	44	31	364	890103 900102
WI36	fal	1989	92.3	100.0	93.4	86.7	0.14	0.024	0.014	0.117	0.37	1.29	0.20	1.42	4.78	12.8	4.67	14.7	0.92	7610.3	13.84	84.6	11	8	91	890829 891128
WI36	win	1989	92.3	100.0	99.5	56.2	0.17	0.019	0.006	0.070	0.19	1.43	0.10	0.94	4.79	11.2	4.75	12.0	0.87	2585.5	9.85	80.9	11	8	91	881129 890228
WI36	spr	1989	84.6	100.0	89.2	89.6	0.15	0.027	0.041	0.054	0.22	0.93	0.07	1.08	4.82	11.5	4.55	15.5	1.02	9013.8	15.79	50.4	11	9	91	890228 890530
WI36	sum	1989	84.6	100.0	82.3	96.5	0.23	0.044	0.038	0.028	0.72	1.47	0.08	1.94	4.88	14.2	4.75	15.6	1.06	11901.1	22.07	81.5	10	7	91	890530 890829
WI36	ann	1990	95.9	100.0	99.2	92.2	0.17	0.025	0.065	0.036	0.39	1.06	0.12	1.23	4.88	11.1	4.81	12.3	1.05	50338.3	92.25	98.9	44	41	365	900102 910102
WI36	fal	1990	100.0	100.0	100.0	89.6	0.25	0.032	0.020	0.036	0.54	1.34	0.06	1.68	4.82	13.6	4.74	15.4	1.07	18717.8	30.77	99.9	12	11	91	900904 901204
WI36	win	1990	100.0	100.0	100.0	68.0	0.19	0.031	0.633	0.068	0.09	1.24	0.68	0.39	4.91	11.0	4.78	9.5	1.02	3477.5	7.08	92.1	11	9	91	891128 900227
WI36	spr	1990	100.0	100.0	100.0	95.4	0.12	0.024	0.015	0.049	0.44	1.04	0.11	1.38	4.83	12.0	4.76	13.2	1.03	12976.5	19.88	99.0	12	10	91	900227 900529
WI36	sum	1990	100.0	100.0	100.0	99.2	0.13	0.017	0.017	0.024	0.27	0.85	0.07	0.86	4.96	8.4	4.90	9.8	1.04	16038.6	35.49	100.0	13	13	98	900529 900904
WI36	ann	1991	81.6	100.0	82.6	96.7	0.23	0.036	0.015	0.037	0.33	1.09	0.07	1.17	4.91	10.7	4.85	11.7	1.08	48975.4	95.84	80.4	38	33	364	910102 920101
WI36	fal	1991	75.8	100.0	64.4	95.2	0.26	0.042	0.017	0.038	0.34	1.00	0.06	1.15	4.99	9.8	4.94	11.4	1.14	11640.2	27.97	64.4	10	10	91	910903 911203
WI36	win	1991	71.4	100.0	75.0	44.4	0.09	0.016	0.007	0.213	0.09	1.87	0.15	0.60	4.63	14.2	4.56	13.6	0.92	1170.3	5.18	36.8	5	2	84	901204 910226
WI36	spr	1991	85.9	100.0	84.9	101.4	0.17	0.021	0.018	0.033	0.37	1.14	0.06	1.17	4.90	10.4	4.80	11.9	1.02	16863.0	28.90	84.7	11	10	99	910226 910605
WI36	sum	1991	100.0	100.0	100.0	101.6	0.29	0.047	0.013	0.019	0.34	1.04	0.06	1.28	4.90	11.3	4.84	11.9	1.12	19107.1	32.47	99.7	12	11	90	910605 910903
WI36	ann	1992	90.4	100.0	87.6	90.0	0.13	0.022	0.013	0.040	0.35	1.29	0.06	1.70	4.57	17.1	4.42	20.6	0.98	39041.2	71.87	57.2	41	22	363	920101 921229
WI36	fal	1992	92.3	100.0	83.6	86.7	0.10	0.015	0.008	0.037	0.29	1.02	0.05	1.27	4.72	12.2	4.81	10.8	0.98	12664.7	25.55	51.4	9	5	91	920901 921201
WI36	win	1992	68.1	100.0	76.7	70.8	0.09	0.010	0.007	0.042	0.24	1.40	0.09	0.85	4.76	11.6	4.65	12.5	0.88	2977.2	8.08	72.3	9	7	91	911203 920303
WI36	spr	1992	84.6	100.0	78.3	96.9	0.14	0.025	0.018	0.049	0.48	1.34	0.07	1.86	4.63	17.2	4.34	20.6	0.98	8273.7	15.82	39.8	10	5	91	920303 920602
WI36	sum	1992	84.6	100.0	94.5	98.4	0.16	0.031	0.017	0.036	0.40	1.52	0.07	2.37	4.39	23.7	4.25	30.2	0.99	13988.0	22.15	75.8	10	6	91	920602 920901
WI36	ann	1993	86.8	100.0	84.7	95.9	0.11	0.018	0.012	0.033	0.23	0.96	0.05	0.84	4.88	9.3	4.75	11.1	1.01	39564.2	71.33	70.7	41	33	371	921229 940104
WI36	fal	1993	61.5	100.0	47.3	96.3	0.32	0.044	0.025	0.032	0.31	1.07	0.05	0.99	5.13	9.3	4.99	9.6	1.18	6009.0	19.43	47.3	8	8	91	930831 931130
WI36	win	1993	92.3	100.0	99.2	78.6	0.06	0.007	0.006	0.040	0.08	1.14	0.08	0.62	4.70	11.2	4.63	10.8	0.89	3748.1	6.93	36.3	11	2	91	921201 930302
WI36	spr	1993	92.3	100.0	98.6	94.8	0.08	0.014	0.008	0.031	0.29	1.08	0.04	1.00	4.79	10.4	4.64	12.8	0.99	11398.4	17.93	98.6	10	10	91	930302 930601
WI36	sum	1993	92.3	100.0	98.7	100.0	0.08	0.013	0.011	0.032	0.20	0.76	0.05	0.74	4.95	8.1	4.82	10.0	0.99	18820.0	28.08	67.6	12	9	91	930601 930831
WI36	ann	1994	90.4	98.1	96.7	99.2	0.19	0.026	0.018	0.034	0.39	1.22	0.06	1.16	4.86	11.5	4.76	12.4	1.08	46099.8	70.78	84.2	41	32	364	940104 950103
WI36	fal	1994	84.6	100.0	92.6	99.3	0.16	0.021	0.012	0.026	0.33	1.12	0.06	1.37	4.70	14.1	4.64	14.5	1.03	17957.6	28.77	92.6	11	11	91	940830 941129
WI36	win	1994	84.6	100.0	97.2	80.8	0.07	0.008	0.004	0.052	0.11	1.63	0.09	0.50	4.61	12.6	4.59	13.4	0.95	2475.5	4.55	96.1	9	8	91	931130 940301
WI36	spr	1994	84.6	100.0	99.3	100.8	0.27	0.036	0.027	0.033	0.62	1.47	0.05	1.25	5.32	9.7	5.11	10.8	1.13	9857.6	14.54	98.2	10	8	91	940301 940531
WI36	sum	1994	92.3	92.3	100.0	100.4	0.20	0.029	0.021	0.040	0.37	1.11	0.07	0.98	4.99	9.4	4.87	9.9	1.13	16516.1	24.24	64.8	11	7	91	940531 940830
WI36	win	1995	100.0	100.0	100.0	86.6	0.15	0.020	0.008	0.073	0.22	1.84	0.12	0.65	4.67	13.1	4.56	15.1	0.99	1776.8	3.02	92.4	11	7	91	941129 950228
WI36	spr	1995	78.0	100.0	96.5	99.5	0.19	0.022	0.011	0.029	0.27	1.11	0.05	0.85	4.86	10.3	4.76	11.3	1.12	14102.0	21.64	96.5	10	10	91	950228 950530

POPPLE RIVER

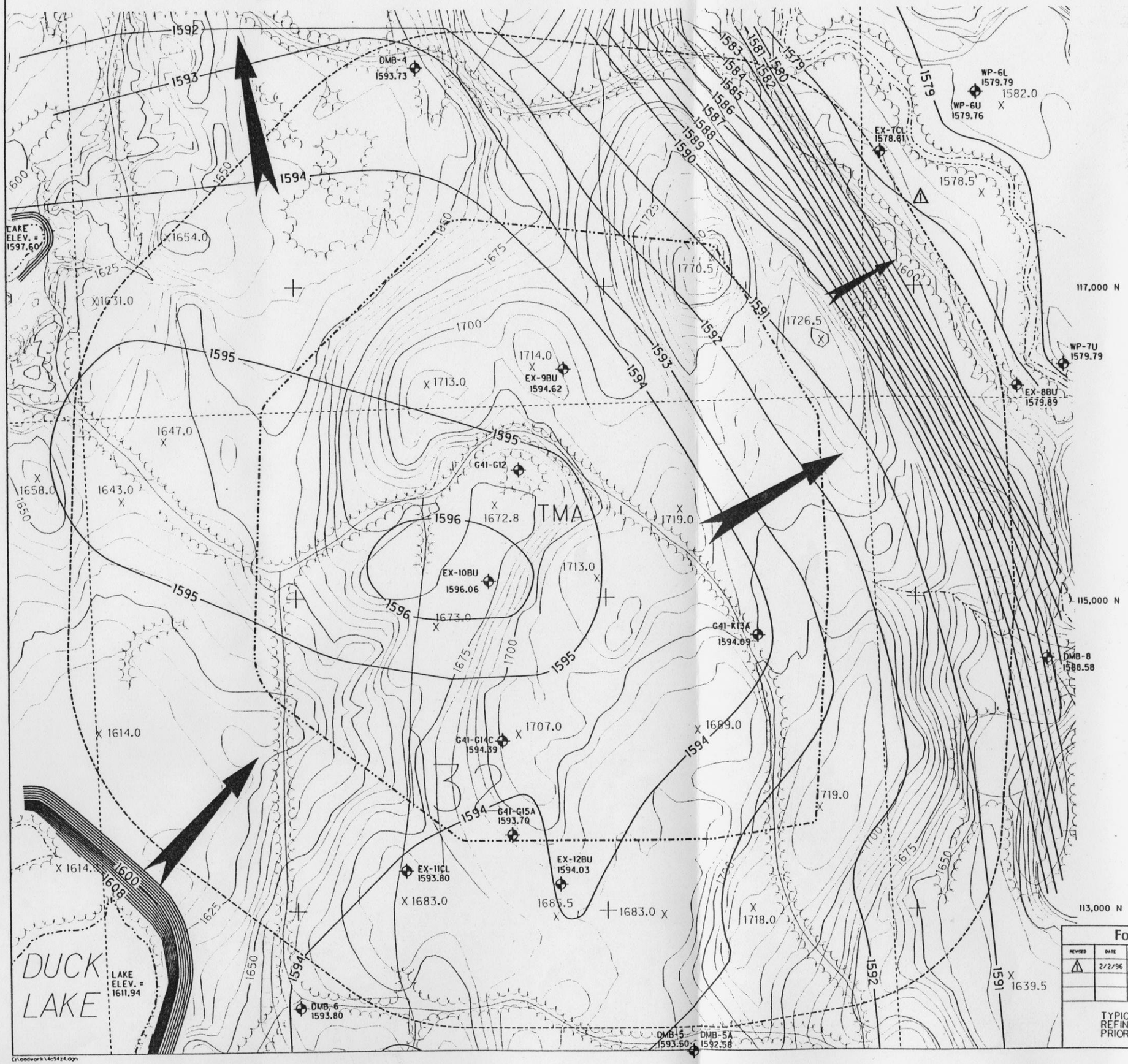
NATIONAL ATMOSPHERIC DEPOSITION PROGRAM/NATIONAL TRENDS NETWORK

PRECIPITATION-WEIGHTED MEANS
(Reported in Milligrams/Liter)
Printed: 960201

CAL	Summ.		Data Completeness Criteria (Percent)				Laboratory Means (mg/L)								uS/cm	Field Means pH	uS/cm	Ratio c/a	....Totals .... mL	cm	% Ppt Rep.by	Valid Samp.			
code	Per.	Year	1	2	3	4	Ca	Mg	K	Na	NH4	NO3	Cl	SO4	pH	Cond.	pH	Cond.	(lab)	Svol	Fpt	F Chem.	L	F	Days	Dates
WI09	ann	1987	71.2	100.0	52.9	90.6	0.24	0.043	0.034	0.081	0.41	1.51	0.13	1.95	4.61	17.5	4.47	20.1	0.97	18580.0	56.99	45.7	32	22	364	861230 871229
WI09	fal	1987	76.9	100.0	63.4	92.3	0.18	0.027	0.026	0.066	0.28	1.41	0.12	1.83	4.51	18.6	4.39	21.4	0.95	7323.4	18.44	48.6	10	7	91	870901 871201
WI09	win	1987	38.5	69.2	85.2	61.7	0.20	0.034	0.023	0.159	0.37	1.96	0.21	1.31	4.75	14.8	4.54	13.2	0.91	734.4	2.06	38.2	5	1	63	861230 870303
WI09	spr	1987	92.3	100.0	87.6	92.9	0.32	0.062	0.040	0.083	0.57	1.57	0.13	2.18	4.76	16.5	4.51	20.2	1.00	7949.5	14.38	86.9	10	8	91	870303 870602
WI09	sum	1987	30.8	100.0	15.0	102.0	0.14	0.030	0.045	0.069	0.36	1.26	0.08	1.91	4.60	16.5	4.57	17.3	0.94	2074.7	20.03	15.0	4	4	91	870602 870901
WI09	ann	1988	83.0	100.0	81.9	89.7	0.29	0.044	0.028	0.077	0.39	1.72	0.10	2.01	4.61	17.8	4.50	18.7	0.95	33254.4	66.27	70.7	41	28	371	871229 890103
WI09	fal	1988	84.6	100.0	85.9	95.2	0.19	0.030	0.024	0.061	0.30	1.43	0.08	2.08	4.50	18.8	4.42	18.8	0.92	13780.3	24.64	83.9	11	9	91	880830 881129
WI09	win	1988	76.9	100.0	75.2	29.7	0.14	0.022	0.017	0.105	0.19	1.81	0.15	1.08	4.54	16.9	4.54	15.3	0.96	985.7	4.90	60.7	9	4	91	871201 880301
WI09	spr	1988	69.2	100.0	86.5	88.8	0.44	0.074	0.032	0.103	0.76	2.74	0.15	2.99	4.48	25.7	4.35	29.5	0.98	5786.3	11.10	80.5	9	8	91	880301 880531
WI09	sum	1988	84.6	100.0	73.8	99.6	0.36	0.052	0.032	0.074	0.33	1.42	0.09	1.73	4.84	13.8	4.78	13.3	0.97	11965.7	24.00	57.0	11	8	91	880531 880830
WI09	ann	1989	82.7	100.0	82.9	86.6	0.21	0.034	0.033	0.057	0.40	1.40	0.09	1.54	4.74	14.0	4.60	14.1	0.99	20707.7	42.34	74.3	37	24	364	890103 900102
WI09	fal	1989	92.3	100.0	99.4	95.4	0.12	0.021	0.026	0.039	0.20	1.01	0.08	0.96	4.80	10.6	4.68	10.9	0.96	7687.8	11.94	99.2	11	10	91	890829 891128
WI09	win	1989	92.3	100.0	92.5	63.3	0.27	0.033	0.025	0.093	0.28	1.98	0.15	1.08	4.84	12.6	4.99	11.9	0.86	2566.8	6.45	27.9	11	2	91	881129 890228
WI09	spr	1989	76.9	100.0	87.7	77.6	0.23	0.041	0.039	0.102	0.49	1.89	0.12	2.07	4.56	19.3	4.45	19.5	0.97	4037.2	8.69	82.5	10	7	91	890228 890530
WI09	sum	1989	61.5	100.0	65.6	88.6	0.29	0.047	0.045	0.038	0.62	1.37	0.08	2.07	4.82	15.0	4.64	14.4	1.06	6906.9	17.37	61.7	5	4	91	890530 890829
WI09	ann	1990	94.2	100.0	92.2	97.2	0.17	0.029	0.023	0.042	0.45	1.29	0.11	1.47	4.74	13.9	4.67	15.4	1.04	44088.1	72.01	67.4	46	27	364	900102 910101
WI09	fal	1990	100.0	100.0	100.0	93.8	0.23	0.038	0.018	0.030	0.51	1.70	0.09	1.73	4.65	16.2	4.65	16.3	1.02	13229.0	20.40	99.0	13	11	91	900904 901204
WI09	win	1990	92.3	100.0	97.1	72.6	0.19	0.023	0.020	0.090	0.30	1.60	0.15	0.93	4.89	11.1	4.66	13.3	0.91	2090.0	4.37	74.4	11	5	91	891128 900227
WI09	spr	1990	92.3	100.0	97.2	95.9	0.13	0.028	0.019	0.062	0.38	1.13	0.12	1.49	4.70	14.3	4.61	15.4	1.00	12191.3	18.99	71.5	11	5	91	900227 900529
WI09	sum	1990	85.7	100.0	82.1	103.2	0.15	0.022	0.031	0.030	0.47	1.00	0.10	1.27	4.87	11.7	4.80	13.4	1.13	16351.2	28.43	40.2	12	5	98	900529 900904
WI09	ann	1991	94.2	100.0	97.2	97.1	0.20	0.030	0.017	0.033	0.35	1.21	0.07	1.39	4.73	13.4	4.71	14.6	1.03	55992.5	86.96	93.4	42	38	364	910101 911231
WI09	fal	1991	100.0	100.0	100.0	99.6	0.13	0.021	0.015	0.035	0.26	1.08	0.07	1.26	4.63	14.1	4.61	16.0	1.06	18373.2	27.15	88.4	13	11	91	910903 911203
WI09	win	1991	91.7	100.0	99.1	102.9	0.06	0.011	0.010	0.056	0.15	1.52	0.11	0.71	4.60	13.7	4.58	14.5	0.93	1977.0	2.90	98.1	8	7	84	901204 910226
WI09	spr	1991	78.6	100.0	92.5	91.1	0.19	0.027	0.022	0.032	0.45	1.46	0.07	1.53	4.76	13.8	4.73	14.7	0.98	18655.7	31.64	92.5	10	10	98	910226 910604
WI09	sum	1991	100.0	100.0	100.0	100.3	0.30	0.047	0.016	0.031	0.36	1.12	0.08	1.46	4.81	12.8	4.81	13.8	1.10	16496.4	24.23	100.0	11	11	91	910604 910903
WI09	ann	1992	92.3	100.0	91.4	95.0	0.12	0.022	0.019	0.042	0.33	1.35	0.07	1.59	4.56	17.1	4.50	18.5	0.98	39097.5	66.27	82.0	42	33	364	911231 921229
WI09	fal	1992	100.0	100.0	100.0	96.1	0.08	0.013	0.009	0.036	0.23	1.13	0.05	1.27	4.59	14.8	4.54	15.2	0.98	14828.5	22.69	90.3	11	9	91	920901 921201
WI09	win	1992	92.3	100.0	98.6	76.1	0.03	0.005	0.006	0.028	0.14	1.07	0.08	0.83	4.69	11.7	4.65	12.4	0.86	3659.3	7.19	88.3	10	7	91	911203 920303
WI09	spr	1992	69.2	100.0	65.7	90.7	0.13	0.025	0.017	0.064	0.56	2.01	0.11	2.47	4.34	27.7	4.31	29.7	1.02	6615.9	16.35	65.7	8	8	91	920303 920602
WI09	sum	1992	100.0	100.0	100.0	103.6	0.19	0.039	0.037	0.041	0.39	1.36	0.07	1.83	4.65	16.3	4.56	16.7	0.97	13538.1	19.25	99.3	12	11	91	920602 920901
WI09	ann	1993	94.3	100.0	94.0	94.8	0.12	0.020	0.019	0.042	0.28	1.20	0.07	1.20	4.70	12.9	4.60	13.6	0.97	35121.8	67.26	84.1	46	34	371	921229 940104
WI09	fal	1993	100.0	100.0	100.0	100.4	0.12	0.018	0.013	0.047	0.25	0.94	0.06	0.89	4.87	9.7	4.74	10.0	1.04	7375.3	19.46	90.1	13	11	91	930831 931130
WI09	win	1993	84.6	100.0	97.6	77.9	0.05	0.007	0.019	0.029	0.14	1.26	0.09	0.74	4.67	12.2	4.48	19.9	0.88	3332.9	6.45	27.9	10	2	91	921201 930302
WI09	spr	1993	92.3	100.0	94.0	87.8	0.09	0.017	0.012	0.029	0.33	1.37	0.07	1.60	4.53	17.2	4.47	17.5	0.96	10855.7	19.38	89.9	11	9	91	930302 930601
WI09	sum	1993	92.3	100.0	88.7	101.8	0.15	0.027	0.027	0.046	0.27	1.14	0.06	1.21	4.80	11.6	4.63	12.8	0.96	14834.7	24.20	80.5	12	11	91	930601 930831
WI09	ann	1994	92.3	100.0	99.0	99.4	0.15	0.022	0.021	0.027	0.36	1.16	0.05	1.13	4.82	11.6	4.72	11.7	1.06	46211.8	69.13	92.7	44	34	364	940104 950103
WI09	fal	1994	84.6	100.0	99.5	96.5	0.08	0.010	0.009	0.017	0.23	0.86	0.04	1.14	4.68	12.5	4.60	12.2	1.02	16979.4	25.71	91.0	11	9	91	940830 941129
WI09	win	1994	92.3	100.0	90.9	73.1	0.13	0.018	0.014	0.102	0.17	1.73	0.14	0.76	4.59	13.9	4.49	14.0	1.00	1664.1	3.35	49.9	10	4	91	931130 940301
WI09	spr	1994	84.6	100.0	98.4	99.0	0.24	0.038	0.030	0.032	0.63	1.57	0.05	1.38	5.09	11.2	4.85	12.9	1.08	11212.2	16.97	97.2	11	10	91	940301 940531
WI09	sum	1994	100.0	100.0	100.0	103.6	0.16	0.026	0.027	0.027	0.35	1.15	0.06	0.97	4.89	10.6	4.80	10.1	1.10	16816.7	23.90	94.9	13	11	91	940531 940830
WI09	win	1995	84.6	100.0	95.7	54.0	0.26	0.023	0.032	0.139	0.22	2.07	0.21	1.35	4.60	17.1	4.43	17.7	0.87	685.6	1.78	37.3	8	3	91	941129 950228
WI09	spr	1995	100.0	100.0	100.0	97.3	0.17	0.026	0.014	0.045	0.37	1.36	0.07	1.22	4.73	13.0	4.59	15.7	1.06	13034.5	19.74	100.0	11	11	91	950228 950530

Attachment 3

Groundwater Table Contour Map



LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- —1675— EXISTING CONTOUR
- 1692.0 X SPOT ELEVATION
- SECTION LINE
- PERIMETER OF MINE WASTE SITE (AS PER NR182)
- COMPLIANCE BOUNDARY
- —1580— GROUNDWATER CONTOUR (CONTOUR INTERVAL = 1 FOOT)
- GROUNDWATER FLOW DIRECTION
- EX-14BU 1592.41 MONITORING WELL LOCATION, NUMBER AND WATER TABLE ELEVATION

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. GROUNDWATER ELEVATIONS MEASURED OCTOBER, 1984.
6. ADDED GROUNDWATER TABLE CONTOUR 1579.

SCALE
0 300' 600'

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION
1	2/2/96	REM	SEE NOTE 6

TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

Crandon Mining Company

TITLE
GROUNDWATER TABLE CONTOUR MAP
OCTOBER, 1984

SCALE AS SHOWN	STATE: WISCONSIN		COUNTY FOREST		
DRAWN BY GAM, JPRI	DATE 5/95	CHECKED BY JKSI	DATE 5/95		
APPROVED BY REM	DATE 5/95	APPROVED BY NXP	DATE 5/95		
APPROVED BY GWS	DATE 5/95	CRANDON MINING COMPANY DEM	DATE 5/95		
DRAWING NO. 4R	SHEET OF 1 1	REVISION NO. 0			

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C:\loadwork\4c54z4.dgn
02/14/96 GAM

Attachment 4

- 1995 ABA and Bulk Chemical Data for the Tailings Composites. Table 1 from the Crandon Project's Waste Characterization Update Report, December 1995.

- The Chemical Resistance of Polyethylene and Polypropylene Polyolefins

- General Chemical Resistance Guidelines of Commonly Used Geomembranes. Table 5.7 from R. Koener's *Designing With Geotextiles*, 1990.

Table 1

1995 ABA and Bulk Chemical Data for the Tailings Composites

ABA Data

Composite	S %	S^{2-} %	CO_2 %	NP kg/tonne	$NP-CO_2$ kg/tonne	AP kg/tonne	SAP kg/tonne	Net NP kg/tonne	NP / AP	NP / SAP	$NP-CO_2$ / SAP	Paste pH
Fine Tailings[1]	30.3	24.0	1.76	35	40	947	750	-912	0.04	0.05	0.05	6.61
Fine Tailings[2]	31.1	30.0	1.3	26	30	972	938	-946	0.03	0.03	0.03	6.3
Coarse Tailings[1]	29.6	28.2	1.58	29	36	925	881	-896	0.03	0.03	0.04	5.59
Coarse Tailings[2]	28.4	28.4	1.0	21	23	888	888	-867	0.02	0.02	0.03	6.3

Bulk Chemical Composition

Composite	Al mg/kg	As mg/kg	Ba mg/kg	Be mg/kg	Ca mg/kg	Cd mg/kg	Co mg/kg	Cr mg/kg	Cu mg/kg	Fe mg/kg	Hg mg/kg	K mg/kg	Mg mg/kg	Mn mg/kg	Mo mg/kg	Na mg/kg	Ni mg/kg	P mg/kg	Pb mg/kg	Sb mg/kg	Se mg/kg	Te mg/kg	Zn mg/kg	CO_2 %
Fine Tailings[1]	18,900	3,300	41	<5.5	7,260	57	95	<2.2	575	301,000	3.0	4,675	11,600	570	<5.5	933	<2.2	135	975	25	<22	<11	6,830	1.76
Coarse Tailings[1]	19,700	2,950	42	<5.5	7,280	56	91	<2.2	538	294,000	2.5	4,950	11,900	575	<5.5	998	<2.2	129	930	28	<22	<11	6,000	1.58

[1]Results from Lakefield Research, Lakefield, Ontario.
[2]Results from Chemex Labs, Vancouver, British Columbia.

Prepared by: JET
Checked by: DJL

THE CHEMICAL RESISTANCE

OF

POLYETHYLENE AND POLYPROPYLENE POLYOLEFINS

TTN:PT2.0
4/16/86

T-055

SUMMARY

Based on research performed by our polypropylene suppliers (Himont, Shell, Soltex), the chemical resistivity of polypropylene is outstanding. At room temperature it is essentially insoluble in common solvents. When it is removed from the solvent, its swelling is reversible. It resists acids, alkalies, moisture, and salt solutions. It is attacked by strong oxidizing agents such as concentrated nitric acid, hydrogen peroxide, and wet chlorine, especially at temperatures approaching 60°C. Except in oxidizing environments, polypropylene is immune to stress cracking, as determined by accepted testing procedures.

Based on research performed by our suppliers of high density polyethylene (Soltex and British Petroleum), due to its molecular structure, HDPE is resistant to attack by all chemicals which may be reasonably considered to be present in soil. Soltex studies find no known solvent for their high molecular weight, high density polyethylene below 60°C (140°F). The higher the molecular weight, the more HDPE is resistant to chemical attack. The Tensar Corporation employs high molecular weight fractional melt polyethylenes in the manufacture of geogrids and geonets.

Attached to this Tensar Technical Note is support documentation on the resistance to chemical attack of TENSAR® Geogrids. Specifically, The Tensar Corporation uses Himont, Shell, and Soltex polypropylenes for all biaxial products and Soltex XF 409 and BP HDPE for the uniaxial soil reinforcement products. Enclosed are Himont and Soltex Polypropylene and Soltex XF409 and BP High Density Polyethylene chemical resistance data. Also included in this technical note are two exerpts from research done by Dr. J. P. Giroud on the chemical resistivity of TENSAR Geogrid and Geonets and from research done by G. H. Burke of BP Chemicals on aging of HDPE in buried situations.

Requests for information on specific chemicals or their concentrations not included in the enclosed data tables can be requested from The Tensar Corporation, Director of Production Technology.

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HIMONT

HIMONT U.S.A., Inc
1313 N. Market Street
Wilmington, DE 19894
(302) 594-5500

BEST COPY AVAILABLE

Product Data

NUMBER 51
(Supersedes PPD-32F

PRO-FAX[1] Polypropylene
Chemical Resistance

PRO-FAX polypropylene, like most of the polyolefins, is highly resistant to solvents and chemicals.

The results of extensive laboratory and actual field installation tests of polypropylene's chemical resistance are reported in this data sheet, which is updated at intervals.

The corrosion resistance data presented here are based on unstressed specimens of Pro-fax, 3 in. long by 0.025 in. thick, in the shape of dumbbells. Results are reported after 1-month immersion. As it is difficult to create actual service conditions in the laboratory, the results of many of the environments should be taken only as an indication of behavior in service.

Pro-fax polypropylene has outstanding resistance to water and other inorganic environments. In most aqueous environments, its weight increase is less than 0.2% when it has been stored for 6 months at ambient temperatures. When the temperature is increased to 60°C (140°F), the weight increase is less than 0.5% for a similar period. According to ASTM D 570-63T, its 24-hr water absorption rate is 0.03%. It resists most strong mineral acids and bases, but, like the other polyolefins, it is subject to attack by oxidizing agents.

Pro-fax polypropylene is appreciably affected by chlorosulfonic acid and oleum at room temperature, 98% sulfuric acid, 30% hydrochloric acid, and 30% hydrogen peroxide at 100°C (212°F). It is also affected by 98% sulfuric acid at 60°C (140°F) and fuming nitric acid and liquid bromine at room temperatures. Under strain, failure could occur with strong oxidizing acids at temperatures lower than those mentioned. With few exceptions, however, inorganic chemicals produce little or no effect on Pro-fax over a period of 6 months at temperatures up to 120°C (248°F).

The permeation resistance of Pro-fax polypropylene to organic chemicals depends on the rate and extent to which absorption occurs. This, in turn, will govern the suitability of the resin to serve in a particular environment. When the plastic is removed from the environment, evaporation will take place and cause it to return almost to its original dimensions. Property changes resulting from the absorption will be reversed if evaporation is complete.

Temperature and polarity of the organic medium are the foremost factors determining the extent of absorption by polypropylene. Absorption becomes greater as temperatures are increased and polarity of the medium is decreased. Copolymers swell more than homopolymers, indicating greater absorption. Such non-polar liquids as benzene, carbon tetrachloride, and petroleum ether have a higher absorption rate by polypropylene than polar media such as ethanol and acetone. Some reduction in tensile strength and an increase in flexibility and elongation to break in tension can be expected, depending on the nature and amount of the organic medium absorbed.

Pro-fax polypropylene has excellent resistance to environmental stress-cracking. When it is tested according to ASTM D 1693-60T, the brittle fractures that occur with certain polyethylenes in contact with polar organic liquids, detergents, and silicone fluids are not observed. Failure of this type with polypropylene is rare. Those environments known to cause such cracking to polypropylene are 98% sulfuric acid, concentrated chromic/sulfuric acid mixtures, and concentrated hydrochloric acid/chlorine mixtures.

The useful life of Pro-fax polypropylene at elevated temperatures is limited by oxidative degradation. The expected life of polypropylene at any given temperature is also determined by the nature of the environment, and by the extraction of some of the antioxidant system. Any environment that tends to extract the antioxidants may lead to more rapid breakdown of the polypropylene, especially at elevated temperatures.

[1] Registered trademark of HIMONT Incorporated.

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in combination with our products, may be used. We accept no responsibility for results obtained by the application of
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liability for loss or damage arising from the handling and use of our products, whether used alone or in combination with other produ
Date

RATING SYSTEM

This chart rates the chemical resistance of Pro-fax polypropylene according to the following code:

A = NEGLIGIBLE EFFECT — Should be suitable for all applications where these environmental conditions exist.

B = LIMITED ABSORPTION OR ATTACK — Should be suitable for most applications, but the user is advised to make his own tests to determine the suitability of polypropylene in the particular environment.

C = EXTENSIVE ABSORPTION AND/OR RAPID PERMEATION — Should be suitable for applications where only intermittent service is involved, or where the swelling produced has no detrimental effect on the part. The user should make his own tests to determine the suitability of polypropylene in the particular environment.

D = EXTENSIVE ATTACK — The specimen dissolves or disintegrates. Polypropylene is not recommended.

Environment	Conc., %	Temperature, °C		
		20	60	100
Acetic acid (glacial)	97	A	B (80°C)	—
Acetic acid	50	A	A (80°C)	—
Acetic acid	40	A	—	—
Acetic acid	10	A	A	—
Acetone	100	A	A	—
Acetophenone	100	B	B	—
Acriflavine (2% solution in H_2O)	2	A	A (80°C)	—
Acrylic emulsions		A	A	—
Aluminum chloride		A	A	—
Aluminum fluoride		A	A	—
Aluminum sulfate		A	A	—
Alums (all types)		A	A	—
Ammonia (aqueous)	30	A	—	—
Ammonia gas (dry)		A	A	—
Ammonium carbonate	Satd.	A	A	—
Ammonium chloride	Satd.	A	A	—
Ammonium fluoride	20	A	A	—
Ammonium hydroxide	10	A	A	—
Ammonium metaphosphate	Satd.	A	A	—
Ammonium nitrate	Satd.	A	A	—
Ammonium persulfate	Satd.	A	A	—
Ammonium sulfate	Satd.	A	A	—
Ammonium sulfide	Satd.	A	A	—
Ammonium thiocyanate	Satd.	A	A	—
Amyl acetate	100	B	C	—
Amyl alcohol	100	A	B	—
Amyl chloride	100	C	C	—
Aniline	100	A	A	—
Anisole	100	B	B	—
Antimony chloride		A	A	—
Aqua regia	(a)	B	B	—
Aviation fuel (115/145 octane)	100	B	C	—
Aviation turbine fuel	100	B	C	—
Barium carbonate	Satd.	A	A	—
Barium chloride	Satd.	A	A	—
Barium hydroxide		A	A	—
Barium sulfate	Satd.	A	A	—
Barium sulfide	Satd.	A	A	—
Beer		A	A	—
Benzene	100	B	C	C
Benzoic acid		A	A	—
Benzyl alcohol		A	A (80°C)	—
Bismuth carbonate	Satd.	A	A	—
Borax		A	A	—
Boric acid		A	A	—
Brine	Satd.	A	A	—
Bromine liquid	100	D	—	—
Bromine water	(a)	C	—	—
Butyl acetate	100	—	C	C
Butyl alcohol	A	—	—	100

Environment	Conc., %	Temperature, °C		
		20	60	100
Calcium carbonate	Satd.	A	A	—
Calcium chlorate	Satd.	A	A	—
Calcium chloride	50	A	A	—
Calcium hydroxide		A	A	—
Calcium hypochlorite bleach	20	A	B	—
Calcium nitrate		A	A	—
Calcium phosphate	50	A	—	—
Calcium sulfate		A	A	—
Calcium sulfite		A	A	—
Carbon dioxide (dry)		A	A	—
Carbon dioxide (wet)		A	A	—
Carbon disulfide	100	B	C	—
Carbon monoxide		A	A	—
Carbon tetrachloride	100	C	C	C
Carbonic acid		A	A	—
Castor oil		A	—	—
Cetyl alcohol	100	A	—	—
Chlorine (gas)	100	D	D	—
Chlorobenzene	100	C	C	—
Chloroform	100	C	D	D
Chlorosulfonic acid	100	D	D	D
Chrome alum		A	A	—
Chromic acid	80(a)	A	—	—
Chromic acid	50(a)	A	A	—
Chromic acid	10(a)	A	A	—
Chromic/sulfuric acid		D	D	—
Cider		A	A	—
Citric acid	10	A	A	—
Copper chloride	Satd.	A	A	—
Copper cyanide	Satd.	A	A	—
Copper fluoride	Satd.	A	A	—
Copper nitrate	Satd.	A	A	—
Copper sulfate	Satd.	A	A	—
Cottonseed oil		A	A	—
Cuprous chloride	Satd.	A	A	—
Cyclohexanol	100	A	B	—
Cyclohexanone	100	B	C	—
Decalin	100	C	C	C
Detergents	2	A	A	A
Developers (photographic)		A	A	—
Dibutyl phthalate	100	A	B	D
Dichloroethylene	100	A	—	—
Diethanolamine	100	A	A	—
Diisooctyl phthalate	100	A	A	—
Emulsifiers		A	A	—
Ethanolamine	100	A	A	—
Ethyl acetate	100	B	B	—
Ethyl alcohol	96	A	A	A (80°C)
Ethyl chloride	100	C	C	—
Ethylene dichloride	100	B	—	—
Ethylene glycol		A	A	—
Ethylene oxide	100	B (10°C)	—	—
Ethyl ether	100	B	—	—

Environment	Conc., %	Temperature, °C		
		20	60	100
Fatty acids (C_n)	100	A	A	—
Ferric chloride	Satd.	A	A	—
Ferric nitrate	Satd.	A	A	—
Ferric sulfate	Satd.	A	A	—
Ferrous chloride	Satd.	A	A	—
Ferrous sulfate	Satd.	A	A	—
Fluosilicic acid		A	A	—
Formaldehyde	40	A	A	—
Formic acid	100	A	—	—
Formic acid	10	A	A	—
Fructose		A	A	—
Fruit juices		A	A	—
Furfural	100	C	C	—
Gas liquor		C	—	—
Gasoline	100	B	C	C
Gearbox oil	100	A	B	—
Gelatin		A	A	—
Glucose	20	A	A	—
Glycerin	100	A	A	A
Glycol		A	A	—
Hexane	100	A	B	—
Hydrobromic acid	50[a]	A	A	—
Hydrochloric acid	30[a]	A	B	D
Hydrochloric acid	20	A	A (80°C)	—
Hydrochloric acid	10	A	A (80°C)	B
Hydrochloric acid	2	A	A	A
50-50 HCl-HNO_3	[a]	B	D (80°C)	—
Hydrofluoric acid	40	A	—	—
Hydrofluoric acid	60[a]	A	A (40°C)	—
Hydrogen chloride gas (dry)	100	A	A	—
Hydrogen peroxide	30	A	—	D
Hydrogen peroxide	10	A	B	—
Hydrogen peroxide	3	A	—	—
Hydrogen sulfide		A	A	—
Hydroquinone		A	A	—
Inks		A	A	—
Iodine tincture		A	—	—
Isooctane	100	C	C	—
Isopropyl alcohol	100	A	A	—
Ketones		A	—	—
Lactic acid	20	A	A	—
Lanolin	100	A	A	—
Lead acetate	Satd.	A	A	—
Linseed oil	100	A	A	—
Lubricating oil	100	A	B	—
Magenta dye (aqueous solution)	2	A	A Some staining	—
Magnesium carbonate	Satd.	A	A	—
Magnesium chloride	Satd.	A	A	—
Magnesium hydroxide	Satd.	A	A	—
Magnesium nitrate	Satd.	A	A	—
Magnesium sulfate	Satd.	A	A	—
Magnesium sulfite	Satd.	A	A	—
Meat juices		A	A	—
Mercuric chloride	40	A	A	—
Mercuric cyanide	Satd.	A	A	—
Mercurous nitrate	Satd.	A	A	—
Mercury	100	A	A	—

Environment	Conc., %	Temperature, °C		
		20	60	100
Methyl alcohol	100	A	A	—
Methylene chloride	100	A	—	—
Methyl ethyl ketone	100	A	B	—
Milk and its products		A	A	A
Mineral oil	100	A	B	—
Molasses		A	A	—
Motor oil	100	A	B	—
Naphthalene	100	A	A	A
Nickel chloride	Satd.	A	A	—
Nickel nitrate	Satd.	A	A	—
Nickel sulfate	Satd.	A	A	—
Nitric acid	fuming	D	D	D
Nitric acid	70[a]	C	D	—
Nitric acid	60	A	D (80°C)	—
Nitric acid	10	A	A	A
50-50 HNO_3-HCl	[a]	A	D (80°C)	—
50-50 HNO_3-H_2SO_4	[a]	C	D (80°C)	—
Nitrobenzene	100	A	A	—
Oleic acid		A	B	—
Oleum		—	—	D
Olive oil	100	A	A	—
Oxalic acid (aqueous)	50	A	B	—
Paraffin	100	A	B	—
Paraffin wax	100	A	A	—
Petrol	100	B	C	—
Petroleum ether (boiling point 100-140°C)	100	C	C	—
Phenol	95	A	A	—
Phosphoric acid		A	A	—
Plating solutions, brass		A	A	—
Plating solutions, cadmium		A	A	—
Plating solutions, chromium		A	A	—
Plating solutions, copper		A	A	—
Plating solutions, gold		A	A	—
Plating solutions, indium		A	A	—
Plating solutions, lead		A	A	—
Plating solutions, nickel		A	A	—
Plating solutions, rhodium		A	A	—
Plating solutions, silver		A	A	—
Plating solutions, tin		A	A	—
Plating solutions, zinc		A	A	—
Potassium bicarbonate	Satd.	A	A	—
Potassium borate	1	A	A	—
Potassium bromate	10	A	A	—
Potassium bromide	Satd.	A	A	—
Potassium carbonate	Satd.	A	A	—
Potassium chlorate	Satd.	A	A	—
Potassium chloride	Satd.	A	A	—
Potassium chromate	40	A	A	—
Potassium cyanide	Satd.	A	A	—
Potassium dichromate	40	A	A	—
Potassium ferri-/ferrocyanide		A	A	—
Potassium fluoride		A	A	—
Potassium hydroxide	50	A	A	—
Potassium hydroxide	10	A	A	A
Potassium nitrate	Satd.	A	A	—
Potassium perborate	Satd.	A	A	—
Potassium perchlorate	10	A	A	—
Potassium permanganate	20	A	A	—
Potassium sulfate		A	A	—
Potassium sulfide		A	A	—
Potassium sulfite		A	A	—
Propyl alcohol	100	A	A	—
Pyridine	100	A	—	—
Silicone oil	100	A	A	—
Soap solution (concentrated)		A	A	—

Environment	Conc., %	Temperature, °C		
		20	60	100
Sodium acetate		A	A	—
Sodium bicarbonate	Satd.	A	A	—
Sodium bisulfate	Satd.	A	A	—
Sodium bisulfite	Satd.	A	A	—
Sodium borate		A	A	—
Sodium bromide oil solution		A	A	—
Sodium carbonate	Satd.	A	A	—
Sodium chlorate	Satd.	A	A	—
Sodium chloride	Satd.	A	A	A
Sodium chlorite	2	A	A (80°C)	—
Sodium chlorite	5	A	A (80°C)	—
Sodium chlorite	10	A	A (80°C)	—
Sodium chlorite	20	A	A (80°C)	—
Sodium cyanide	Satd.	A	A	—
Sodium dichromate	Satd.	A	A	—
Sodium ferricyanide	Satd.	A	A	—
Sodium ferrocyanide	Satd.	A	A	—
Sodium fluoride	Satd.	A	A	—
Sodium hydroxide	50	A	A	—
Sodium hydroxide	10	A	A	A
Sodium hypochlorite	20	A	B	B
Sodium nitrate		A	A	—
Sodium nitrite		A	A	—
Sodium silicate		A	A	—
Sodium sulfate	Satd.	A	A	—
Sodium sulfide	25	A	A	—
Sodium sulfite	Satd.	A	A	—
Stannic chloride	Satd.	A	A	—
Stannous chloride	Satd.	A	A	—
Starch		A	A	—
Sugars and syrups		A	A	—
Sulfamic acid		A	A (80°C)	—
Sulfates of calcium and magnesium	Satd.	A	A	—
Sulfites of potassium and sodium	Satd.	A	A	—
Sulfur		A	A	—
Sulfuric acid	98[a]	C	—	D

Environment	Conc., %	Temperature, °C		
		20	60	100
Sulfuric acid	60	A	B (80°C)	—
Sulfuric acid	50	A	B	—
Sulfuric acid	10	A	A	A
50-50 H_2SO_4/HNO_3	(a)	C	D (80°C)	—
Tallow		A	A	—
Tannic acid	10	A	A	—
Tartaric acid		A	A	—
Tetrahydrofuran	100	C	C	C
Tetralin	100	C	C	C
Toluene	100	C	C	—
Transformer oil	100	A	C	—
Trichloroacetic acid	10	A	A	—
Trichloroethylene	100	C	C	C
Triethanolamine	100	A	A (80°C)	—
Turpentine	100	C	C	C
Urea		A	A	—
Urine		A	A	—
Vaseline[b]		A	A	—
Vinegar		A	A	—
Water (distilled, soft, hard, and vapor)		A	A	A
Wet chlorine gas		—	D (70°C)	—
Whisky		A	A	A
White paraffin	100	A	B (80°C)	—
White spirit	100	B	C	—
Wines		A	A	—
Xylene	100	C	C	C
Yeast		A	A	—
Zinc chloride	Satd.	A	A	—
Zinc oxide		A	A	—
Zinc sulfate	Satd.	A	A	—

[a] May produce cracking in material under stress.
[b] Registered trademark of Chesebrough-Ponds, Inc.

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Table 4

CHEMICAL RESISTANCE OF FORTILENE POLYPROPYLENE

Legend: S = Satisfactory. O = Some Attack. U = Unsatisfactory

Reagent	70°F (21°C)	140°F (60°C)	212°F (100°C)
Acetic Acid (10%)	S	S	
Acetic Acid (50%)	S	S	O
Acetic Acid (100%)	S	S	
Acetic Anhydride	S	S	
Acetone	S	S	
Acetonitrile	S		
Acetophenone	O	O	U
Aluminum Ammonium Sulfate	S	S	
Aluminum Chloride	S	S	O
Aluminum Fluoride	S	S	
Aluminum Hydroxide	S	S	
Aluminum Nitrate	S	S	S
Aluminum Potassium Sulfate	S	S	
Alums (all types)	S	S	
Ammonia (anhydrous)	S	S	
Ammonia (30% aqueous)	S	S	
Ammonium Bifluoride	S	S	
Ammonium Carbonate	S	S	S
Ammonium Chloride	S	S	O
Ammonium Fluoride (25%)	S	S	
Ammonium Hydroxide	S	S	
Ammonium Nitrate	S	S	S
Ammonium Sulfate	S	S	S
Ammonium Sulfide	S	S	
Ammonium Thiocyanate	S	S	
Amyl Acetate	O	U	
Amyl Alcohol	S	O	U
Amyl Chloride	U	U	
Aniline	S	S	O
Anisole	O	O	U
Antimony Trichloride	S	S	
Aqua Regia	O	O	
Arsenic Acid	S	S	
Aviation Fuel	O	O	
Barium Carbonate	S	S	
Barium Chloride	S	S	O
Barium Hydroxide	S	S	
Barium Soap Grease	S	O	
Barium Sulfate	S	S	
Barium Sulfide	S	S	S
Beer	S	S	
Benzaldehyde	S	S	
Benzyl Alcohol	S	S	
Benzyl Chloride	S	S	
Bismuth Carbonate	S	S	
Borax	S	S	S
Boric Acid	S	S	
Brake Fluid	S	O	
Brine	S	S	S
Bromic Acid	U	U	
Bromine	U	U	
Bromine Water	U	U	
Butyl Acetate	U	U	
Butyl Acrylate	U	U	
Butyl Alcohol	S	S	
Calcium Bisulfate	S	S	
Calcium Carbonate	S	S	S
Calcium Chlorate	S	S	
Calcium Chloride	S	S	O
Calcium Hydroxide	S	S	S
Calcium Hypochlorite	S	S	
Calcium Nitrate	S	S	
Calcium Soap Grease	S	O	
Calcium Sulfate	S	S	
Calgonite (1%)	S	S	
Carbon Dioxide (dry)	S	S	
Carbon Dioxide (wet)	S	S	
Carbon Disulfide	O	U	
Carbon Monoxide	S	S	
Carbon Tetrachloride	U	U	
Carbonic Acid	S	S	
Castor Oil	S	S	
Cellusolve	S	S	
Cetyl Alcohol	S	S	
Chlorine (dry)	U	U	
Chlorine (wet)	O	U	
Chloroacetic Acid	S	U	
Chlorobenzene	O	U	
Chloroform	U	U	
Chlorosulfonic Acid	U	U	
Chromic Acid (10%)	S	S	
Chromic Acid (50%)	S	S	
Chromic Acid (80%)	S	S	
Cider	S	S	
Citric Acid	S	S	S
Clorox	S	S	
Copper Chloride	S	S	
Copper Cyanide	S	S	
Copper Fluoride	S	S	
Copper Nitrate	S	S	
Copper Sulfate	S	S	
Corn Oil	S	S	
Cottonseed Oil	S	S	
Cresol	S	S	
Cuprous Chloride	S	O	
Cyclohexane	S	O	
Cyclohexanol	O	U	
Cyclohexanone			
Decalin	U	U	
Developers (photographic)	S	S	
Dextrin	S	S	U
Dibutyl Phthalate	S		
Dichloroethylene	S	S	
Diethanolamine	O	O	
Diethyl Ether	S	S	
Diglycolic Acid	S	S	
Diisooctyl Phthalate	S	S	
Dimethyl Phthalate	S	O	
p-Dioxane			
Ethyl Acetate	S	S	S
Ethyl Alcohol	S	S	
Ethylamine	S	S	
Ethylene Chloride	U	U	
Ethylene Chlorohydrin	S	S	

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CHEMICAL RESISTANCE OF FORTILENE POLYPROPYLENE
Legend: S=Satisfactory. O=Some Attack. U=Unsatisfactory

Reagent	70°F (21°C)	140°F (60°C)	212°F (100°C)
Ethylene Glycol	S	S	
Ethanolamine	S	S	
Ethyl Ether	O	O	
Ethyl Chloride	O	O	
Ethylene Dichloride	S		
Ethylene Oxide	S		
Ferric Chloride	S	S	
Ferric Nitrate	S	S	
Ferric Sulfate	S	S	
Ferrous Chloride	S	S	
Ferrous Nitrate	S	S	O
Ferrous Sulfate	S	S	
Fluorine	U	U	
Fluorosilicic	S	S	
Formaldehyde	S	S	O
Formic Acid (10%)	S	S	
Formic Acid (100%)	S		
Fructose	S	S	
Fruit Juice	S	S	
Fuel Oil	S	O	
Furfural	U	U	
Gasoline	O	U	
Gelatin	S	S	
Glucose	S	S	
Glycerol	S	S	S
Glycol	S	S	O
Glycolic Acid	S	S	
Heptane	U	U	
Hexadecyl Alcohol	S	S	
Hexane	S	S	
Hydroiodic Acid	U	U	
Hydrobromic Acid(50%)	S	S	
Hydrochloric Acid(20%)	S	S	O
Hydrochloric Acid(100%)	S	S	
Hydrofluoric Acid(35%)	S	S	
Hydrogen Peroxide(30%)	S	O	
Hydrogen Peroxide(90%)	O	O	
Hydrogen Chloride Gas(dry)	S	S	
Hydrogen Sulfide	S	S	
Hydroquinone	S	S	
Igepal	S	S	
Iodine(dry)	S	S	
Iodine(wet)	U		
Isopropyl Alcohol	S	S	
Isooctane	U		
Jet Fuel(JP 4 & 5)	O	U	
Lactic Acid	S	S	
Lanolin	S	S	
Lauric Acid	S	S	
Lead Acetate	S	S	S
Lemon Oil	O		
Linseed Oil	S	S	
Lubricating Oil	S	O	

Reagent	70°F (21°C)	140°F (60°C)	212°F (100°C)
Magnesium Sulfite	S	S	
Malic Acid	S	O	
Mercuric Chloride	S	S	
Mercuric Cyanide	S	S	
Mercuric Nitrate	S	S	
Mercury	S	S	
Merthiolate (Tincture)	S	S	
Methane	S	S	
Methanol	S	S	
Methyl Cellusolve	S		
Methyl Chloride	U		
Methylene Chloride	S	O	
Methyl Ethyl Ketone	S	S	
Methyl Isobutyl Ketone	S	S	
Methyl Sulfuric Acid	S	S	
Milk	S	S	
Mineral Oil	S	U	
Mineral Spirits	S	S	
Motor Oil	S	S	
Naphtha	S	S	
Naphthalene	S	S	S
Nickel Chloride	S	S	
Nickel Nitrate	S	S	S
Nickel Sulfate	S	S	S
Nitric Acid (10%)	S	U	
Nitric Acid (concentrate)	O	U	
Nitric Acid (fuming)	U		
Nitric/Sulfuric Acid 50:50%	U		
Nitrobenzene	S	O	
Nitrous Acid	O		
Oleic Acid	S	S	
Oleum	U		
Olive Oil	S	S	
Oxalic Acid	S	S	
Oxygen	U	U	
Ozone	U	U	
Paradichlorobenzene	S	S	
Paraffin	S	S	
Peanut Oil	S	S	
Perchloroethylene	U	U	
Phenol (10%)	S	S	O
Phosgene (gas)	U	U	
Phosgene (liquid)	U	U	
Phosphoric Acid (30%)	S	S	O
Phosphoric Acid (85%)	S	S	O
Phosphorus	S		
Phathalic Acid	S		
Polyvinyl Acetate	S		
Potassium Bromide	S	S	S
Potassium Carbonate	S	S	S
Potassium Chlorate	S	S	O
Potassium Chloride	S	S	O
Potassium Cyanide	S	S	
Potassium Dichromate	S	S	S
Potassium Ferrocyanide	S	S	
Potassium Hydroxide	S	S	S
Potassium Nitrate	S	S	

Table 4 (continued)

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CHEMICAL RESISTANCE OF FORTILENE POLYPROPYLENE

Legend: S = Satisfactory. O = Some Attack. U= Unsatisfactory

Reagent	70°F (21°C)	140°F (60°C)	212°F (100°C)
Magnesium Carbonate	S	S	S
Magnesium Chloride	S	S	O
Magnesium Hydroxide	S	S	S
Magnesium Nitrate	S	S	
Magnesium Sulfate	S	S	
Potassium Permanganate	S	O	
Potassium Sulfate	S	S	S
Potassium Sulfide	S	S	S
Propanol	S	S	
Pyridine	S		
Silicone Oil	S	S	
Silver Cyanide	S	S	
Silver Nitrate	S	S	S
Sodium Acetate	S	S	
Sodium Benzoate	S	S	S
Sodium Bicarbonate	S	S	
Sodium Bisulfate	S	S	
Sodium Bisulfite	S	S	
Sodium Bromide	S	S	
Sodium Carbonate	S	S	S
Sodium Chlorate	S	S	O
Sodium Chloride	S	S	O
Sodium Cyanide	S	S	
Sodium Fluoride	S	S	
Sodium Hydroxide (concentrated)	S	S	S
Sodium Sulfate	S	S	
Sodium Sulfite	S	S	
Starch	S	S	
Stannic Chloride	S	S	
Stannous Chloride	S	S	
Sucrose (20%)	S	S	
Sulfuric Acid (10%)	S	S	S
Sulfuric Acid (50%)	S	S	
Sulfuric Acid (concentrated)	S	O	U
Sulfuric Acid (fuming)	U	U	
Sulfamic Acid	S	S	
Tannic Acid (10%)	S	S	
Tetrahydrofuran	S	O	O
Tetralin	O	O	O
Toluene	U	U	
Tributyl Phosphate	S	O	
Trichloroacetic Acid	S	S	
Trichloroethylene	U	U	
Tricresyl Phosphate	S	S	
Triethanolamine	O	O	
Trisodium Phosphate	S	S	
Turpentine	S	O	O
Urea	S	S	
Urine	S	S	
Water	S	S	O
Whiskey	S	S	S
Wines	S	S	
Xylene	O	U	
Xylol	S		
Yeast	S	S	
Zinc Chloride	S	S	
Zinc Oxide	S	S	
Zinc Sulfate	S	S	

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Table II
Chemical Resistance of Fortiflex HDPE

Legend: S = Satisfactory, O = Some Attack, U = Unsatisfactory

Reagent	21°C (70°F)	60°C (140°F)
Acetaldehyde	S	O
Acetic Acid 1-10%	S	S
Acetic Acid 10-60%	S	O
Acetic Acid 80-100%	S	O
Acetic Anhydride	S	S
Acetone	S	S
Acids, Aromatic	S	S
Acrylic Emulsions	S	S
Adipic Acid	S	S
Aluminum Chloride Dilute	S	S
Aluminum Chloride Conc.	S	S
Aluminum Fluoride Conc	S	S
Aluminum Sulfate Conc.	S	S
Alums (all types) Conc.	S	S
Amino Acetic Acid	S	S
Ammonia 100% Dry Gas	S	S
Ammonium Acetate	S	S
Ammonium Bromide	S	S
Ammonium Carbonate	S	S
Ammonium Chloride Sat'd	S	S
Ammonium Fluoride 20%	S	S
Ammonium Hydroxide	S	S
Ammonium Metaphosphate Sat'd	S	S
Ammonium Nitrate Sat'd	S	S
Ammonium Persulfate Sat'd	S	S
Ammonium Phosphate	S	S
Ammonium Sulfate Sat'd	S	S
Ammonium Sulfide Sat'd	S	S
Ammonium Thiocyanate Sat'd	S	S
Amyl Acetate 100%	O	U
Amyl Alcohol 100%	S	S
Amyl Chloride 100%	O	U
Aniline 100%	S	U
Anise Seed Oil	O	U
Antimony Chloride	S	S
Aqua Regia	O	U
Aromatic Hydrocarbons	U	U
Arsenic	S	S
Aspirin	S	S
Barium Carbonate Sat'd	S	S
Barium Chloride Sat'd	S	S
Barium Hydroxide	S	S
Barium Sulfate Sat'd	S	S
Barium Sulfide Sat'd	S	S
Beer	S	S
Benzaldehyde	O	U
Benzene	S	S
Benzene Sulfonic Acid		
Benzoic Acid		
Crystals	S	S
Saturated	S	S
Bismuth Carbonate Sat'd	S	S
Black Liquor	S	S
Bleach Lye 10%	S	S
Borax Cold Sat'd	S	S

Reagent	21°C (70°F)	60°F (140°F)
Boric Acid Dilute	S	S
Boric Acid Conc.	S	S
Brine	S	S
Bromic Acid 10%	S	S
Bromine Liquid 100%	O	U
Bromochloromethane	U	U
Butadiene	U	U
Butanediol 10%	S	S
Butanediol 60%	S	S
Butanediol 100%	S	S
Butter	S	S
Butyl Acetate 100%	O	U
Butyl Alcohol 100%	S	S
Butylene Glycol	S	S
Butyric Acid 100%	S	S
Caffeine Citrate Sat'd	S	S
Calcium Bisulfide	S	S
Calcium Bromide	S	S
Calcium Carbonate Sat'd	S	S
Calcium Chlorate Sat'd	S	S
Calcium Chloride Sat'd	S	S
Calcium Hydroxide	S	S
Calcium Hypochlorite Bleach Sat'd	S	S
Calcium Nitrate 50%	S	S
Calcium Sulfate	S	S
Camphor Crystals	U	U
Camphor Oil	U	U
Carbon Dioxide 100% Dry	S	S
Carbon Dioxide 100% Wet	S	S
Carbon Dioxide Cold Sat'd	S	S
Carbon Disulphide	O	U
Carbon Monoxide	S	S
Carbon Tetrachloride	U	U
Carbonic Acid	S	S
Carnauba Wax	S	S
Carrot Juice	S	S
Castor Oil Conc.	S	S
Catsup	S	S
Caustic Soda	U	U
Cedar Leaf Oil	U	U
Cedar Wood Oil	U	U
Chlorine Liquid	O	U
Chlorobenzene	U	U
Chloroform	U	U
Chlorosulfonic Acid 100%	U	U
Chrome Alum Sat'd	S	S
Chromic Acid 10-20%	S	O
Chromic Acid 50%	S	O
Cider	S	S
Cinnamon	S	S
Cinnamon Oil	U	U
Citric Acid Sat'd	S	S
Citronella Oil	O	U
Cloves (Ground)	S	S
Coconut Oil Alcohols	S	S
Cod Liver Oil	S	S
Coffee	S	S

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Table II
Chemical Resistance of Fortiflex HDPE

Legend: S = Satisfactory, O = Some Attack, U = Unsatisfactory

Reagent	21°C (70°F)	60°C (140°F)
Copper Chloride Sat'd	S	S
Copper Cyanide Sat'd	S	S
Copper Fluoride 2%	S	S
Copper Nitrate Sat'd	S	S
Copper Sulfate Dilute	S	S
Copper Sulfate Sat'd	S	S
Corn Oil	S	S
Cottonseed Oil	S	S
Cranberry Sauce	S	S
Cresols	S	O
Cuprous Chloride Sat'd	S	S
Cuprous Oxide	S	S
Cyclohexane	U	U
Cyclohexanone	U	U
Decalin	S	U
Detergents Synthetic	S	S
Developers Photographic	S	S
Dextrin Sat'd	S	S
Dextrose Sat'd	S	S
Dibutyl Ether	O	U
Dichlorobenzene (ODB)	U	U
Diethylene Glycol	S	S
Disodium Phosphate	S	S
Dioxane	S	S
Emulsions Photographic	S	S
Ether	O	O
Ethyl Acetate 100%	O	O
Ethyl Alcohol 100%	S	S
Ethyl Alcohol 35%	S	S
Ethylbenzene	O	U
Ethylene Glycol	S	S
Ferric Chloride Sat'd	S	S
Ferric Nitrate Sat'd	S	S
Ferrous Ammonium Citrate	S	S
Ferrous Chloride Sat'd	S	S
Ferrous Sulfate	S	S
Fluoboric Acid	S	S
Fluorine	S	U
Fluosilicic Acid 32%	S	S
Fluosilicic Acid Conc.	S	S
Formaldehyde		
10-30%	S	S
30-40%	S	O
Formic Acid 20%	S	S
Formic Acid 50%	S	S
Formic Acid 100%	S	S
Fructose Sat'd	S	S
Fuel Oil	S	U
Furfural 100%	O	U
Furfuryl Alcohol	S	O
Gallic Acid Sat'd	S	S
Gasoline	S	U
Glucose	S	S
Glycerine	S	S
Glycol	S	S

Reagent	21°C (70°F)	60°C (140°F)
Glycolic Acid 30%	S	S
Grape Juice	S	S
Grapefruit Juice	S	S
Heptane	O	U
Hexachlorobenzene	S	S
Hexane	U	U
Hydrobromic Acid 50%	S	S
Hydrocyanic Acid Sat'd	S	S
Hydrochloric Acid 10%	S	S
Hydrochloric Acid 30%	S	S
Hydrochloric Acid 35%	S	S
Hydrocyanic Acid	S	S
Hydrofluoric Acid 40%	S	S
Hydrofluoric Acid 60%	S	S
Hydrofluoric Acid 75%	S	S
Hydrogen 100%	S	S
Hydrogen Bromide 10%	S	S
Hydrogen Chloride Gas Dry	S	S
Hydrogen Peroxide 30%	S	S
Hydrogen Peroxide 90%	S	S
Hydroquinone	S	S
Hydrogen Sulfide	S	S
Hypochlorous Acid Conc.	S	S
Inks	S	S
Iodine Crystals	O	O
Isobutyl Alcohol	S	S
Isopropyl Alcohol	S	O
Isopropyl Ether	O	O
Kerosene	S	O
Lactic Acid 10%	S	S
Lactic Acid 90%	S	S
Lanolin	S	S
Lard	S	S
Lead Acetate Sat'd	S	S
Lead Nitrate	S	S
Lemon Juice	S	S
Lemon Oil	O	U
Lime Juice	S	S
Linseed Oil	S	S
Magnesium Carbonate Sat'd	S	S
Magnesium Chloride Sat'd	S	S
Magnesium Hydroxide Sat'd	S	S
Magnesium Nitrate Sat'd	S	S
Magnesium Sulfate Sat'd	S	S
Margarine	S	S
Mercuric Chloride	S	S
Mercuric Cyanide Sat'd	S	S
Mercurous Nitrate Sat'd	S	S
Mercury	S	S
Methyl Alcohol 100%	S	S
Methyl Ethyl Ketone 100%	U	U
Methylsulfuric Acid	S	S
Methylene Chloride 100%	U	U

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Table II
Chemical Resistance of Fortiflex HDPE

Legend: S = Satisfactory, O = Some Attack, U = Unsatisfactory

Reagent	21°C (70°F)	60°C (140°F)
Milk	S	S
Mineral Oils	S	U
Molasses	S	S
Mustard (Prepared)	S	S
Naphtha	O	U
Napthalene	S	U
Natural Gas (Wet)	S	S
Nickel Chloride Sat'd	S	S
Nickel Nitrate Conc.	S	S
Nickel Sulfate	S	S
Nicotinic Acid	S	S
Nitric Acid 0-30%	S	S
Nitric Acid 30-50%	S	O
Nitric Acid 70%	S	O
Nitric Acid 95-98%	U	U
Nitrobenzene 100%	U	U
Nitroglycerine	O	U
Octane	S	U
Oleum Conc.	U	U
Olive Oil	S	S
Orange Juice	S	S
Oxalic Acid Dilute	S	S
Oxalic Acid Sat'd	S	S
Ozone	O	O
Palm Oil	S	O
Paraffin Oil	S	O
Peanut Butter	S	S
Perchloroethylene	U	U
Pepper (Fresh Ground	S	S
Peppermint Oil	O	U
Perchloric Acid 50%	S	O
Petroleum Ether	U	U
Petroleum Jelly	S	S
Phenol	S	S
Phosphoric Acid 0-30%	S	S
Phosphoric Acid 30-90%	S	S
Phosphoric Acid Over 90%	S	S
Photographic Solutions	S	S
Phthalic Anhydride	S	S
Pickling Baths		
Sulfuric Acid	S	S
Hydrochloric Acid	S	S
Sulfuric-Nitric	S	U
Pine Oil	O	U
Plating Solutions		
Brass	S	S
Cadmium	S	S
Chromium	S	S
Copper	S	S
Gold	S	S
Indium	S	S
Lead	S	S
Nickel	S	S
Rhodium	S	S
Silver	S	S
Tin	S	S
Zinc	S	S
Potassium Bicarbonate Sat'd	S	S
Potassium Borate 1%	S	S
Potassium Bromate 10%	S	S
Potassium Bromide Sat'd	S	S
Potassium Carbonate	S	S
Potassium Chlorate Sat'd	S	S
Potassium Chloride Sat'd	S	S
Potassium Chromate 40%	S	S
Potassium Cyanide Sat'd	S	S
Potassium Dichromate 40%	S	S
Potassium Ferri/Ferro Cyanide	S	S
Potassium Fluoride	S	S
Potassium Hydroxide 20% Conc	S	S
Potassium Nitrate Sat'd	S	S
Potassium Perborate Sat'd	S	S
Potassium Perchlorate 10%	S	S
Potassium Permanganate 20%	S	S
Potassium Sulfate Conc.	S	S
Potassium Sulfide Conc.	S	S
Potassium Sulfite Conc	S	S
Potassium Persulfate Sat'd	S	S
Propane Gas	S	S
Propargyl Alcohol	S	S
Propyl Alcohol	S	S
Propylene Glycol	S	S
Pyridine	S	O
Rayon Coagulating Bath	S	S
Resorcinol	S	S
Salicylic Acid	S	S
Sea Water	S	S
Shortening	S	S
Silicic Acid	S	S
Silver Nitrate Soln	S	S
Soap Solution Conc.	S	S
Sodium Acetate Sat'd	S	S
Sodium Benzoate 35%	S	S
Sodium Bicarbonate Sat'd	S	S
Sodium Bisulfate Sat'd	S	S
Sodium Bisulfite Sat'd	S	S
Sodium Borate	S	S
Sodium Carbonate Conc.	S	S
Sodium Chlorate Sat'd	S	S
Sodium Chloride Sat'd	S	S
Sodium Cyanide	S	S
Sodium Dichromate Sat'd	S	S
Sodium Ferricyanide Sat'd	S	S
Sodium Ferrocyanide	S	S
Sodium Fluoride Sat'd	S	S
Sodium Hydroxide Conc.	S	S

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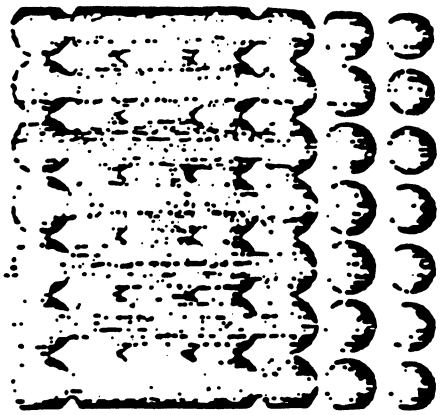
Table II
Chemical Resistance of Fortiflex HDPE

Legend: S = Satisfactory, O = Some Attack, U = Unsatisfactory

Reagent	21°C (70°F)	60°C (140°F)
Sodium Hypochlorite	S	S
Sodium Nitrate	S	S
Sodium Nitrite	S	S
Sodium Perborate	S	S
Sodium Phosphate	S	S
Sodium Sulfide 25% to Satd	S	S
Sodium Sulfite Satd	S	S
Sodium Thiosulphate	S	S
Soybean Oil	S	S
Stannous Chloride Satd	S	S
Stannic Chloride Satd	S	S
Starch Solution Satd	S	S
Stearic Acid 100%	S	S
Sulfuric Acid 0-50%	S	S
Sulfuric Acid 70%	S	O
Sulfuric Acid 80%	S	U
Sulfuric Acid 95%	O	U
Sulfuric Acid 98% Conc	O	U
Sulfuric Acid Fuming	U	U
Sulfurous Acid	S	S
Tartaric Acid	S	S
Tartaric Acid 10%	S	S
Tea	S	S
Tetrahydrofurane	O	O

Reagent	21°C (70°F)	60°C (140°F)
Toluene	U	U
Tomato Juice	S	S
Transformer Oil	S	O
Trisodium Phosphate Satd	S	S
Trichloroethylene	U	U
Turpentine	O	U
Urea	S	S
Urine	S	S
Vanilla Extract	S	S
Vaseline	S	S
Vinegar Comm.	S	S
Wetting Agents	S	S
Whiskey	S	S
Wines	S	S
Xylene	U	U
Yeast	S	S
Zinc Chloride Satd	S	S
Zinc Oxide	S	S
Zinc Sulfate Satd	S	S

Rigidex
high density
polyethylene



Technigram T800/1

Chemical resistance of Rigidex

Introduction

A guide to the effect that a variety of chemicals has on high density polyethylene (HDPE) is given in the following Table which is a compendium of BP Chemicals Limited information and other published literature sources.

Polyethylene materials as a class have a high resistance to chemical attack and are insoluble in all known solvents at room temperature. However, when considering the suitability of Rigidex HDPE for a particular application, certain other factors should be taken into account.

Permeation effects

HDPE has a closely packed molecular structure and as a result provides an effective barrier to many liquids, gases and vapours. Consequently, Rigidex grades are used extensively to package and transport a wide range of household and industrial products, foodstuffs, pharmaceuticals, agrochemicals and cosmetics. However, HDPE, in common with all thermoplastics is incapable of providing a complete barrier to all substances and loss by relatively low permeation rates can sometimes be accompanied by partial collapse of the container (panelling). In some instances, this can influence the stacking performance of the container in addition to detracting from the aesthetic appeal.

If panelling cannot be overcome by improving bottle rigidity, then it might sometimes be possible to camouflage the effect by using an oval cross section bottle or incorporating concave surfaces.

Photo-degradation effects

Panelling can also occur with products that are either photo-degradable or result in the absorption of oxygen from the ullage space. However, the use of opaque pigmentation and/or flushing the head space with nitrogen immediately prior to capping, will often eliminate panelling.

Absorption

This phenomenon is similar to permeation and in general the two effects tend to present problems with the same liquids. One notable exception is motor oil, which often exhibits quite high absorption levels yet negligible permeation.

When HDPE absorbs a liquid, there may be a change of dimensions and swelling. In severe cases, buckling of the container walls and panelling effects similar to those observed by permeation can occur. The swelling is usually accompanied by some loss of mechanical properties, notably tensile strength and softening of the polymer.

Products made from HDPE sometimes fail prematurely in service in the presence of certain surface active environments. Examples of these are detergents, chlorinated hydrocarbons, alcohols and some silicone products.

The brittle type of failure which occurs is always associated with a combination of the active environment and mechanical stresses in the moulded product. In any moulding there will always be regions of moulded-in stress in addition to stresses which result from externally applied loads. Also, some features of container design such as sharp corners or notches will produce areas of stress concentration which intensify the effects of applied loads. These stresses can result in brittle failure in the presence of active environments, even though the stresses involved would normally be within the mechanical limits of the polymer. In addition, these effects can be accelerated by elevated temperatures.

The activity of a liquid as a stress cracking environment and the resistance to stress cracking provided by the polymer may be assessed by a range of test methods. Generally, polyethylene materials of lower density and melt flow rate have better resistance to environmental stress cracking.

Packaging suitability

The use of small scale accelerated tests should be used only as an indication of the suitability of HDPE as a packaging material for a particular product. Information inferred from these tables for a single product may not, of course, be relevant when it is used as a component in a mixture of chemicals. Consequently, potential users of HDPE containers should always satisfy themselves that the containers are suitable for their particular product, taking into account the conditions of storage and distribution.

Guide to chemical resistance

Key

S. Satisfactory. This chemical is only absorbed to a low level and thus has little or no measurable effect on physical properties.

L. Limited resistance. A higher level of absorption occurs resulting in definite loss of physical properties. The question of the suitability of high density polyethylene would have to be considered with respect to the particular environment.

E. Environmental stress cracking may occur.

NS. Not satisfactory. Chemical attack or a high level of absorption occurs. In both cases the loss of physical properties is such that high density polyethylene is not suitable where prolonged contact is likely.

Substance	Conc.%	20°C	60°C
General chemical products			
Acetaldehyde	100	S	L
Acetic acid	10	S/E	S/E
Acetic acid	100	S/E	L/E
Acetic anhydride	100	S	L
Acetone	100	S	S
Acetophenetidin		S	S
Acetophenone	100	S	S
Acetylene	All	S	S
Acrylic emulsions	All	S/E	S/E
Acrylonitrile	100	S	S
Adipic acid		S	S
Aliphatic alcohols	100	S	S
Allyl chloride	100	S	S
Allyl alcohol	96	S	S
Allyl chloride	100	L	L
Aluminium acetate	All	S	S
Aluminium carbonate	All	S	S
Aluminium chloride		S	S
Aluminium fluoride		S	S
Aluminium hydroxide		S	S
Aluminium nitrate		S	S
Aluminium oxalate		S	S
Aluminium oxychloride		S	S
Aluminium sulphate		S	S
Alums	All	S	S
Amino acetic acid	All	S	S
Ammonia (gaseous)	100	S	S
Ammonium acetate	All	S	S
Ammonium bicarbonate	All	S	S
Ammonium carbonate		S	S
Ammonium chloride		S	S
Ammonium fluoride		S	S
Ammonium hydroxide		S	S
Ammonium metaphosphate		S	S
Ammonium nitrate		S	S
Ammonium oxalate		S	S
Ammonium persulphate		S	S
Ammonium phosphate		S	S
Ammonium sulphate		S	S
Ammonium sulphide		S	S
Ammonium thiocyanate		S	S
Amyl acetate	100	L	L

Amyl alcohol	10	L	L
Amyl chloride	All	L	L
Aniline	100	L	L
Antimony	100	S	S
Antimony trichloride	100	S	S
Aqua regia	100	NS	NS
Arsenic	100	S	S
Arsenic acid		S	S
Aryl sulphonic acid	100	S	S
Benzaldehyde	100	S	L
Benzaldehyde (AQ)	Sat.	S	—
Benzene	100	L	NS
Benzene sulphonic acid	100	S/E	S/E
Benzoic acid	Sat.	S	S
Benzophenone	100	S	S
Benzoyl cloride	100	L	L
Bismuth carbonate		S	S
Boric acid		S	S
Boron trifluoride	100	S	
Bromic acid	10	S	S
Bromine (liquid)	100	NS	NS
Bromine (vapour)	High	NS	NS
Bromine water	Sat.	NS	NS
Bromochloromethane	100	NS	NS
Butadiene	100	NS	NS
Butanediol	100	S/E	
Butane (gaseous)	100	S	S
Butane (liquid)	100	L	—
Butanol	100	S	S
Butoxyl (methoxy butyl acetate)	100	S	L
Butyl acetate	100	L	NS
Butyl alcohol	100	S/E	S/E
Butylene glycol	100	S	S
Butyric acid	100	S	L
Carbon dioxide (dry)	100	S	S
Carbon dioxide (wet)	100	S	S
Carbon disulphide	100	L	—
Carbon monoxide	100	S	S
Carbon tetrachloride	100	NS	NS
Caustic potash (soln.)	50	S	S
Caustic potash (soln.)	10	S	S
Caustic soda	50	S	S
Caustic soda	10	S	S
Chloral hydrate	100	S	S
Chlorine gas (moist)		L	NS
Chlorine liquid		NS	NS
Chlorine water		L	NS
Chloroacetic acid	100	S	S
Chlorobenzene	100	L	NS

Chloroethanol	100	S	S
Chloroform	100	NS	NS
Chloromethane	100	L	—
Chlorosulphonic acid	100	NS	NS
Chrome alum		S	S
Chromic acid	Sat.	S/L	NS
Chromium salts	Sat.	S	S
Citric acid		S/E	S/E
Copper salts (aqueous)	Sat.	S	S
Cresols	100	S	S
Cresylic acid	100	L	—
Cresylic acid	50	S	S
Cyclohexane	100	L	L
Cyclohexanol	100	S/E	S/E
Cyclohexanone	100	S	L
Decahydronaphthalene	100	L	NS
Dibutyl ether	100	L	NS
Dibutyl phthalate	100	L	L
Dibutyl sebacate	100	S	—
Dichloroacetic acid	100	S	L
Dichloroacetic acid	50	S	S
Dichloroacetic acid/methyl ester		S	S
o-dichlorobenzene		L	NS
p-dichlorobenzene		L	NS
Dichloroethane	100	L	L
Dichloroethylene	100	NS	NS
Diethyl ether	100	L	L
Diethylene glycol	100	S/E	S/E
Diglycolic acid	100	S/E	S/E
Dihexyl phthalate	100	S	S
Diisobutyl ketone	100	S	NS
Dimethyl carbinol	100	S	—
Dimethyl formamide	100	S	L
Dimethyl sulphoxide	100	S	S
Dinonyl adipate	100	S	—
Dinonyl phthalate	100	S	L
Dioctyl adipate	100	S	—
Dioctyl phthalate	100	S	L
1,4-Dioxane	100	S	S
Diphenyl ether	100	L	L
Disodium phosphate	100	S	S
Epichlorhydrin	100	S	S
Epoxy resins	100	S	S
Ethanediol	100	S	S
Ether	100	S/E	L
Ethyl acetate	100	S	L
Ethyl acrylate	100	L	L
Ethyl alcohol	100	S/E	S/E
Ethylbenzene	100	L	NS

PAC

Substance	Conc.%	20°C	60°C
Ethyl butyrate	100	L	NS
Ethyl chloride	100	L	NS
Ethylene chloride	100	L	NS
Ethylenediaminetetra-acetic acid	100	S	S
Ethylene dichloride	100	L	NS
Ethylene glycol	100	S/E	S/E
2-Ethylhexanol	100	S	—
Fatty acids (> 6)		S/E	S/E
Ferric chloride		S	S
Ferric nitrate		S	S
Ferric sulphate		S	S
Ferrous ammonium citrate chloride	Sat.	S	S
Ferrous sulphate		S	S
Fluoboric acid	100	S	S
Fluoric acid	40	S	S
Fluorine	100	NS	NS
Fluorosilicic acid		S	S
Formaldehyde (aqueous)	40	S/E	S/E
Formalin		S	S
Formic acid		S/E	S/E
Furfural	100	L	NS
Furfuryl alcohol	100	S	L
Gallic acid		S/E	S/E
Glycolic acid	30	S/E	S/E
Glycolic acid butyl ester	100	S	S
Heptane	100	S	NS
Hexachlorobenzene	100	S	S
Hexamine	100	S/E	S/E
Hexane	100	NS	NS
Hydrazine	100	S/E	S
Hydrazine hydrate	100	S/E	S
Hydrobromic acid	50	S	S
Hydrochloric acid	Conc.	S	S
Hydrocyanic acid	100	S	S
Hydrocyanic acid	Sat.	S	S
Hydrocyanic acid	10	S	S
Hydrofluoric acid	40	S	S
Hydrofluoric acid	70	S	S
Hydrogen	100	S	S
Hydrogen bromide	10	S	S
Hydrogen peroxide	30	S	S
Hydrogen peroxide	90	S	NS
Hydrogen phosphite	100	S	S
Hydrogen sulphide	Low	S	S
Hydroquinone		S	S
Hypochlorites	100	S	S
Hypochlorous acid	All	S	S

Substance	Conc.%	20°C	60°C
Iron salts (aqueous)	Sat.	S	S
Isobutyl alcohol	100	S	—
Isooctane	100	S	L
Isopropanol	100	S	S
Isopropyl ether	100	L	NS
Lactic acid	100	S/E	S/E
Lead acetate	Sat.	S	S
Lead tetraethyl		S	
Magnesium carbonate		S	S
Magnesium chloride		S	S
Magnesium hydroxide		S	S
Magnesium nitrate		S	S
Magnesium sulphate		S	S
Maleic acid	50	S	S
Manganese sulphate		S	S
Mercuric chloride		S	S
Mercuric cyanide		S	S
Mercurous nitrate		S	S
Mercury	100	S	S
Methoxybutanol	100	S	L
Methyl acrylate		NS	NS
Methyl alcohol		S/E	S/E
Methyl bromide		L	NS
Methyl cyclohexane		L	NS
Methylene chloride		NS	NS
Methyl ethyl ketone	100	S	L
Methyl glycol		S	S
4-Methyl-2-pentanol		S	L
Methyl sulphuric acid		S/E	S/E
Monochloroacetic acid		S	S
Monochlorobenzene		S	S
Naphthalene	100	S	
Natural gas		S	S
Nickel salts (aqueous)	Sat.	S	S
Nicotine	Dil.	S/E	S/E
Nicotinic acid		S/E	S/E
Nitric acid	50	L	NS
Nitric acid	98	NS	NS
Nitrobenzene	100	NS	NS
Nitroglycerine	100	NS	NS
Nitropropane		L	L
o-nitrotoluene	100	S	L
Nitrous gases	100	S	S
Nonyl alcohol	100	S	—
Oleic acid	100	S/E	L/E
Oleum		NS	NS
Oxalic acid		S/E	S/E

Substance	Conc.%	20°C	60°C
Oxygen	100	S	S
Ozone		NS	NS
Palmitic acid		S/E	S/E
Pentane		NS	—
Perchloric acid	20	S	S
Perchloric acid	50	S	S
Perchloric acid	70	S	NS
Petroleum ether	100	S	L
Phenol (aqueous phase)		S	S
Phenol (solid phase)	100	S	S
Phenyl sulphonate		S	S
Phosgene		S	—
Phosphoric acid	25	S	S
Phosphoric acid	50	S	S
Phosphoric acid	Conc.	S/L	NS
Phosphoric anhydride		S	S
Phosphorous		S	S
Phosphorous oxychloride		S	L
Phosphorous pentoxide		S	S
Phosphorous trichloride		S	L
Phthalic acid	50	S	S
Phthalic anhydride		S	S
Picric acid		S	S
Polyglycol ethers		S	S
Potassium antimonate		S	S
Potassium bicarbonate		S	S
Potassium bichromate		S	S
Potassium bisulphate		S	S
Potassium borate		S	S
Potassium bromate		S	S
Potassium bromide		S	S
Potassium carbonate		S	S
Potassium chlorate		S	S
Potassium chloride		S	S
Potassium chromate		S	S
Potassium cuprocyanide		S	S
Potassium cyanide		S	S
Potassium dichromate		S	S
Potassium ferri/ ferrocyanide		S	S
Potassium fluoride		S	S
Potassium hydroxide		S	S
Potassium hypochlorite		S	S
Potassium iodide	Sat.	S	S
Potassium nitrate		S	S
Potassium orthophosphate		S	S

Substance	Conc.%	20°C	60°C
Potassium perborate		S	S
Potassium permanganate		S	S
Potassium persulphate		S	S
Potassium sulphate		S	S
Potassium sulphide		S	S
Potassium sulphite		S	S
Propane (gaseous)	100	S	S
Propane (liquid)	100	S	—
Propargyl alcohol		S/E	S/E
Propionic acid	50	S	S
Propionic acid	100	S	L
Propyl alcohol	100	S/E	S/E
Propylene dichloride	100	NS	NS
Propylene glycol		S/E	S/E
Pseudocumene		L	L
Pyridine	100	S	NS
Quinine		S	
Resorcinol	100	S	S
Salicylic acid		S	S
Selenic acid	100	S	S
Silicic acid		S	S
Silicone fluids		S/E	S/E
Silver nitrate		S	S
Silver salts (aqueous)	Sat.	S	S
Sodium acetate		S	S
Sodium benzoate		S	S
Sodium bicarbonate		S	S
Sodium bisulphate		S	S
Sodium borate		S	S
Sodium bromide		S	S
Sodium carbonate		S	S
Sodium chlorate		S	S
Sodium chloride		S	S
Sodium chlorite		S	S
Sodium cyanide		S	S
Sodium dichromate		S	S
Sodium dodecyl-benzenesulphonate		S	S
Sodium ferricyanide		S	S
Sodium ferrocyanide		S	S
Sodium fluoride		S	S
Sodium hydroxide		S	S
Sodium hypochlorite		S	S
Sodium hyposulphate		S	—
Sodium nitrate		S	S
Sodium nitrite		S	S

Substance	Conc.%	20°C	60°C
Soya bean oil	100	S	S
Tallow	100	S	—
Transformer oil	100	S	L
Turpentine oil	100	L	NS
White spirit		S/L	L
Foods etc.			
Beer		S	S
Brandy		S	—
Butter		S	—
Buttermilk		S	—
Cider		S/E	S/E
Cinnamon		S	—
Cloves		S	—
Coca Cola		S	S
Cocoa		S	—
Coffee		S	—
Cream		S	—
Curds		S	—
Dextrose		S	S
Fructose		S	S
Fruit juices		S	S
Gelatine		S	S
Gin	40	S	L
Glucose		S	S
Glycerine	100	S/E	S/E
Glycerine (aqueous)	High	S	S/E
Glycerine (aqueous)	Low	S	S
Grapefruit juice		S	S
Honey		S	S
Horse radish		S	—
Jam	100	S	S
Jelly	100	S	S
Lard		S	
Lemon juice		S	S
Lime juice		S	S
Margarine	100	S	S
Mayonnaise	100	S	—
Milk		S	S
Molasses		S	S
Mustard		S	S
Orange juice		S	S
Paprika	100	S	S

Substance	Conc.%	20°C	60°C
Pectin	Sat	S	S
Pepper		S	S
Pineapple juice		S	S
Rum		S	S
Saccharose	100	S	S
Soda water		S	—
Starch		S	S
Sugar beet syrup	100	S	S
Tea (leaves)		S	S
Tomato juice	100	S	S
Tomato ketchup	100	S	S
Vanilla	100	S	S
Vinegar	All	S	S
Whisky	40	S/E	
Wine (mulled claret)	100	S	S
Wine spirit	100	S	S
Yeast	100	S	S
Car, garden, household products			
Antifreeze		S	S
Bleach		L	L
Borax		S	S
Brake fluid	100	S/E	S/E
Brine		S	S
Creosote	100	S	S
Cresol (aqueous)		S	S
Detergents		S/E	S/E
Dextron		S	S
Emulsions (photographic)	100	S/E	S/E
Floor wax	100	S	L
Furniture polish	100	S/E	L
Hair shampoo		S	S
Hydraulic fluid	100	S	L
Ink	100	S	S
Methylated spirit		S/E	S/E
Nail polish and remover	100	S	L
Petroleum jelly	100	S	S
Shoe polish	100	S	L
Talc		S	S
Tar	100	S	L

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Substance	Conc.%	20°C	60°C
Sodium orthophosphate		S	S
Sodium perborate		S	S
Sodium peroxide	10	S	—
Sodium peroxide	Sat.	L	—
Sodium phosphate		S	S
Sodium silicate		S	S
Sodium sulphate		S	S
Sodium sulphide		S	S
Sodium sulphite		S	S
Sodium tetraborate		S	S
Sodium thiosulphate		S	S
Stannic chloride		S	S
Stannous chloride		S	S
Stearic acid	100	S/E	S/E
Succinic acid	Sat.	S	S
Sulphur		S	S
Sulphur dioxide (dry)		S	S
Sulphur dioxide (wet)		S	S
Sulphur trioxide		NS	NS
Sulphuric acid	10	S	S
Sulphuric acid	50	S	S
Sulphuric acid	95	S	L
Sulphurous acid	30	S	S
Sulphuryl chloride		NS	
Tannic acid		S/E	S/E
Tartaric acid	100	S	S
Tartaric acid (aqueous)	Sat.	S	S
Tetrabromomethane	100	NS	NS
Tetrachloroethane	100	NS	NS
Tetrahydrofuran	100	L	NS
Tetralin	100	S	L
Thioglycolic acid	100	S	S
Thionyl chloride		NS	
Thiophene	100	L	L
Toluene	100	L	NS
Trichloroacetic acid	50	S	S
Trichloroacetic acid	100	L	NS
Trichloroethylene	100	L	NS
Tri ß chloroethylene phosphate	100	S	S
Tricresyl phosphate	100	L	L
Triethanolamine		L	L
Urea		S/E	S/E

Substance	Conc.%	20°C	60°C
Xylene	100	L	NS
Zinc ammonium carbonate		S	S
Zinc carbonate		S	S
Zinc chloride		S	S
Zinc oxide		S	S
Zinc sulphate		S	S
Oils and Waxes			
Aniseed oil	100	L	NS
Beeswax	100	S	S
Carnauba wax		S	S
Castor oil	100	S/E	S/E
Cedar leaf oil		NS	NS
Cedar wood oil		NS	NS
Cinnamon oil		NS	NS
Citronella oil		NS	NS
Clove oil		S	S
Coconut oil		S	NS
Coconut oil alcohols		S/E	S/E
Cod liver oil	100	S	—
Corn seed oil		S	L
Cotton seed oil		S/E	S/E
Diesel oil		S	S
Fuel oil	100	S	L
Kerosene		L	L
Lanolin	100	S	—
Lemon peel oil		S	L
Linseed oil	100	S	S
Menthol	100	S	S
Mineral oil		L	L
Motor oil	100	S	L
Olive oil	100	S	S
Orange peel oil	100	S	—
Palm oil	100	S	—
Paraffin oil	100	S	L
Paraffin wax	100	S	S
Peanut oil	100	S	S
Peppermint oil		L	NS
Petrol		S/L	S/L
Pine needle oil	100	S	S
Pine oil	100	L	NS
Salad oils	100	S	L
Silicone oil	100	S/E	L/E

PAC

BEST COPY AVAILABLE

EVALUATION OF RESISTANCE OF TENSAR POLYPROPYLENE BIAXIAL GEOGRIDS TO CHEMICAL ATTACK AND SOIL BURIAL FROM AVAILABLE INFORMATION.

Technical Note
Prepared for The Tensar Corporation
by J. P. Giroud, GeoServices, Inc.

Tensar biaxial geogrids, SS1, SS2 and AR1, are made of polypropylene. This polymer is known for having a high chemical resistance. In addition, the molecular orientation, imparted to the polymer by the manufacutirng process of Tensar geogrids, decreases polypropylene permeability, which is considered likely to increase chemical resistance. A summary of data regarding chemical resistance of polypropylene is presented below, with conclusions on the use of geogrids in civil engineering.

Polypropylene is not affected by detergents, organic salts in aqueous solutions, and by almost all inorganic acids and alkalis, even at high concentration and high temperture (60°C or more). Due to the resistance of polypropylene to alkalis, polypropylene Tensar geogrids are not affected by cement and concrete.

Polypropylene is attacked by strong oxidizing agents, such as fuming sulphuric acid, concentrated nitric acids and halogens. Such chemicals are not normally encountered in civil engineering but they can be present in a waste disposal cell. To decide if a Tensar polypropylene geogrid can be put in contact with such chemicals, the attached table can be used as a first guide and tests should be conducted.

Polypropylene has some sensitivity to certain solvents, oils, and hydrocarbons, such as asphalt. Polypropylene geogrids could be slowly affected if they were exposed during a long period of time to diesel fuel. Also, polypropylene geogrids could be slowly affected if they were placed below a thin layer of asphalt exposed to the sun in a very hot climate (where the surface of asphalt can reach 140°F during several hours every summer day). Polypropylene is inert to sulphur included in some asphalt pavements.

Polypropylene is not a nutrient medium for micro-organisms, and is therefore not attacked by them. Consequently, polypropylene Tensar geogrids can be used safely in the ground, even in highly organic soils. In fact, polypropylene geotextiles have been extensively used in the past two decades, and experience has shown that they can be expected to have a service life of several dozens of years when placed in most naturally occurring soil environments. Since geogrid rib thickness is at least 20 times the diameter of typical geotextile fibers, the durability of polypropylene geogrids is expected to be greater than the durability of polypropylene geotextiles.

J. P. Giroud
1984 August

EVALUATION OF CHEMICAL RESISTANCE OF TENSAR DRAINAGE NETS FROM AVAILABLE INFORMATION

Technical Note
Prepared for The Tensar Corporation
by J.P. Giroud, GeoServices, Inc.

Tensar drainage nets are made from polyethylene. This polymer is known for having a high resistance to chemical attack and being insoluble in all known solvents at room temperature.

The chemical resistance of polyethylene materials increases in general with increasing density. As shown in the attached Table, the resistance of polyethylene to aromatic solvents is affected by density. However, the effect is known to be small and, as shown in the Table, the resistance of polyethylene to acids and alkalis is not noticeably affected by density.

The influence of density on the chemical behavior of polyethylene is linked to the structure of the polymer. A high density polyethylene macromolecule is a linear chain of CH_2 elements, while low density polyethylene macromolecules are usually a complex arrangement of branches of CH, CH_2, and CH_3. Because of its many branches, a low density polyethylene is more prone to react with chemials than a high density polyethylene, while a high density polyethylene is more likely to crack in certain environments (stress cracking) because it is made of parallel chains.

Tensar drainage nets (with a specific gravity of 0.925 to 0.930) and high density polyethylene geomembranes (0.935 to 0.945) are in the middle of the range of existing polyethylenes (0.91 to 0.97). It may therefore be concluded that there should be no significant difference in chemical behavior between the polyethylene used for Tensar drainage nets and the polyethylene used for high density polyethylene geomembranes.

High density polyethylene geomembranes have been subjected to extensive chemical compatibility testing in the past five years in view of their utilization in waste management facilities. Test results have shown that high density polyethylene geomembranes have a better compatibility with most chemicals than other available geomembranes. As a result, they are now used routinely to line hazardous waste disposal facilities.

The thickness of materials exposed to chemcials is also believed to have some influence on their durability. The thickness of Tensar net strands is typically two or three times the thickness of a 60mil-thick geomembrane. However, geomembranes are exposed on only one side and one may conclude that Tensar nets and 60mil-thick geomembranes are equivalent regarding thickness.

Some of the Tensar drainage nets are made of a foamed polyethylene. The foam structure results from the inclusion of bubbles that do not communicate. Therefore, foaming should not increase exposure to chemicals. Also, according to the manufacturer of the net, the foaming agent used in the manufacturing process has no effect on the chemical resistance of the polymer.

From our present knowledge on chemical compatibility, and considerations on density and thickness, it may be concluded that Tensar drainage nets can be used in waste disposal facilities where the use of currently available high density polyethylene geomembranes has been approved.

J.P. Giroud
1984.08.01

PA

'AGEING' OF HIGH DENSITY POLYETHYLENE IN BURIED SITUATIONS

Publications such as BSI CP312 and manufacturers' data sheets which refer to ageing tests relate to the effects of ultraviolet or near visible radiation attack on the polymer which can result in oxidative degradation and embrittlement. Although buried PE does not suffer from this problem changes in free volume, crystallinity, and the possible effect of chemical and microbiological attack need to be considered with respect to any potential long term effect on properties.

Work initiated by RAPRA (Reference 1) some 16 years ago has involved a storage and examination of HDPE. Samples of polymer were stored, in Aluminium boxes with free air circulation, in temperate, hot wet and hot dry climates in the absence of radiation. No significant changes occurred in the basic properties of the HDPE after this period. This leads to the conclusion that any crystallinity changes, had an insignificant effect.

HDPE has been used in buried pipe applications for agricultural drainage, potable water, effluent and gas distribution for up to 30 years. A major reason is its corrosion resistance to acid soils and its generally excellent chemical resistance - HDPE is generally inert to chemicals other than strongly oxidising acids because of its chemical structure (2). HDPE has also been used to sheathed metal pipes in buried soil conditions in order to eliminate corrosion. Rigidex is an approved grade in the U.K.

HDPE sheathed Transatlantic telephone cables have also been used in a salt water environment for nearly 20 years without problems of chemical attack.

Certain types of chemicals such as detergents cause stress cracking of unoriented HDPE test pieces but creep rupture tests carried out in water and 2% detergent solutions at 23°C on samples of Tensar to compare the environments, have shown no deleterious effects. These data compare well with tests normally carried out on pressure pipe grades which are required to possess a high resistance to stress cracking in order to fulfill their 50 year design life requirement.

HDPE also has excellent resistance to microbiological attack and will not rot away when buried (3).

Field service evidence to date on the use of HDPE in civil engineering applications is based on non-annealed products. Orientation is known to reduce the permeability of HDPE and this enhancement coupled with the evidence of improved stress crack resistance lends support to the deduction that oriented grid structures will have no less a permanence in buried soil conditions than that of the established uses of non-oriented products. For example, HDPE gas pipe is supplied on a prognosis of a 50 year minimum life - the critical element is the risk of internal wall softening due to occluded gas condensate - the risk of attack resulting from the buried soil environment is considered to be not critical.

G. H. BURR

30th October, 1981

'AGEING' OF HIGH DENSITY POLYETHYLENE IN BURIED SITUATIONS

REFERENCES

1. RAPRA Members Journal, July/August 1975, P53 and March/April 1976, P19 by R. C. Moakes.

2. Vinyl and Allied Polymers, Volume 1, Iliffe Books P148 (1968).

3. British Plastics, October 1967, P105, B. Dolezal, Micro-organisms and Plastics.

30th October, 1981

CHEMICAL RESISTANCE OF VLDPE

REAGENT	VLDPE
Acetaldehyde	S
Acetic acid, 1-80%	S
Acetic acid, 80-100%	U
Acetic acid, glacial	U
Acetic anhydride	D
Acetone	D
Acetphenetidine	S
Acetophenone	U
Acrylic emulsions	S
Allyl alcohol	U
Allyl chloride	U
Aluminum bromide, sat. sol.	S
Aluminum chloride, dil. sol.	S
Aluminum chloride, conc. sol.	S
Aluminum fluoride, conc. sol.	S
Aluminum hydroxide	S
Aluminum sulfate, concl. sol.	S
Alums (all types) conc. sol.	S
Ammonia, 100% dry gas	S
Ammonium carbonate	S
Ammonium chloride, sat. sol.	S
Ammonium fluoride, 20%	S
Ammonium hydroxide	S
Ammonium metaphosphate, sat. sol.	S
Ammonium nitrate, sat. sol.	S
Ammonium oxalate	S
Ammonium parsulfate, sat. sol.	S
Ammonium phosphate, 75%	S
Ammonium sulfate, sat. sol.	S
Ammonium sulfide, sat. sol.	S
Ammonium thiocyanate, sat. sol.	S
Amyl acetate, 100%	U
Amyl alcohol, 100%	U
Amyl chloride, 100%	U
Aniline, 100%	D
Antimony chloride	S
Apple juice	S
Aqua regia	U
Argyrol	S
Arsenic acid, 100%	S
Aspirin	S
Atabrine	S
Automotive oil	U
Barium carbonate, sat. sol.	S
Barium chloride, sat. sol.	S
Barium hydroxide	S
Barium sulfate, sat. sol.	S
Barium sulfide, sat. sol.	S

REAGENT	VLDPE
Beer	S
Benzaldehyde	U
Benzene	U
Benzene sulfonic acid	S
Benzoic acid	S
Benzyl alcohol	U
Bismuth carbonate, sat. sol.	S
Bleach lye	S
Black liquor	S
Borax, cold, sat. sol.	S
Boric acid, sol.	S
Brake fluid	U
Brandy	S
Bromic acid, 10%	S
Bromine, liq.	U
Bromine water	U
Bromobenzene	U
Butanedoil, 1-100%	S
Butter	S
Butyl acetate	U
Butyl alcohol, 100%	S
n-Butylamine	U
Butyraldehyde	U
Bulyfic acid	U
Calcium bisulfide	S
Calcium carbonate, sat. sol.	S
Calcium chlorate, sat. sol.	S
Calcium chloride, sat. sol.	S
Calcium hydroxide	S
Calcium hypochlorite, bleach sol.	S
Calcium nitrate, 50%	S
Calcium sulfate	S
Camphor oil	U
Carbon dioxide, 100% dry	S
Carbon dioxide, 100% wet	S
Carbon dioxide, cold, sat. sol.	S
Carbon disulfide	U
Carbon monoxide	S
Carbon tetrachloride	U
Carbonic acid	S
Castor oil, conc.	S
Cetane	U
Cheese	S
Chloracetic acid	U
Chlorine, 100% dry gas	U
Chlorine, moist gas	U
Chlorine, liq.	U
Chlorobenzene	U
Chloroform	U
Chlorosulfonic acid, 100%	U
Chocolate syrup	S
Chrome alum. sat.	S

REAGENT	VLDPE
Chromic acid, 1-50%	S
Chromic acid + sulfuric acid (cleaning solution)	D
Cider	S
Citric acid, sat. sol.	S
Clove oil	S
Coconut oil alcohols	S
Cola concentrates	S
Copper chloride, sat. sol.	S
Copper cyanide, sat. sol.	S
Copper fluoride, 2%	S
Copper nitrate, sat. sol.	S
Copper sulfate, dil. sol.	S
Corn seed oil	S
Cottonseed oil	S
Cresol	U
Cresylic acids, 50%	U
Cuprous chloride, sat. sol.	S
Cyclohexane	U
Cyclohexanol	D
Cyclohexanone	U
Cyclohexylamine	U
Decahydronaphthalene	U
n-Decane	U
Decyl alcohol	U
Detergents, synthetic	S
Developers, photographic	S
Dextrin, sat. sol.	S
Dextrose, sat. sol.	S
Diazo salts	S
Di-n-butylamine	U
Di-n-butylether	U
Dibutyl phthalate	D
Dichloroethylene	U
Diethylene glycol	S
Diethyl uther	U
Dighycolic acid	S
Dihydronaphthalene	U
Disobutylene	U
Disopropyl ketone	U
Dimethylamine	U
Dipermine	U
Disinfectant (pine)	U
Disinfectant eucalyptus	U
Disodium phosphate	S

REAGENT	VLDPE
Eggs	S
Ethyl acetate	U
Ethyl alcohol, 35%	S
Ethyl alcohol, 100%	S
Ethyl aniline	U
Ethyl butyrate	U
Ethyl chloride	U
Ethylether	U
Ethylene	-
Ethylene chlorohydrin	U
Ethylene dichloride	U
Ethylene glycol	S
Fabric conditioner	S
Ferric chloride, sat. sol.	S
Ferric nitrate, sat. sol.	S
Ferric sulfate	S
Ferrous chloride, sat. sol.	S
Ferrus sulfate	S
Fish solubles	S
Fluoboric acid	U
Fluorine	S
Fluosilicic acid, 32%	S
Fluosilicic acid, conc.	S
Formaldehyde, 40$	S
Formamide	S
Formic acid, 0-20%	S
Formic acid, 20-50%	S
Formic acid, 100%	S
Frutcose, sat. sol.	S
Fruit pulp	U
Fuel oil	U
Furfural	U
Furfuryl alcohol	
Gallic acid, sat. sol.	S
Gasoline	U
Gin	U
Glucose	S
Glycerine	S
Glycol	S
Glycolic acid, 30%	S
Grape juice	S
Grape syrup	
Hair shampoo	S
Hand creams	S
Heptane	U
Hexachlorophene	S
tart-Hexanol	S

REAGENT	VLDPE
Honey	S
Hydrazine hydrate	S
Hydrobromic acid, 50%	S
Hydrochloric acid, 10%	S
Hydrochloric acid, 35%	S
Hydrochloric acid, conc.	S
Hydrochloric acid, sat. sol.	S
Hydrofluoric acid, 40%	S
Hydrofluoric acid, 60%	S
Hydrofluoric acid, 75%	S
Hydrogen, 100%	S
Hydrogen chloride, gas, dry	S
Hydrogen peroxide, 30%	S
Hydrogen peroxide, 90%	D
Hydrogen phosphide, 100%	S
Hydroquinone	S
Hydrogen sulfide, dry gas	S
Hypochlorous acid, conc.	S
Inks	S
Iodine, potassium iodide sol. conc.	U
Iodine tincture	U
Jams and jellies	S
Kerosene	D
Lactic acid, 10-90%	S
Latex	S
Lard	D
Lauryl alcohol	U
Lauryl sulfate	U
Lead acetate, sat. sol.	S
Lemon syrup	S
Linseed oil	U
Liqueur	S
Lube oil	U
Lysol	U
Magnesium carbonate, sat. sol.	S
Magnesium chloride, sat. sol.	S
Magnesium hydroxide, sat. sol.	S
Magnesium nitrate, sat. sol.	S
Magnesium sulfate, sat. sol.	S
Margarine	U
Malsic acid	S
Mercuric chloride, sat. sol.	S
Mercuric cyanide, sat. sol.	S
Mercurous nitrate, sat. sol.	S

REAGENT	VLDPE
Mercury	S
Methallyl chloride	U
Methane	U
Methyl alcohol, 100%	S
Methylated spirits	U
Methyl bromide	U
Methyl chloride	U
Methylene chloride	U
Methyl ethyl ketone	U
Methyl formate	U
Methyl Isobutyl ketone	U
Methyl salicylate	S
Methylsulfuric acid	S
Milk	U
Mineral oils	S
Molasses	
Naphtha	U
Naphthalene	U
Nickel chloride, sat. sol.	S
Nickel nitrate, conc. sol.	S
Nickel sulfate, sat. sol.	S
Nicotine, dil. sol.	S
Nicotinic acid	S
Nitric acid, 0-30%	S
Nitric acid, 30-50%	S
Nitric acid, 70%	U
Nitric acid, 95-98%	U
Nitric acid, fuming	U
Nitrobenzene	S
Nitroethane	S
Nitromethane	
Octyl alcohol	U
Octyl cresol	U
Oleic acid	U
Oleum	U
Olive oil	-
Orange extract	S
Orange syrup	S
Oxalic acid, sat. sol.	S
Ozone, 100%	U
Paper mill liquors	S
Peanut oil	-
n-Pentane	U
Perchloric acid, 10%	S
Petrol	U
Petroleum ether	U
Phosphoric acid, 30%	S
Phosphoric acid, 90%	S

REAGENT	VLDPE
Phosphorus, yellow, 100%	S
Phosphorus oxychloride	U
Phosphorus pentoxide	S
Phosphorus trichloride	S
Photographic solutions	S
Pickling baths (H_2SO_4, HCl)	S
Picric acid	S
Pineapple juice	S
Pine oil	U
Plating solutions (brass, cadmium, copper, gold, indium, lead, nickel, silver tin, zinc)	S
Plating solutions (chromium)	U
Plumbing cleaner	S
Potato chips	S
Potassium bicarbonate, sat. sol.	S
Potassium borate, 1%	S
Potassium bromate, 10%	S
Potassium bromide, sat. sol.	S
Potassium carbonate	S
Potassium chlorate, sat. sol.	S
Potassium chloride, sat. sol.	S
Potassium chromate, 40%	S
Potassium cyanide, sat. sol.	S
Potassium dichromate, 40%	S
Potassium fluoride	S
Potassium hydroxide, dil. sol.	S
Potassium hydroxide, conc. sol.	S
Potassium nitrate, sat. sol.	S
Potassium perborate, sat. sol.	S
Potassium perchlorate, 10%	S
Potassium permanganate, 20%	S
Potassium persulfide, sat. sol.	S
Potassium sulfate, conc. sol.	S
Potassium sulfide, conc. sol.	S
Potassium sulfite, conc. sol.	S
Propargyl alcohol	S
Propyl alcohol	S
Propylene dichloride	U
Propylene glycol	S
Rayon coagulating bath	S
Rum	S
Sea water	S
Selenic acid	S
Shortening	S
Silicic acid	S
Silicone oil	U
Silver nitrate sol.	S
Soap sol., all conc.	S
Sodium acetate, sat. sol.	S

REAGENT	VLDPE
Sodium benzoate, 35%	S
Sodium bicarbonate, sat. sol.	S
Soidum bisulfate, sat. sol.	S
Sodium bisulfite, sat. sol.	S
Sodium borate	S
Sodium bromide, dil. sol.	S
Sodium carbonate, conc. sol.	S
Sodium carbonate	S
Sodium chlorate, sat. sol.	S
Sodium chloride, sat. sol.	S
Sodium cyanide	S
Sodium dichromate, sat. sol	S
Sodium ferricyanide, sat. sol.	S
Sodium ferrocyanide, sat. sol.	S
Sodium fluoride, sat. sol.	S
Sodium hydroxide, dil. sol.	S
Sodium hydroxide, conc. sol.	S
Sodium Hyperchlorite	S
Sodium hypochlorite, 20%	S
Sodium nitrate	S
Sodium nitrite	S
Sodium sulfate	S
Sodium sulfide, 25%	S
Sodium sulfite, sat. sol.	S
Soy bean oil	-
Stannic chloride, sat. sol.	S
Stannous chloride, sat. sol.	S
Starch solution, sat. sol.	S
Stearic acid, 100%	S
Sugar sol., 50%	S
Sulfur	S
Sulfuric acid, 0-50%	S
Sulfuric acid, 80%	S
Sulfuric acid, 98%	U
Sulfuric acid, fuming	U
Sulfurous acid	S
Sulfur dioxide	S
Sulfur trioxide	S
Sulfuryl chloride	U
Tallow	S
Tannic acid, 10%	S
Tanning extracts, comm.	S
Tartaric acid	S
Tea	S
Tetrachloroethane	U
Tetrachlorethylene	U
Tetrahydrofurane	U
Tetrahydronaphthalene	U
Toluene	U
Tomato sauce	S
Transformer oil	U
Trichlorobenzene	U

REAGENT	VLDPE
Trichloroethylene	U
Triethanolamine	U
Trisodium phosphate, sat. sol.	S
Turpentine	U
Urea, D-30%	S
Urine	S
Vegetable oil	U
Vinegar, comm.	S
Vanilla extract	S
Water	S
Wax	S
Whiskey	D
Wines	S
Wine vinegar	U
Worchestershire sauce	U
Xylene	U
Yeast	S
Zinc chloride, sat. sol.	S
Zinc fluoride	S
Zinc sulfate, sat. sol.	S

KEY TO RATING:

S - Satisfactory
D - Limited recommendation (many applications possible depending on mil thickness, temperature and package design.
U - Unsatisfactory

TABLE 5.7 GENERAL CHEMICAL RESISTANCE GUIDELINES OF COMMONLY USED GEOMEMBRANES*

	Geomembrane type																	
	Butyl rubber		Chlorinated polyethylene (CPE)		Chloro-sulfonated polyethylene (CSPE)		Elasticized polyolefin		Epichlorohydrin rubber		Ethylene propylene diene monomer (EPDM)		Polychloroprene (neoprene)		polyethylene		Polyvinyl chloride (PVC)	
Chemical	100°F	158°F	100°F	158°F	100°F	158°F	100°F	158°F	100°F	158°F	100°F	158°F	100°F	158°F	100°F	158°F	100°F	158°F
General:																		
Allphatic hydrocarbons			×	×			×		×	×			×	×	×	×		
Aromatic hydrocarbons							×		×	×			×	×	×	×		
Chlorinated solvents	×	×					×		×	×	×		×		×	×		
Oxygenated solvents	×	×					×		×		×	×	×	×	×	×		
Crude petroleum solvents			×	×			×		×	×			×	×	×	×		
Alcohols	×	×	×	×			×		×	×	×	×	×	×	×	×	×	×
Acids:																		
Organic	×	×	×	×	×		×		×		×	×	×	×	×	×	×	×
Inorganic	×	×	×	×	×		×		×		×	×	×	×	×	×	×	×
Bases:																		
Organic	×	×	×	×	×		×		×	×	×	×	×	×	×	×	×	×
Inorganic	×	×	×	×	×		×		×	×	×	×	×	×	×	×	×	×
Heavy metals	×	×	×	×	×		×	×	×	×	×	×	×	×	×	×	×	×
Salts	×	×	×	×	×		×	×	×	×	×	×	×	×	×	×	×	×

* × = generally good resistance.

Source: After Vandervoort [11].

Source: Koener, Robert, 1990. *Designing with Geosynthetics*. 2nd Edition.

Attachment 5

Manufacturer's Literature for

- ROAD OYL®
- SOILSEAL®
- DUSTROL™
- CFM 400™
- ConCover®

SSPCo

Environmentally Appropriate Product Technologies
for Pavements, Dust Control, Erosion Control & Soil Stabilization

March 23, 1995

Pat Drossart
Project Manager
Foth VanDyke & Associates
PO Box 19012
Green Bay, WI 54307-9012

Hi Pat,

This to update possible application methods of **ROAD OYL** for your review.

Something you might consider: This past season we were delighted to discover that some very light (.03 gallons concentrate/SY) applications of **ROAD OYL** proved effective. Diluted about 6 gallons of water to 1 of product traffic can continue to operate without any pickup on tires. Over time this can build up to a rather permanent "water proofing" and dust control.

For the more conventional approach: For materials with good integrity that hold up well to traffic and the concerns are dust and surface moisture intrusion consider multiple applications of **ROAD OYL Resin Modified Emulsion**. Suggest an initial application of .05 to .15 gallons of concentrate/SY. Then at intervals convenient to your operation apply at .05 gals of concentrate/SY. Continue this until a total of .20 to .25 gallons of concentrate/SY has been achieved. Between each application allow regular traffic on the road. Expect to build up a dust free water repelling running surface. The subsequent "as needed" applications at .03 to .05 gallons of concentrate/SY rate.

The water shedding characteristics of a properly sealed and drained **ROAD OYL** surface protects moisture susceptible aggregate materials and foundation soils. By shedding water away from the foundation materials and reducing saturation while hardening the treated surfaces against dusting, potholing and washboarding, **ROAD OYL** "locks in" the value of the existing surface investment.

Many projects just do not lend themselves to a single application of a dust control treatment. For these projects, regular watering is a necessity, and water trucks must be kept on site. In this case **DUSTROL** additive is used as part of regular watering operations to improve wetting efficiency, to reduce frequency of watering passes and to reduce total water use both for roads and stockpiles. This organic chemical formulation increases the adhesion and agglomeration of fine particle soil materials on the road and assists in the formation of hardened running surfaces.

Our disciplines at SSPCo include construction technology, estimating, engineering, environmental science and pavement materials production. We understand your need for cost-effective, high-performance, environmentally appropriate products and for timely technical support. We anticipate being of service.

We look forward to your comments and questions. Our toll free number 1(800) 523-9992.

Best Regards,

G. B. "Randy" Randolph Enclosures GBR/rr

Soil Stabilization Products Company, Inc.
P. O. Box 2779, Merced, CA 95344 U.S.A.
(800) 523-9992 Phone: (209) 383-3296 FAX: (209) 383-7849

ROAD OYL™

RESIN MODIFIED EMULSION

Manufactured By Road Products Corp.

PETROLEUM-FREE ● HIGH BONDING STRENGTH ● COLD APPLIED



DUST CONTROL ● PAVEMENT CONSTRUCTION ● SOIL STABILIZATION

EROSION CONTROL ● TACKIFIER FOR ROVING MATERIALS

Soil Stabilization Products Co., Inc.

DUST CONTROL, EROSION CONTROL, ROAD SURFACING & PAVEMENTS

ROAD OYL™ Resin Modified Emulsion

ROAD OYL is a high bonding strength, resin modified emulsion formulated from natural forest product ingredients. Cold - applied, this waterborne emulsion can be used in undiluted form for pavement construction, or it can be diluted with water for surface penetration applications such as dust control, erosion control and soil stabilization. **ROAD OYL** has both the environmental credentials needed for applications in environmentally sensitive areas and the strength and stability required for tough road surface treatments and pavements.

DUST CONTROL AND SURFACE TREATMENTS

ROAD OYL Resin Modified Emulsion was originally developed to control dust on mine haul roads - the toughest proving ground available. Now, with several years of successful field histories, this innovative product has demonstrated the ability to produce safe, all-weather, economical, year-round working surfaces. Operations Managers have found **ROAD OYL** to be a welcome change from traditional methods - seasonal applications of water soluble dust palliatives, constant grading maintenance and continuing operation of water trucks.

As demonstrated by superior performance on the toughest road applications, **ROAD OYL Resin Modified Emulsion** excels as a penetrated surface treatment and dust suppressant. This patented resin modified emulsion has the bonding strength and durability to provide all-weather surface protection for stable, well designed, unpaved roads. The water shedding characteristics of a properly sealed and drained **ROAD OYL** surface protects moisture susceptible aggregate materials and foundation soils. By shedding water away from the foundation materials and reducing saturation while hardening the treated surfaces against dusting, potholing and washboarding, **ROAD OYL** "locks in" the value of the existing road investment.

PAVEMENT STRENGTH

The **ROAD OYL Resin Modified Emulsion** is formulated with some of nature's strongest bonding agents and can transform soil materials into pavements. The best results, of course, are obtained with pavement mix designs that incorporate well graded aggregate materials.

A significant and growing body of test results provided by independent materials testing laboratories confirms the tremendous strength of **ROAD OYL Resin Modified Emulsion** pavement. Using the Marshall Stability Test, engineering professionals are providing hard evidence that **ROAD OYL** is a realistic alternative to asphalt.



The cylindrical samples pictured on this page represent various **ROAD OYL Resin Modified Emulsion** mix designs, prepared for testing as pavement structural sections. Following the Marshall Stability Test procedure, these samples are placed into a split breaking head and a standard load is applied, increasing at a set rate until the sample fails. The maximum load achieved during this test is measured and recorded in pounds as the "stability" of the sample. Because the sample is unconfined while compressive loading occurs, the Marshall Stability is a measure of the strength of the binder in the pavement mix which holds the rock and soil particles together.

The high bonding strength of **ROAD OYL** results in dramatic increases in pavement stability. Test results of 10,000 pounds and higher are not uncommon. Samples prepared from hot mix asphalt and asphalt emulsion mixes usually test under 3,000 pounds. **ROAD OYL Resin Modified Emulsion** is a giant step forward in emulsion and paving technology.

AIR QUALITY BENEFITS

ROAD OYL Resin Modified Emulsion opens up a new world for road construction when the time comes for penetration coats, prime coats and tack coats applied in preparation for placement of final pavement surfaces. Asphalt products have traditionally been used for these applications and diluted with solvents to achieve surface penetration. Evaporation of these solvents is a serious air quality concern. **ROAD OYL** provides a solvent - free alternative along with the performance of a resin modified emulsion that has greater bonding strength than asphalt emulsions.

A VERSATILE PERFORMER

ROAD OYL Resin Modified Emulsion is easily applied by pressurized distributor trucks, hydroseeders, water trucks and pressurized water spray equipment. In addition to providing exceptional service for traffic bearing surfaces such as roads, streets, runways, helipads, parking lots, truck yards, path and trails, **ROAD OYL** is also effective as a UV resistant stabilizer against wind and water erosion for exposed soils and material stockpiles. For those bare earth protection projects which require an extra tough but natural appearing surface protection, **ROAD OYL** provides the strongest bonding strength of any surface sprayed treatment. And, when additional protection is required, **ROAD OYL** can be used in conjunction with strands of polypropylene thread (known as roving). The roving is sprayed on a soil surface and then bonded to the soil with **ROAD OYL** to form a protective webbing for the revegetation of critical soil surfaces.

ROAD OYL is a Trademark of Road Products Corp., Product Manufacturer and Patent Holder

Road Products Corp. warrants that this material conforms to the chemical description herein. Road Products Corp. neither makes nor authorizes any agent or representative to make any other warranty of fitness or of merchantibility, guarantees or representation, express or implied, concerning this material. Critical and unforeseeable factors beyond Road Products Corp.'s control prevent it from eliminating all risks in connection with the use of this material. Buyer and user acknowledge and assume all risks and liability resulting from handling, storage, and use of the material. This paragraph is not an express warranty and buyer and user so understand.

*This brochure has been prepared for the benefit of customers interested in **ROAD OYL**. The information in this brochure is intended for general information only. It was reviewed carefully prior to publication. Soil Stabilization Products Company, Inc. assumes no liability for its reliability or completeness. Final determination of the suitability of any information or material for the use contemplated, or for its manner of use, is the sole responsibility of the user.*

For further information on how the **ROAD OYL Resin Modified Emulsion** matches up to your unique requirements, Contact:

Soil Stabilization Products Co., Inc.
P. O. Box 2779, Merced, California 95344
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ROAD OYL™ TEST RESULTS

Resin Modified Emulsion

ROAD OYL™ Resin Modified Emulsion has unique bonding strength for pavement construction and base course stabilization. This same bonding power has also made it highly effective as a surface penetrated dust control treatment for unpaved roads. The performance of this patented Resin Modified Emulsion in mix designs evaluated by Marshall Stability Tests provides clear documentation that **ROAD OYL** is a major advance in product technology for road construction and road maintenance.

The Marshall Stability Test (ASTM D 1559) has long been a standard procedure used by materials testing laboratories in evaluating mix designs for pavement construction. The Marshall Method is utilized to determine the optimum percentage addition rate of the binder for a paving mixture containing a specific blend of aggregate materials. Test results are also compared to standard index values for stability and flow rate; "stability" is the maximum load resistance that a test specimen will develop under compression, and "flow value" is the total movement or strain occurring in the specimen during the compression test.

The Marshall Method was originally designed to evaluate mix designs for asphalt concrete and other hot mix types. Marshall Design Criteria have been developed through extensive research correlation studies for cold mix as well as hot mix materials. A primary focus of this research has been to develop layer-equivalency factors between cold mix and hot mix asphalts. The Marshall Method as modified for use with cold mix asphalt emulsions is also utilized to evaluate mix designs of **ROAD OYL** (a cold applied emulsion).

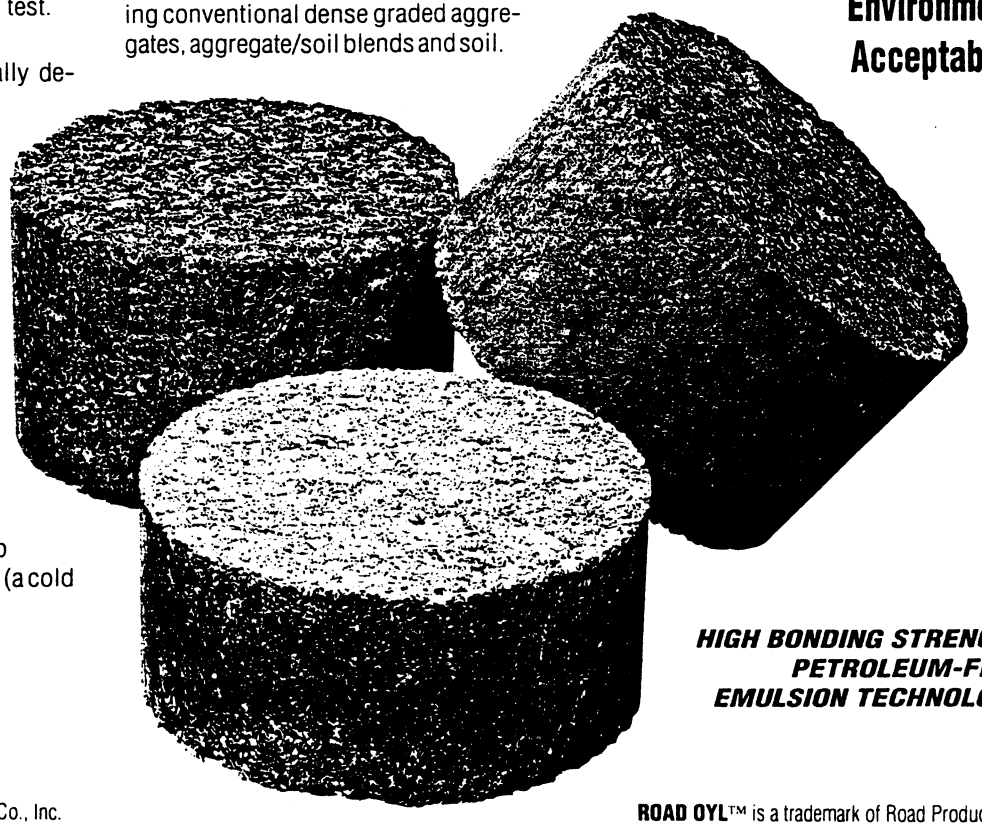
The Marshall Design Criteria supplied by the Asphalt Institute (January 1992 Addendum to Mix Design Methods For Asphalt Concrete And Other Hot-Mix Types, Manual Series No. 2) provide a baseline for comparison with test results obtained with mix designs that utilize the **ROAD OYL** Resin Modified Emulsion as the binder. Based upon Asphalt Institute criteria, allowable Flow Values (0.01in.) range from 8-14 for the Heavy Traffic classification. As you will note, the Flow Values recorded in these tests using **ROAD OYL** as the binding agent for a wide variety of aggregate and soil combinations, all fall within the target range of the Asphalt Institute.

The Marshall Design Criteria for Stability provided by the Asphalt Institute require minimum values for different traffic classifications starting at 750 pounds for Light Traffic, 1200 pounds for Medium Traffic and 1800 pounds for Heavy Traffic. In all three classifications, these minimum values apply for both base and surface course pavement mixtures. The results from **ROAD OYL** testing programs on the back of this page include mix designs utilizing conventional dense graded aggregates, aggregate/soil blends and soil.

Stabilities throughout these mix designs easily exceed the Asphalt Institute design criteria for Light, Medium and Heavy Traffic. It is important to note that stabilities above 10,000 pounds are recorded not only for dense graded aggregates; in the test series which follows, a **ROAD OYL** mix design based upon a silty sand with 26% passing the #200 sieve also displayed stabilities in excess of 10,000 pounds.

Stability translates into resistance to distortion, to displacement, to shearing stresses, to rutting and to shoving. Stability is a measure of the cohesion and bonding power of the binding agent. The **ROAD OYL** multi-purpose resin modified emulsion has tremendous bonding power. Whether you are working with pavements, dust control or erosion control applications, **ROAD OYL** opens up a whole new world of possibilities.

ROAD OYL™ State of the Art for Performance and Environmental Acceptability.



HIGH BONDING STRENGTH
PETROLEUM-FREE
EMULSION TECHNOLOGY

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ROAD OYL™ Resin Modified Emulsion - Marshall Stability Test Results

1. Dense Graded Aggregate

Sieve	% Passing
1/2"	100
3/8"	99
No. 4	82
No. 10	55
No. 40	20
No. 100	5
No. 200	3

2. Dense Graded Aggregate

Sieve	% Passing
1/2"	100
3/8"	99
No. 4	82
No. 10	55
No. 40	20
No. 100	5
No. 200	3

3. Aggregate / Soil Blend

Crushed Limestone (CA 16) & Silty Sand

Sieve	% Passing
3/8"	100
No. 4	64
No. 16	51
No. 40	40
No. 80	18
No. 100	13
No. 200	5

4. Aggregate / Soil Blend

Crushed Limestone (CA 16) & Clayey Soil

Sieve	% Passing
3/8"	99
No. 4	66
No. 16	50
No. 40	40
No. 80	10
No. 100	8
No. 200	3

5. Silty Sand

Material	% Composition
Gravel	6
Sand	68
Non-Plastic Silt Clay	26

Sample	RESIDUAL BINDER (%)	PRE-WET WATER (%)	STABILITY (Pounds)	FLOW (.01in.)
A	3.0	1.0	10,350	8.5
B	3.0	1.0	10,420	8.0
C	3.0	1.0	9,920	8.5
A	1.0	3.5	5,192	10
B	1.0	3.5	5,320	8
C	2.0	3.5	6,055	9
D	2.0	3.5	5,810	9
E	3.0	2.0	6,486	8
F	3.0	2.0	6,486	9
A	2.0	2.0	6,590	9
B	2.0	2.0	6,650	8.5
C	2.0	2.0	6,490	8.25
A	2.0	3.5	2,990	9
B	2.0	3.0	3,060	9.5
C	2.0	2.5	3,440	8.75
D	2.0	2.5	3,180	8.25
E	2.0	2.5	3,360	8.75
A	4.0	4.0	1,985	9
B	6.0	3.0	10,000+	*
C	8.0	2.0	10,000+	*
D	10.0	2.0	7,198	14

** Stabilities at 6% and 8% residual solids exceeded the capacity of the testing equipment (10,000 lb.), as a result, actual Flow Values could not be determined at these points.*

*The following additional tests were run with the silty sand materials described in testing series #5 above, using the mix design incorporating 10% **ROAD OYL** residual solids (percentage addition rates are based on the dry weight of aggregate and soil materials). (1) Hveem Stabilometer Tests, which measure the resistance of the compacted mix to lateral displacement under vertical loading, were conducted using the standard modifications for testing cold mix asphalt emulsions. Asphalt Institute criteria for asphalt concrete, using dense graded aggregates, require a minimum Stabilometer Value (ASTM D 1560) of 37 for the Heavy Traffic classification. The Stabilometer Value for this **ROAD OYL** mix design with the silty sand was 62 (a three test average). (2) Results of the Resistance R-Value Test (ASTM D 2844), which is typically used to evaluate the potential strength of untreated and treated soils and aggregate base course materials for use in the structural sections of road and airfield pavements, averaged 93 (a three test average) on a scale of 100.*

Testing series #1, #2, #3, &#4 conducted by Akzo Chemicals, Inc.
Testing series #5 conducted by Chen Northern, Inc., for the National Park Service.

FOR FURTHER INFORMATION CONTACT:

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Soil Stabilization™ Products Company INC.

State-of-the Art ***ENVIRONMENTAL PRODUCTS*** for the Protection of ***SOIL, WATER*** and ***AIR QUALITY***

Featuring:

SOIL SEAL®

Soil Seal is a registered trademark of the Soil Seal Corporation

A patented high grade copolymer formulation for soil surface stabilization. This product sets the standard for durability, environmental acceptability and ease of application.

Dust Control
Blow Sand Control
Revegetation
Erosion Control
Hydroseeding
Water Conservation

HOT TOPIC
PM10 Regulations Ahead

- ☑ **Dust Control Products**
- ☑ **Erosion Control Products**
- ☑ **Stabilization Products for Soil and Aggregate Materials**
- ☑ **Liners for Liquid and Solid Waste Containment**

SOIL SEAL® - *A PROVEN PERFORMER*

WHEN YOU NEED TO HOLD SOIL WHERE IT BELONGS

When you need to stop dusting, erosion and siltation.

For over twenty years, this unique copolymer formulation has been setting the standard for soil surface stabilization. **SOIL SEAL®** has been specified for the most environmentally sensitive sites by agencies such as the National Park Service, the Forest Service and the Environmental Protection Agency. When EPA remedial action clean-ups or Superfund sites need reliable dust control, erosion control or protection of hydroseeding and hydromulching applications, **SOIL SEAL®** fits the bill.

While the environmental acceptability of **SOIL SEAL®** is an outstanding attribute for projects where environmental cleanliness is carefully reviewed, the ***durability and cost - effectiveness*** of the treatment is equally important. For agencies or industries with a requirement to control large expanses of bare soil, partially vegetated land, mine and mill tailings, or newly planted seed on erosive soils or steep slopes, ***cost - effectiveness must be a priority concern.***

Why is SOIL SEAL® *Unique in Effectiveness and Unique in Durability?*

There are three primary natural erosive forces at work with which a soil surface stabilizer must contend - wind, water and sun. Whether the goal is to control dust or to stop wind and water erosion, an effective treatment must be well integrated with the soil to hold against high winds, rain impact and heavy sheet - flow of water. The treatment also needs to be resistant to the erosive force of the sun; ultraviolet degradation. The patented high grade copolymer formulation of the **SOIL SEAL®** product meets the three forces of nature head - on with three unique capabilities. Use of the high grade copolymer base allows **SOIL SEAL®** to be highly diluted with water for penetration during application, yet still able to polymerize and form a cohesive matrix within the soil once the water evaporates. Special additives further improve the ability of the **SOIL SEAL®** solution to first penetrate the soil materials and then to harden for maximum holding power. ***PENETRATION*** **and** ***HOLDING POWER*** **- two of the three unique factors.**

Cheaper polymers may briefly hold against wind and water, but the sun (force number three) passes final judgement. When it comes to an environmentally acceptable base material that is effective for soil surface stabilization, a pure acrylic copolymer is unsurpassed in its resistance to breakdown under ultraviolet exposure. **SOIL SEAL®** is formulated with a pure acrylic base, allowing for maximum dilution, maximum penetration and durability. We have single treatments still providing dust control and erosion control over four years after application.

SOIL SEAL® *PROMOTES VEGETATION!*

If you want to keep an area of bare earth "in control" and free of vegetation, first apply an appropriate pre - emergent herbicide. Otherwise, naturally dispersed seed will be given a major boost in effectiveness as the soil surface is held in place by the **SOIL SEAL®** treatment, providing a stable germination bed. **SOIL SEAL®** is formulated to reinforce the ability of the soil surface to shed sheet water flow, yet still be permeable to the gradual moisture infiltration needed to support vegetation.

For a more active approach to revegetation, **SOIL SEAL®** is state - of - the - art as a tackifier for seed, mulch and soil. **SOIL SEAL®** has been effective in promoting vegetation on near vertical, crumbling slopes, turning them green with growing grass cover. When success of a revegetation program is critical, **SOIL SEAL® is your best insurance.**

DUST CONTROL AND WATER CONSERVATION

Federal PM_{10} Regulations and local county and city regulations for the control of fugitive dust are putting pressure on anyone with a lot of disturbed ground to hold in place. Agencies, industry, developers and contractors can call on **SOIL SEAL®** to provide a dollar saving alternative to ineffective spray treatments and to provide a water - conserving alternative to daily dust control watering.

PRODUCT APPLICATIONS:

BARE EARTH

- ☐ Dust Control & Blow Sand Stabilization
- ☐ Erosion Control for Temporary & Permanent Closure Caps
- ☐ Maintenance of Easements & Right - of - Ways
- ☐ Maintenance of Test Ranges
- ☐ Mine & Mill Tailings Stabilization
- ☐ Protection of Desert Earthworks
- ☐ Runway Perimeter Maintenance
- ☐ Stabilization of Material & Topsoil Stockpiles
- ☐ Surface Stabilization of Berms & Dikes
- ☐ Temporary Stabilization of Contaminated Soils
- ☐ Winterization of Construction Sites

VEGETATION

- ☐ Promotion of Natural Revegetation
- ☐ Reclamation & Fire Restoration
- ☐ Revegetation for Slopes & Erosive Soils
- ☐ Tackifier for Hydromulching & Hydroseeding

WHO is using **SOIL SEAL®**?

- Highway & Public Works Departments
- Federal & State Land Management Agencies
- Military Facilities & Military Contractors
- Petroleum & Petrochemical Industries
- Developers & Contractors
- Mines, Mills & Quarries
- Public Utilities & Power Plants
- Landfills & Waste Containment Closures
- Railroads & Port Facilities
- Environmental Clean-up Contractors
- Airports & Test Ranges
- Hydroseeding & Hydromulching Contractors
- Parks & Conservation Departments

SOIL SEAL® Easy to Apply, Environmentally Acceptable, Tenacious in Holding Soil in Place.

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Soil Stabilization Products™ Co., INC.

Call Toll Free at 1 (800) 523-9992

P.O. Box 2779, Merced, CA 95344 (209) 383-3296 Fax (209) 383-7849

DUSTROL™

WATER TRUCK ADDITIVE

Economical Dust Control

DUST CONTROL CAN BE PROVIDED by dozens of approaches. The oldest approach is using water alone. Today, water trucks are in use around the clock, sprinkling water for dust control. It's a simple approach, but not necessarily cost-efficient.

DUSTROL is an organic chemical binding agent formulated to streamline the investment going into a water truck based dust control program. As a water truck additive, **DUSTROL** increases the adhesion and agglomeration of soil particles and assists in the formation of a hardened running surface. Water trucks are often used for dust control of material stockpiles as well as roads. DUSTROL provides a low-cost protective treatment, penetrating and bonding a wide variety of stockpiled materials. THE **DUSTROL** PROGRAM PROVIDES BETTER ROADS, BETTER DUST CONTROL AND A BETTER VALUE THAN WATERING ALONE.

HOW DUSTROL HELPS CONTROL DUST

DUSTROL is an ORGANIC CHEMICAL PREPARATION which causes minute soil particles to adhere to each other, forming a larger sized particle which resists blowing when dry.

DUSTROL contains components which cause WATER to immediately penetrate into the soil of roadbeds to a greater depth - reducing loss by evaporation, reducing chuck-holes caused by standing puddles of water, and holding the dust in the road surface.

DUSTROL mixes instantly with water (no agitation needed) and remains as a homogeneous solution, even with extended storage in the water truck.

DUSTROL will freeze at approximately 20°F and should be stored in a protected area (above 32°F). Freezing will not affect performance or cause separation of the compound.

DUSTROL is the result of 15 years of experimentation, development and field testing.

DUSTROL is ecologically clean. It is a biodegradable organic chemical which is non-polluting and non-toxic to plants, animals and humans.

DUSTROL can cut *your water requirements for dust control by 40 - 50 - 60%!*

YOUR CHOICE - MUD OR DUST?

Typically, dust is mud 1/3 of the time; **dust** 2/3rds of the time, and people are irritated by both! **DUSTROL** CAN REDUCE THIS NUISANCE.

NUISANCE, HAZARD, & HEALTH THREAT

On Dirt Roads: (Haul Roads - Detours - Farm Roads, etc.) **Dust is a hazard to traffic;** causes excessive wear and higher maintenance costs for vehicles and equipment; impairs the health of persons moving equipment; and deposits itself on the leaves of trees and plants - providing a hiding place for mites and other insects and preventing natural predators from controlling them - damaging crops and trees and requiring expensive spraying.

On Paved Roads: Dust is still a problem because of spillage from trucks and the swirl created by large vehicles moving along roads.

Wind blows dust off of parking areas, equipment yards where light vehicle traffic occurs, stock piles and slag piles.

Conveyor belts and tipples, carrying ores and aggregates to be processed or loaded, create considerable dust.

Mining Operations: Drilling and blasting are also a large source of dust.

Grinding or crushing of ores and aggregates produce dust.

DUST seldom adds to the PROFIT of any operation. GENERALLY, it lowers PROFIT in many ways and IRRITATES EVERYONE. The use of **DUSTROL** can increase PROFITS.

SOIL STABILIZATION PRODUCTS COMPANY, INC.
P.O. Box 2779, Merced, CA 95344
(800) 523-9992 FAX: (209) 383-7849

DUSTROL™ is a trademark of BD Chemicals, Inc.

DUSTROL™ CONCENTRATE APPLICATION INSTRUCTIONS

DUSTROL CONCENTRATE - Water Truck Application

Dirt Roads or Parking Yards or Parking Areas, Arenas, or Racetracks

1. **Fill water tank to 90% of capacity,** and add **DUSTROL** at the rate of 1/2 gallon per 1,000 gallons of water (foaming is characteristic of DUSTROL). **Fill balance of tank.**

2. **Drive truck slower than normal,** allowing more water to be applied than usual.

3. **Repeat on newly treated areas** at least 6 times at this rate.

4. **Reduce amount of DUSTROL** to 1/4 gallon per 1,000 gallons - continue driving slowly.

5. **Reduce application of DUSTROL in water to first trip** in morning and **last trip** at night on stubborn areas and heavily traveled roads.

6. **Reduce application frequency** as control becomes apparent (often to 1/2 or less). (Some soil types respond sooner than others.)

7. **Heavy vehicle traffic** scuffs the surface of the hard strata being formed, occasional watering will be necessary.

8. **Race track - arenas:** Control can usually be obtained within 12 applications.

DUSTROL SPRAY CONCENTRATE - Metered Pump Injection Application

Conveyors, tipples, etc.

1. **DUSTROL** may be injected into water lines leading to spray nozzles with Blue White Type Metering Pumps, directly from shipping drums at any convenient point.

2. **Inject at the rate of** 1/4 gallon per 1,000 gallons of water. **Reduce water volume 1/2 or more.**

3. **Barks,** sawdust, and other dry organic materials require approximately **1/2 ounce per cubic yard of material.**

4. **Mining Operations:** Inject at the rate of 1/4 gallon per 1,000 gallons of water into the water line leading to sprayers at the nearest convenient point. Reduce water volume 1/2 to 2/3.

5. **Dirt banks and small yards: DUSTROL can be applied** with hose-end applicator - **dilute as needed.** Areas with little foot traffic can be controlled with 1 application per week.

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(800) 523-9992

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MATERIAL SAFETY DATA SHEET: DUSTROL

SECTION 01: IDENTIFICATION

INFORMATION FURNISHED BY:	B-D Chemicals
ADDRESS:	17561 Vierra Canyon Road Salinas, CA 93907
DATE EFFECTIVE:	January 1, 1994
CHEMICAL FAMILY:	Colloidal Liquid Compound
EMERGENCY PHONE NO.:	(408) 663-0378
PRODUCT OR TRADE NAME:	DUSTROL™
HAZARDOUS INGREDIENTS OVER 1% IN MIX:	None

SECTION 02: HAZARDOUS INGREDIENTS

ALLOYS AND METALLIC COATINGS:	N/A
MIXTURES OF OTHER LIQUIDS, SOLIDS, OR GASES:	N/A

SECTION 03: PHYSICAL DATA

BOILING POINT:	> 500°F
FIRE POINT:	570°F - 630°F
PERCENT VOLATILE BY VOLUME:	0.00
MELTING POINT:	N/A
VAPOR PRESSURE:	Not Volatile
VAPOR DENSITY (Air = 1):	Not Volatile
SOLUBILITY IN WATER:	Complete
APPEARANCE AND ODOR:	Red, Slightly Aromatic
SPECIFIC GRAVITY (Water = 1):	1.06
EVAPORATION RATE:	Not Volatile

SECTION 04: FIRE AND EXPLOSION HAZARD DATA

FLASH POINT:	535°F - 555°F
TEST METHOD:	OC
AUTOIGNITION TEMPERATURE:	N/A
FLAMMABLE LIMITS IN AIR:	
Lower Limit:	N/A
Upper Limit:	N/A
EXTINGUISHING MEDIA:	Use Media Proper to the Primary Cause of Fire
SPECIAL FIRE FIGHTING PROCEDURES:	None
UNUSUAL FIRE AND EXPLOSION HAZARDS:	None

6702.DTR

SECTION 05: HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE:	Not Volatile
EFFECTS OF OVEREXPOSURE:	Eye Contact May Result in Irritation
EMERGENCY AND FIRST AID PROCEDURES:	Wash With Copious Amounts of Cold If Irritation Persists, Consult Physician

SECTION 06: REACTIVITY DATA

STABILITY:	Stable
CONDITIONS TO AVOID:	N/A
MATERIALS TO AVOID:	Concentrated Oxidizing Agents
HAZARDOUS POLYMERIZATION:	Will Not Occur
HAZARDOUS DECOMPOSITION PRODUCTS:	N/A

SECTION 07: SPILL OR LEAK PROCEDURES

IF MATERIAL IS RELEASED OR SPILLED:	Flush Spill Area With Water
WASTE DISPOSAL METHOD:	Flush to Sewer With Plenty of Water

SECTION 08: SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION:	Not Needed
VENTILATION REQUIREMENTS:	Mechanical Ventilation Satisfactory
PERSONAL PROTECTIVE EQUIPMENT:	Goggles Recommended Gloves and Protective Clothing Not Normally Required

SECTION 09: SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING:	Avoid Splashing, Spilling
OTHER PRECAUTIONS:	None - Normal Precautionary Procedures

SSPCo

Environmentally Appropriate Product Technologies
for Pavements, Dust Control, Erosion Control & Soil Stabilization

MATERIAL SAFETY DATA SHEET: DUSTROL SPRAY

SECTION 01: IDENTIFICATION

INFORMATION FURNISHED BY:	B-D Chemicals
ADDRESS:	17561 Vierra Canyon Road Salinas, CA 93907
DATE EFFECTIVE:	January 1, 1994
CHEMICAL FAMILY:	Colloidal Liquid Compound
EMERGENCY PHONE NO.:	(408) 663-0378
PRODUCT OR TRADE NAME:	DUSTROL™ SPRAY
HAZARDOUS INGREDIENTS OVER 1% IN MIX:	None

SECTION 02: HAZARDOUS INGREDIENTS

ALLOYS AND METALLIC COATINGS:	N/A
MIXTURES OF OTHER LIQUIDS, SOLIDS, OR GASES:	N/A

SECTION 03: PHYSICAL DATA

BOILING POINT:	> 500°F
FIRE POINT:	570°f - 630°f
PERCENT VOLATILE BY VOLUME:	0.00
MELTING POINT:	N/A
VAPOR PRESSURE:	Not Volatile
VAPOR DENSITY (Air = 1):	Not Volatile
SOLUBILITY IN WATER:	Complete
APPEARANCE AND ODOR:	Blue, Slightly Aromatic
SPECIFIC GRAVITY (Water = 1):	1.06
EVAPORATION RATE:	Not Volatile

SECTION 04: FIRE AND EXPLOSION HAZARD DATA

FLASH POINT:	535°F - 555°F
TEST METHOD:	OC
AUTOIGNITION TEMPERATURE:	N/A
FLAMMABLE LIMITS IN AIR:	
Lower Limit:	N/A
Upper Limit:	N/A
EXTINGUISHING MEDIA:	Use Media Proper to the Primary Cause of Fire
SPECIAL FIRE FIGHTING PROCEDURES:	None
UNUSUAL FIRE AND EXPLOSION HAZARDS:	None

6703.DTR

SECTION 05: HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE:	Not Volatile
EFFECTS OF OVEREXPOSURE:	Eye Contact May Result in Irritation
EMERGENCY AND FIRST AID PROCEDURES:	Wash with Copious Amounts of Cold Water If Irritation Persists, Consult Physician

SECTION 06: REACTIVITY DATA

STABILITY:	Stable
CONDITIONS TO AVOID:	N/A
MATERIALS TO AVOID:	Concentrated Oxidizing Agents
HAZARDOUS POLYMERIZATION:	Will Not Occur
HAZARDOUS DECOMPOSITION PRODUCTS:	N/A

SECTION 07: SPILL OR LEAK PROCEDURES

IF MATERIAL IS RELEASED OR SPILLED:	Flush Spill Area With Water
WASTE DISPOSAL METHOD:	Flush to Sewer With Plenty of Water

SECTION 08: SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION:	Not Needed
VENTILATION REQUIREMENTS:	Mechanical Ventilation Satisfactory
PERSONAL PROTECTIVE EQUIPMENT:	Goggles Recommended Gloves and Protective Clothing Not Normally Required

SECTION 09: SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING:	Avoid Splashing, Spilling
OTHER PRECAUTIONS:	None - Normal Precautionary Procedures

CONSTRUCTION FABRICS AND MATERIALS
2525 Pieper Road
Cottage Grove, WI 53527
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January 31, 1996

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FOTH & VAN DYKE

FOTH & VAN DYKE AND ASSOCIATES, INC.
2737 SOUTH RIDGE ROAD
P.O. BOX 19012
GREEN BAY, WI 54307-9012

Dear Mr. Meister,

DUST CONTROL
CFM 400 EROSION CONTROL POLYMERS APPLICATION RATES.

TANK SIZE 1500 GAL

MIX RATIOS:	5 LBS (1 BAG) WHITE POLYMER	
	10 LBS (1 BAG) GREEN POLYMER	
	50# GYPSUM	
ADD OPTIONS:	AIRTROL	400# PER ACRE
	PAPER FIBER MULCH AS MARKER	150# PER ACRE
	SEED	AS SPECIFIED
	FERTILIZER	AS REQUIRED

FILL TANK WITH WATER.
AGITATE.
PUT WHITE POLYMER IN TANK FIRST.
PUT GREEN POLYMER IN TANK SECOND.
PUT OTHER ADDITIVES IN NEXT.

MSDS SHEETS INCLUDED WITH ORDER.
WEAR GLOVES AND MASK WHEN ADDING POLYMERS TO TANK.
NOT REQUIRED AFTER POLYMER IS MIXED WITH WATER.

COVERAGE RATES:	3/1 SLOPE	1 ACRE
	2/1 SLOPE	1/2 ACRE
	1/1 SLOPE	1/3 ACRE
	CHANNEL	1/3 ACRE

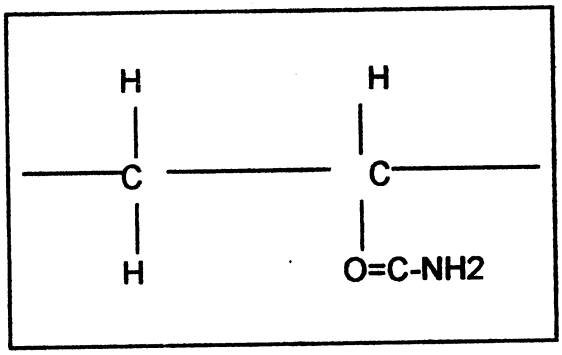
PLEASE CONTACT OUR OFFICE WITH QUESTIONS.

Steve Decker
Construction Fabrics and Materials

EROSION CONTROL FORMULATION TO ENHANCE SOIL AGGREGATE STABILITY AND PREVENT PARTICLE DETACHMENT DURING CONSTRUCTION.

MATERIAL

What is CFM W-1000 PAM?
CFM W-1000 PAM is a polyacrylamide. The polyacrylamide is a polymeric chain of many subunits of acrylamide molecules. Acrylamide is a relatively simple organic compound that can be linked to identical copies of itself to form chain like molecules. A single acrylamide molecule is referred to as a "monomer". The linked monomers create the polymer. (fig 1)



Glucose, the simplest sugar, is a monomer. Starch and cellulose are compounds of long chains of glucose monomers. The chemical and physical characteristics of polymers are typically very different. For example, glucose is easily broken down, whereas cellulose is resistant. Starch and intermediate polymers break down less easily than cellulose and more easily than glucose. The physical properties of PAM differ greatly from the acrylamide monomer and vary depending on the atomic weight of the polymer.

There are thousands of "kinds" of PAM. The term PAM is generic. Depending on the chain length and monomer alterations of some of the subunits, PAMs can have unique properties. The PAM currently in use in erosion control have more than 100,000 monomer units per molecule, and carry a negative charge in one fifth of the links in each chain like molecule.

The use of PAM for erosion control is new. The use of PAM with a high molecular weight in erosion control is revolutionary. The new generation of PAM are moderately anionic (18% active sites). When they are applied via hydroseeder to the small part of the soil layer that plays a role in the physical process of erosion , i.e. particle detachment, the excess of runoff yield suspends sediment and causing crust formation in the few millimeters of soil depth in the treated zone. This crust formation and sediment suspension also provides superior dust control.

APPLICATION RATES OF PAM USING 2,000-4,000 GAL OF WATER PER ACRE :

4,000 gallons per acre for slopes from 0 - 12%.
2,000 gallons per acre for slopes from 12 -40%.

Note: cfm P-1000 and P-2000 are used alternatively but not both.

APPLICATION RATES: UNIT LBS.

% slope	cfm S-1000	cfm P-1000	cfm P-2000	cellulose	gypsum
0 - 3%	1	5	5	100	25
3 - 6%	1	5	5	100	50
6 - 12%	1	5	5	150	75
12 - 20%	2	8	8	150	100
20 - 30%	2	8	8	200	150
30 - 40%	2	10	10	200	150
> - 40%	2	15	15	200	150

What does PAM do to control erosion and fugitive dust on construction sites? In a study of the stability of aggregates on soil from Dane County it was found that there is a variability in the aggregate stability when treated with ionic, anionic and neutral acrylamides. Not all of the polymers bind the soil and increase cohesion and strength of aggregates. Some polymers react with the particles that form the aggregate and bond them together more securely than other polymers. When the soil particles that form the aggregate are bound securely, detachment due to the energy of the raindrops or wind is reduced. This increased cohesion of the aggregate will reduce slaking or weakening of the aggregate due to moisture increase and internal pressure of the air being expelled by the moistening process. In a construction area, once the particles are detached they are transported immediately due to the high runoff from the denuded and compacted soils. From the 50 polymers tested only two provided aggregate stability and improved inter-aggregate bonding. (table 1)

PAM AS A CLARIFIER

PAM is a flocculant and a coagulant aid. PAM clumps together silts (20 - 4 um) and clay (< 4 um) that are carried in the sheet flow and later concentrated flows. These fine particles are dislodged or detached by the impact of the raindrop. Once these fine particles are suspended and carried in the flow they cause larger aggregates to settle in areas where the flow velocities are reduced due to changes in the slope and ponding of the water. (table 2) shows that the soils in Dane County are composed of fine particles with 60 to 90% of the particles having a size less than 20um and 30% of the particles having a size less than 5 um. Therefore, large amounts of fine particles remain in suspension and

take long periods of time to settle out in ponds. Also, these settled "fines" infiltrate the soils that make up the bottom of the pond blocking the micropores and inducing crust formations thus reducing infiltration rates. The reduced infiltration rates increase the amount of runoff from the construction site during the period when the bare soil is most likely to be effected by the erosive forces of raindrops and wind. This blocking action of the micropores and crust formation from the fine silts and clay that are washed in to settling ponds also reduces the ponds effectiveness. Under ideal conditions to cause a 1 um particle to settle one foot will take 84 hours. The reduced water absorbtion rate of the ponds causes an increase in the retention time and pond sizing must be increased to handle a given amount of water.

PAM is a cost effective method for reducing site soil erosion caused by wind and water. Please contact Construction Fabrics & Materials Corp. at 608-839-8031 for additional information and pricing.

ConCover®
Daily Cover

Solid waste material profile



ConCover application



Before ConCover



After ConCover

"When sprayed over most surfaces, ConCover forms a uniform encapsulating layer between the waste and the environment..."

ConCover is the result of years of research and development by engineers, chemists and analysts from some of North America's most respected environmental firms. Designed as an alternative to traditional landfill daily covers, ConCover is specified by more sites than any other applied technology today. A technologically advanced blend of polymers and recycled fiber, ConCover creates a slurry when mixed with water, which is biodegradable and non-flammable. When sprayed over most surfaces, ConCover forms a uniform encapsulating layer between the waste and the environment, providing reliable daily coverage in a variety of climate conditions.

ConCover controls:

- Blowing litter
- Odors
- Volatile Organic Compound (VOC) emissions
- Vectors and rodents
- Ash and dust
- Fire

The space-saving and timesaving alternative to soil

An alternative to daily soil cover, ConCover solves the problem of non-revenue generating space consumption. ConCover is quickly and easily sprayed over waste to a uniform depth of only 1/8 to 1/4 inch (0.3 - 0.6 cm). A near zero volume cover, exceeding the requirements of daily soil, is created which makes your airspace go further. Moving less dirt around means significant labor and equipment savings for you.

ConCover applications

- Solid waste landfills
- Mono fills
- Ash fills
- Landfill mining
- Bale fills

NWC
New Waste Concepts

Superior to six inches of soil

In laboratory tests to determine permeation ratings for migrating gases and water, ConCover performed superior to 6 inches (15 cm) of clayey soil.

ConCover received a rating of non-hazardous (0 rating) for health, fire and reactivity. No oral, inhalation, or other hazards are indicated on ConCover's Material Safety Data Sheet (MSDS).

Analysis with the standards established for the Toxicity Characteristic Leaching Procedure (TCLP) test proved no detection in every category.

More environmental protection

ConCover is an industry leader in air-borne emission control and worker safety. For more information about how ConCover can reduce soil related costs while increasing environmental protection, call 1-800-359-2783.

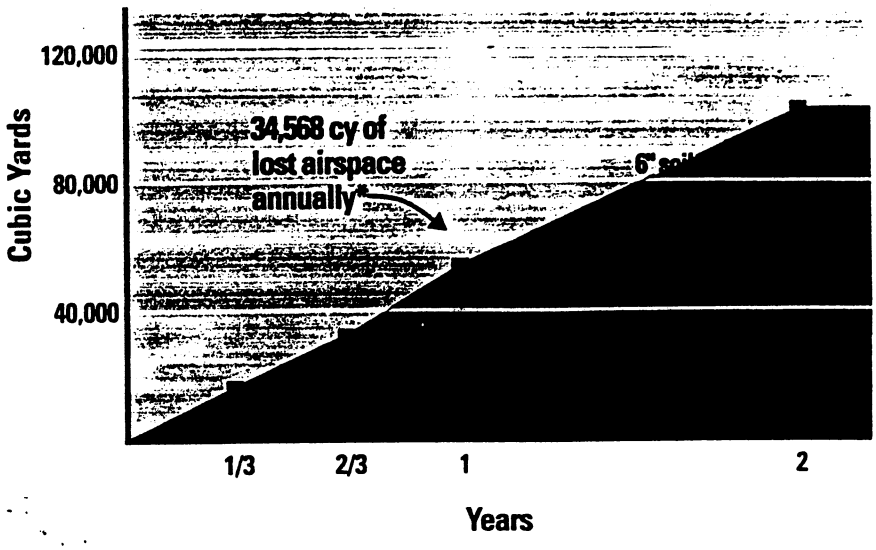
"CONCOVER IS SPECIFIED BY MORE SITES THAN ANY OTHER APPLIED TECHNOLOGY."

NEW WASTE CONCEPTS

New Waste Concepts
7401 Fremont Pike
P.O. Box 443
Perrysburg, OH 43552
U.S.A.
1-800-359-2783
1-419-872-8160
FAX 1-419-837-2692

Printed on recycled paper

VOLUME OCCUPIED BY DAILY COVER

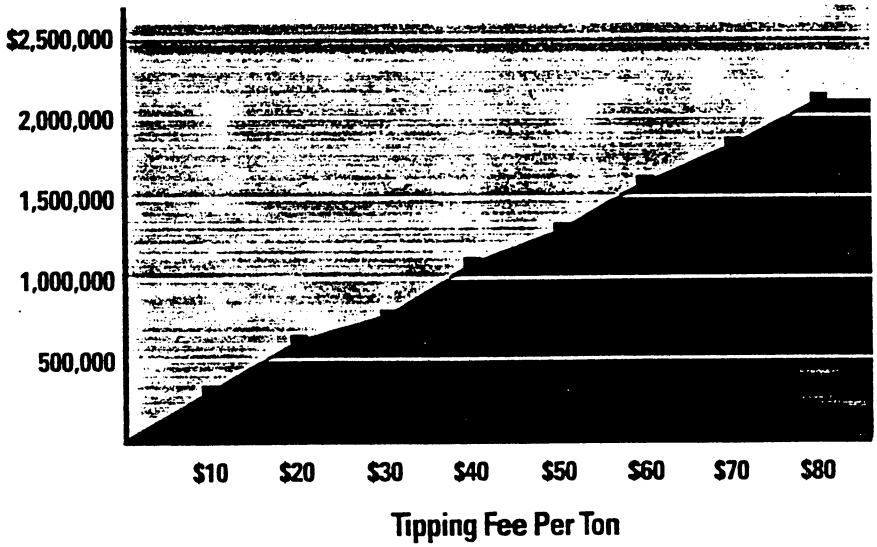


Graph represents a model landfill operating 280 days/yr with a working face of 10,000 ft^2.

* Dashed line represents the difference between space consumed using 6 inches of soil cover versus 1/4 inch of ConCover.

** No alternative daily cover eliminates the need for soil. Analysis is based on an average landfill using 1/3 soil and 2/3 ConCover.

VALUE OF AIRSPACE SAVED (Annual)



Cost savings are based on 34,568 cy/yr of conserved airspace using ConCover versus 6 inches of soil. Cross referencing your tipping fee in the graph will give you your annual value of airspace saved.

NEW WASTE CONCEPTS

7401 FREMONT PIKE · PO BOX 443
PERRYSBURG · OH 43552 U·S·A

✆ 419·872·8160 FAX 419·837·2692

Product Description

A spray applied temporary cover for use to minimize infiltration of precipitation, to control blowing litter and particulate matter, to control air emissions of volatile materials and odors. The system consists of two components that are nontoxic Part A that is a binding agent and part B a treated recycled cellulose fiber to provide structural integrity. When cured these two components form a 1/8" - 1/4" crust for normal application.

Specifications Blended ConCover

Property	Specification
Appearance, 25° C	-Slurry of a consistent nature -dark green color with solids fully suspended in solution.
pH, slurry	-9.5 max. -8.0 min.
Flash Point, T.C.C.	-None
Water Solubility	-100% soluble (binder components only)
D.O.T. Shipping Class	-N/A
D.O.T. Hazard Class	-N/A

Typical US E.P.A. Toxicity Ext' Procedure (SW846)

	Units	Results	Detection Limit
EP Arsenic	mg/L	<0.04	0.04
EP Barium	mg/L	<4	4
EP Cadmium	mg/L	<0.1	0.1
EP Chromium	mg/L	<0.2	0.2
EP Copper	mg/L	<0.2	0.2
EP Lead	mg/L	<0.2	0.2
EP Mercury	mg/L	<0.004	0.004
EP Selenium	mg/L	<0.04	0.04
EP Silver	mg/L	<0.2	0.2
EP Zinc	mg/L	.27	0.2

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SS-4/93

New Waste Concepts believes all information in this document to be true and reliable to the best of its knowledge. No guarantee, warranty, or representation is made as to the suitability of this sales specification. The user should conduct his own investigation as to the suitability of this product for his own use.

NEW WASTE CONCEPTS
7401 FREMONT PIKE · PO BOX 443
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TCLP Zero Headspace Extraction	Units	Results	Detection Limit
Multicomponent analysis: TCLP Volatile			
Benzene	mg/L	Not Detected	0.0006
Carbon Tetrachloride	mg/L	Not Detected	0.002
Chlorobenzene	mg/L	Not Detected	0.0006
Chloroform	mg/L	Not Detected	0.0006
1,4-Dichlorobenzene	mg/L	Not Detected	0.002
1,2-Dichloroethane	mg/L	Not Detected	0.001
1,1-Dichloroethene	mg/L	Not Detected	0.0008
Methyl Ethyl Ketone	mg/L	Not Detected	0.002
Tetrachloroethene	mg/L	Not Detected	0.001
Trichloroethene	mg/L	Not Detected	0.001
Vinyl Chloride	mg/L	Not Detected	0.001
TCLP Non-Volatile Extraction			
Multicomponent Analysis: TCLP Metals			
Arsenic	mg/L	Not Detected	0.04
Barium	mg/L	Not Detected	4.0
Cadmium	mg/L	Not Detected	0.1
Chromium	mg/L	Not Detected	0.2
Lead	mg/L	Not Detected	0.2
Mercury	mg/L	Not Detected	0.004
Selenium	mg/L	Not Detected	0.04
Silver	mg/L	Not Detected	0.2
Multicomponent analysis: TCLP Phenolics			
o-Cresol	mg/L	Not Detected	0.001
m+p-Cresol	mg/L	Not Detected	0.001
Pentachlorophenol	mg/L	Not Detected	0.004
2,4,5-Trichlorophenol	mg/L	Not Detected	0.003
2,4,6-Trichlorophenol	mg/L	Not Detected	0.002

	Units	Results	Detection Limit
Multicomponent analysis: TCLP Base/Neutrals			
1,4-Dichlorobenzene	mg/L	Not Detected	0.001
2,4-Dinitrotoluene	mg/L	Not Detected	0.005
Hexachlorobenzene	mg/L	Not Detected	0.002
Hexachlorobutadiene	mg/L	Not Detected	0.002
Hexachloroethane	mg/L	Not Detected	0.002
Nitrobenzene	mg/L	Not Detected	0.001
Pyridine	mg/L	Not Detected	0.001
Multicomponent analysis: TCLP Pesticides			
Chlordane	mg/L	Not Detected	0.02
Endrin	mg/L	Not Detected	0.04
Heptachlor	mg/L	Not Detected	0.008
Heptachlor Epoxide	mg/L	Not Detected	0.008
Lindane	mg/L	Not Detected	0.005
Methoxychlor	mg/L	Not Detected	0.001
Toxaphene	mg/L	Not Detected	0.06
Multicomponent analysis: TCLP Herbicides			
2,4-D	mg/L	Not Detected	0.10
2,4,5-TP (Silvex)	mg/L	Not Detected	0.02

NEW WASTE CONCEPTS

7401 FREMONT PIKE · PO BOX 443
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✆ 419·872·8160 FAX 419·837·2692

MATERIAL SAFETY DATA SHEET

Distributor: New Waste Concepts, Inc., 7401 Fremont Pike P.O.443 Perrysburg,Ohio
Product Name: ConCover® "A" Bag
Emergency Ph: 419/872-8160
Chemical Name: Cellulosic polymer / Clay blend/final product a slurry
Chemical Family: Polymer Blend/Clay blend

Hazard Rating: 0 Health: 1 Fire: 0 Reactivity: 0

SECTION I. INGREDIENTS

Binding material blended with special clays biodegradable organic compounds with other inert material, and fibrous, cellulose based materials. Small Amounts of *Crystalline silica is present in this clay material. Respirable amounts are present.

Crystalline quartz CAS# 14808-60-7 % 2-6%
Respirable Crystalline Quartz %<2

OSHA PEL	ACGIH TLV	NIOSH	
TVA Present-0.1mg/m^3	0.1mg/m^3	50ug/m^3	TWA

See section II and III

SECTION II. SPECIAL PROTECTION

Use a NIOSH/MSHA approved dust mask. Avoid breathing dust, use an approved NIOSH/MSHA respirator where TLV limits exceed for Crystalline Silica dust. Protective gloves are optional and may be desirable in work conditions. Safety glasses recommended. Ventilation exhaust required if generating large quantities of dust. IARC Monographs on the evaluation of the Carcinogenic Risks of Chemicals to Humans (vol. 42, 1987) concludes that there is "limited evidence " of the carcinogenicity of crystalline silica to humans. IARC classification 2A. Respirator type -OSHA standard 1910.134 or ANSI Z88.2-1980 specification. This material is a low hazard if dusting is kept to a minimum and a dust mast is used and precautions are taken when mixing.

SECTION III. HEALTH HAZARD DATA

May be harmful if dust inhaled over long periods and can cause delayed lung injury. Irritation to nose, throat and respiratory passages may result from inhalation of dust. Routes of entry Inhalation-yes ,Skin-no, Ingestion-no. This material is non toxic by oral and skin absorption.

SECTION IV. EMERGENCY FIRST AID

No oral toxicity known. Gross inhalation of dust remove to fresh air ; give oxygen or artificial respiration as needed If materials come into contact with skin, wash affected area with soap and water. Flush eyes with water for 15 minutes. If necessary seek medical attention take this sheet with you.

SECTION V. FIRE AND EXPLOSION HAZARDS

There is no flash point or flammable limit. Recommended extinguishing media: dry chemical, CO_2, foam, water. Unusual hazards: keep away from strong basic materials such as sodium, potassium hydroxides. Keep away from oxidizers.

SECTION VI. PHYSICAL DATA

Boiling Point:	N/A	Specific Gravity:	N/A
Vapor Pressure:	N/A	Percent Volatile:	0%
Vapor Density:	N/A	Evaporation rate:	N/A
Water solubility:	SLIGHTLY SOLUBLE	Odor:	NO SMELL
Appearance:	BROWNISH POWDER		

SECTION VII. REACTIVITY DATA

Stability:	Stable
Incompatibility:	Strong basics or oxidizers
Polymerization:	Will not occur
Decomposition hazards:	CO_2, CO_3
Conditions/materials to avoid:	Heat, fire and water

SECTION VIII. SPILL AND LEAK PROCEDURES

Eliminate ignition sources. Slippery when wet.
Sweep material into drums and dispose of in a landfill in accordance with local, state and federal laws.

SECTION IX. SPECIAL PRECAUTIONS

This material is very slippery when wet. Use caution when walking over dusted wet areas. Use a dust mask, impervious gloves and goggles or a face shield. Mix product in well ventilated area. The long exposures to any dust should be avoided. Practice good house keeping and keep work areas clean.

SECTION X. TRANSPORTATION AND LABELING

D. O. T. Shipping Name:	Synthetic Resin/Clay materials
D. O. T. Hazard Class:	N/A
D. O. T. ID Number:	N/A
Precautionary labels:	Slippery When Wet; May Cause Irritation/avoid dust Small amounts of Crystalline dust is present

User will treat the above information as "CONFIDENTIAL TECHNICAL INFORMATION", which information shall be usec only by the user or subsidiaries or parent of the user. This data when transmitted to other parties should always be labelec "CONFIDENTIAL TECHNICAL INFORMATION", irrespective of to whom it is being transmitted.

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Date: Feb. 4, 1993

Prepared by: Thomas J. Nachtman

NEW WASTE CONCEPTS

7401 FREMONT PIKE · PO BOX 443
PERRYSBURG · OH 43552 U·S·A

✆ 419·872·8160 FAX 419·837·2692

MATERIAL SAFETY DATA SHEET

Distributor: New Waste Concepts, Inc., 7401 Fremont Pike P.O.443 Perrysburg,Ohio
Product Name: ConCover® "B" Bag Paper
Emergency Ph No: 419 / 872-8160
Chemical Name: Recycled paper and wood pulp
Chemical Family: Recycled cellulose

Hazard Rating: 0 Health: 0 Fire: 0 Reactivity: 0

SECTION I. INGREDIENTS

Made from various paper sources with water and surfactant added to improve blendability.

SECTION II. SPECIAL PROTECTION

Use impervious, protective gloves and face shield. Mix in well ventilated area.

SECTION III. HEALTH HAZARD DATA

Avoid prolong inhalation of fiber material. Use gloves and eye goggles or face shield.
Routes of entry--Inhalation-yes Skin-no Ingestion-no

SECTION IV. EMERGENCY FIRST AID

If materials come into contact with skin, wash affected area with soap and water. Flush eyes with water for 15 minutes. If inhaled remove to fresh air and seek medical assistance immediately.

SECTION V. FIRE AND EXPLOSION HAZARDS

There is no flash point or flammable limit. This is a paper product keep in cool dry place. Any dust has a potential for exploding under the right conditions so use caution if dusts is confined to a closed area with a ignition source.

Unusual hazards: keep away from strong basic materials such as sodium, potassium hydroxides. Keep away from oxidizers. Fire fighting use CO_2, Dry chemical Foam or Water.

SECTION VI. PHYSICAL DATA

Boiling Point:	N/A	Specific Gravity:	N/A
Vapor Pressure:	N/A	Percent Volatile:	N/A
Vapor Density:	N/A	Evaporation rate:	N/A
Water solubility:	SLIGHTLY SOLUBLE	Odor:	NO SMELL
Appearance:	Fiberous with brown and greenish color		

SECTION VII. REACTIVITY DATA

Stability:	Stable
Incompatibility:	Strong basics or oxidizers
Polymerization:	Will not occur
Decomposition hazards:	CO_2, CO_3
Conditions/materials to avoid:	Heat, fire and water

SECTION VIII. SPILL AND LEAK PROCEDURES

Eliminate ignition sources. Slippery when wet. Sweep material into drums and dispose of in a landfill in accordance with local, state and federal laws. Does not need to be reported to CERCLA or RCHA.

SECTION IX. SPECIAL PRECAUTIONS

Use caution when walking over wet areas. Use impervious gloves recommended goggles or a face shield recommended. Always use common sense when using any chemicals. Practice good house keeping and keep work areas clean.

SECTION X. TRANSPORTATION AND LABELING

D. O .T. Shipping Name:	Recycled cellulose
D. O. T. Hazard Class:	N/A
D. O. T. ID Number:	N/A
Precautionary labels:	N/A

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Prepared by: Thomas J. Nachtman © 1993

Date: FEBRUARY 24, 1993

ADDED VALUE SLUDGE COVERING

Winter odors from processed sewage sludge placed in a landfill operated by the Holland, Michigan, Board of Public Works were quickly controlled with applications of ConCover, a product originally brought to the site for purpose of controlling blowing fly-ash from the Board's nearby power plant.

David Nuismer, power plant operations superintendent, explains that he had started using ConCover® to keep fly ash from blowing off the utility's monofill — a facility some five miles from the municipality's power plant. The products did such a good job eliminating the problem of blowing fly-ash that it was a logical choice for odor control when department officials opted to use the landfill for winter disposal of sewage sludge from the municipal waste treatment plant.



Ordinarily, in warmer months such sludge is used for agricultural purposes; but once the ground freezes to a three-inch depth, this use is not practical. During this past winter, the sludge coming from the waste treatment plant was wetter than usual because only one press was used (this summer a second sludge press will be installed at the waste treatment plant). This material was particularly odiferous, causing some neighbors living near the landfill to complain. Mr. Nuismer described the odor control strategy as beginning with an application of the ConCover material, which hardened quickly to encapsulate the sludge and contain the odor.

ConCover also has been useful in erosion control work at the landfill. Mr. Nuismer reported that it has been applied on the surfaces of several banks which are too steep to permit plant root systems from taking hold.

PUTTING TECHNOLOGY TO WORK

... using alternative covers instead of soil is just good business sense.

One of the first landfills in the country to change from soil to alternative cover materials was Wisconsin's Outagamie County Landfill, which served the Appleton area. The facility began applying alternative covers in 1984, first with a foam product produced by 3M and presently with ConCover.

Gary Steede, Superintendent of Solid Waste for Outagamie County, has long believed that using alternative covers instead of soil is just good business sense. Good business sense combined with the fact that the soil at this landfill contains large amounts of heavy clay, a difficult material to use for daily cover, is stated as another contributing factor in their decision to use an alternative cover. "With the extremely heavy, fatty clay soil we have here," he said, "there's no way on earth you'd put down six inches, it would be more like a foot or two feet."

"It used to be that we'd construct a cell, fill it up, construct another cell, and so on," he recalls. "Year after year we'd do the same thing. If somebody had told me nine years ago that we'd be using alternative covers, I'd have said they were crazy. But you have to go with the technologies available. You've got to run like a business, and that's what business does."

He estimates that with alternative covers the Outagamie landfill has been gaining some 30 percent additional life at each cell, or about seven months per cell. "In the nine years we've been using synthetics, I imagine we've added three years to the landfill — and that's a conservative estimate."

One of the side benefits that comes with alternative covers at the Outagamie County landfill has been the ability to use its dirt to produce income. Mr. Steede reports that the landfill has sold some two million cubic yards of dirt to contractors, and in one case a contractor bore the expense of excavating 1.5 million cubic yards of soil — saving the county more than $500,000 as a result.

Number of Landfill Closures as a Result of Subtitle D

Region	No. of MSWLFs	% of Total	No. Closing
Atlantic	703	42%	295
South	1,174	27%	317
Mid-West	1,357	33%	448
Pacific	553	15%	83
Western	1,489	34%	506
Total	**5,276**	**31%**	**1,629**

Adopted from Landfill Price Digest, 1992

FLEXIBILITY OF ConCover® EQUIPMENT ADDING VALUE

The flexibility of the ConCover CAPS 1700 spray application requipment now in use at the Outagamie County landfill is expected to be a versatile performer. In addition to using the equipment for applying ConCover, one of the most impressive capabilities offered by the Caps 1700 is its fire-fighting performance. "We might have a half dozen fires a year; but getting the two water trucks around has been difficult and we've been limited by pump pressures as to how far we could spray," Mr. Steede said. "With the ConCover machine and its turret [spray] gun on top, it is ideal. We can put water where we want it. We can spray 150 feet minimum and with a good wind from behind maybe 200 feet. It really does an excellent job."

Mr Steede also envisions using the ConCover machine for in-the-field equipment washing, dust control and perhaps other uses he hasn't thought of yet. "I'm sure there are other uses, the list is probably endless."

CURRENT
Coverage
An Environmental Publication

VOLUME 20 SPRING 1993

PREPARING FOR STRONG SMELLS OF SUMMER

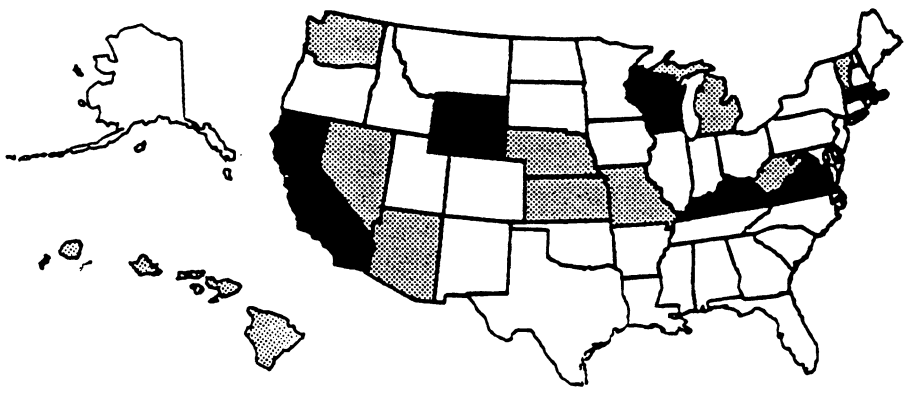
"Those that smell the best are those that smell the least."

There's a truism that has universal application, even to the growing number of yard waste piles standing at landfill sites. Those that smell the best are those that smell the least. That's how many citizens of Illinois feel when it comes to the subject of composting of yard waste, a method decreed mandatory as a means of keeping this material out of landfills. There are a number of composting opponents in that state, which was the first of 21 states to enact a yard waste ban when its law went into effect in July, 1990.

It seems it immediately raised a stink, and in the first year 12 of the state's 78 composting facilities had received odor complaints. Officials now look back and realize that the problem may have been one of bad timing. By implementing the ban in July the principle type of yard waste coming into composting sites were tons of grass clippings. Leaves, of which most break down quickly, and are essential to reducing compost odor, were hard to find. Faced with citizen complaints, operators were told to turn the piles more frequently, but all this did was to stir up the more pungent grass within the piles, making everything worse. It is this legacy which plagues composting operations in Illinois to this day, even though most sites now stock-pile leaves and extend hours in order to more quickly take in bags of grass cuttings.

Composting is gaining ground in Illinois. The 418,000 tons of yard waste now being taken in annually, represents almost three percent of the state's solid waste. During the ban's first year, some 222,000 tons of yard waste were diverted from Illinois' landfills.

STATUS OF SUBTITLE D APPLICATIONS



Made Application | Application in March/April 1993 | Application May 1993 or later

COMPOSTING AND MURPHY'S LAW

One law of probability, authorized by a curmudgeon named Murphy, states that if anything can go wrong, it will.

For several weeks, officials at California's Guadalupe Landfill near San Jose were victims of Murphy's dictum. The landfill's composting operation, which in nine months has processed more than 50,000 tons of yard waste for the City of San Jose, was plagued with unexpected problems. According to Jim Lord, engineer at the site,

". . . everything that could go wrong went wrong, and with that we ended up with stockpiles . . ."

of aging yard waste. He cited a combination of 20 straight days of rain, equipment problems, and receiving more material than had been anticipated. Adhering to the Peter's Law — if anything can go wrong, fix it — Mr. Lord turned to New Waste Concepts' long-term cover (New) ConCover 180™, an air entrained, technically advanced cover product designed to be used when a longer duration cover is required or in conditions of heavy precipitation. Sprayed over the large stockpiles of aging yard waste, the ConCover 180 material performed exceptionally well in shedding rain water and eliminating the offensive smells. Soon the skies cleared, equipment problems were corrected and the yard waste was promptly processed.

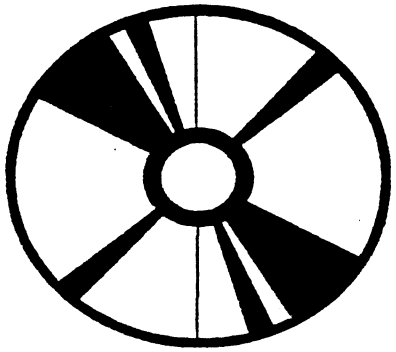
SOMETHING TO CONSIDER

According to calculations offered by the Atlanta Journal, if you placed all of the solid waste generated in the nine counties constituting the greater Atlanta area into the Georgia Dome, you'd fill it five times a year. That's a lot of trash to chop!

PACKAGING INITIATIVES

Years ago, Will Rogers observed that "we live in the age of urge. We do nothing until somebody shoves us."

That may well be the case in the recording industry, where executives clearly heard the music concerning packaging reduction. This summer record manufacturers will begin placing



their CDs in small containers, called "jewel boxes", instead of in the cumbersome 6-by-12 inch boxes which currently are being used.

Some credit the Canadian singer Raffi for being the first performer to take a stand in support of more environmentally friendly packaging. He did so in his contract, stipulating that his recordings could be packaged only in the smaller "jewel box" containers. Others to follow suite include Sting, U2 and Bonnie Raitt — all top selling artists.

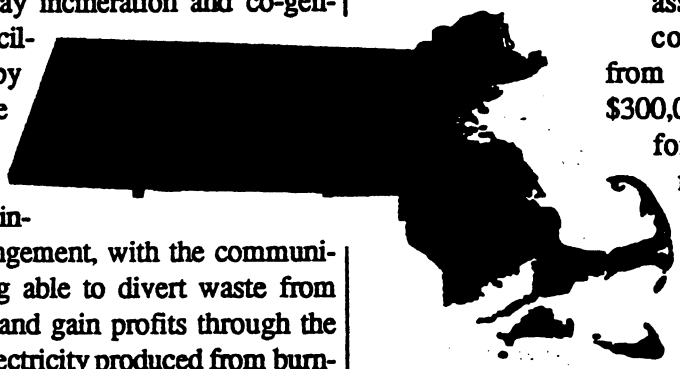
Their concern obviously centered around the more than 16,700 tons of CD packaging Americans discard annually.

BURNED UP AT THE INCINERATOR

It appeared to be a win-win arrangement . . .

A number of Massachusetts communities are wondering whether the waste-reduction-by-incineration program they embarked on several years ago may not have created a monster that can't be fed.

About two dozen communities in the state had signed 20-year agreements in the 1980s to supply waste to a 1,500-ton-per-day incineration and co-generation facility built by a private firm. It appeared to be a win-win arrangement, with the communities being able to divert waste from landfills and gain profits through the sale of electricity produced from burning that waste. To protect its investment, the contractor included a clause in the contract which required the communities to pay a penalty if they failed to supply the quantities of waste they had promised. At the time, no one seemed to think that supplying waste would ever be a problem.



That was before recycling programs reduced, by an estimated 20 percent, the amount of waste these communities were discarding. That, combined with competitive tipping fees at area landfills and an excess of energy capacity, has made it difficult for the incinerator to pay its operational costs and recoup its $100 million cost. The incinerator operator had to invoke the penalty clause, in order to keep its head above water, assessing the communities from $100,000 to $300,000 annually for failing to meet waste commitments. This, in turn, is causing some delays in expanding recycling programs in a state which hopes to be recycling some 46 percent of its waste by the year 2000. Officials in the affected communities complain that they are being made to pay for recycling twice because they are not taking waste to the incinerator. One community hasn't implemented curbside recycling, because it can't afford to pay twice.

THE GARBAGE TRUCKS KEEP ROLLING ALONG

While Americans apparently are discarding less packaging from the supermarket, the nation has posted a six percent increase in the amount of paper, plastic, wood, steel, glass and aluminum it is putting into the waste stream — an estimated 24.5 million tons in 1990.

Franklin Associates Ltd., a consulting firm in Prairie Village, Kansas reported that on the average individuals threw out 144 pounds of grocery store packaging in 1990, 18 percent less than what was pitched ten years earlier. Yet, the waste stream grows in size, possibly because the population has increased 10 percent in the last decade.



A LOOK AT SOURCE REDUCTION

At a recent meeting of the Coalition of Northeastern Governors, the matter of source reduction was on the agenda. Model legislation was drafted which would require companies to cut the weight of packaging they use 15 percent by 1996.

As of yet, no state has enacted such a measure, and action is unlikely considering the packaging industry's resistance to any such proposals.

All things considered, the best possible means of source reduction is to reach individual citizens, encouraging them to cut down on the amount of waste they discard by making it more costly.

In Seattle, for example, residents pay $10.70 per month for trash removal if they can place their garbage in a 19-gallon can. The cost increases to $31.75 gallon can. The cost increases to $31.75 per month for households needing a 90-gallon capacity.

The Swiss may have come up with an even more clever scheme. In Zurich, households have to place their trash in special "designer" garbage bags marketed by the city. These bags come in different sizes, differentiated by graphic designs in pink, yellow, blue, or red. Waste charges are then levied according to the bag placed out by the resident. And those who don't use the city-inspired sacks will be fined.

The "designer" bags cost about seven times what ordinary trash bags cost, however the city believes the added expense will encourage residents to cut down on the amount of trash being disposed.

NEW LANDFILL BRINGS THREAT OF SECESSION

If you thought the Civil War ended all talk of secession, check out Montgomery County, Ohio where a group of residents are considering seceding and becoming part of an adjacent county.

Their urgency to split has to do with a new landfill which Montgomery County officials have been considering. While only some test drilling has been conducted so far, the sight of drilling equipment is making some residents see "red" and already one outdoor anti-landfill rally has been held where speakers talked of seceding from the county. It isn't clear whether state law would permit such action, and things may never come to that point if tests indicate a landfill would not threaten ground water.

In any event, Ohioans are tossing out more trash. The State estimates that its citizens discarded almost 16 million tons of solid waste in 1991 (the latest year for which statistics have been compiled). That's a seven percent increase from the previous year. State EPA officials estimate that Ohio's landfills have an average life expectancy of between 7.4 and 9.4 years.

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Attachment 6

Sideslope Drainage Calculation

Foth & Van Dyke	Client: Crandon Mining Co Scope I.D.: 93C049 Project: TMA Page: 1 of 9 Prepared by: N.P Date: 2-9-96 Checked by: MRS Date: 2-14-96

PERCOLATION CALCULATION

ASSUMPTION: ① For each TMA cell, the first stage plan area is 43% of the total sidewall area

② If the drainage system is placed upto 1/3 height this area is 13% of the sidewall area

③ If the drainage system is placed upto 2/3 height, this area is 27% of the sidewall area

④ Drainage area upto 1/2 height, 20% of sidewall area OF STAGE 1.

⑤ The above values were calculated based on surface areas taken from Intergraph CADD system.

⑥ Sideslopes form 56.6 percent and Base form 43.4% of the total plan area (Foot note of Table 6.7-19)

Percolation rates with Drainage System

FIRST STAGE

No sideslope drainage 0.401257 in/yr
(Table 6.7-17)

sideslope drainage 15' vert

undrained area = 0.229325 in/yr
(Run A)

drained area = 0
(Run B)

Sideslope drainage 30' vert

undrained area = 0.094797 in/yr
(Run C)

drained area = 0
(Run D)

SECOND STAGE

No sideslope drainage = 1.159335 in/yr
(Table 6.7-18)

Sideslope drainage 15' vert

undrained area = 0.870712 in/yr
Run E

drained area = 0 (Run F)

Foth & Van Dyke	Client: Crandon Mining Company Scope I.D.: 93C049 Project: TMA Page: 3 of 9 Prepared by: N.P Date: 02-09-96 Checked by: MRS Date: 2-14-96

sideslope drainage 30' vert

undrained area = 0.622912 in/yr (Run G)

drained area = 0.00001 in/yr (Run H)

Base Percolation .002211 in/yr FIRST STAGE Table 6.7-17

.000959 in/yr SECOND STAGE Table 6.7-18

Total Percolation rates

FIRST STAGE

No sideslope drainage.

$(0.401257)(.43)(.566)+(.002211)(.434)$

$=0.0976579 + .0009595$

$=0.0986174$ in/yr

sideslope drainage 15' vertical

$(.229325)(.43-.13)(.566)+(.002211)(.434)$

$.0389393 + .0009595$

$=0.0399$ in/yr (40.5%)

Sideslope drainage 30' vertical

$(.090673)(.43-.27)(.566)+(.002211)(.434$

$= .0082113 + .0009595$

$= .00917$ (9.3%)

At 22.5' vertical linear interpolation (25%)
Graph (23%)

SECOND STAGE

No sideslope drainage

$(1.159335)(.566)+(.000959)(.434)$

$.6561836 + .0004162$

$= 0.6566$ in/yr

sideslope drainage 15' vertical

$(.870712)(1-.13)(.566) + .0004162$

$.4287591 + .0004162$

$= 0.4291721$ (65.3%)

sideslope drainage 30' vertical

$(.622912)(1-.27)(.566) + .0004162$

.2573747 + 0.0004162

= 0.2577909 in/y = 39.3%

By linear interpolation,

For Drain System 22.5 Vertical, 52.3%

(By a graph the percolation is seen to be 50%.)

Percolation rates with Sand Drainage Layer to 22.5' vertical (1/2 Height of First stage)

FIRST STAGE

Undrained area = .112530 in/yr (Run M)

drained area = .000013 in/yr (Run N)

Total Percolation rate = (.11253)(.2)(.566) + (.000013)(.23)(.566) + (.002211)(.434)

= .0136994 in/yr

TOTAL PERCOLATION RATE: FIRST STAGE WITH SAND DRAINAGE TO 22.5 / TOTAL PERCOLATION RATE: FIRST STAGE NO SIDE SLOPE DRAINAGE = 0.0136994 / 0.0986174 = 13.9%

SECOND STAGE

undrained area = .728049 in/yr (Run O)

drained area = .000015 in/yr (Run P)

Total Percolation rate = (.728049)(.8)(.566) + (.000015)(.2)(.566) + (.000959)(.434)

TOTAL PERCOLATION RATE: SECOND STAGE WITH SAND DRAINAGE TO 67.5 / TOTAL PERCOLATION RATE SECOND STAGE WITH NO SIDE SLOPE DRAINAGE = 0.3300783 / 0.6566

= .3296605 + .0000016 + .0004162

= .3300783 = 50.3%

Foth & Van Dyke	Client: Crandon Mining Company Scope I.D.: 930049 Project: TMA Page: 6 of 9 Prepared by: NxP Date: 2-9-96 Checked by: MRS Date: 2-14-96

Post Closure conditions

Data:

No sideslope drainage. Report: Table 6.7-19

Sideslope drainage 15' vert

No Drain area Run I

Drain Area Run J

Sideslope drainage 30' vert

No drain area Run K

Drain area Run L

Drainage Layer First stage

No drain area Run Q

drain area Run R

Table 6.7-19

Percolation Through TMA 60 mil Thermoplastic Geomembrane Bottom Liner

Year from Placement of Final Cover for TMA	Sideslope (in/yr)	Sideslope[1] Proportional (in/yr)	Base (in/yr)	Base[1] Proportional (in/yr)	Combined Sideslope & Base Proportional (in/yr)
1	0.825931	0.467642	0.000816	0.000344	0.467996
2	0.627056	0.355039	0.000956	0.000415	0.355454
3	0.404497	0.229026	0.000956	0.000415	0.229441
4	0.245185	0.138824	0.000718	0.000311	0.139135
5	0.103574	0.058644	0.000243	0.000105	0.058749
6	0.010155	0.005750	0.000211	0.000092	0.005842
7	0.002831	0.001603	0.000190	0.000082	0.001685
8-15	0.002498	0.001414	0.000175	0.000076	0.001490
16-25	0.001702	0.000964	0.000109	0.000047	0.001011
26-35	0.001112	0.000630	0.000074	0.000032	0.000662
36-40	0.000733	0.000415	0.000003	0.000001	0.000416
41-50	0.000593	0.000336	0.000027	0.000012	0.000348
51-60	0.000396	0.000224	0.000026	0.000011	0.000235
61-70	0.000274	0.000155	0.000030	0.000013	0.000168
71-80	0.000191	0.000108	0.000042	0.000018	0.000126
81-90	0.000132	0.000075	0.000049	0.000021	0.000096
91-115	0.000092	0.000052	0.000072	0.000031	0.000083
116-140	0.000039	0.000022	0.000096	0.000042	0.000064
141	0.024768	0.014024	0.032713	0.014191	0.028215
142-165	-	-	-	-	-
166-175	-	-	0.000546	0.0010237	0.000237
176-185	-	-	0.000864	0.000375	0.000375
186-195	-	-	0.000970	0.0030421	0.000421
196-205	-	-	0.000653	0.000283	0.000283

Foth & Van Dyke

Client: Crandon Mining Company Scope I.D.: 93C049
Project: TMA Page: 8 of 9
Prepared by: NxP Date: 2-9-96
Checked by: MRS Date: 2-14-96

PERCOLATION CALCULATIONS

Sideslope drainage 15' vert

Year from Placement of Final Cover (1)	Percolation no drain area (2)	Percolation drain area (3)	(2) x .87 x .366 (4)	Base proportion Table 6.7-19	(4) + (5) (6)	% of Base Case
1	0.545668	0	0.268698	.000344	.269042	57.5%
2	0.393088	0	0.193564	.000415	.193979	54.6
3	0.236528	0	0.116471	.000415	.116886	50.9
4	0.094669	0	0.046617	.000311	.046928	33.7
5	0.008785	0	0.004326	.000105	.004431	7.5
6	0.002757	0	0.001358	.000092	.00145	24.8
7	0.002481	0	0.001222	.000082	.001304	77.4
8-15	0.001976	0	0.000973	.000076	.001049	70.4
16-25	0.001314	0	0.000647	.000047	.000694	68.6
26-35	0.000839	0	0.000413	.000032	.000445	67.2
36-40	0.000598	0	0.000294	.000001	.000295	70.9

Sideslope drainage 30' vert

			(2) x .73 x .516			
1	.351469	0	.145220	.000344	.145564	31.1
2	.237385	0	.098083	.000415	.098498	27.7
3	.095624	0	.039510	.000415	.039925	17.4
4	.008978	0	.003710	.000311	.004021	2.9
5	.002764	0	.001142	.000105	.001247	2.1
6	.002483	0	.001026	.000092	.001118	19.1
7	.002341	0	.000967	.000082	.001049	62.3
8-15	.002005	0	.000828	.000076	.00091	61.1
16-25	.001109	0	.000458	.000047	.000505	49.9
26-35	.000636	0	.000263	.000032	.000295	44.6
36-40	.000418	0	.000173	.000001	.000174	41.8

Foth & Van Dyke

Client: Crandon Mining Co Scope I.D.: 93C049
Project: TMA Page: 9 of 9
Prepared by: N x P Date: 2-20-96
Checked by: B Kreseck Date: 2/20/96

SAND DRAINAGE LAYER

Year from Placement of Final Cover ①	Peralation from No drain Area ②	Percolation from drain Area ③	②x(.8)(.566) + ③x(.2)(.566) ④	Base Perc Table 6.7-19		
1	.463741	.000015	.209983	.000344	.210327	45%
2	.274761	.000006	.124412	.000415	.124827	35%
3	.112004	.000003	.050716	.000415	.051131	22%
4	.008051	.000002	.003646	.000311	.003957	3%
5	.002445	.000002	.001107	.000105	.001212	2%
6	.002175	.000002	.000985	.000092	.001077	18%
7	.001996	.000002	.000904	.000082	.000986	56%
8-15	.001432	.000001	.000649	.000076	.000725	49%
16-25	.000726	0	.000329	.000047	.000376	37%
26-35	.000350	0	.000158	.000032	.000190	29%
36-40	.000209	0	.000095	.000001	.000096	23%

Attachment 7

Leachate Collection System Calculation

Foth & Van Dyke

Client: CMC Scope I.D.: 930049
Project: TMA - Addendum NO. 1 Page: 1/2
Prepared by: REM Date: 2/5/96
Checked by: NxP Date: 2-14-96

Determine if 4" leachate collection system laterals have adequate size

GIVEN:

1. peak daily flow from HELP model of .09352 in/day

.09352 in/day x 365 day/yr = 34.1348 say 35 in/yr

2. leachate flow distance (new design) = 260'
3. Slope ~ .5% (5' per 1000')

Calculate Annual Flow w/maximum pipe length of 470' - worst case

$470' \times 260' \times 35''/yr \times \frac{1Ft}{12''} = 3564166.7 CF \times 7.4805 gals/CF = 2,666,174.9$

say 2.7×10^6 gal/yr

2.7×10^6 gal/yr $\times \frac{1 yr}{365 days} \times \frac{1 day}{24 hrs} \times \frac{1 hr}{60 min} = 5.137$

say 5.1 gals/min REQUIRED Capacity
or .0115 CF/SEC

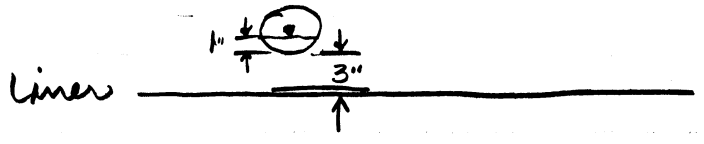
PER ATTACHED chart 4" diameter pipe @ 0.5% slope (ie 5'/1000') has a capacity of 80 gals/min (~.18 CF/SEC) ∴ required capacity is exceed with a safety factor of > 15

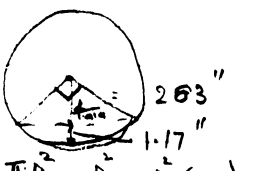
Determine if max. 1 Foot head on liner is met

Given:
① FROM TBL 6.7-13 AV. head across liner base is 3.196" say 3.2" ∴ max head 2 x 3.2 = 6.4"
② 80gpm is full pipe flow for 4" ϕ

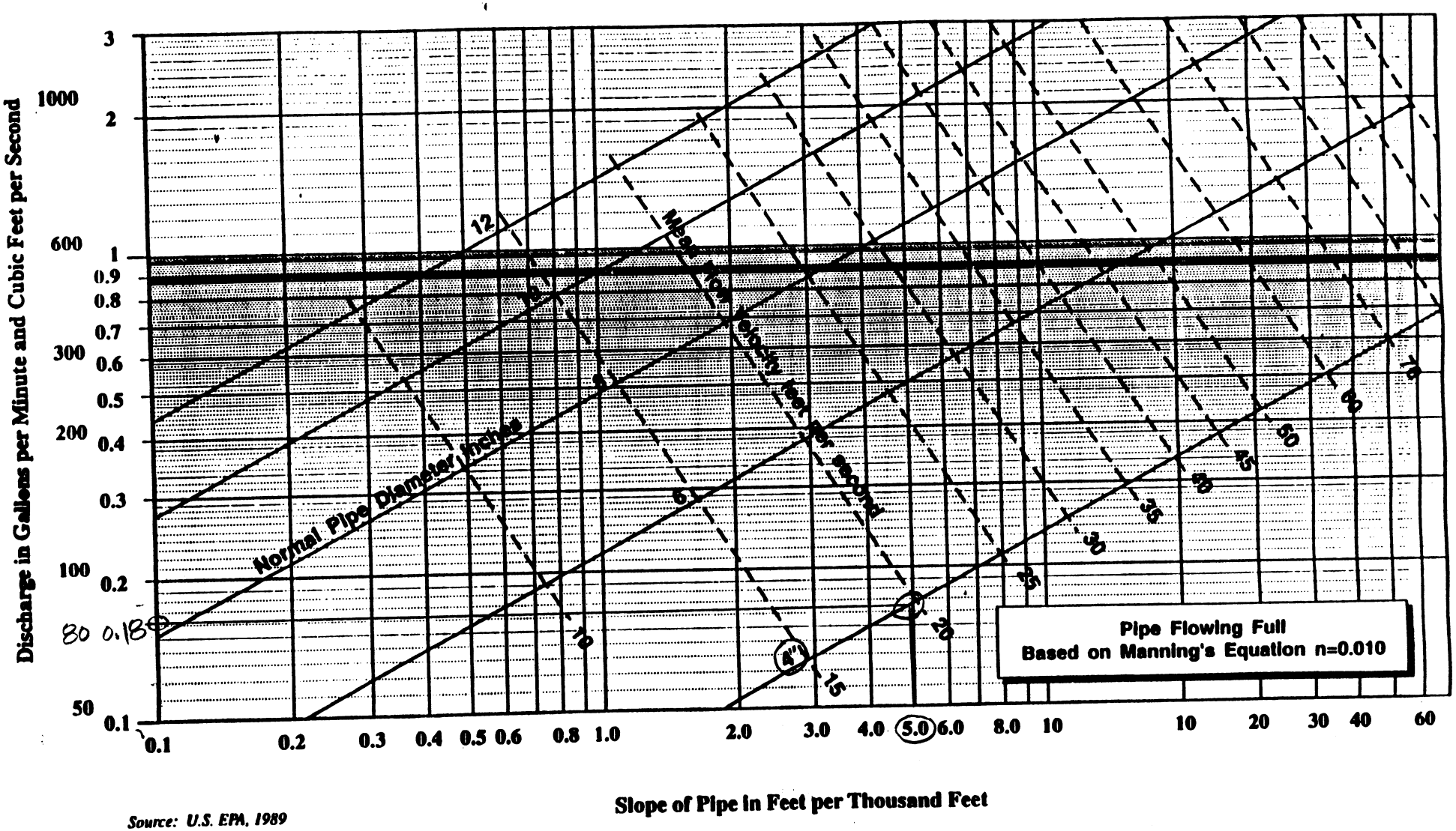
Required flow < $\frac{1}{15}$ capacity ∴ Depth of flow ≈ 1"

Max head on liner is 6.4" + 3" + 1" = 10.4" ∴ 12" max. head on liner is not exceeded.





.285 r^2 > $\frac{1}{11}$ area Area = $\frac{\pi r^2}{4} - \frac{r^2}{2} = \frac{r^2}{4}(\pi - 2)$



Source: U.S. EPA, 1989

Figure 4-10. Leachate Collection Pipe Sizing Chart

Attachment 8

Summary of Properties of Available Geosynthetic Clay Liners

GEOSYNTHETIC CLAY LINERS

Product Name	GCL Dimensional Properties: Panel Size Roll width/length m/m (ft/ft)	GCL Dimensional Properties: Average Roll Weight kN (lb)	GCL Dimensional Properties: Bentonite Mass/Unit Area Exclusion of Glue Weight kN/m² (lb/ft²)	GCL Hydraulic Properties: Flux at i = 1.0 [1] ASTM D 5084 [2] m/sec	Base Bentonite Properties: Swell Index USP-NF-XVII (min) ml/2g	Base Bentonite Properties: Fluid Loss API-13B	GCL Structural Components: Upper Geosynthetic: Type or Structure	GCL Structural Components: Upper Geosynthetic: Weight ASTM D 3776 or Thickness ASTM D 1593 g/m² or mm (oz/yd² or mil)	GCL Structural Components: Lower Geosynthetic: Type or Structure	GCL Structural Components: Lower Geosynthetic: Weight ASTM D 3776 or Thickness ASTM D 1593 g/m² or mm (oz/yd² or mil)	GCL Tensile Properties ASTM D 4595 for geotextiles as lower component ASTM D 4685 for geomembranes as lower component: Tensile Strength kN/m (lb/in)	GCL Tensile Properties: Tensile Elongation %	Manufacturer's Suggested Applications [3]
Colloid Environmental Technologies Co. (CETCO)													
Bentomat ST	4.75/38.1 (15/125)	10.75 (2400)	0.046 (0.95)	5×10^{-11} A (5×10^{-9})	24	18	woven	112 g/m² (3.3 oz/yd²)	nonwoven	203 g/m² (6 oz/yd²)	6.17 (35)	10	LL, LC, SIC
Bentomat DN	4.57/38.1 (15/125)	10.75 (2400)	0.046 (0.95)	5×10^{-11} A (5×10^{-9})	24	18	nonwoven	203 g/m² (6 oz/yd²)	nonwoven	203 g/m² (6 oz/yd²)	14.6 (83)	135	LL, LC, SIC
Claymax 200R	4.21/45.7 (13.83/150)	11.2 (2500)	0.046 (0.95)	5×10^{-11} A (5×10^{-9})	24	18	woven	108 g/m² (3.19 oz/yd²)	woven	108 g/m² (3.19 oz/yd²)	8.8 (50)	10	LL, LC, SIC
Claymax 500SP	4.21/45.7 (13.83/150)	11.2 (2500)	0.046 (0.95)	5×10^{-11} A (5×10^{-9})	24	18	woven	108 g/m² (3.19 oz/yd²)	woven	108 g/m² (3.19 oz/yd²)	14.1 (80)	10	LL, LC, SIC
GSE Lining Technology Inc.													
GSE Gundseal[B] HD	5.3/61[C] (17.5/200)	18.5 (4150)	0.048 (1.0)	$<4 \times 10^{-14}$ ($<4 \times 10^{-12}$)	28	18	NA	NA	smooth geomembrane	0.3–2.0 mm (12–80 mil)	varies w/type of GM	≥10	All
GSE Gundseal[B] HD Textured	5.3/61[C] (17.5/200)	18.5 (4150)	0.048 (1.0)	$<4 \times 10^{-14}$ (<4 x1 10^{-12})	28	18	NA	NA	textured geomembrane	0.75–2.0 mm (30–80 mil)	varies w/type of GM	≥10	Slopes or seismic areas
GSE Gundseal[B] HD Geobond	5.3/61[C] (17.5/200)	18.5 (4150)	0.048 (1.0)	$<4 \times 10^{-14}$ ($<4 \times 10^{-12}$)	28	18	nonwoven	25 g/m² (0.7 oz/yd²)	smooth or textured geomembrane	0.3–2.0 mm (12–80 mil)	varies w/type of GM	≥10	All

GSE Lining Technology Inc. (cont.)

GSE Bentoliner	4.57/38.1 (15/125)	10.75 (2400)	0.046 (0.95)	5×10^{-11} (5×10^{-9})	24	18	woven	112 g/m² (3.3 oz/yd²)	nonwoven	203 g/m² (6 oz/yd²)	6.17 (35)	10	LC, LL, SIC

National Seal Co./Fluid Systems/Columbia Geosystems Ltd.

Bentofix Thermal-Lock	4.7/38 (15.5 x 125)	977 (2190)	(1.0)	5×10^{-11} (5×10^{-9})	25	18	nonwoven	200 g/m² (6.00 oz/yd²)	nonwoven	247 g/m² (7.4 oz/yd²)	17.5 (100)	NP	LC, LL

GFR recommends you contact the manufacturers before making any specifying/purchasing decisions.

[1] *Flux is defined as "Flow rate/unit area" which can be converted to permeability using the equation: Permeability = Flux/hydraulic gradient*

[2] *Report result at a confining stress of 69 kN/m² (10psi) and 34 Kpa (5psi) head pressure*

NP = *Not provided by manufacturer*

NA = *Not applicable, per manufacturer*

[3] CL = *Canal liner*
LL = *Landfill liner*
S/C = *Surface impoundment cover*

[A] *Results reported at a confining stress of 34 kPa (5 psi) and a head pressure of 14 kPa (2 psi).*

[B] *All Gundseal products are available with contaminant resistant bentonite.*

[C] *All Gundseal products are available in 2.4 m (8 ft) widths and any length up to 61 m (200 ft).*

GEOSYNTHETIC CLAY LINERS

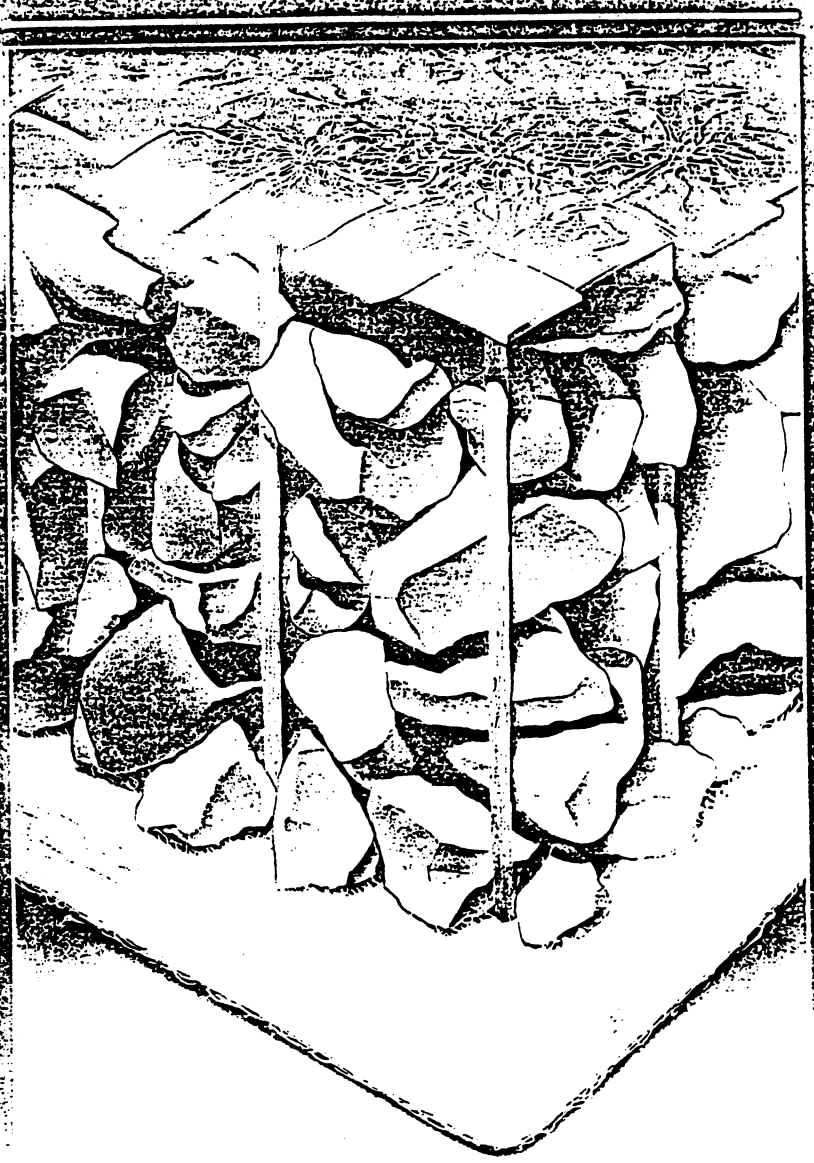
Attachment 9

Geosynthetic Clay Liner Manufacturer's Technical Literature

BENTOMAT®

BENTOMAT®

GEOSYNTHETIC CLAY LINER



CETCO

COLLOID ENVIRONMENTAL TECHNOLOGIES COMPANY

BENTOMAT

BENTOMAT® STRUCTURAL COMPOSITION AND MANUFACTURING PROCESS

Bentomat® is a flexible high strength geosynthetic clay liner (GCL) that can be used for a wide variety of environmental containment applications. Manufactured by CETCO, Bentomat utilizes polypropylene geotextiles and Volclay® sodium bentonites to provide high strength and low permeability.

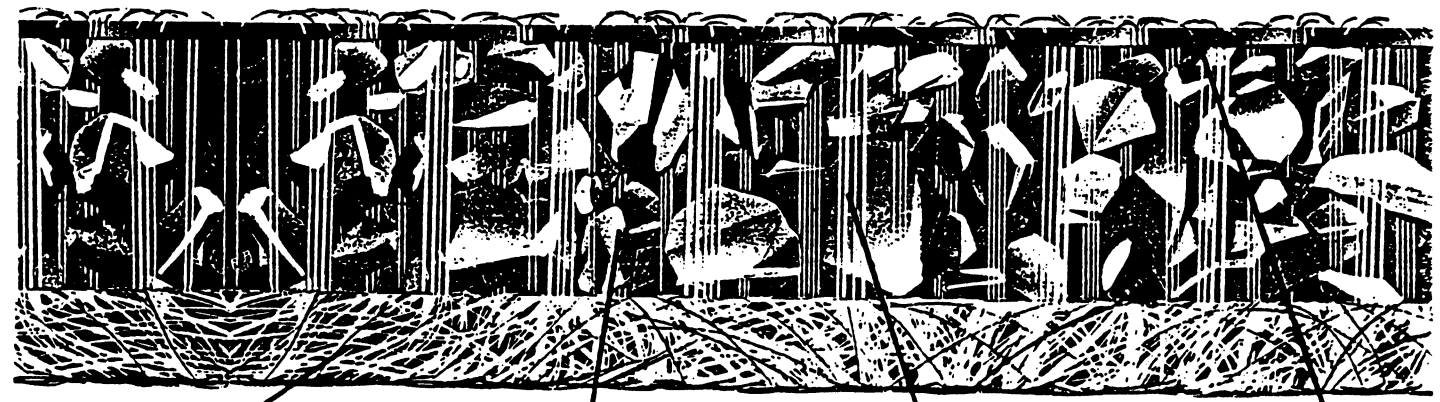
Bentomat is fabricated by distributing Volclay sodium bentonite in a uniform thickness between a woven and non-woven polypropylene geotextile. CETCO's state-of-the-art needlepunching equipment pushes fibers from the non-woven geotextile through the sodium bentonite and into the woven geotextile. Connecting fibers between the two geotextiles encapsulate the granular bentonite, inhibiting migration of the clay in either the dry or hydrated state. This mechanical bonding of the geotextiles provides Bentomc with unequaled internal shear strength necessary for stability on steep slopes.

Bentomat is wound into rolls to facilitate handling, storage, and installation. No special seaming equipment is required because a simple Volclay enhanced overlap forms a positive seal upon hydration. The result is a continuous and uniform liner with the permeability characteristics of 2 - 3 feet of compacted 1 X 10^{-7} cm/sec clay!

VOLCLAY® SODIUM BENTONITE SWELLING PROPERTIES

When the containment of contaminated liquids is required, Volclay sodium bentonite is the answer. In addition to untreated natural bentonites, CETCO utilizes a patented series of chemical treatment processes to produce a number of contaminant resistant bentonites. Each bentonite product has properties suited to specific applications. Treated bentonites are recommended for use in applications where the performance of untreated bentonite could be impaired.

The unique swelling properties of Volclay sodium bentonite allow it to swell many times its dry volume when exposed to fresh water. This phenomenon also permits the bentonite to be dried and hydrated an infinite number of times. When a pure layer of Volclay is confined and hydrated, this property creates a uniform, low permeability clay seal.



BENTOMAT® ENGINEERED LINING MATERIALS

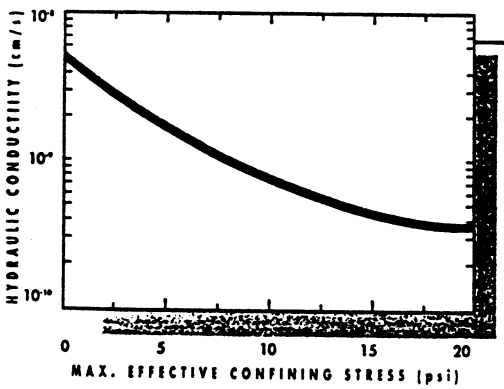
Bentomat® is not just one liner but a family of value added lining products constructed of polypropylene geotextiles and Volclay® sodium bentonites. The many possible custom engineered variations of Bentomat make it the most unique and versatile liner in the industry.

The types of Volclay sodium bentonite utilized in Bentomat vary in contaminant resistance and end use. The three bentonites available have the following designations and properties.

BENTOMAT "CS" utilizes high swelling Volclay sodium bentonite. It is intended for use in containing water which is relatively uncontaminated such as in sewage lagoons, reservoirs, fresh water lakes, and on landfill caps where contamination resistance is typically not required.

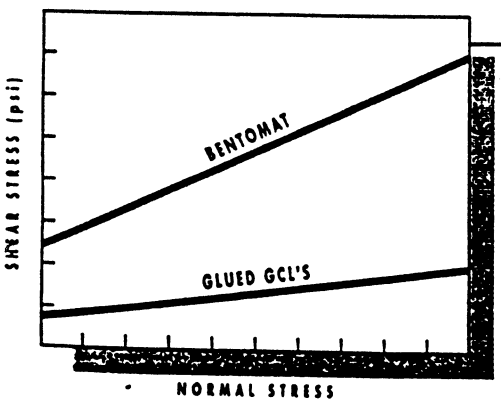
BENTOMAT "PL" is manufactured utilizing a chemically treated, high swelling Volclay sodium bentonite. Bentomat "PL" has been formulated for use in containing mildly contaminated wastes, most municipal solid waste landfill leachates, and low concentrations of organics such as aromatic and aliphatic hydrocarbons.

BENTOMAT "SS" is also made with a chemically treated, high swelling Volclay sodium bentonite. Utilizing the most contaminant resistant sodium bentonite available, Bentomat "SS" has been developed for use in containing wastes with high levels of dissolved salts, acids, alkalis, organic, and inorganic contaminants.



PERMEABILITY CHARACTERISTICS OF BENTOMAT

Bentomat's unique needlepunching process provides superb permeability characteristics, even at very low confining pressures. Bentomat's permeability (hydraulic conductivity) actually improves as the hydraulic head increases. Bentomat with its typical 1 X 10^{-9} cm/sec hydraulic conductivity (at 5 psi confining pressure) is a more effective hydraulic barrier than 2 - 3 feet of a 1 X 10^{-7} cm/sec clay.

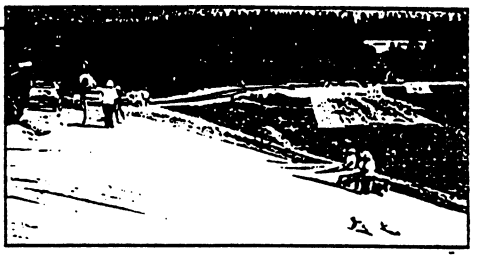


BENTOMAT INTERNAL SHEAR STRENGTH

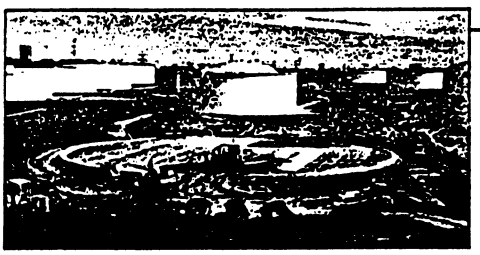
The needlepunched construction of Bentomat also provides a mechanical bond between the two confining geotextiles. Laboratory shear testing indicates that Bentomat has a significantly higher internal friction angle than other GCLs. Bentomat can be installed on steep slopes and remain stable even when fully hydrated whereas glued GCLs are easily sheared even on moderate slopes.

BENTOMAT®

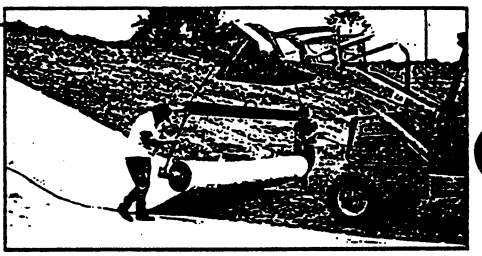
APPLICATIONS



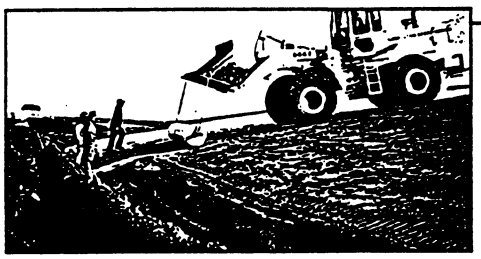
LANDFILL LINERS — Bentomat® may be used in hazardous, municipal solid waste landfills or ash monofills. Volclay® sodium bentonites give Bentomat the contamination resistance and low permeability required for landfill applications. When installed beneath a geomembrane (composite liner system), Bentomat provides a synergistic effect that results in the most secure liner system available.



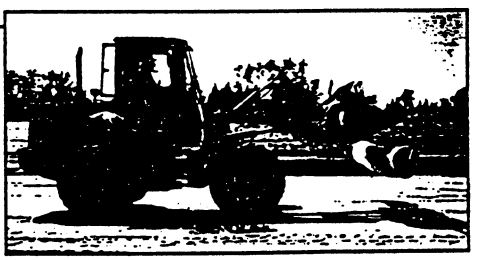
SECONDARY CONTAINMENT — Bentomat is an ideal liner for secondary containment applications. Utilizing the patented Volclay contaminant resistant sodium bentonites and polypropylene geotextiles, Bentomat resists infiltration by many organic and inorganic chemicals. The large quantity of pipework commonly found at tank farms is easily managed due to the simplicity of Bentomat's® installation.



LAGOONS — Bentomat is an excellent primary liner for both industrial and decorative lagoons. The needlepunch manufacturing technique gives Bentomat frictional characteristics which make it ideal for use on slopes where compaction of conventional clay materials may be difficult.



LANDFILL CAPS — Because Bentomat is virtually unaffected by freeze/thaw and desiccation/hydration cycles, it is ideally suited for landfill caps and waste impoundment closures. Unlike conventional clays, Bentomat's flexibility follows the contours of a settling subgrade while its high frictional characteristics provide a stable final cover.



MINING APPLICATIONS — Bentomat is quick and easy to install, durable and economical. Large areas can be covered in a fraction of the time and cost required for conventional clay lining materials. No special seaming personnel or equipment is required and costly time-consuming field QA/QC measures are unnecessary.

The information contained herein supersedes all previous versions printed prior to 3/92.

The information and data contained herein are believed to be accurate and reliable. CETCO makes no warranty of any kind and accepts no responsibility for the results obtained through application of this information.

CETCO reserves the right to update the information contained herein without notice.

CETCO

COLLOID ENVIRONMENTAL TECHNOLOGIES COMPANY

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The following patents apply to Bentomat either in full or in part: #3,986,365; #4,048,373; #4,084,382; #4,139,588; #4,344,722; Foreign patents and other patents pending.

BENTOMAT®

Seepage Control Liner

By American Colloid Company's Environmental Products Division

American Colloid Company, the worlds largest producer of bentonite clay introduces the Sodium Bentonite-Geotextile ***composite membrane liner of the future!***

Features

- *Self Sealing - Seamed by a Simple Overlap*
- *Flexible - Does Not Crack During Installation*
- *Self Healing if Punctured*
- *Fabricated onto Rolls for Ease of Transportation, Storage and Installation*
- *A Wide Range of Contaminant Resistant Volclay® Sodium Bentonites Available*
- *Contaminant Resistant Polypropylene Fabrics*
- *Activated with Water or Leachates*
- *Custom Engineered Designs Available*
- *Durable and Economical*

U.S. Patents # 4,048,373 ; # 4,139,588 ; # 4,344,722 ; # 4,084,382 ; Foreign patents and other patents pending

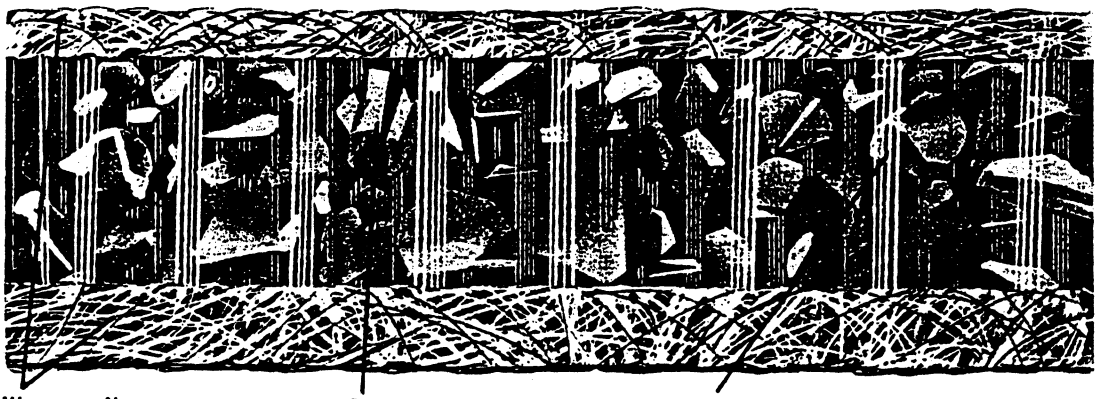
AMERICAN COLLOID COMPANY
1500 W. Shure Drive • Arlington Heights, IL 60004-1434, USA • (708) 392-4600

WHAT IS BENTOMAT® ?

BENTOMAT® is a flexible, virtually impervious, high strength sodium bentonite - geotextile composite lining material manufactured by AMERICAN COLLOID COMPANY. BENTOMAT® is produced on *state of the art* needlepunching equipment, utilizing polypropylene geotextiles and the high swelling contaminant resistant Volclay® sodium bentonites.

BENTOMAT® is manufactured onto rolls to facilitate handling during transportation, storage and installation. The standard roll size is 13.5 to 15 feet wide and 100 feet long. No special seaming equipment is required. A bond is formed between panels by a simple 6 inch to 1 foot overlap. A positive seal will form upon hydration.

BENTOMAT® may be used in environmental sealing applications ranging from tank farm, leach pad and pond liners to waste impoundments, decorative lagoons, landfill liners and caps. Virtually any environmental sealing project may use BENTOMAT® both economically and efficiently. With BENTOMAT® you are assured a uniform and continuous seal of high swelling Volclay® contaminant resistant sodium bentonite.



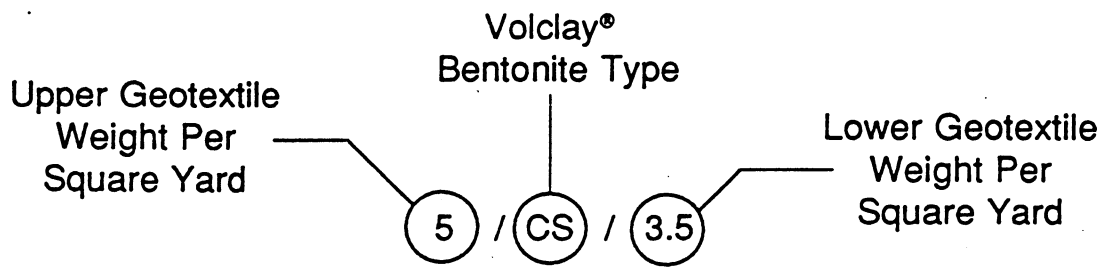
BENTOMAT® is fabricated by distributing Volclay® sodium bentonite in a uniform thickness between two layers of polypropylene geotextile. This "sandwich" is then needlepunched on AMERICAN COLLOID COMPANY's *state of the art* equipment, which pushes the fibers from one layer of geotextile, through the layer of sodium bentonite into the opposite layer of geotextile.

The connecting fibers between the two geotextiles essentially encapsulate the bentonite, inhibiting migration of the clay in either the dry or hydrated state. This mechanical bonding of the layers gives BENTOMAT® unequaled friction characteristics. The result is a strong, flexible, uniform, virtually impermeable sodium bentonite-geotextile liner (1×10^{-9} cm/sec @ 4 psi pressure) with the characteristics of a 3 foot layer of compacted 1×10^{-7} cm/sec clay!

BENTOMAT® PRODUCTS

BENTOMAT® is not just one lining material but a family of value added lining materials utilizing polypropylene geotextiles and Volclay® sodium bentonites. There are virtually thousands of variations of BENTOMAT® that can be custom engineered to your site specific needs.

For example, BENTOMAT® 5 / CS / 3.5 consists of a 5oz. per square yard nonwoven polypropylene geotextile, needlepunched through an untreated Volclay® sodium bentonite (CS), into a 3.5 oz. per square yard woven polypropylene geotextile.



The upper layer of geotextile in BENTOMAT® is always a nonwoven material. The fibers that exist within BENTOMAT® are needlepunched from the upper layer. The lower geotextile of BENTOMAT® can be <u>either</u> a woven or nonwoven depending upon what properties are required for the given application.

There are four basic types of Volclay® sodium bentonite which may be incorporated into BENTOMAT®. These clays vary in swelling properties as well as contaminant resistance and end use. The four bentonites available have the following designations and properties.

" CS " - CS - 50, Untreated Granular Bentonite

" SG " - SG - 40, Polymer Treated High Swelling Bentonite

" PL " - PLS - 50, Medium Contaminant Resistant Bentonite

" SS " - SS - 100, High Contaminant Resistant Bentonite

This wide range of contaminant resistant sodium bentonites together with the variety of geotextiles that may be used, make BENTOMAT® seepage control liner the most unique and versitile lining material in the industry!

BENTOMAT® APPLICATIONS

LANDFILL LINERS - BENTOMAT® may be used in hazardous, solid municipal waste landfills or even ash monofills. The Volclay®sodium bentonites give BENTOMAT®contamination resistance and low permeability which are critical in landfill applications. When used with synthetic membrane liners, there is a synergistic effect which results in the most secure landfill possible.

LANDFILL CAPS - BENTOMAT® is both flexible and self sealing making it ideally suited to landfill caps and waste impoundment closures. Minor irregularities and punctures are easily conformed to and sealed against. A unique feature of BENTOMAT® is that it may be custom engineered to an individual project. Gas venting geotextiles may be used as one of the BENTOMAT® components virtually eliminating the extra materials and labor required to install a conventional gas collection system. The geotextiles will transmit accumulated gas while the Volclay® prevents the intrusion of rainwater. The functions of two layers in a single lining material!

LAGOONS - BENTOMAT® is an excellent primary liner for both industrial and decorative lagoons. The needlepunching method of manufacturing gives BENTOMAT® frictional characteristics which make it ideal for use on slopes, where compaction of conventional clay materials may be difficult.

TANK FARMS - BENTOMAT® is an ideal liner for secondary containment applications. Utilizing the patented Volclay®contaminant resistant sodium bentonites and polypropylene geotextiles, BENTOMAT® is resistant to most organic and inorganic chemicals as well as a wide range of acids and bases. The large quantity of pipework commonly found at tank farms is easily dealt with due to the simplicity of BENTOMAT®'s installation.

LEACH PADS - BENTOMAT® is quick and easy to install, durable and economical. Large areas can be covered in a fraction of the time and cost required for conventional lining materials. No special seaming personnel or equipment is required so a BENTOMAT® installation may proceed on your schedule.

BENTOMAT®

Seepage Control Liner

For further details contact your local representative or AMERICAN COLLOID COMPANY

The information and data contained herein are believed to be accurate and reliable. AMERICAN COLLOID COMPANY makes no warranty of any

BENTOFIX®

BENTOFIX PRODUCT DESCRIPTION

Bentofix is manufactured by placing 1 lb/sf of sodium bentonite on a carrier layer woven slit film polypropylene 3.25 oz/sy geotextile. A cover layer of non-woven 6.5 oz/sy polypropylene geotextile is placed on top of the bentonite. The non-woven fibers are needlepunched through the bentonite layer bonding the three layers together as one.

Needlepunching is a major benefit in regards to the performance of Bentofix. It provides shear resistance within Bentofix. Bentonite inherently has poor shear resistance when hydrated. The needlepunched fibers provide added shear strength removing the critical interface out of the Bentofix in most cases. Also, the needlepunching prevents the bentonite from migrating laterally within or out of the geosynthetic clay liner. In non-needlepunched materials, the bentonite can migrate within the product leaving areas with less than optimum bentonite coverage. The needlepunching also prevents delamination of the geotextiles from the bentonite when the bentonite hydrates, and it enhances durability.

The bentonite within the GCL hydrates when wetted, producing low permeable ($< 10^{-9} \frac{cm}{s}$) containment. This low permeable layer equates to thick clay layers used for liquid containment.

NSC

National Seal Company

BENTOFIX TECHNICAL SPECIFICATIONS

PROPERTY	STANDARD	UNITS	SPECIFIED VALUES
BENTONITE			
Bentonite Content	Minimum	lb/ft^2	1.0
Water Permeability ASTM D-5084 with a confining stress of 30 psi at a hydraulic gradient of 30 using tap water	Maximum	cm/sec	1.0×10^{-9}
Volumetric Increase (Free Swell)	Minimum	%	300
GEOTEXTILE CARRIER LAYER (WOVEN)			
Weight ASTM D 3776	Minimum	oz/yd^2	3.25
Grab Strength ASTM D 4632	Minimum	lb.	135
Burst Strength ASTM D 3786	Minimum	psi	275
GEOTEXTILE COVER LAYER (NON-WOVEN)			
Weight ASTM D 3776	Minimum	oz/yd^2	6.5
Grab Strength ASTM D 4632	Minimum	lb.	80
Burst Strength ASTM D 3786	Minimum	psi	300
Internal Friction Resistance	Minimum	degrees	25°
Roll Size		15.0 ft. x 100.0 ft.	
Roll Weight		1610 lb. (approx.)	
Required Overlap		6 in. (minimum)	

Bentofix™ GEOSYNTHETIC CLAY LINER

Bentofix™ Slope Stability

TECHNICAL NOTE

Bentofix Geosynthetic Clay Liner (GCL) is needle-punched in order to provide the internal shear resistance necessary for use on steep slopes. Needle-punching attaches the top geotextile to the bottom geotextile by pushing fibers from the non-woven fabric through the bentonite layer and embedding them in the fabric on the opposite side. This reinforces the otherwise weak layer of clay, enabling the composite to resist the shear stresses that can develop on lined slopes.

DESIGN:

Because the consistent needle-punching process gives Bentofix such a high internal shear strength, and because the outer geotextiles have such favorable interface friction angles with soils and other geosynthetics, Bentofix NS is suitable for use on increasingly steep slopes. Whether Bentofix NS is used alone or in conjunction with other geosynthetic liner components the resulting shear strengths make Bentofix NS the ideal GCL for even the most demanding designs.

Bentofix™ - Average Direct Shear Test Results

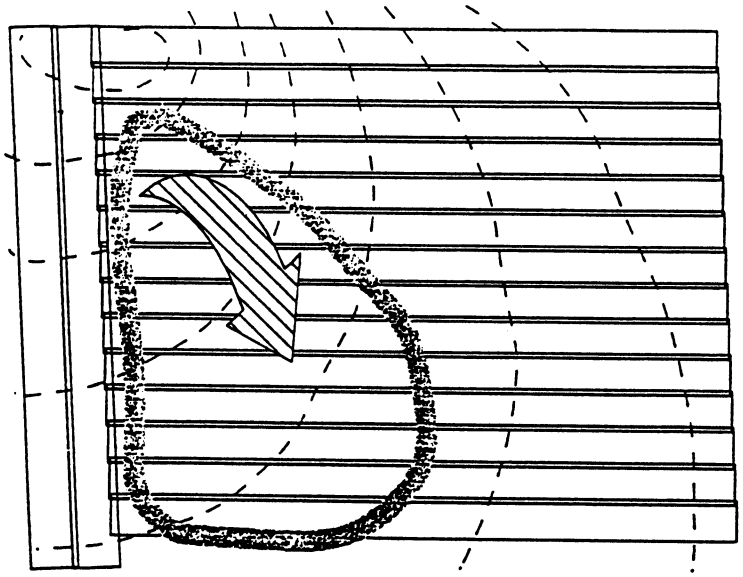
Interface	Normal Stress Range (psf)	Peak Friction Angle	Peak Adhesion (psf)	Residual Friction Angle	Residual Adhesion (psf)
Bentofix- Woven/TN3002-1120	500-4000	21.4°	9	16.4°	48
Bentofix-Nonwoven/TN3002-1120	500-4000	24.3°	14	21.3°	26
Bentofix-Woven/60 mil Textured HDPE	500-4000	28.3°	209	15.7°	110
Bentofix-Nonwoven/60 mil Textured HDPE	500-4000	33.5°	354	18.8°	255

GCL Average Internal Direct Shear Test Results

GCL Type	Normal Stress Range (psf)	Friction Angle
Bentofix NS Needle-punched	500-4000	27°
Bentonite glued to geomembrane or geotextile	500-4000	9°

CONSTRUCTION:

Bentofix, being a needle-punched geosynthetic clay liner, also has significant advantages over other GCLs in deployment on slopes. Unlike stitch-bonded bentonite composites, in which all the shear strength is in the machine direction, Bentofix has the same high shear strength in all directions. This is particularly important on mound closures or compound slopes. Other GCLs must be oriented so that the machine direction is parallel with the direction of the slope in order to resist the downward driving force developed by the cover material. Since these products have very limited shear strength in the cross direction, any cross slopes or transverse breaks in grade create areas where the potential for shear slope failure is high.



This is a typical layout pattern for Bentofix on a cap that is steep on one side and breaks gradually on the other. Bentofix, with its multi-directional shear strength, can resist the stress across the panels in the shaded area. A GCL with shear strength only in the machine direction would need to be oriented parallel to the slope everywhere on the cap, requiring a complex series of anchor trenches and a layout plan that would be much more difficult to install.

Fig. 2 In areas where the slope breaks across the GCL panels, slope failure may occur unless the GCL has sufficient shear strength in all directions, not just along the length of the panel.

MANUFACTURING QUALITY CONTROL:

It is important to consider product consistency when qualifying a material for use on a slope. Only high quality consistent geotextile components and the proper needle-punch frequency will produce a GCL capable of withstanding the long term stresses that exist on a slope.

Products in which the geotextiles vary in weight will not have the necessary fibers to reinforce the entire width of the GCL. Inconsistent needle-punching will not provide sufficient internal peel or shear strength, and immediate or long term failure may result. Bentofix uses high quality geotextile components manufactured specifically for our product. Our needle-punching process produces peel strengths that are consistently higher than other needle-punched GCLs and as a result long term slope stability is ensured. While polymeric enhancers are required to improve the long term shear strength of other needle-punched GCLs, Bentofix simply demands the highest quality and produces the strongest GCL available.

Bentofix™ GCL TECHNICAL NOTE

Dimensional Stability of GCLs During Installation

Background

Most liners, whether they are natural or synthetic, experience dimensional change when exposed during construction. Polymeric geomembranes may expand and contract as ambient and surface temperatures increase and decrease. Compacted clay liners shrink in the heat of the sun and their surfaces crack as moisture is driven out of the clay.

Certain geosynthetic clay liners (GCLs) also experience a dimensional change during installation. This change in panel dimensions can cause problems during deployment and installation of the GCL component of the liner system.

Types of GCLs

There are essentially three methods used to manufacture GCLs currently in use:

- Bentonite granules are glued between carrier geotextiles with a water based adhesive.
- Bentonite granules are glued to a single geomembrane by a water based acrylic adhesive.
- Granular or powdered bentonite is needle-punched between two carrier geotextiles. Synthetic fibers extend through the bentonite layer and are embedded in the geotextiles on both sides, encapsulating the bentonite, reinforcing it, and bonding the three layers into a single durable composite.

Deployment Problems

The dimensions of the first two types of GCL can change with ambient conditions during installation. This dimensional instability is a result of the methods of manufacture and the materials used.

- The glue used to adhere the bentonite to the geotextiles is water based, and when applied to the bentonite, partially hydrates the clay causing it to swell. The product is delivered to the construction site in this partially swollen state. As the sun heats the liner, moisture is driven off and the clay shrinks as it dries. This shrinkage results in a change in the dimensions of the GCL panel that has been deployed. The panel width may decrease as much as seven inches (7") in the space of a few hours. This may virtually eliminate the overlap that was carefully monitored when the panels were originally deployed. Adjustment of several thousand square feet of GCL to reposition the overlaps is difficult and time consuming. An exaggerated overlap is costly in the amount of additional material that must be purchased to compensate for the shrinkage.

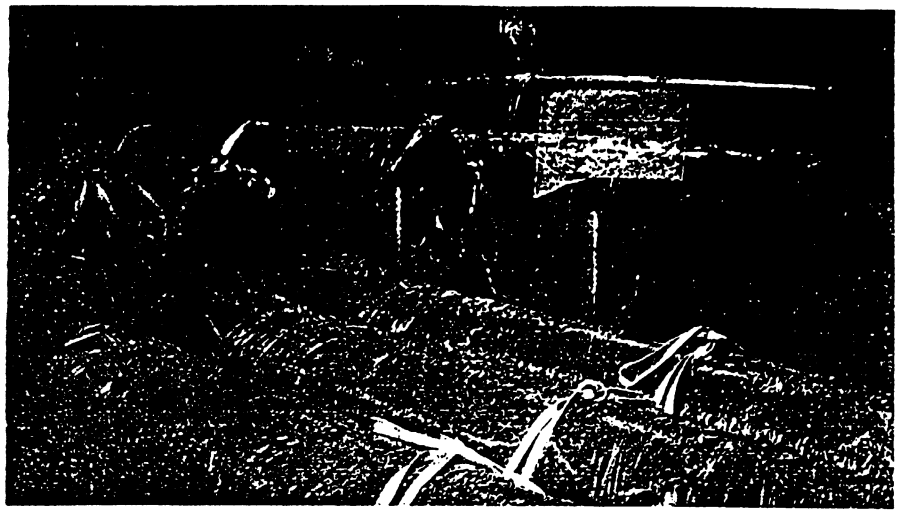
- When bentonite is adhered to a geomembrane the GCL composite is subject to the same expansion and contraction as the geomembrane. In hot conditions, or as the sun heats the membrane, it will expand, and as the liner cools it will contract. The difference in dimension may be as much as three inches (3") in the width and several feet in the length. Under harsh conditions the bentonite may even flake off the membrane as the adhesive bond is weakened.

Bentofix is Stable

- Bentofix, being a needle-punched GCL is shipped at the lowest moisture content possible and , as a result, does not experience the shrinkage caused by desiccation of the clay. In fact, in laboratory tests, samples of Bentofix were placed in an oven at 50°C for 24 hours. No variation in the dimension of the samples was recorded at the termination of the test.

Installers and contractors concerned that the GCL will shrink in the few hours before they can cover it should use Bentofix. Similarly, engineers can rest assured that the GCL covered by a geomembrane and hidden from sight will not shrink, exposing the subgrade and compromising the liner system. Bentofix GCL is trouble free.

An Added Barrier Of Protection From Gundle: High Performance HDPE/Bentonite Composite Landfill Liner



17½-ft. wide Gundseal rolls wrapped for shipment from our Spearfish, South Dakota plant.

As concern for our environment continues to grow worldwide, the demand for reliable synthetic landfill liners is escalating. More than ever, legislation mandates these lining systems, and often requires double lining solutions.

Responding to state-of-the-art engineering strategy of designing liner systems which combine synthetic and clay layers, Gundle offers GUNDSEAL. Gundseal is a bentonite clay/polyethylene composite liner for one step deployment (usually as an addition to a conventional single or double liner system). Gundseal is made by attaching the highest quality sodium bentonite to the highest quality synthetic liner using a patented nontoxic adhesive application system. This forms a single composite liner, which takes advantage of the complementary behavior of the synthetic liner together with the bentonite clay, and forms a complete barrier.

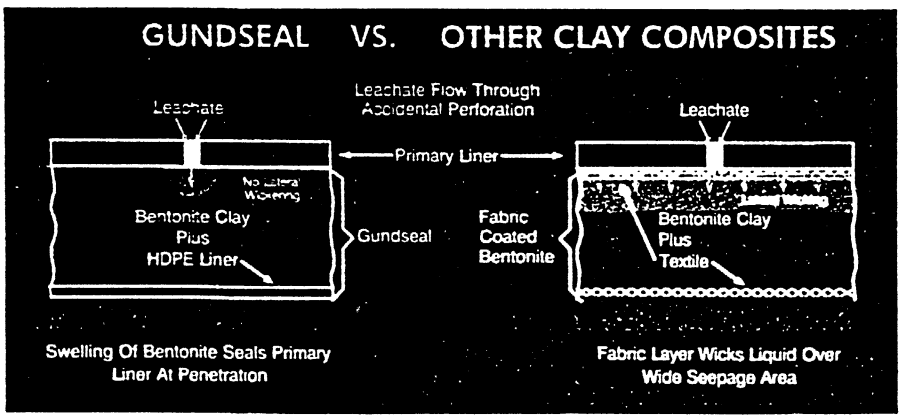
Swelling to several times its original volume when wet, the bentonite layer in Gundseal is able to seal potential leaks in a synthetic liner under confining pressures as low as 27 psf.

In a single composite liner application, the bentonite side is deployed face up. The primary liner is then installed on top and in direct contact with the bentonite. Any possible leakage becomes blocked by the bentonite layer with 10^{-10}cm/sec k-value followed by a polyethylene membrane with 10^{-12}cm/sec effective k-value. This means tremendous insurance is built into the liner system.

Using Gundseal, double composite liner systems can be constructed without having to compact soil on top of synthetic layers. The addition of a Gundseal blanket (bentonite face up) under a primary liner and above the drainage layer will add factors of safety in eliminating fluids in the leak detection zone. This is very attractive in light of EPA's new Response Action Plan (RAP) for leak detection systems.

Desiccation/weathering problems in standard clay caps can be solved by constructing a much less permeable, weathering- and settlement - resistant composite liner closure with Gundseal. In this case, the bentonite side of the Gundseal is deployed face down and dry against fine grained, compacted soils. The bentonite must be protected if the Gundseal is to be placed bentonite side down over coarse grained soils. These are but two of the potential applications for Gundseal.

Compared with fabric coated bentonite blankets, Gundseal will not shrink after getting wet because, unlike fabric, the membrane cannot be flexed by bentonite. And there is no fabric to transmit fluids laterally over a wide area when a Gundseal bentonite blanket is used. With Gundseal, moisture is confined to a point, not distributed over a broad area. In contrast to many fabric-coated bentonite blankets, Gundseal packs very fine mesh bentonite particles in a dense layer. There are few agglomerates or areas of loose particles.



Gundseal HDT

Textured Gundseal combines Gundline® HDT textured high density polyethylene sheet with the high quality fine mesh grade bentonite.

Textured Gundseal provides excellent slope stability due to the textured surface of Gundline HDT. Textured surface of Gundseal is therefore ideal for steeper slopes.

GUNDSEAL HDPE/BENTONITE COMPOSITE LINER

Standard Construction

Membrane Backing	Gundline HD Membrane	20 mil*
Coating	Sodium Bentonite	1 lb./ft.²*
Roll Width		17 ft. 6 in. (5.3 m)
Roll Length		200 ft. (60 m)
Roll Weight		3950 lbs.

* Other Gundle liner products and different coating weights available for special non-standard orders.

Typical Properties

Bentonite Loading	1lb./ft.²
Effective Hydraulic Conductivity (Gundseal)	No Measurable Leakage
Coefficient of Permeability (Membrane)[1], ASTM E96	2.7×10^{-13} cm/sec
Hydraulic Conductivity (Bentonite)[2]	3.7×10^{-10} cm/sec
Resistance to Hydrostatic Head[3] (Ft. of water), ASTM D751	Tested to 150 ft. Head No Failure
Resistance to Water Migration Through Overlap[4]	No Measurable Leakage
Resistance to Water Migration Under Membrane[5]	Tested to 150 ft. Head No Measurable Leakage
Wet/Dry Cycles, ASTM D559	No Effect
Freeze/Thaw Cycles, ASTM D559	No Effect
Pliability: 180° bend over 1" mandrel @ -25°F, ASTM D146	10,000 cyc. No Failure

TYPICAL PROPERTIES OF GUNDLINE HD 20 MIL

(Used As Membrane For Gundseal)

Puncture Resistance, FTMS 101, Method 2065	22 lbs.
Tear Resistance, ASTM D1004	15 lbs.
Dimensional Stability, ASTM D1204	±2%
Tensile Strength, ASTM D638	
yield	2300 psi
break	4000 psi
Tensile Elongation, ASTM D638	
yield	13%
break	700%
Resistance to Soil Burial, ASTM D3083	
Tensile strength @ yield and break	±10%
Elongation @ yield and break	±10%
Environmental Stress Crack, ASTM D1693	1500 hrs.

TYPICAL PROPERTIES OF HIGH SWELLING SODIUM BENTONITE

(Used As Coating For Gundseal)

Percent Montmorillonite	80-90%
Silicon Dioxide (SiO_2)	55-64%
Aluminum Oxide (Al_2O_3)	16-22%
Ferric Oxide (Fe_2O_3)	3-6%
Sodium Oxide (Na_2O)	1-3%
Magnesia (MgO)	2-4%
Lime (CaO)	1-3%
Miscellaneous	1-5%
Water Content	5-10%
Bulk Density	77 lb/ft.³
Dry Particle Size	20-50 mesh
Free Swell	20-28 ml/2 gm

1. Darcy's Law Coefficient of permeability for membrane calculated from moisture vapor transmission data (ASTM E96).
2. A 2-1/2" diameter sample was placed in a permeameter form 5 days water soaking. Permeability determined in a 15 hour time frame with a 15' falling head permeameter.
3. Membrane applied to porous stone and placed in permeameter. Pressure increased to equivalent of 150 ft. water head.
4. Two samples placed one against the other clamped between two half cyclinders of lucite and placed in a flexible wall permeameter for 25 days. Also, standing 2 ft. head of water over an 8 ft. long 3 in. overlap Gundseal seam for 5 months at U. of Texas, Austin, had no measurable leakage.
5. A 1" diameter hole was cut in the middle of a 3 1/2" diameter sample. Sample clamped in 3" diameter permeameter, 150 ft. of head applied.

Gundle Lining Systems Inc

Gundle®

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Houston, Texas 77073 U.S.A.
Phone: (713) 443-8564
Toll Free: (800) 435-2008
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Fax: (713) 875-6010

GUNDSEAL is rolled on 6" I.D. hollow cores. Each roll is provided with 2 slings to aid handling on site. Dimensions and weights are approximate. Rolls are stretch-wrapped to keep dry. Each roll has an overall sheet thickness of 0.125" (3 mm). Gundseal adhesive is non-toxic and non-polluting.

These specifications are to be used only as a general guideline by engineers in formulating preliminary specifications, and should not be relied upon absent site-specific product testing; Gundle assumes no responsibility for the improper reliance upon or misuse of such data. In addition, product design and specifications are subject to change without notice.

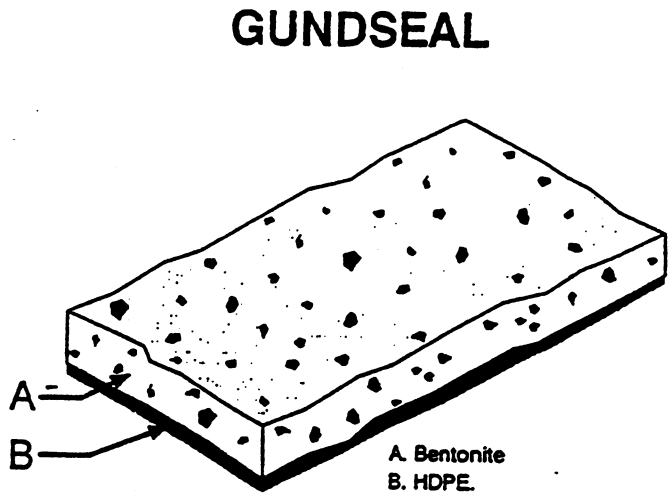
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GUNDSEAL - GEOSYNTHETIC CLAY LINER

"ROLL OUT THE CLAY"

Gundseal is a geosynthetic clay liner consisting of bentonite clay and polyethylene sheet (Figure 1). Attached to the membrane backing is one pound per square foot of high quality sodium bentonite. This composite design lets the contractor conveniently "roll out" a blanket of clay that can competitively replace or supplement compacted clay liner requirements (Figure 2).



Self Sealing Composite Geomembrane (Gundseal).

Figure 1

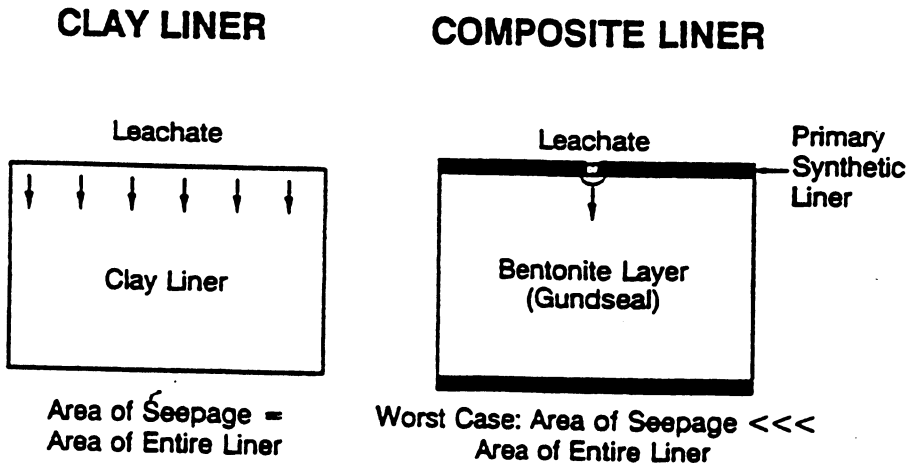


Figure 2

THE UNIQUE STRUCTURE OF BENTONITE

Bentonite clay consists of tightly packed ionically charged platelets. Within and between these platelets, there is separation of positive and negative charges. Polar molecules, such as water molecules, are attracted by and interact with the positive and negative charges in this unique clay structure. When they come into contact with Gundseal, polar water molecules wedge their way between the bentonite platelets, causing the platelets to separate and swell apart (Figure 3). This swelling gives hydrated bentonite an extremely low permeability. The hydrated bentonite platelets form an almost impenetrable maze which limits possible fluid migration (Figure 4). Hydrated bentonite in Gundseal achieves this very low permeability under a confining pressure of only 27 pounds per square foot (equivalent to four inches of sand cover).

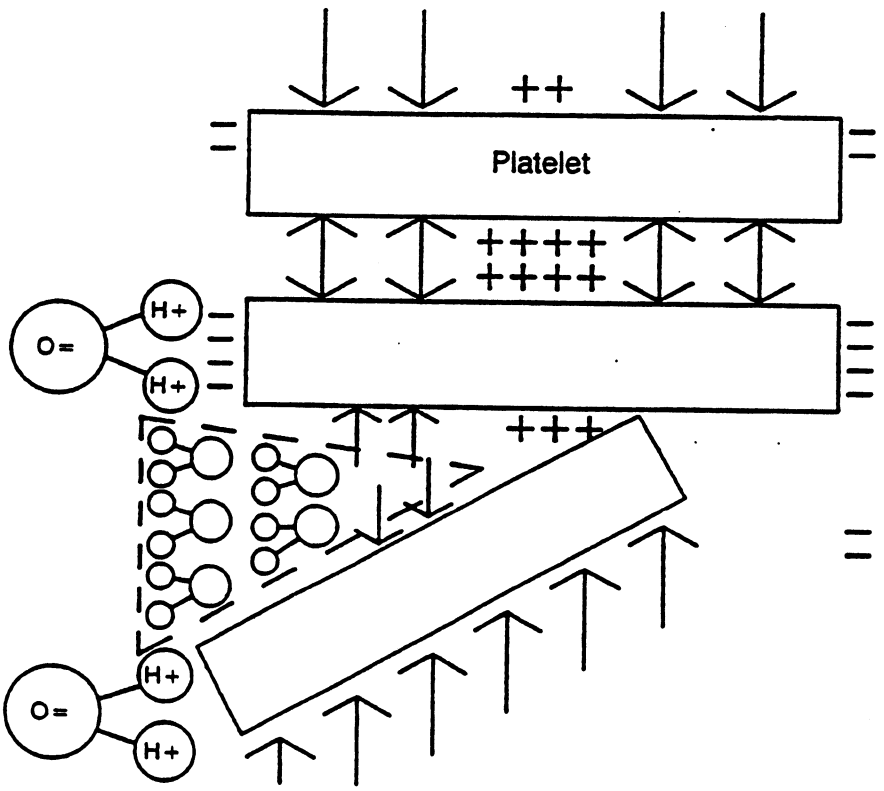


Figure 3

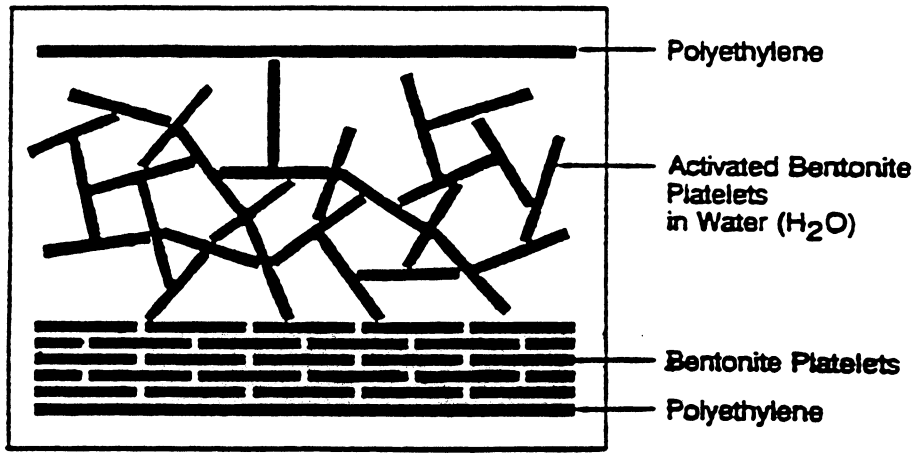


Figure 4

FACTORY-CONTROLLED VS. FIELD COMPACTION

Gundseal offers numerous advantages over standard, field-compacted soil liners. Gundseal blankets are installed dry, eliminating the problem of soil liner dessication. Heavy equipment required for grading and compaction of clay liners is eliminated by simply unrolling Gundseal. (Figure 5)

Furthermore, Gundseal does not require complicated, difficult to construct, soil test pads to verify field permeabilities. Much better quality control is available with Gundseal than that achieved in construction of soil liners. The reason for this is that Gundseal is produced in a controlled factory environment and is not subjected to field variation (material consistency, weather, etc.) which can affect soil liners. In addition, Gundseal's extremely low permeability makes up for its lack of thickness. The bentonite component of Gundseal alone has a Darcy's Law permeability coefficient of less than 1.0×10^{-9} cm/sec. Traditional compacted clay liners do well to obtain 1×10^{-7} cm/sec. In fact, the amount of Darcy's Law flow through Gundseal's bentonite layer is equivalent to the flow through one foot of compacted clay with a permeability of 1×10^{-7} cm/sec. This comparison does not take into account the extremely low permeability of the polyethylene component of Gundseal (effective permeability of 3×10^{-13} cm/sec.). Using an average permeability of 1×10^{-11} cm/sec, Gundseal is equivalent to 100 feet of compacted clay with a permeability of 1×10^{-7} cm/sec.

Compacted Soil	Gundseal Bentonite/Synthetic "Equivalent Barrier"
Can Desiccate	Goes In Dry
Constructed with Heavy Equipment	Light Equipment Can Be Used
Requires Test Pad for Hazardous Waste	Repeated Field Testing Not Needed
Thickness	Less Permeable

Figure 5

SEALING AN ACCIDENTAL BREACH

Should there be an accidental breach in the upper synthetic component of a composite liner system, the high quality bentonite in Gundseal will be wetted, swell into the breach, and seal the breach (Figure 6). This seal is extremely effective since there is no fabric coating, as is the case with other prefabricated bentonite clay blankets. These fabric coverings prevent development of "intimate contact" between the bentonite and the synthetic liner. The fabric encasement of other bentonite blankets also acts to "wick" the fluids and transmit these fluids over a wide area underneath the membrane (Figure 7). Placing Gundseal over (bentonite face down) or under (bentonite face up) another sheet of membrane protects the bentonite layer from fluids because a synthetic liner is on both top and bottom sides (Figure 8). Therefore the bulk of the bentonite always remains dry because fluid cannot reach it.



Figure 6

GUNDSEAL VS. OTHER CLAY COMPOSITES

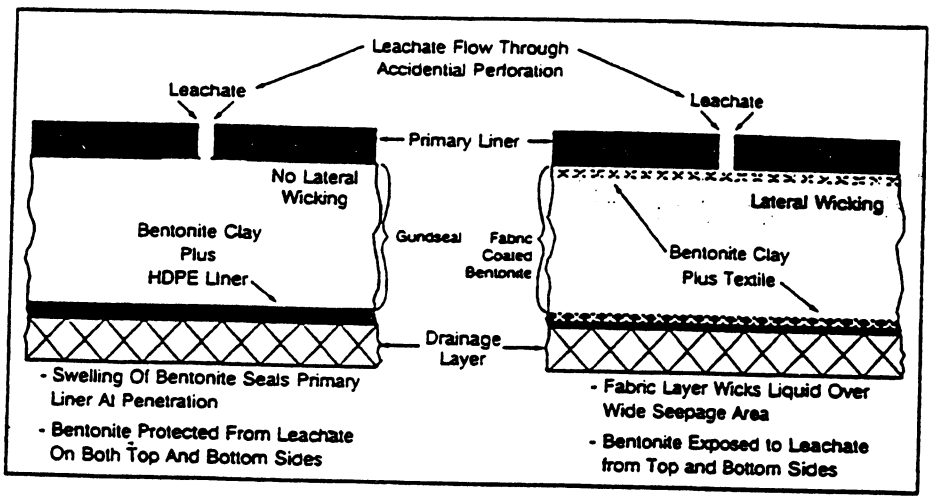


Figure 7

DOUBLE COMPOSITE LINER SYSTEM USING GUNDSEAL

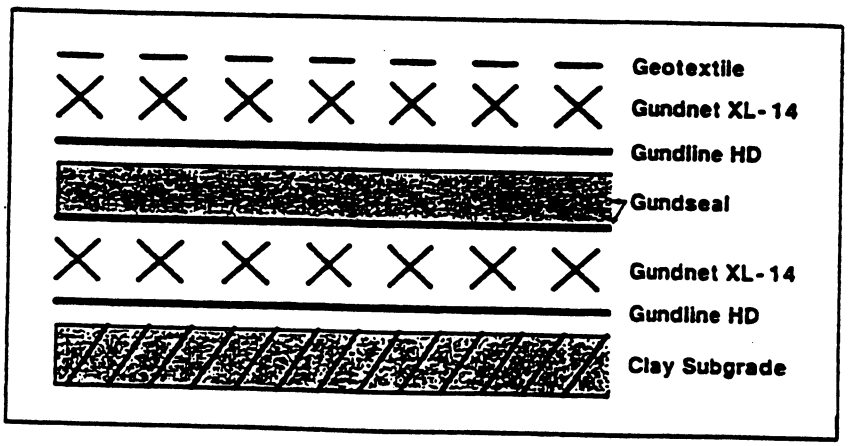


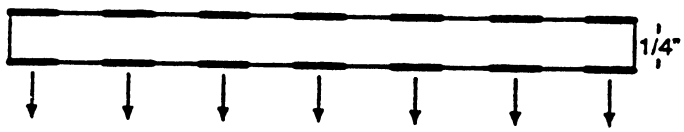
Figure 8

SEAMS

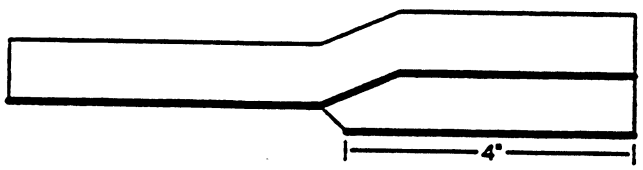
An overlapped Gundseal seam provides exceptional protection. The only possible path a fluid can take through a Gundseal blanket is through the overlapped seam. As with any breach, contact with a polar fluid will initiate the swelling action of the bentonite and develop intimate contact with the overlapped HDPE backing. The result is a much thicker layer of bentonite through which the fluid must pass before breaching the liner (Figure 9), than for fabric encapsulated bentonite blankets. A four inch overlap is equivalent to approximately 33 feet of 1×10^{-7} cm/sec clay.

The product design virtually eliminates liquids from appearing in a leak detection system underneath a membrane/Gundseal composite liner. This has been confirmed by long term standing-head permeation tests described later.

LEAKAGE OVER WHOLE AREA



LEAKAGE ONLY AT EDGE



$\frac{4"}{1/4"}$ = 16 Times More Thickness

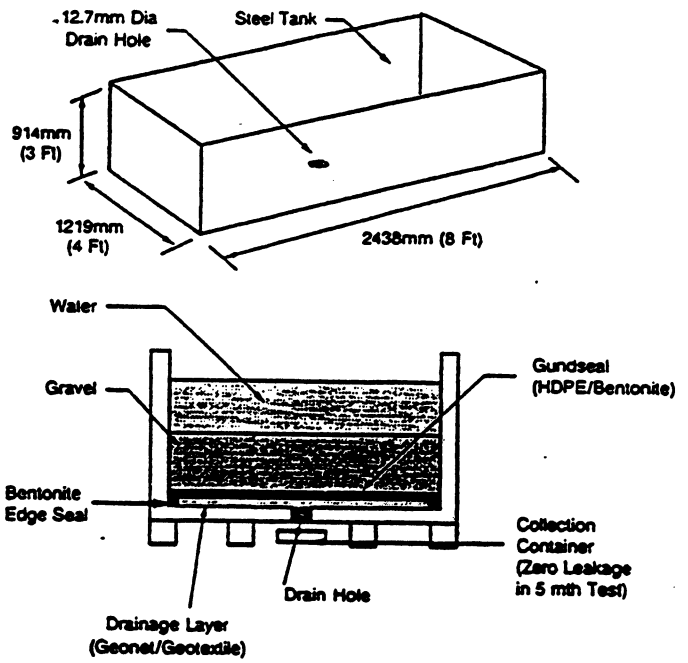
Figure 9

An HDPE primary liner can be seamed together directly on top of the bentonite face of Gundseal. In this way the bentonite is completely encapsulated, protecting it from a subterranean source of moisture. Therefore, the dry shear strength value of bentonite ($\phi = 22°$) can be used for design purposes.

A similar configuration can be achieved by placing Gundseal over top of a welded HDPE liner. Gundseal seams can be simply overlapped or extrusion welded.

UNIVERSITY OF TEXAS TESTS

A very interesting series of tests to determine permeation rates through bentonite blankets has been conducted at the University of Texas at Austin, under the direction of Dr. David Daniel. In these tests, a number of eight foot by four foot tanks were constructed with drain holes in the middle of each tank (Figure 10). Various bentonite blankets were placed over fluid drainage systems in the bottom of these tanks.



Schematic Diagram of Test to Measure Leakage through Gundseal and Gundseal Overlap Seams

Figure 10

The drainage systems were set to collect any migration of liquids through the blankets. The bentonite blankets were placed in the tanks in two ways: 1) as a single unit, and, 2) as two units with an overlapped seam down the middle of the tank. The edges of the blankets were sealed with bentonite. The total test system in each tank consisted of a

drainage layer overlain by a bentonite blanket, followed by a one foot soil cover and then a standing head of liquid of about two feet, as illustrated. During the six month test period, the amount of fluid flowing into the drainage systems was monitored through the hole in the bottom of each tank.

The fluid detection system in the tanks containing Gundseal did not reveal any fluid movement through the Gundseal. There was absolutely zero leakage. In fact, when the bentonite blankets were uncovered, only a small amount of bentonite was noted to have hydrated along the edges and at the overlapped seam. (Figure 11).

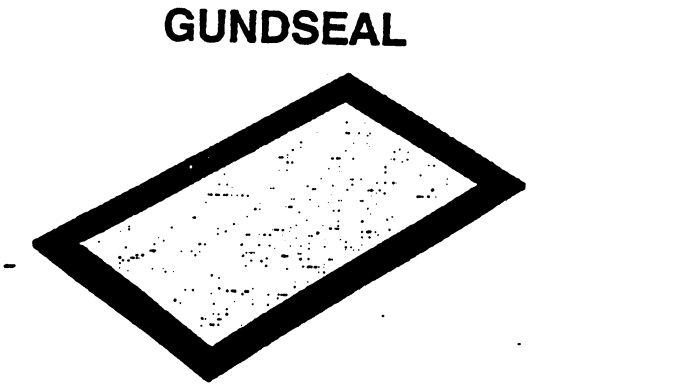


Figure 11

While the bulk of the bentonite in Gundseal remained dry, the fabric encased bentonite blankets were completely hydrated. In another test, Gundseal was placed in a tank with the bentonite side facing upward. An HDPE geomembrane with holes and slits cut into it was placed on top of the Gundseal. Gravel and water were placed over the Gundseal-geomembrane liner system as described previously. The purpose of this test was to investigate the effectiveness of Gundseal when used in conjunction with a worst-case

synthetic liner. After five months, the water and HDPE synthetic liner were removed to expose the Gundseal. Inspection of the Gundseal revealed that the water had moved outward from the defects and into the bentonite about three inches. Once again, the bulk of the bentonite remained dry under the standing head of liquid.

These tests demonstrated that "intimate contact" developed between the bentonite and an overlying HDPE geomembrane. In addition, these tests demonstrated the effectiveness of the overlapped seam (Figure 12). Such intimate contact does not develop between a gemembrane and a fabric encased bentonite blanket.

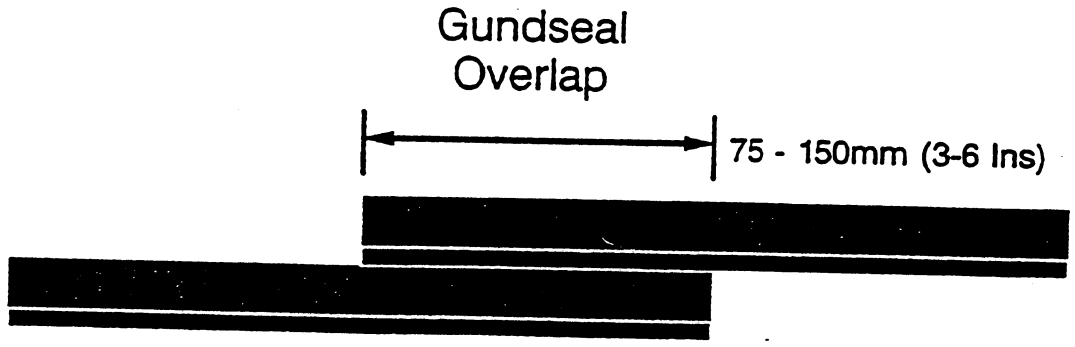


Figure 12

COMPOSITE LINER SYSTEMS

Because composite liner systems are the state-of-the-art in liner system design, the engineering community is experiencing, world-wide, a movement toward designing with synthetic/soil composite systems. Gundseal can supplement or replace soil liner requirements in these systems.

Many states are requiring double composite liner system for municipal waste containment (Figure 13). One problem in this approach is that proper clay compaction is difficult without potentially damaging the lower geosynthetic components. One way to reduce potential damage to the lower geomembrane is to use Gundseal in place of the intermediate layer of clay. In this way a composite type of liner system can still be constructed without the possibility of damaging the lower HDPE liner.

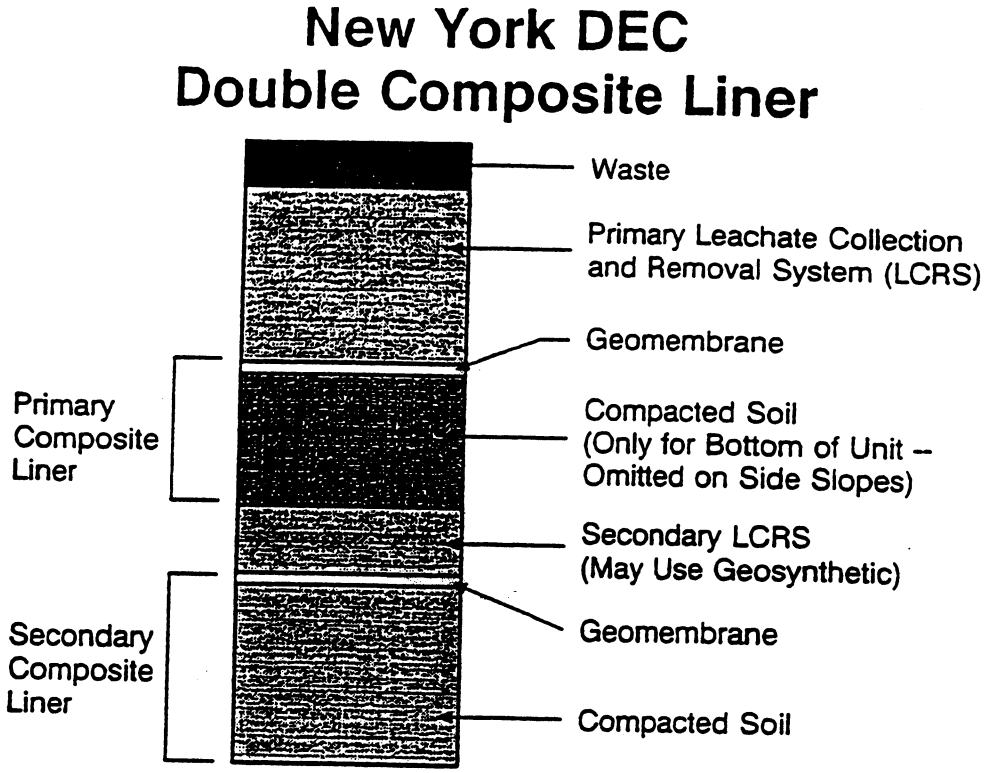
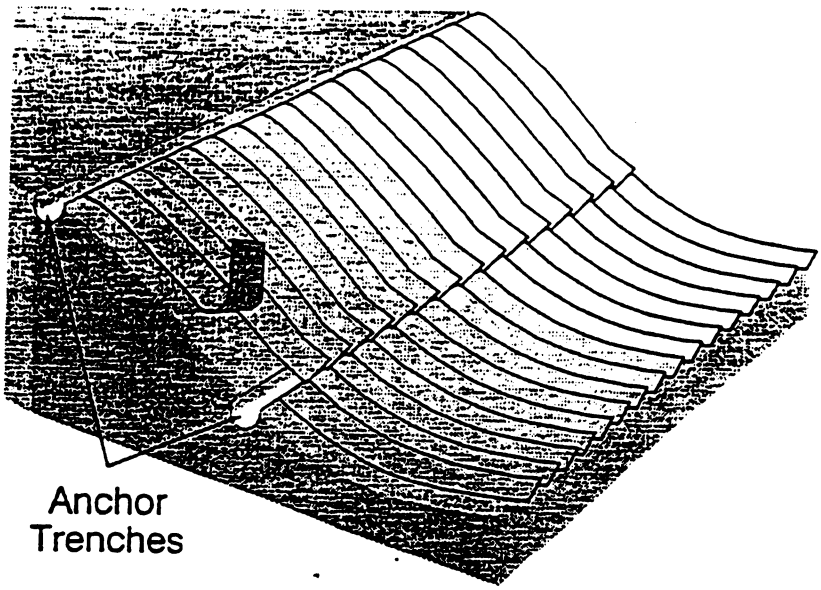


Figure 13

CLOSURES

Gundseal is not only available in conjunction with geomembranes for composite liner systems with the bentonite installed face up or face down. It can also supplement clay by itself in cap systems with the bentonite component facing down (Figure 14). In this case, a synthetic/clay composite system is deployed in one single step. The material can be held in anchor trenches to improve slope stability, and can be either overlapped or heat seamed with Gundle's extrusion welder. However, the designer should be aware that the bentonite side of Gundseal will absorb moisture from the underlying soils when placed in contact with these soils. Therefore, slope stability of the Gundseal should be determined using the hydrated shear strength of the bentonite. (See Figure 15 for hydrated shear strength parameters.)



Possible Landfill Cap Sealing Systems Using Gundseal

Figure 14

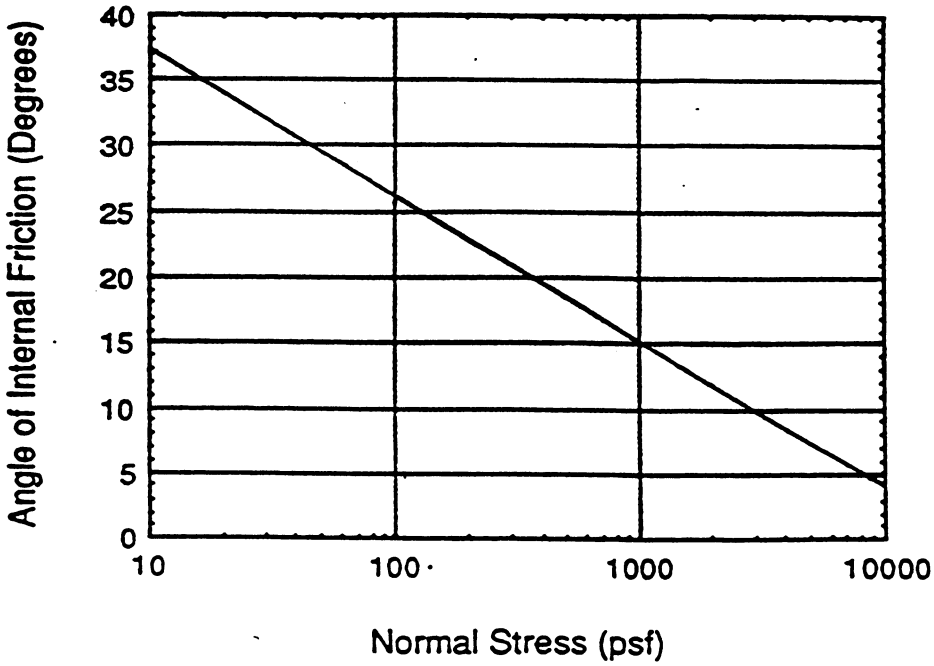


Figure 15. Relationship of Angle of Internal Friction vs Normal Stress For Hydrated Bentonite

Figure 15

Attachment 10

Liner Equivalency Evaluation

Foth & Van Dyke

Client: Crandon Mining Co Scope I.D.: 93C049
Project: Crandon Mine TMA Page: 1
Prepared by: NXP Date: 1-31-96
Checked by: REM Date: 2/2/96

LINER EQUIVALENCY EVALUATION

Purpose: To compare the flow through composite liners with different soil components for evaluating the equivalency of GCL-backed membrane to a clay backed membrane

Scope: Calculate flow through three composite liner configurations, with the same type of geomembrane (with the same type of defects) backed by three types of soil component;

a) 1' clay of $k = 10^{-7}$ cm/sec b) 3' clay of $k = 10^{-7}$ cm/sec

c) GCL with $k = 3 \times 10^{-9}$ cm/sec.

Head on the liner = 1.0 ft

Use the equations used in HELP model Version 3

Equations and data

$$\text{Flowrate } q_h \text{ in m/s} = k_s \, i_{av} \, n \, \pi \, R^2 \left(\frac{\eta_{20}}{\eta_{15}}\right)$$

where k_s = Soil hydraulic conductivity m/s

i_{av} - Average hydraulic gradient on wetted area

n = number of flaws/m^2

R = radius of wetted area m

η_{20} = viscosity at 20°C = 0.00100 kg/m-sec

η_{15} = viscosity at 15°C = 0.00114 kg/m-sec

$$i_{av} = 1 + \frac{h_g}{2 T_s \ln\left(\frac{R}{r_o}\right)}$$

h_g = Hydraulic head, m

T_s = Thickness of soil layer, m

r_o = Radius of geomembrane flaw, m

$$R = 0.26\, a_o^{0.05}\, h_g^{0.45}\, k_s^{-0.13}$$

$$R_{pinhole} = 0.26 \times (.000000785)^{0.05} (.3048)^{0.45} k_s^{-0.13}$$

$$= .12874 \times (.58588)\, k_s^{-0.13}$$

$$= .07543\, k_s^{-0.13}$$

$$R_{defect} = 0.26 (.0001)^{0.05} (.58588)\, k_s^{-0.13}$$

$$= (.16405)(.58588)\, k_s^{-0.13}$$

$$= 0.09611\, k_s^{-0.13}$$

Foth & Van Dyke

Client: Crandon Mining Company Scope I.D.: 93C049
Project: Crandon Mine TMA Page: 3 of 4
Prepared by: N x P Date: 1-31-96
Checked by: REM Date: 2/2/96

i_{aw} CALCULATION

Item T_s	1' clay .3048	3' clay .9144	0.6cm GCL .006	
h_g	.3048 m	.3048 m	.3048 m	✓
k	10^{-9} m/s	10^{-9} m/s	3×10^{-11} m/s	✓
$(k)^{-.13}$	$(10)^{(-9)(-.13)}$ 1.17 $= 10 = 14.791$	14.791	$3^{-.13}\ (-11)(-.13)$ 1.43 $\times 10 = .8669\times10$ $= 23.33$	✓
$R_{pinholes} = .07543\,k^{-.13}$	1.1157	1.1157	1.76	✓
$R_{defect} = .09611\,k^{-.13}$	1.4216	1.4216	2.24	✓
$\ln\left(\frac{R}{r_o}\right)$				
Pinholes: $\ln\left(\frac{R}{.001}\right)$	7.017	7.017	7.473	✓
Defect: $\ln\left(\frac{R}{.0113}\right)$	4.835	4.835	5.289	✓
$2T_s \ln\left(\frac{R}{r_o}\right)$				
Pinholes	4.2776	12.8327	.0897	✓
Defect	2.9474	8.8422	.0635	✓
$h_g \div 2T_s \ln\left(\frac{R}{r_o}\right)$				
Pinholes	.0713	.0238	3.398	✓
Defect	.1034	.0345	4.8	✓
i PINHOLES	1.0713	1.0238	4.398	✓
DEFECT	1.1034	1.0345	5.8	✓

Flow rate

Pinholes = $k_s i_{av} R^2 \times .000247 \times \pi \times \frac{.001}{.00114}$ ✓

n = 1/acre = .000247/m² = $.00068068\ k_s i_{av} R^2$ ✓

Defects = $k_s i_{av} R^2 \times .000988\ \pi \cdot \frac{.001}{.00114}$

n = 4/acre = .000988/m² = $.002723\ k_s i_{av} R^2$ ✓

	1' clay	3' clay	.6cm GCL	
k	10^{-9} m/s	10^{-9} m/sec	3×10^{-11} m/s	✓
PINHOLES $.00068068 k i R^2$	$.9077 \times 10^{-12}$ m/s	$.8675 \times 10^{-12}$ m/s	$.2782 \times 10^{-12}$	✓
DEFECTS $.002723 k i R^2$	6.072×10^{-12} m/s	5.6929×10^{-12} m/s	2.3773×10^{-12} m/s	✓
TOTAL	6.9797×10^{-12} m/s	6.5604×10^{-12} m/s	2.6555×10^{-12} m/s	✓

Attachment 11

Late Wisconsinan Till Excavation Calculations

Foth & Van Dyke

Client: CRANDON Mining Company Scope I.D.: 93C049
Project: TMA Till Page: 1
Prepared by: JBH Date: 2/7/96
Checked by: NxP Date: 2-13-96

To achieve the design base grades within the TMA, soil will be excavated within the TMA footprint. Most of the soil that will be excavated will consist of LATE /Wisconsin an Till (LWT) with the remainder consisting of coarse-grained outwash deposits. The following discussion and calculations will determine the following :

- Quantity of WLT that will be generated by TMA subgrade excavations.
- Quantity of WLT that will be required to be processed (sieved) TO manufacture the 24" (Liner) drainage layer and 12" (cap) DRAINAGE LAYER.
- Quantity of WLT that will be required to be processed (sieved) to manufacture the 6" Till fines Layer (Liner).
- Quantity of WLT that will be available for the manufacture of of the geosynthetic (both Liner & CAP) sub soil Layer. (1 foot thick)
- GRADATION Requirements of the geosynthetic sub soil layer
- Compactability and compaction requirements of the geosynthetic sub soil layer

FOR the Quantity calculations, an average gradation curve based on historical data will be initially used as representing the soil size characteristics. If quantities are then found to be satisfactory, then "coarse" and "fine" boundary gradation curves will be used to check

the ranges of soil types that exist within the LWT to verify that sufficient quantities of LWT exist to cover those conditions. If sufficient quantities of LWT exist for all three conditions then a large factor of safety exists to allow construction of the TMA, manufacture of the drainage layer, till fines layer and geosynthetic sub soil layer.

Determine the quantity of LWT that will be excavated by TMA subgrade excavations.

method: the percentage of LWT that will be excavated within the TMA footprint will be determined by analyzing crossections through the proposed TMA. The percentage of LWT cut within each cross section will be determined. The gross average of all crossection percentages will then be determined. As a conservative measure, the average of the gross average and the worst case (lowest percentage) cross section will then be averaged. This will, in effect, highly weigh the final result in the favor of a conservative (low) percentage of LWT. This should adequately address the situation where more coarse grained outwash is encountered (and less LWT) during excavation than is anticipated.

Foth & Van Dyke

Client: CRANDON MINING CO. Scope I.D.: 93C049
Project: TMA TILL Page: 3
Prepared by: JBH1 Date: 2/7/96
Checked by: N x P Date: 2-13-96

TASK 1 LWT Quantity

CROSS SECTIONS USED FOR THIS ANALYSIS ARE FROM THE TMA REPORT. See attached Location MAP and crossections.

CROSS SECTION	DIRECTION	TOTAL CROSS SECTION AREA OF CUT (SQFT)	AREA of OVERBURDEN IN CUT (SQFT)	AREA of LWT (SQFT)	% LWT
F''-F'''	N-S	0	0	0	0
G''-G'''	N-S	860(46) + 450(38) + (1180)55	½(250)5 + ½(360)6 + ½(200)36		
		121,560	8725	112,835	93
H''-H'''	N-S	670(52) + 550(39) + ½(350)22	½ (550) 3		
		60,140	825	59,315	99
J''-J'''	E-W	1420(54) + $\frac{(1080+190)}{2}$(65)	0		
		117,955		117,955	100
K''-K'''	E-W	1270(21) + 1080(33) + $\frac{(660+240)}{2}$(31) + ½(320)(29)	75(450) + ½(550)(15) + 25'(425) + 200'(2)		
		80,900	21,900	59,000	73
L''-L'''	E-W	0	0	0	0
O''-O'''	E-W	0	0	0	0

Gross Average of percentages (>0) = $\frac{93+99+100+73}{4}$ = 91.3%

Conservative estimate: Average $\frac{(\text{Gross Ave}) + (\text{Lowest \%})}{2} = \frac{73+91.3}{2} = 82.15\%$

LWT Quantity (with topsoil) = $\frac{82.15}{100} \times (11060{,}200 \text{ cu yd})$ = 9,086,000 cu yd
(from 'CUT', site sequencing)

LWT Quantity without topsoil = 9,086,000 cu yd − 200,000 cu yd = 8,886,000 cu yd

2,277,500 E 2,280,000 E 2,282,500 E 2,285,000 E 2,287,500 E 2,290,000 E

120,000 N
117,500 N
115,000 N
112,500 N
110,000 N
107,500 N

N

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- EXISTING CONTOUR
- TREE LINE
- SPOT ELEVATION
- SECTION LINE
- PROPOSED ACCESS ROAD
- PROPOSED HAUL ROAD
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES

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
0 800' 1600'

Foth & Van Dyke

TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

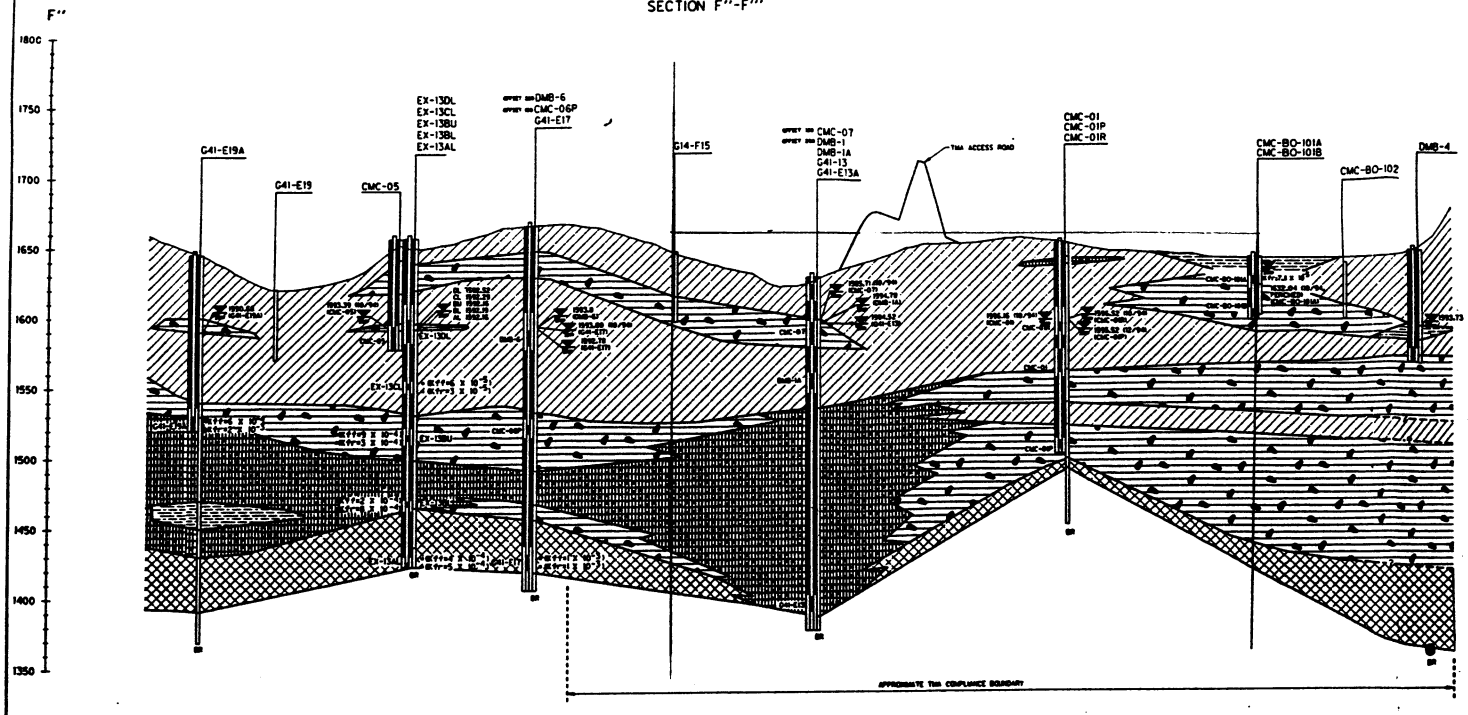
Crandon Mining Company

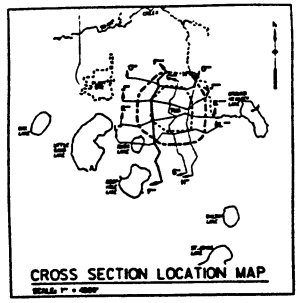
TITLE
GEOLOGIC CROSS SECTION LOCATION MAP

SCALE AS SHOWN	STATE WISCONSIN	COUNTY FOREST	
DRAWN BY GAM, JPRI	DATE 5/95	CHECKED BY JKSI	DATE 5/95
APPROVED BY REM	DATE 5/95	APPROVED BY NXP	DATE 5/95
APPROVED BY GWS	DATE 5/95	CRANDON MINING COMPANY	DATE 5/95
DRAWING NO. 5		DEM	SHEET 5 OF 5 / REVISION NO. 0

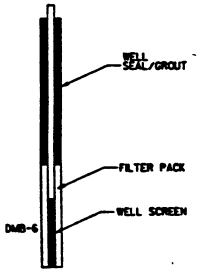
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SECTION F''-F'''



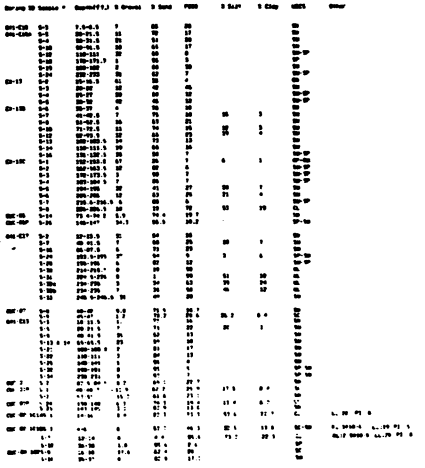


WELL CONSTRUCTION INFORMATION



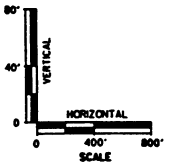
LEGEND

- QH UNDIFFERENTIATED LATE WISCONSIN TILL — NASHVILLE MEMBER, COPPER FALLS FORMATION AND THE MAPLEVILLE MEMBER, HORICON FORMATION
- Qte UNDIFFERENTIATED EARLY-WISCONSIN-TILL AND PRE-WISCONSIN TILL — MARATHON AND LINCOLN FORMATIONS, MAY INCLUDE MASSIVE SAPROLITE
- Qowf FINE-GRAINED OUTWASH DEPOSITS — GLACIAL FLUVIAL STRATIFIED SAND AND SILT OF WISCONSINAN AGE
- Qowf COARSE-GRAINED OUTWASH DEPOSITS — GLACIAL FLUVIAL STRATIFIED SAND AND GRAVEL OF WISCONSINAN AGE
- INFERRED GEOLOGIC CONTACT
- 1594.58 (EX-12BL) WL — WATER LEVEL ELEVATION (MSL) UNLESS INDICATED
- LL — LIQUID LIMIT
- PI — PLASTICITY INDEX
- P200 — PERCENT FINES
- USCS — UNIFIED SOIL CLASSIFICATION SYSTEM
- RL — LABORATORY HYDRAULIC CONDUCTIVITY IN CM/SEC.
- Ql LACUSTRINE DEPOSITS — GLACIO-LACUSTRINE, BEDDED, SILT AND CLAY WITH MINOR AMOUNTS OF SAND OF WISCONSINAN, HOLOCENE AND RECENT AGE.
- Qhic ICE-CONTACT DEPOSITS — ABLATION TILL, FLOW TILL, GLACIO-FLUVIAL SILT, CLAY AND SAND OF WISCONSINAN AGE
- Ms MASSIVE SAPROLITE — UNSTRUCTURED CLAY, SILT AND SAND, HIGHLY WEATHERED BEDROCK
- Ss STRUCTURED SAPROLITE BEDROCK — CLAY, SILT AND SAND WITH RELIC BEDROCK STRUCTURES, PARTLY WEATHERED BEDROCK
- PCu UNDIFFERENTIATED BEDROCK — PRECAMBRIAN METAVOLCANIC BEDROCK, MAY INCLUDE STRUCTURED SAPROLITE
- INFERRED UNDIFFERENTIATED BEDROCK ELEVATION BASED UPON STS 1984 BEDROCK ELEVATION MAP
- K+f FIELD PERMEABILITY - FALLING HEAD TEST IN CM/SEC.
- K+r FIELD PERMEABILITY - RISING HEAD TEST IN CM/SEC.
- WELL ABANDONED



NOTES:

1. WELLS ARE LOCATED IN INDIVIDUAL BORINGS. THE FILTER PACK IS SILICA SAND, AND THE ANNULAR SPACE AROUND THE WELL CASING WAS BACKFILLED WITH BENTONITE PELLETS AND CEMENT/BENTONITE GROUT AND CONCRETE.
2. THIS CROSS SECTION DERIVED FROM THE REGIONAL CROSS SECTION F-F' OF THE EIR, 1995.



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TYPICAL REPRESENTATION. REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Crandon Mining Company

TITLE: GEOLOGIC CROSS SECTION F''-F'''

WISCONSIN | FOREST

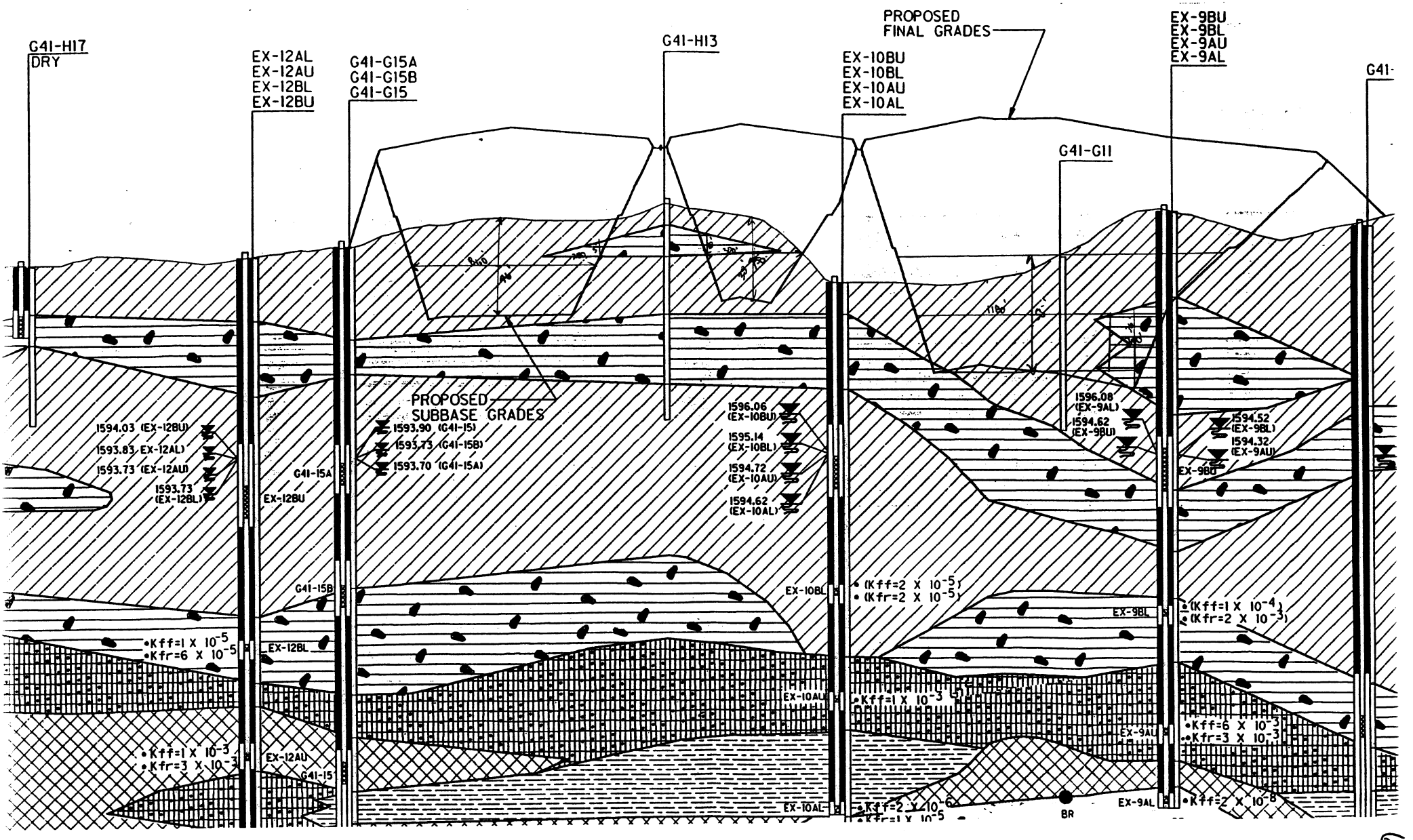
CAM, JPW — 5/95 | JESI — 5/95
REM — 5/95 | A. MMP — 5/95
DRS — 5/95 | DEM — 5/95

6

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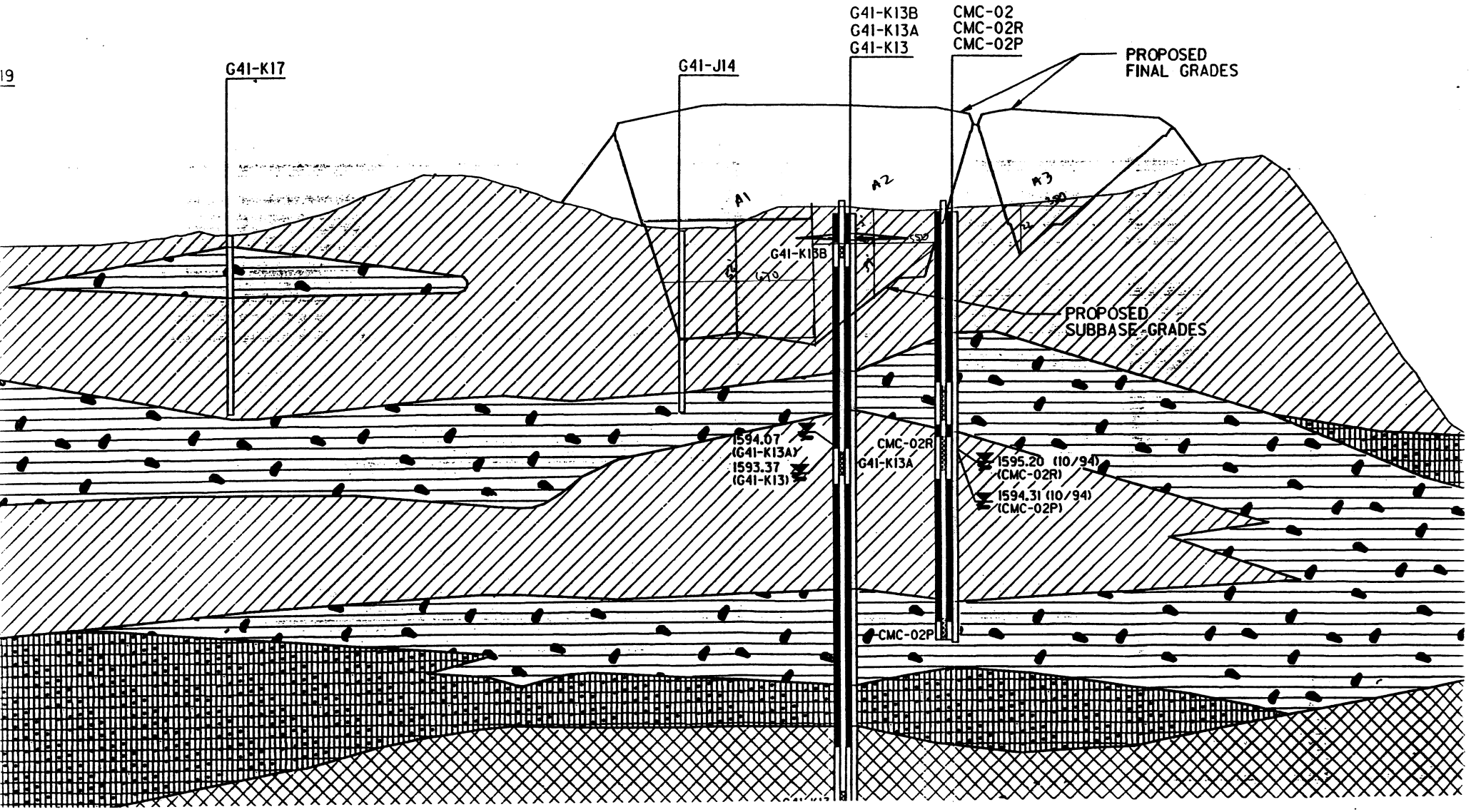
SECTION G''-G'''

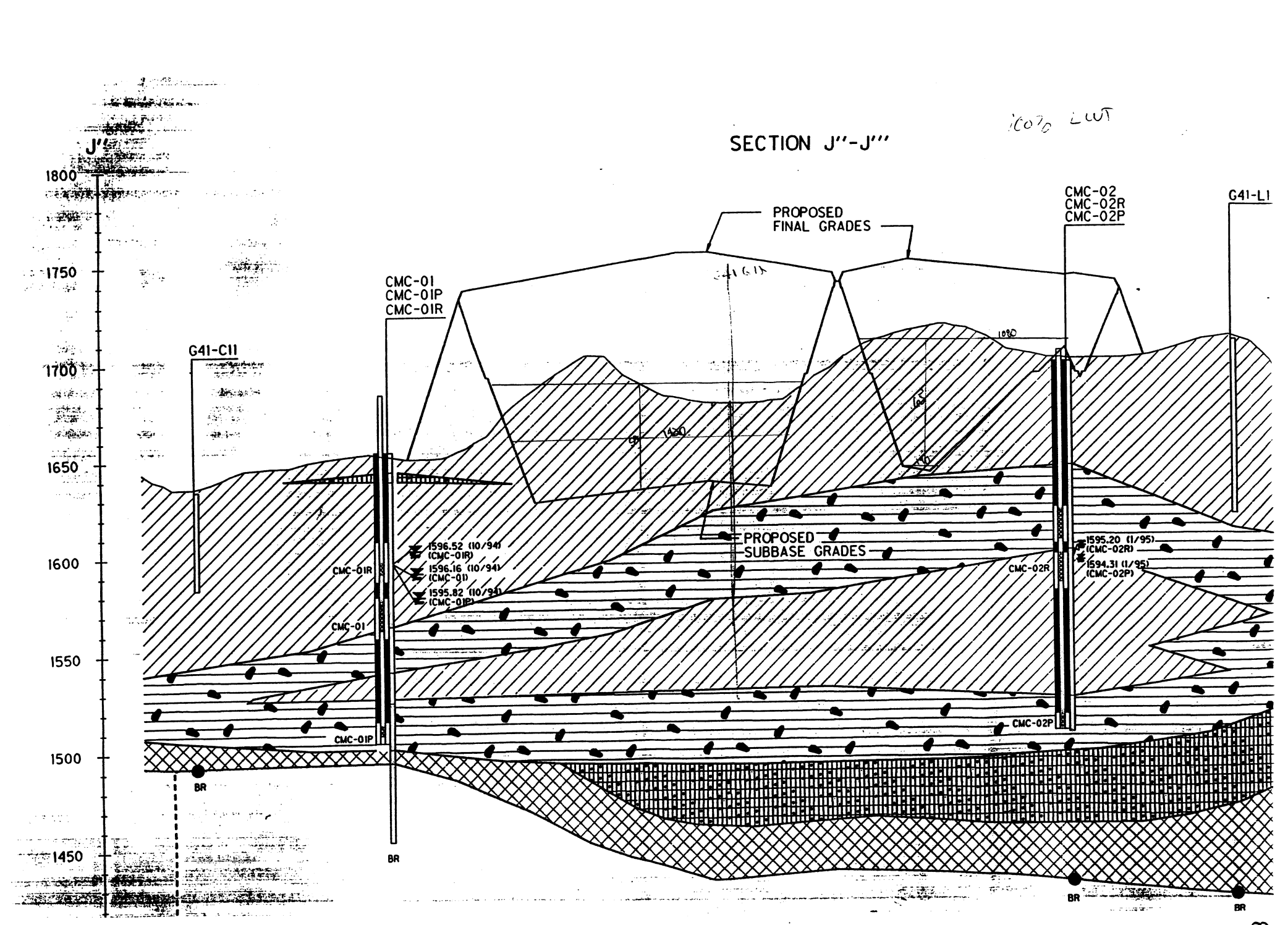
95.78 & LWT



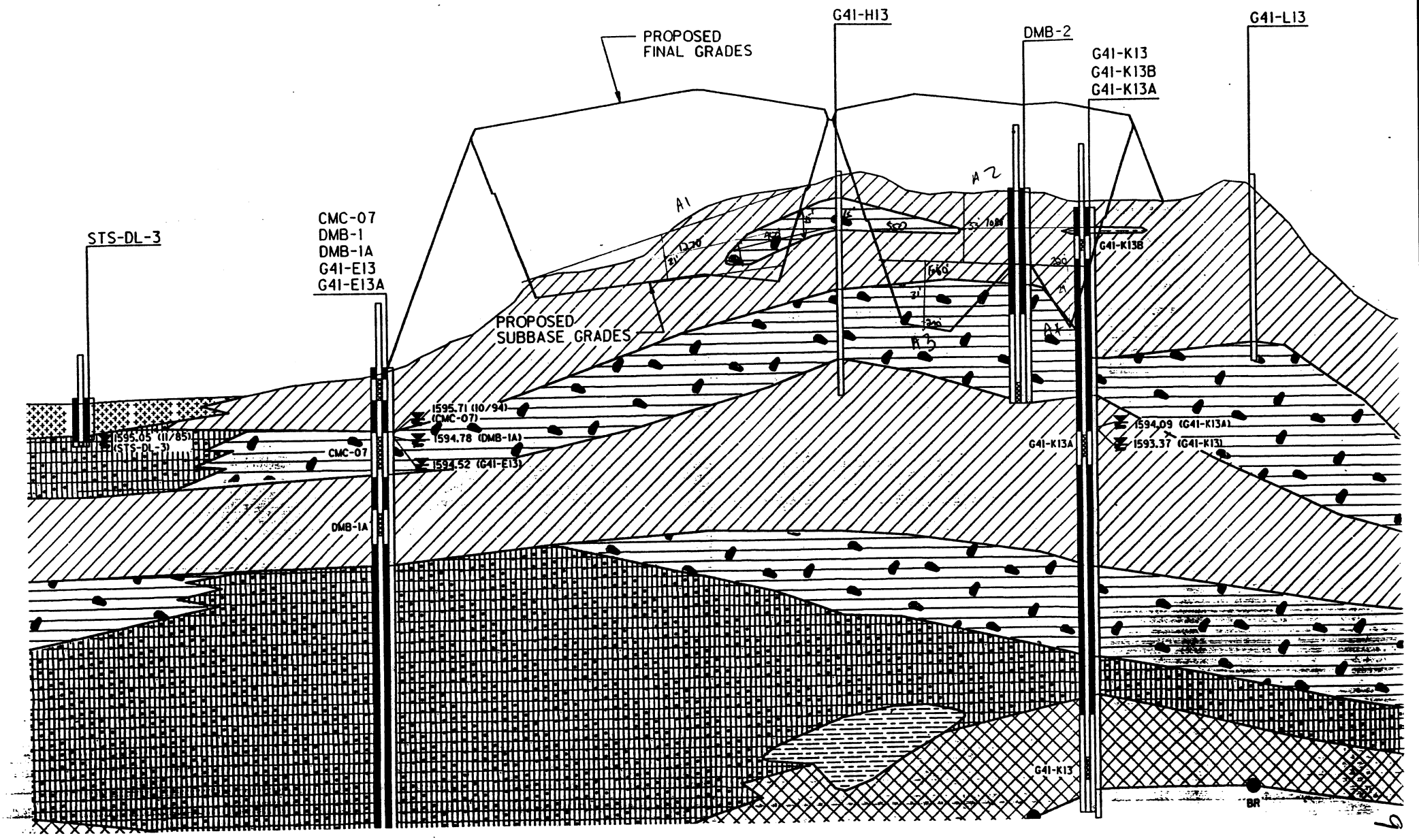
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SECTION H''-H'''

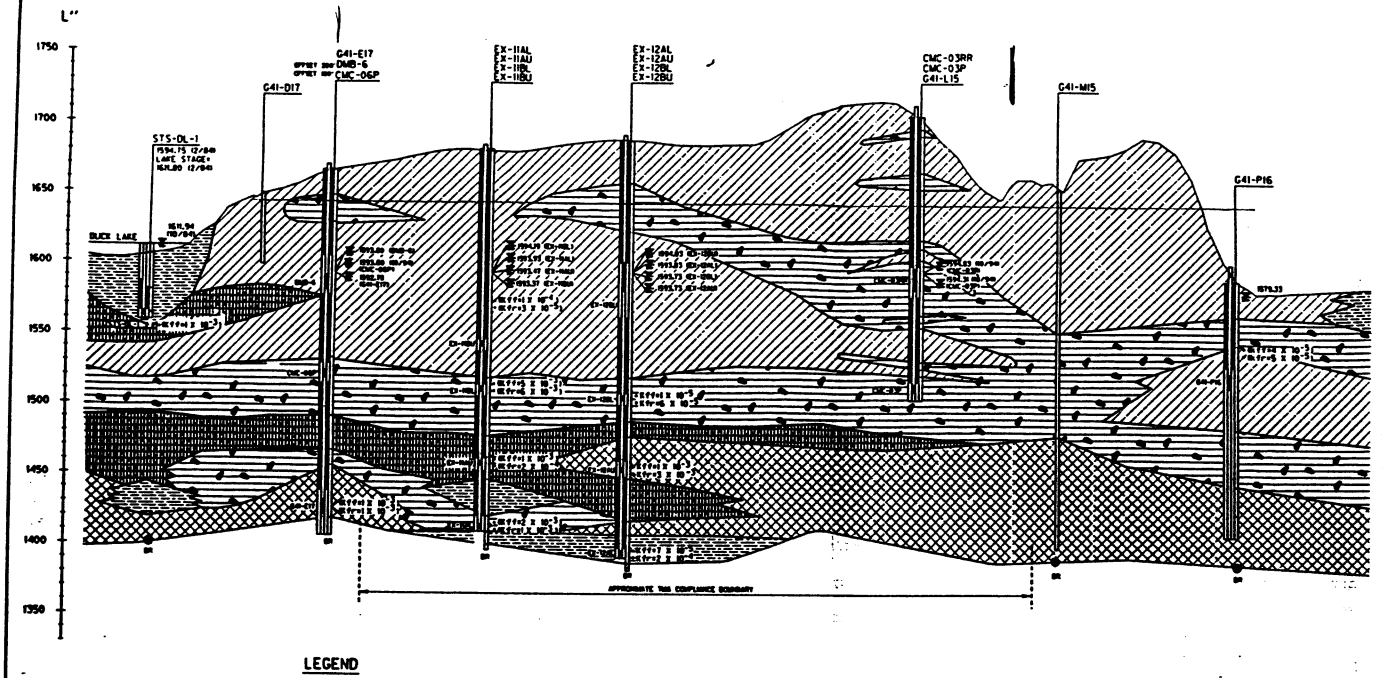

G41-K17
G41-J14
G41-K13B
G41-K13A
G41-K13
CMC-02
CMC-02R
CMC-02P
PROPOSED
FINAL GRADES
A1
A2
K3
G41-K13B
PROPOSED
SUBBASE GRADES
1594.07
(G41-K13A)
1593.37
(G41-K13)
CMC-02R
G41-K13A
1595.20 (10/94)
(CMC-02R)
1594.31 (10/94)
(CMC-02P)
CMC-02P

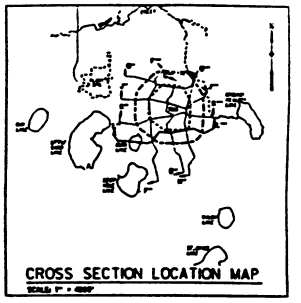

SECTION J''-J'''
J''
J'''
1800
1750
1700
1650
1600
1550
1500
1450
PROPOSED
FINAL GRADES
CMC-02
CMC-02R
CMC-02P
G41-L1
CMC-01
CMC-01P
CMC-01R
G41-C11
PROPOSED
SUBBASE GRADES
1596.52 (10/94)
(CMC-01R)
1596.16 (10/94)
(CMC-01)
1595.82 (10/94)
(CMC-01P)
1595.20 (1/95)
(CMC-02R)
1594.31 (1/95)
(CMC-02P)
CMC-01R
CMC-01
CMC-01P
CMC-02R
CMC-02P
BR
BR
BR
BR

SECTION K''-K'''

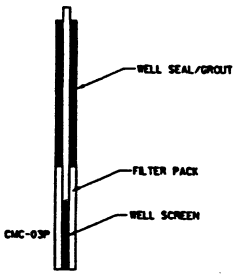

PROPOSED
FINAL GRADES
G41-H13
DMB-2
G41-K13
G41-K13B
G41-K13A
G41-L13
STS-DL-3
CMC-07
DMB-1
DMB-1A
G41-E13
G41-E13A
PROPOSED
SUBBASE GRADES
A1
A2
1595.71 (10/94)
(CMC-07)
1594.78 (DMB-1A)
1594.52 (G41-E13)
1595.05 (11/85)
(STS-DL-3)
CMC-07
DMB-1A
G41-K13B
G41-K13A
1594.09 (G41-K13A)
1593.37 (G41-K13)
G41-K13
BR

SECTION L'' - L'''



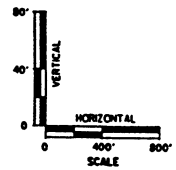


WELL CONSTRUCTION INFORMATION



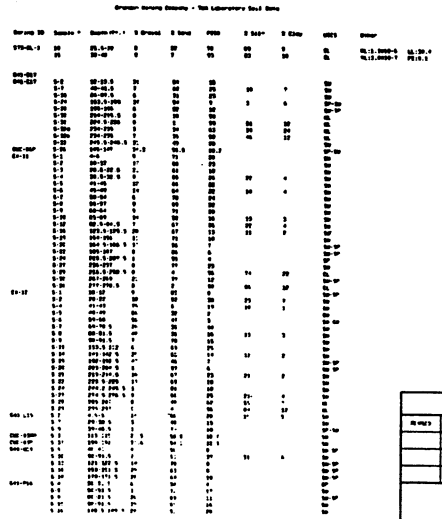
NOTES:

1. WELLS ARE LOCATED IN INDIVIDUAL BORINGS. THE FILTER PACK IS SILICA SAND, AND THE ANNULAR SPACE AROUND THE WELL CASING WAS BACKFILLED WITH BENTONITE PELLETS AND CEMENT/BENTONITE GROUT AND CONCRETE.
2. THIS CROSS SECTION DERIVED FROM THE REGIONAL CROSS SECTION L-L' OF THE EIR, 1995.



LEGEND

- Qtl UNDIFFERENTIATED LATE WISCONSIN TILL — NASHVILLE MEMBER, COPPER FALLS FORMATION AND THE MAPLEVILLE MEMBER, HORICON FORMATION
- Qtla UNDIFFERENTIATED EARLY-WISCONSIN-TILL AND PRE-WISCONSIN TILL — MARATHON AND LINCOLN FORMATIONS, MAY INCLUDE MASSIVE SAPROLITE
- Qowf FINE-GRAINED OUTWASH DEPOSITS — GLACIAL FLUVIAL STRATIFIED SAND AND SILT OF WISCONSINAN AGE
- Qowl COARSE-GRAINED OUTWASH DEPOSITS — GLACIAL FLUVIAL STRATIFIED SAND AND GRAVEL OF WISCONSINAN AGE
- INFERRED GEOLOGIC CONTACT
- 1594.58 (EX-12BL) — WATER LEVEL ELEVATION (10/84)* UNLESS INDICATED
- LL LIQUID LIMIT
- PI PLASTICITY INDEX
- P200 PERCENT FINES
- USCS UNIFIED SOIL CLASSIFICATION SYSTEM
- KL LABORATORY HYDRAULIC CONDUCTIVITY IN CM/SEC.
- Ql LACUSTRINE DEPOSITS — GLACIO-LACUSTRINE, BEDDED, SILT AND CLAY WITH MINOR AMOUNTS OF SAND OF WISCONSINAN, HOLOCENE AND RECENT AGE.
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- Ss STRUCTURED SAPROLITE BEDROCK — CLAY, SILT AND SAND WITH RELIC BEDROCK STRUCTURES, PARTLY WEATHERED BEDROCK
- PCu UNDIFFERENTIATED BEDROCK — PRECAMBRIAN METAVOLCANIC BEDROCK, MAY INCLUDE STRUCTURED SAPROLITE
- INFERRED UNDIFFERENTIATED BEDROCK ELEVATION BASED UPON STS 1984 BEDROCK ELEVATION MAP
- *Kff FIELD PERMEABILITY - FALLING HEAD TEST IN CM/SEC.
- *Kfr FIELD PERMEABILITY - RISING HEAD TEST IN CM/SEC.
- *(Kff) *(Kfr) WELL ABANDONED



Foth & Van Dyke

TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

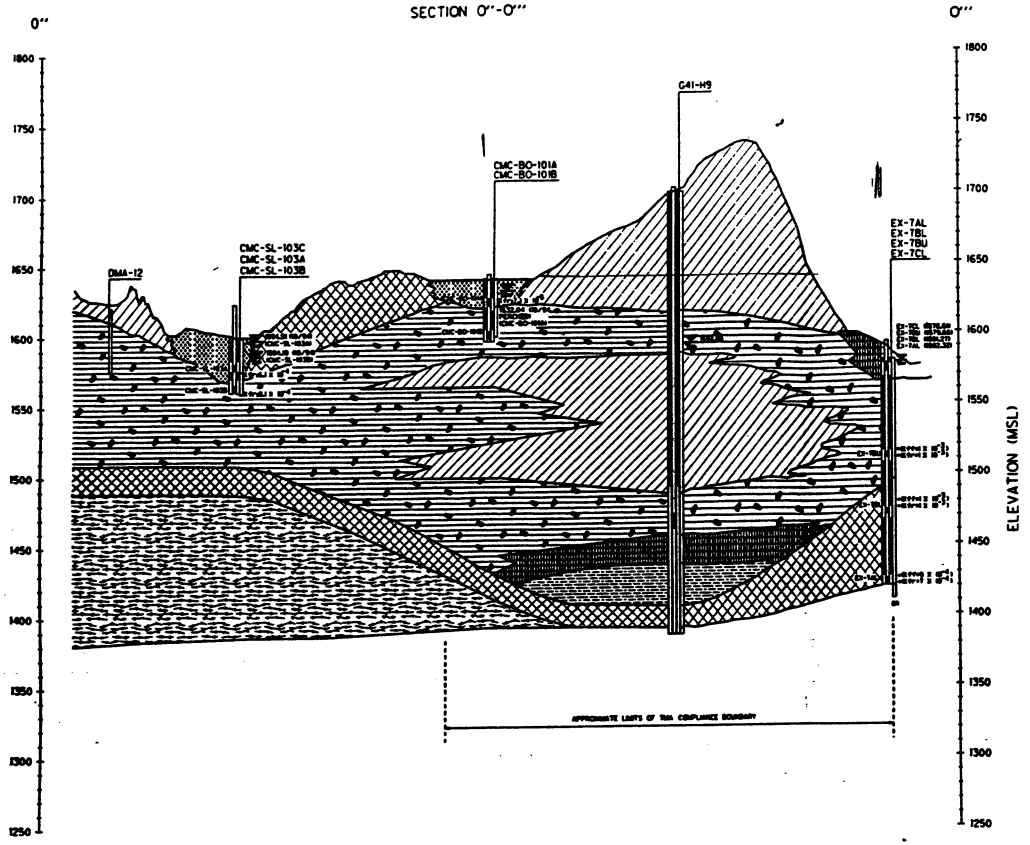
Crandon Mining Company

TITLE: GEOLOGIC CROSS SECTION L''-L'''

WISCONSIN — FOREST

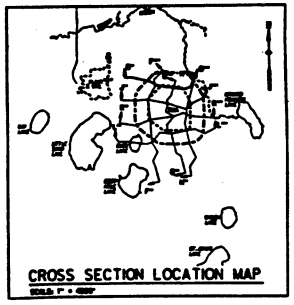
CAM, JPW — 5/95 — JES — 5/95
REM — 5/95 — 5/95
CPS — 5/95 — DEM — 5/95

10

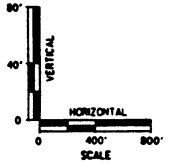


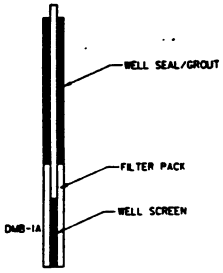
LEGEND

- Qtl UNDIFFERENTIATED LATE WISCONSIN TILL — NASHVILLE MEMBER, COPPER FALLS FORMATION AND THE MAPLEVILLE MEMBER, HORICON FORMATION
- Qte UNDIFFERENTIATED EARLY-WISCONSIN-TILL AND PRE-WISCONSIN TILL — MARATHON AND LINCOLN FORMATIONS, MAY INCLUDE MASSIVE SAPROLITE
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- INFERRED GEOLOGIC CONTACT
- 1615.99 (STS-DL-3) WATER LEVEL ELEVATION (10/84)= UNLESS INDICATED
- LL LIQUID LIMIT
- PI PLASTICITY INDEX
- P200 PERCENT FINES
- USCS UNIFIED SOIL CLASSIFICATION SYSTEM
- Ql LACUSTRINE DEPOSITS — GLACIO-LACUSTRINE, BEDDED, SILT AND CLAY WITH MINOR AMOUNTS OF SAND OF WISCONSINAN, HOLOCENE AND RECENT AGE.
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- + Kff FIELD PERMEABILITY - FALLING HEAD TEST IN CM/SEC.
- + Kfr FIELD PERMEABILITY - RISING HEAD TEST IN CM/SEC.
- + (Kff) + (Kfr) WELL ABANDONED
- KL LABORATORY HYDRAULIC CONDUCTIVITY IN CM/SEC.



WELL CONSTRUCTION INFORMATION





Crandon Mining Company - TRW Laboratory Soil Data

Boring ID	Sample #	Depth (ft.)	% Gravel	% Sand	P200	% Silt	% Clay	USCS	Other
CMC-SL-103A	S-4	6-8.5	0.3	37.4	62.5	19.6	22.9	SC-SM	KL: 4.2 x 10^-7
CMC-SL-103B	ST-4	35-39	0.0	34.8	65.2	61.1	04.1	CL	KL: 3.5 x 10^-6
	S-9	38-40	29.5	70.1	4.4	—	—	SP	
CMC-BC-101A	S-1	14-16	0.4	23.3	73.3	53.6	22.7	CL	LL:20 PI: 8
CMC-BC-101B	S-3	4-6	0	53.7	46.3	32.5	13.8	SC-SM	KL:3350-6 LL:20 PI: 5
	S-7	32-34	0	0.4	99.6	73.3	22.3	CL	KL:2.9X10-9 LL:20 PI: 8
	S-10	36-38	1.0	25.6	7.4			SP	
G41-H9	S-3	23-22.5	14	68	18			SP	
	S-5	48-43	25	63	12			SP	
	S-8	73-71.8	29	58	14			SP	
	S-10	98-91	49	44	7			SP	
	S-15	148-141.5	17	63	20			SP	
	S-16	158-151.3	14	64	22			SP	
	S-21	208-200.8	1	62	9	101.0		SP	
	S-22	218.5-211.4	14	64	22			SP	
EX-7	S-1	61.5-63.5	11	89	9	--	--	SP	--
	S-2	129-131	7	73	21	39	7	SP	--
	S-3	162-164	41	27	32	16	7	SP	--

NOTES:

1. WELLS ARE LOCATED IN INDIVIDUAL BORINGS. THE FILTER PACK IS SILICA SAND, AND THE ANNULAR SPACE AROUND THE WELL CASING WAS BACKFILLED WITH BENTONITE PELLETS AND CEMENT/BENTONITE GROUT AND CONCRETE.
2. THIS CROSS SECTION DERIVED FROM THE REGIONAL CROSS SECTION O-O' OF THE EIR, 1995.

TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

Foth & Van Dyke

Crandon Mining Company

TITLE: GEOLOGIC CROSS SECTION O''-O'''

WISCONSIN | FOREST

GAM, JPW 5/95 | JEB 5/95 | REH 5/95 | GBP 5/95 | GPS 5/95 | JKH 5/95

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Foth & Van Dyke

Client: Crandon Mining Co Scope I.D.: 93C049
Project: TMA TILL Page: 12
Prepared by: JBH1 Date: 2/7/96
Checked by: NxP Date: 2-13-96

Determine Quantity of LWT REQ'D FOR DRAINAGE and fine till layer.

Determine the quantity of LWT that will be required to be processed (sieved) to manufacture the 24" (liner) drainage layer and 12" (cap) drainage layer as well as the till fines layer

Some of the LWT excavated in the TMA footprint will be processed to manufacture soil material that will meet the gradation requirements for the drainage layers and till fines. These requirements are as follows:

Layer type	gradation
DRAINAGE LAYER	½" TO #40 SIEVE (minus ½" size) (+ #40 SIEVE)
till fines layer	below #40 sieve

IT CAN be seen that the fines screened from the LWT processed to manufacture the drainage layer can be used for the Till fines layer.

Foth & Van Dyke

Client: CRAWFORD Mining Co Scope I.D.: 93C044
Project: TMA TILL Page: 13
Prepared by: JBH Date: 2/7/96
Checked by: N x P Date: 2-13-96

Determine AMOUNT of LWT required for DRAINAGE LAYERS and till fines layer continued ...

Determine AMOUNT of LWT required for Drainage layers then check with quantity of fines developed to make sure till fines quantity is met.

1. USE "X AVERAGE" gradation curve to determine quantities. The "X AVERAGE" curve was developed by gross average measurement at various particle sizes. Outliers (up to 5 curve lines) were disregarded with the corresponding numbers on each end of the particle size. Ie if 3 curves were outliers on the fine side of the curve, 3 curves were disregarded on the fine side and coarse side prior to the average measure at that particle size). This method of gradation average is appropriate to determine gross quantities. Checks on the quantities can be made by using the "coarse" and "fine" soil gradation curves (outliers) if the gross average quantities are found to be sufficient. It should be noted that approximately 10% (conservative) of all till may be boulders.

2. DRAINAGE LAYER MATERIAL must fall between the #40 sieve and 1/2".

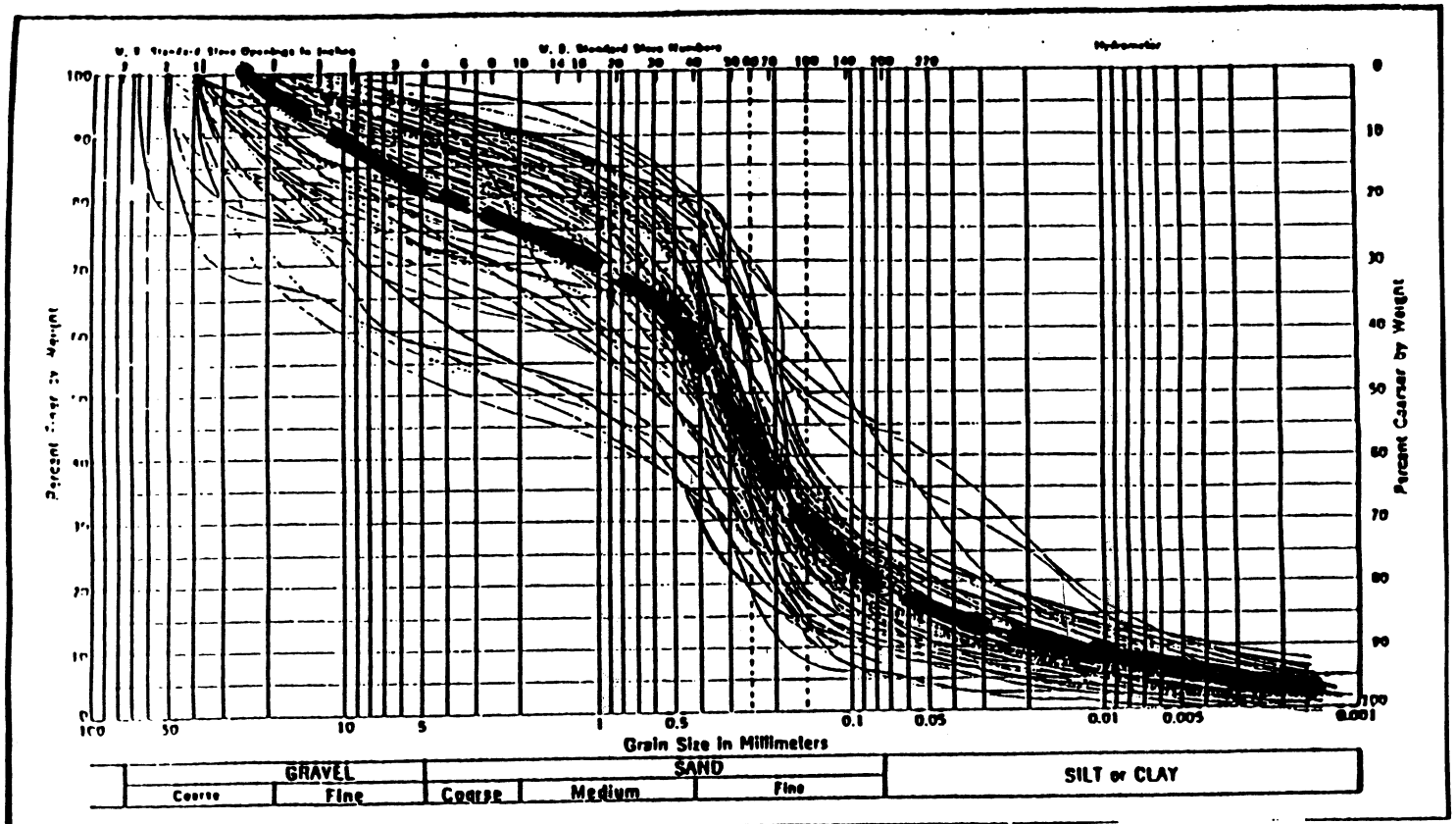
   FROM the "X AVERAGE" CURVE the following are measured

size	% finer by wt
1/2"	92
#40 sieve	57

Therefore 8% of the till is larger in size and will be screened by 1/2" sieve and 57% is finer than the #40 sieve which will drop through.

UNIFIED CLASSIFICATION SYSTEM

JBH1
2/2/96



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
					LATE WISCONSINAN TILL

REFERENCE: STS-1984

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	SVDI	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

Crandon Mining Company

REPRESENTATIVE GRAIN SIZE CURVES
OF LATE WISCONSINAN TILL

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	BSH

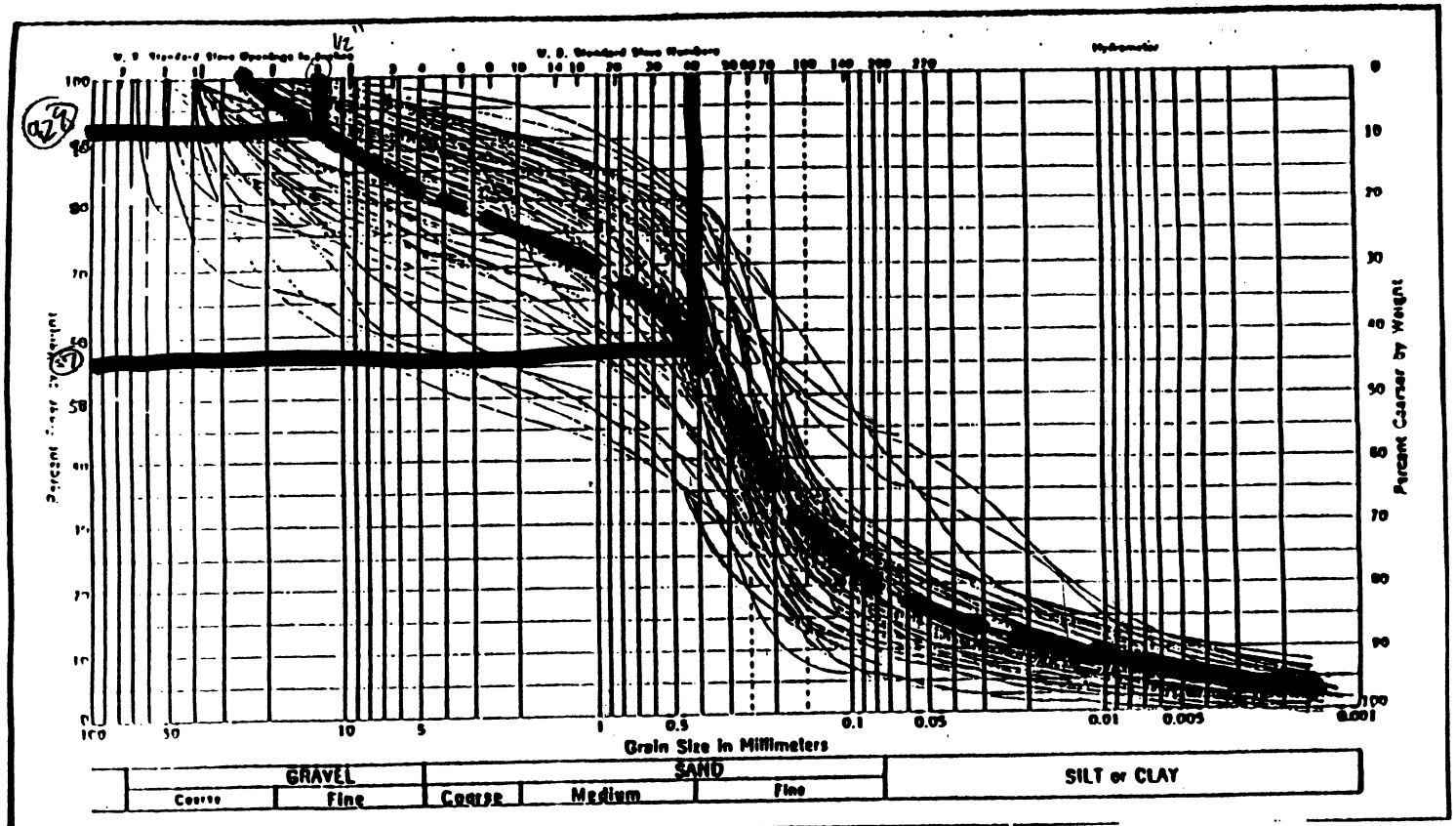
c:\cadwork\4c3341g.dgn

C-5

93C049

UNIFIED CLASSIFICATION SYSTEM

JBH1
2/2/96



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
					LATE WISCONSINAN TILL

REFERENCE: STS-1984

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	SVDI	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

Crandon Mining Company

REPRESENTATIVE GRAIN SIZE CURVES OF LATE WISCONSINAN TILL

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	BSH

93C045

SITE PREPARATION /OPERATION

CELL	STAGE	MINE WASTE VOLUME (CY)	EARTHWORK (CY) CUT ①	EARTHWORK (CY) FILL	12" LPS LAYER (CY)	GEOMEMBRANE (SF)	GEOTEXTILE (CUSHIONING) (SF)	24" DRAINAGE LAYER (CY)	GEOTEXTILE (FILTER) (SF)	18" (BASE) TILL LAYER (CY)	6" TILL FINES LAYER (CY)	18" SIDEWALL TILL LAYER (CY)
1	I	2032900	1339400	911300	73500	1965800	1965800	93000	1270400	69700	23300	36200
	II	2153600	100	1807000	19900	522600	522600	N.A.	N.A.	N.A.	N.A.	30400
2	III	3391200	4038500	145900	89900	2398100	2398100	101800	1389700	76300	25500	53400
	IV	4174600	1200	1616600	33000	885400	885400	N.A.	N.A.	N.A.	N.A.	50700
3	V	1586400	2197900	7100	54000	1430500	1430500	55800	762000	41800	14000	35100
	VI	2649800	2800	614300	26900	725700	725700	N.A.	N.A.	N.A.	N.A.	41100
4	VII	1705600	3435100	700	59900	1588200	1588200	62000	845900	46500	15500	37100
	VIII	2852600	45200	178000	27100	732900	732900	N.A.	N.A.	N.A.	N.A.	43700
TOTALS		20546700	11060200	5280900	384200	10249200	10249200	312600	4268000	234300	78300	327700

① INCLUDES TOPSOIL

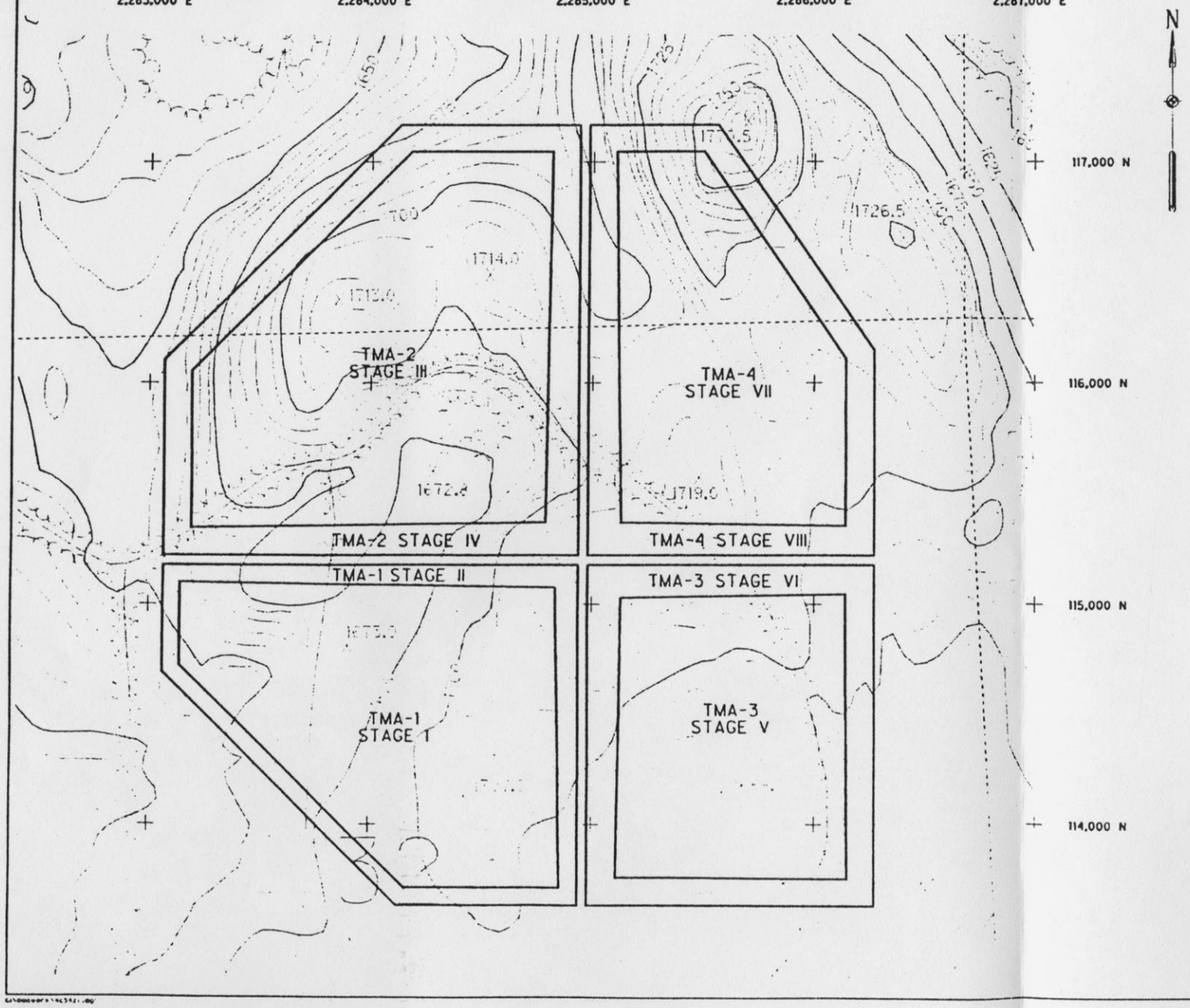
(CY) - CUBIC YARDS
(SF) - SQUARE FEET
LPS - LOW PERMEABILITY SOILS
N.A. - NOT APPLICABLE
ALL VALUES ARE INPLACE QUANTITIES

CLOSURE

CELL	STAGE	FILL MATERIAL (CY) ①	36" SOIL GRADING (CY)	12" LPS LAYER (CY)	GEOMEMBRANE (SF)	12" DRAINAGE LAYER (CY)	36" ROOTING LAYER (CY)	6" TOPSOIL LAYER (CY)
1	I	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	II	373600	258900	87500	2420400	88500	258000	44300
2	III	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	IV	585600	342100	115400	3179700	116400	341100	58300
3	V	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	VI	307900	221800	75100	2076300	75900	220200	38000
4	VII	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	VIII	328300	238900	80800	2234200	81600	238100	40900
TOTALS		1595400	1061700	358800	9910600	362400	1057400	181500

① FILL MATERIAL MAY INCLUDE TAILINGS. WASTE ROCK. TILL SOIL OR OTHER MATERIALS.

(CY) - CUBIC YARDS
(SF) - SQUARE FEET
LPS - LOW PERMEABILITY SOILS
N.A. - NOT APPLICABLE



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.

LEGEND

- EXISTING ROAD
- 1675 EXISTING CONTOUR
- 1692.0 X EXISTING SPOT ELEVATION

SCALE
0 300' 600'

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

Crandon Mining Company

TITLE
SITE SEQUENCING PLAN

SCALE: AS SHOWN	STATE: WISCONSIN		COUNTY: FOREST		
DRAWN BY: GAM, JPRI	DATE: 5/95	CHECKED BY: JRSI	DATE: 5/95		
APPROVED BY: REM	DATE: 5/95	APPROVED BY: NXP	DATE: 5/95		
APPROVED BY: GWS	DATE: 5/95	CRANDON MINING COMPANY: DEM	DATE: 5/95		
DRAWING NO. 13	SHEET 17 OF 51				

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Foth & Van Dyke

Client: Cranberry Mining Co Scope I.D.: 936099
Project: TMA TILL Page: 17
Prepared by: JBH1 Date: 2/7/96
Checked by: N x P Date: 2-13-96

DRAINAGE LAYER and Till Layer Quantity

Then the total percentage of excavated LWT which will be usable for the drainage Layer, taking into account that 10 percent (approximate) of the LWT is boulders is as follows:

A. $(100\% - 57\% - 8\%) \times 90\% = 31.5\%$
($-$#40 sieve) ($+$½") ↑ less than boulders

The Required Quantity of Drainage Layer that will be used in the TMA is as follows:

B. 312,600 cy + 362,400 cy = 675,000 cy TOTAL
(24" Liner) (12" CAP)

The amount of LWT that will be required to be processed to provide 675,000 cy is as follows:

C. $LWT_{required\ (CAVE)} = \frac{675{,}000}{31.5\%} = \frac{675{,}000}{.315} = 2{,}142{,}857$ cy.

2,142,857 < 8,886,000 OK
(DRAINAGE LAYER) (EXCAVATED LWT)

During the screening (sieving) process to manufacture the drainage layer, fines (minus #40 sieve) material will be developed. This fine material can be used for both the Till fines layer and the geosynthetic subsoil layer. After producing the drainage layer (675,000 cy) the amount of fines that will be developed is as follows:

D. fines = (2,142,857 cuyd x) 57%(90%) = 1,099,286 cu yd.

tasks 2&3 continued.

The amount of fines required for the till fines layer is 78,300 c.y.. Therefore the amount of fines available for use in the geosynthetic subsoil layer is as follows:

E. $1,099,286 - 78,300 = 1,020,986$ cu yd

The required quantity of 1 foot thick layer of generally well graded till material for the geosynthetic subsoil are as follows.

F. $[9,910,600 SF + 10,249,200 SF] \times (1 FT) \times \frac{1 CY}{27 CF} = \underline{746,659 CY}$

G. Therefore there is a ratio of AVAILABLE Quantity vs REQUIRED "quantity" of: $\frac{\text{Quantity of fines available}}{\text{Quantity required}} = \frac{1,020,986}{746,659 CY} = \underline{1.4}$

Therefore using the average gradation curve for the LWT and using projected estimates for quantities of LWT excavation (CUT) in the TMA area, the drainage layer quantity and till fines layer quantity, there will be 40% more fine material (minus #40 sieve) generated than will be required for the one foot subsoil Layer for the geosynthitic layer.

Foth & Van Dyke

Client: CRANDON MINING Co Scope I.D.: 93C049
Project: TMA TILL Page: 19
Prepared by: SBH Date: 2/7/96
Checked by: N x P Date: 2-13-96

TO Determine How much control MUST BE USED DURING LWT EXCAVATION, ie will areas need to be identified based upon the LWT till gradation for specific areas based on quantity, the following checks are provided.

Coarse LWT check (perform steps A thru G using coarse grained gradation from XAVE CURVE) CASSUMES ALL LWT is coarse grained)

size	finer by wt
1/2"	62%
#40 sieve	31%

A. $(100\% - 31\% - 38\%) \times 90\% = 27.9\%$

B. 675,000 CY YDS required for drainage layer

C. $LWT_{Reqd\ to\ be\ processed} = \frac{675,000}{27.9\%} = 2,419,935$ cu yd

2,419,935 < 8,886,000 OK

D. fines developed = $(2,419,935 cu yd) \times 31\% \times 90\% = 675,162$ cu yd

E. fines available for geosynthetic subsoil = 675,162 − 78,300 = 596,862 cu yd.

F. geosynthetic subsoil required = 746,659 CY

G. Volume Ratio $\frac{AVAIL.}{REQD} = \frac{596,862}{746,659} = 80\%$ OR 80% of fines required for geosynthetic subsoil will be available from drainage layer screenings.

746,659 − 596,862 = 150,097 cu yd

(extra yards to be process) x 31% x 90% = 150,097 cu YD

OR EXTRA YARDS to be process = $150,097 \left(\frac{1}{(31\%)(90\%)}\right)$ = 537,982 cu yd

2,419,935 cu YD + 537,982 cu Y = 2,957,917 cu YD < 8,886,000 CU YD

∴ There is enough LWT to Generate all fines.

Foth & Van Dyke

Client: CRAWFORD Mining Co. Scope I.D.: 93C049
Project: TMA TILL Page: 20
Prepared by: JBHI Date: 2/7/96
Checked by: N. P Date: 2-13-96

fine LWT check

- perform steps A thru G using fine grained gradation from X AVE CURVE
- Assumes All LWT is fine grained

size	finer by wt
1/2"	99%
#40 sieve	81%

A. $(100\% - 81 - 1)\,90\% = 16.2\%$

B. 675,000 cy req'd for drainage layer

C. $LWT_{\text{RQD to be processed for drainage layer}} = \frac{675{,}00}{16.2\%} = 4{,}166{,}667$ cy yds

$4{,}166{,}667 < 8{,}886{,}000$ OK

D. Fines developed = $(4{,}166{,}667)(81\%)(90\%) = 3{,}037{,}500$ cu yd

E. Fines available for geosynthetic subsoil = 3,037,500 - 78,300 = 2,959,200 cy.

F. Geosynthetic subsoil required = 746,659 cy

G. Volume ratio $\frac{\text{AVAIL}}{\text{REQ'D}} = \frac{2{,}959{,}200}{746{,}659} = \underline{4.0}$

Therefore, if 100% of LWT was found to be graded like the fine grained outlier on the X AVE CURVE, then there would be enough drainage layer material, fine till layer and geosynthetic subsoil layer.

The Quantity check verifies that there is enough LWT to manufacture the DRAINAGE Layers, the fine till layer and geosynthetic subsoil layers in all cases. Therefor strict control of gradation is not required due gross volume.

Foth & Van Dyke

Client: CRAWDON Mining Co Scope I.D.: 93C049
Project: TMA TILL Page: 21
Prepared by: JBH Date: 2/7/96
Checked by: N.P. Date: 2-13-96

GRADATION REQUIREMENTS

It is proposed to use the minus #40 sieve material sieved during the screening of the LWT during generation of the drainage layer for use as the 1 foot thick geosynthetic subgrade. This sieved material will be generaly well-graded ($C_u > 6$) and will contain a substantial amount of fines (p200). To verify this and to estimate the soil gradation characteristics and permeability ranges, 14 soil samples which were taken from 7 soil boring locations across the TMA site will be evaluated. The soil gradation curve from each sample will be analyzed to determine the Cu value, D_{10} values and p200 values. These curves will then be adjusted to simulate screening through a #40 sieve. The #40 sieve percentage will be adjusted to 100%. The remaing finer sieve quantities will be adjusted accordingly and the Cu values, D_{10} values and p200 values will be recalculated. Theoretical permeability values will be determined based on A HAZEN's equation $K = 100\ D_{10}^2$ where D_{10} is in centimeters, k in cm/s The following - "Soil GRADATION DATA" TABLE summarizes the calculations:

Soil Gradation Data

Recalculated Values based on #40 sieve

Boring	Sample Depth (ft)	Cu	p200(%)	D_{10}	permeability K (cm/s)	$C_{U(40)}$	p200(%) (40)	D_{10} (40)	K (cm/s) (40)
EX-9	20.0 to 22.0	~22	12	~0.05	~2.5×10^{-3}	3.1	9	0.09	8×10^{-3}
	30.1 to 31.5	26	17	0.019	3.6×10^{-4}	~70	~27	~0.003	9×10^{-6}
						57	28	.0035	1.2×10^{-5}
EX 10	10.5 - 12.5	32	36	0.006	3.6×10^{-5}	33	44	.0045	2.0×10^{-5}
G41-G11	0 - 1.5	26	32	0.0012	1.4×10^{-6}	228	50	<0.001	$< 1 \times 10^{-6}$
	10 - 11.5	9	17	~0.007	4.9×10^{-5}	"	32	"	"
	20 - 21.5	10	18	~0.007	4.9×10^{-5}	"	32	"	"
G41-G12	14.5 - 16.0	~55	17	~.02	$\sim 4 \times 10^{-4}$	—	39	—	—
	19.5 - 21.0	~90	18	~.01	$\sim 1 \times 10^{-4}$	—	38		
G41 - H9	21.0 - 22.5	~60	18	~0.01	$\sim 1 \times 10^{-4}$	~44	33	—	—
G41 - H13	0 - 1.5	51	35	0.0055	3×10^{-5}	48	54	0.0035	6.2×10^{-6}
	29.0 - 30.5	~33	23	—	—	—	40	—	—
G41 - K13A	5.0 - 6.5	420	22	~.001	$\sim 1 \times 10^{-4}$	>200	36	<0.001	$< 1 \times 10^{-6}$
	35.0 - 35.3'	580	20	~.001	$\sim 1 \times 10^{-1}$	>200	36	<0.001	$< 1 \times 10^{-6}$

Note all values with "~" are estimates based on extending the gradation curve beyond the last sieve size analyzed in the lab.

All samples are generally in or near the WLT that will be excavated within the TMA.

Foth & Van Dyke

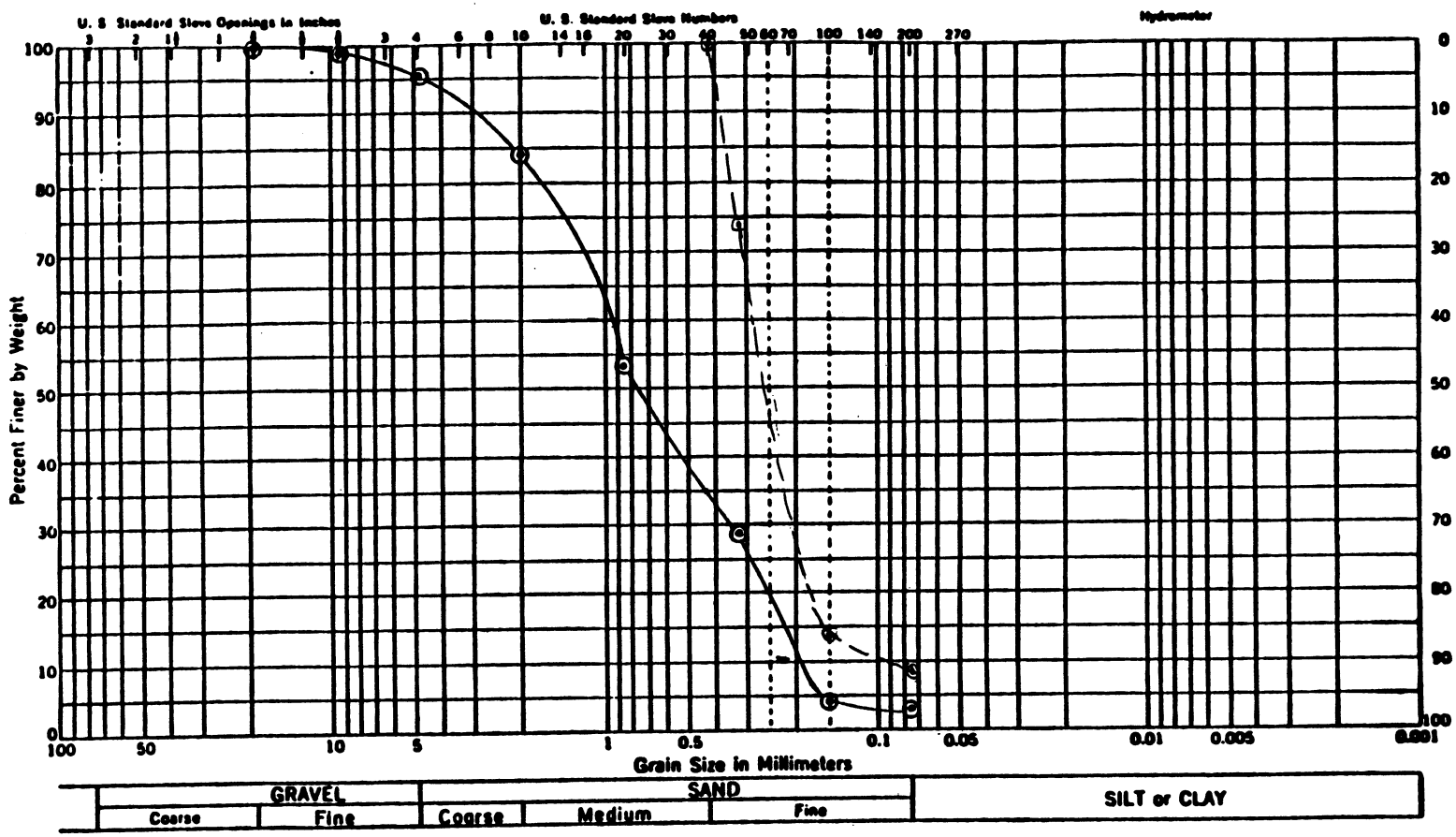
Client: CR Kenyon Mining Co. Scope I.D.: 936049

Project: TMA Till Page: 22

Prepared by: JBH Date: 2/8/96

Checked by: N+P Date: 2-13-96

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
EX-9	4.9				Fine to coarse sand (SP)
S-A					
4.0-6.0'					$C_u = \frac{D_{60}}{D_{10}} = \frac{0.91}{0.20} = 4.5$
					$C_u = \frac{D_{60}}{D_{10}} = \frac{0.29}{0.09} = 3.2$
					$D_{10} = .09$

EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

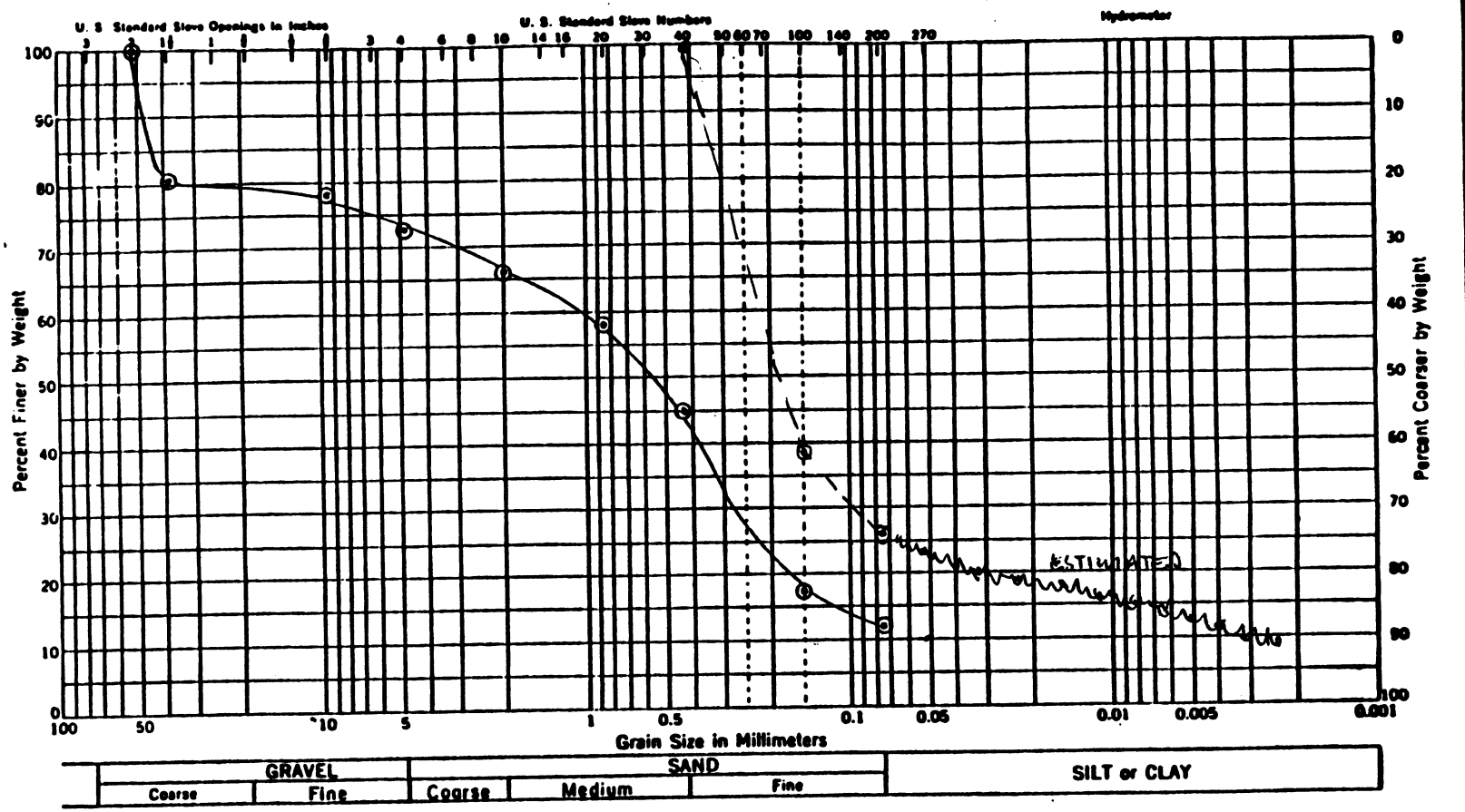
DRAWN	APPROVED	DATE	JOB No.
JJT	JAS	4-2-84	12959

3.5-19-94

BB 302

23

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
EX-9	5.7				silty fine to coarse sand (SM)
S-2					
20.0-22.0'					$C_u = \frac{D_{60}}{D_{10}} \approx \frac{1.1}{.05} = 22$
					$C_u = \frac{0.21}{.003} = 70$
					$D_{10} = 0.003$

EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
JJT	JAS	4-2-84	12959

3.5-19-95

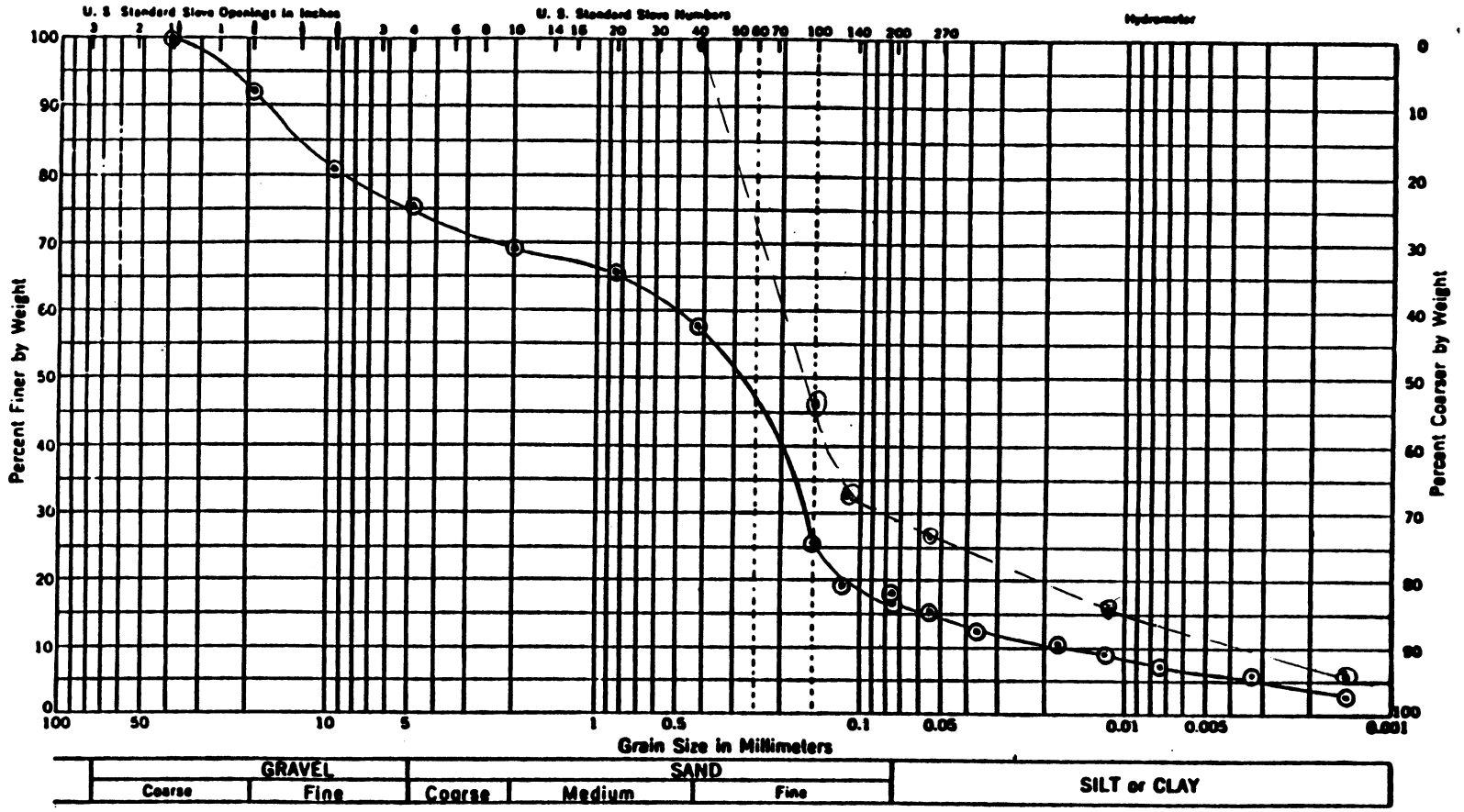
P15

100 = 17/45 = 38
200 = 12/45 = 27

24

P2500202

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
EX-9	4.1				Silty fine to coarse sand (SM)
S-3					
30.1-	31.5'				$C_u = \frac{D_{60}}{D_{10}} = \frac{0.5}{.019} = 26$
					$C_u = \frac{D_{40}}{D_{10}} = \frac{0.12}{.0035} = 57$
					$D_{10} = .0035$

EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
JJT	JAS	4-2-84	12959

576

$100 = \frac{26}{57} = 46$

$0.12 = \frac{19}{57} = 33.3$

$0.035 = \frac{15.5}{57} = 27.2$

$.011 = \frac{9}{57} = 15.9$

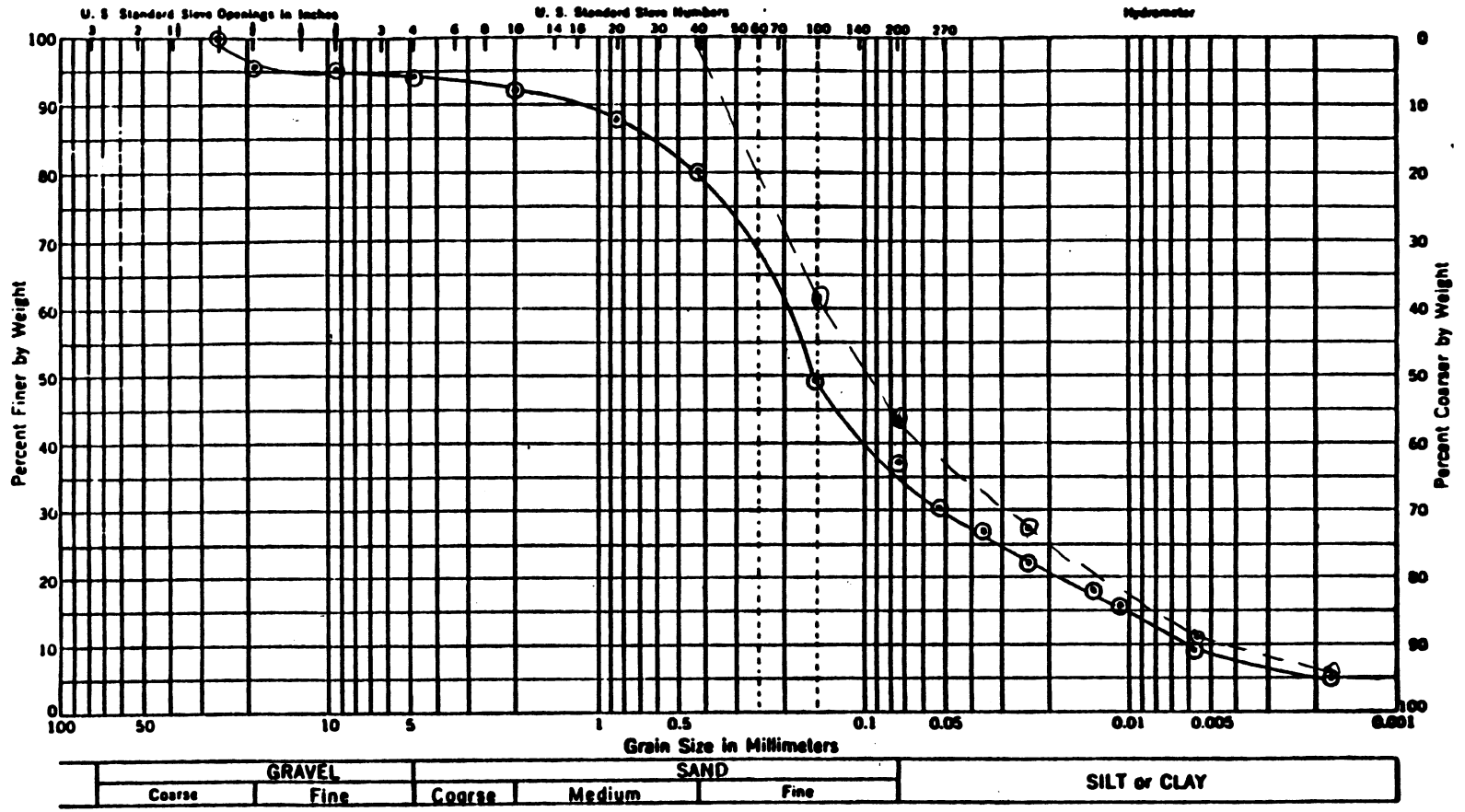
$.0015 = \frac{3}{57} = 5.3$

3.5-19-96

52

BBS 202

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
EX-10	14.6				Silty fine to medium sand (SM)
S-1					
10.5-12.5'					$C_u = \frac{D_{60}}{D_{10}} = \frac{0.19}{.0060} = 31.7$
					$C_c = \frac{D_{60}}{D_{10}} = \frac{0.15}{.0045} = 33$
					$D_{10} = .0045$

EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
JJT	JAS	4-2-84	12959

80%

100 = 19/80 = 61.2

200 = 35/80 = 43.8

.025 = 22/80 = 27.5

.0051 = 9/80 = 11.2

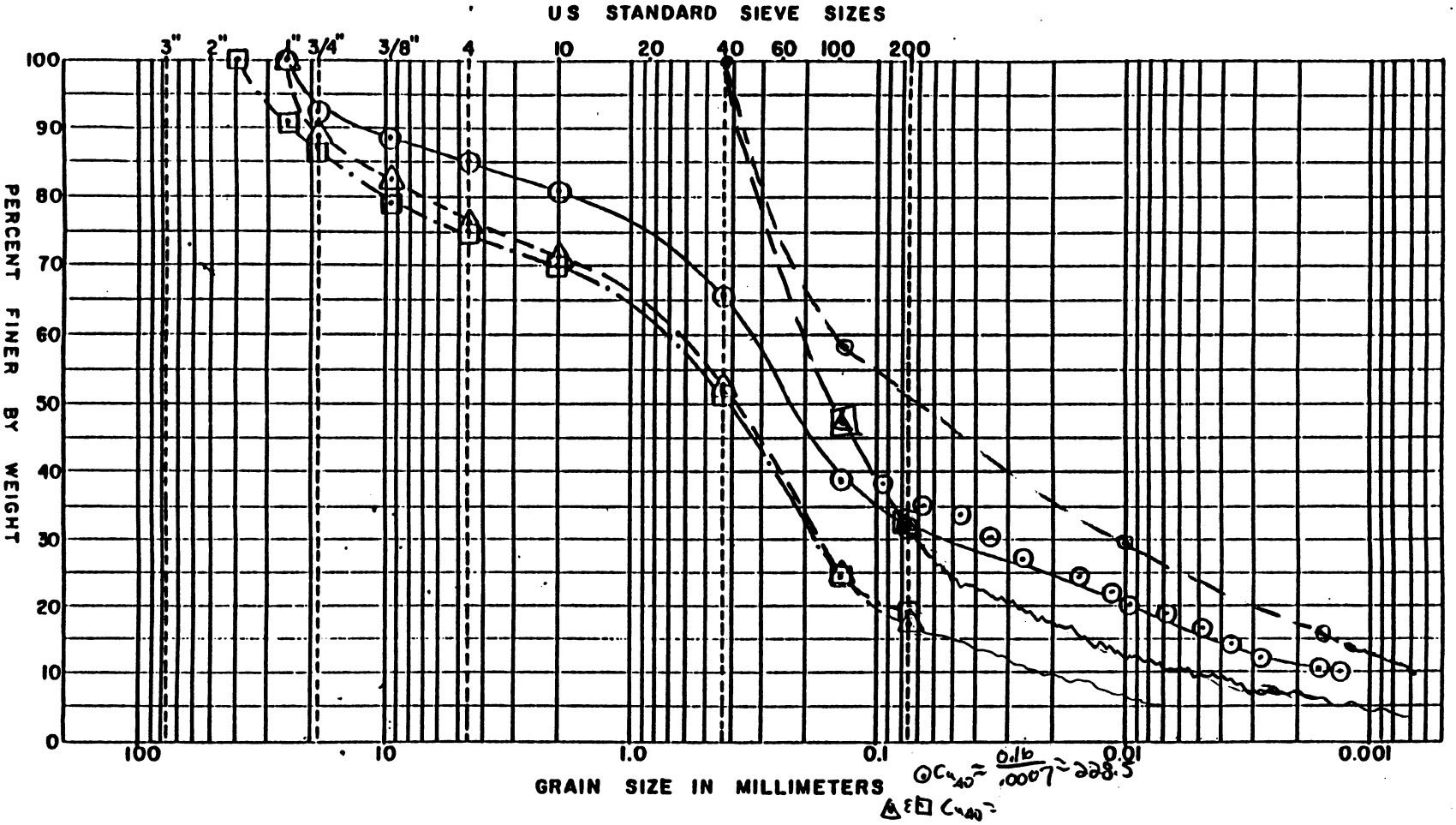
.0018 = 5/80 = 6.25

3.5-19-108

92

Date 5/30/79
Job No. 786085

GRAIN SIZE DISTRIBUTION



COBBLES	GRAVEL		SAND			FINES	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

BORING NO.	ELEV. OR DEPTH	W_n	W_L	W_p	I_p	DESCRIPTION OR CLASSIFICATION
G41-G11 SA-1	0.0m-0.46m (0.0'-1.5')	$C_u = D_{60}/D_{10}$	= 0.33/.012 =	-	26	Red-brown, silty, fine to coarse SAND, some fine to coarse gravel, some clay (SM)
SA-4	3.05m-3.51m (10'-11.5')	$C_u = D_{60}/D_{10}$	= 0.10/0.007 =	-	8.8	Red-brown, fine to coarse gravelly, fine to coarse SAND, some silt, trace clay (SM)
SA-6	6.10m-6.55m (20'-21.5')	$C_u = D_{60}/D_{10}$	= 0.16/.007 =	-	-	Red-brown, fine to coarse gravelly, fine to coarse SAND, some silt, trace clay (SM)

Golder Associates 3.5-17-71

Drawn AST
Checked JFC
Approved JFC

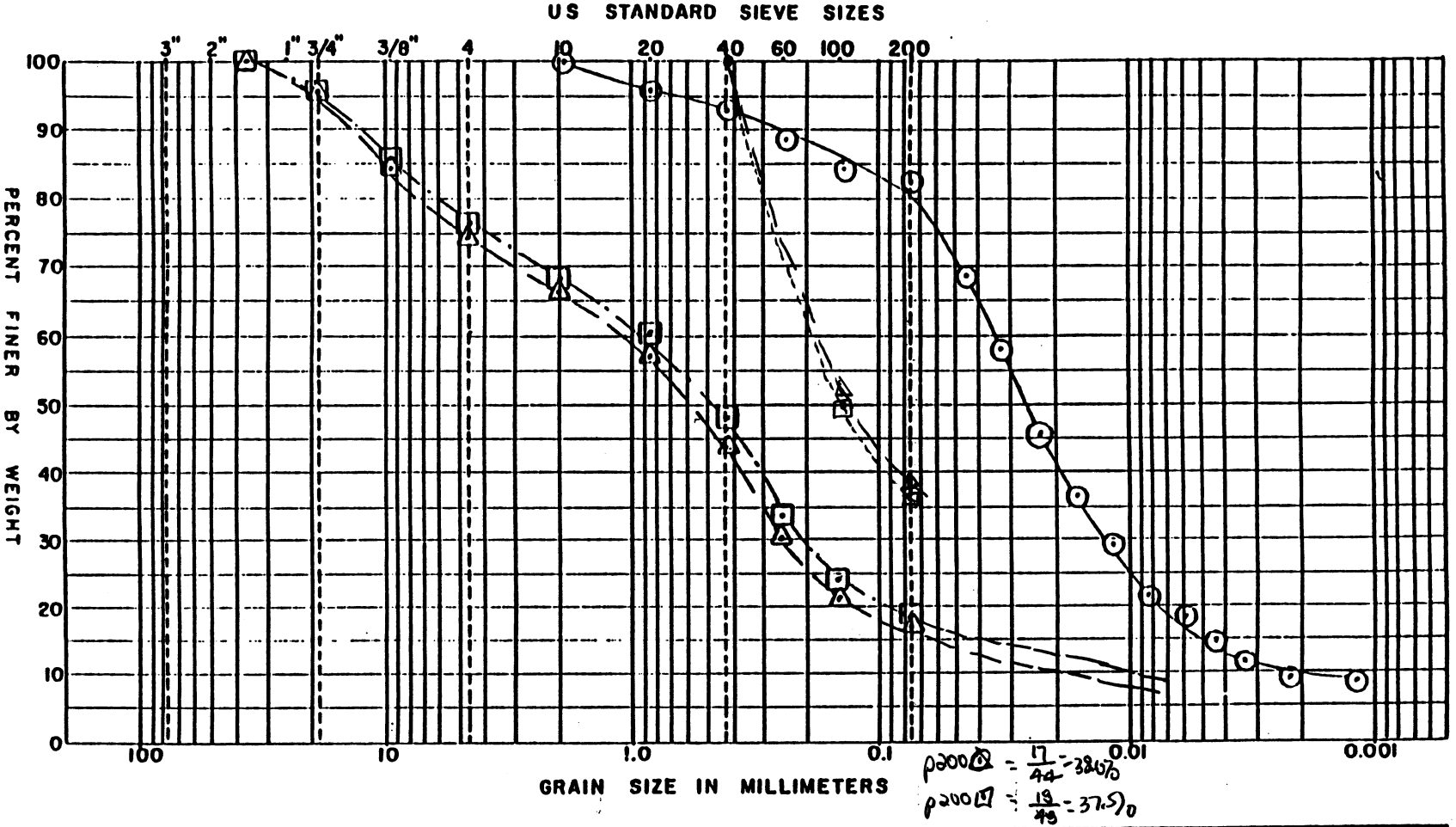
FIGURE 4.27

Date 6/7/79
Job No. 790035

Golder Associates 3.5-17-73

Drawn JTS
Checked JEC
Approved JFC

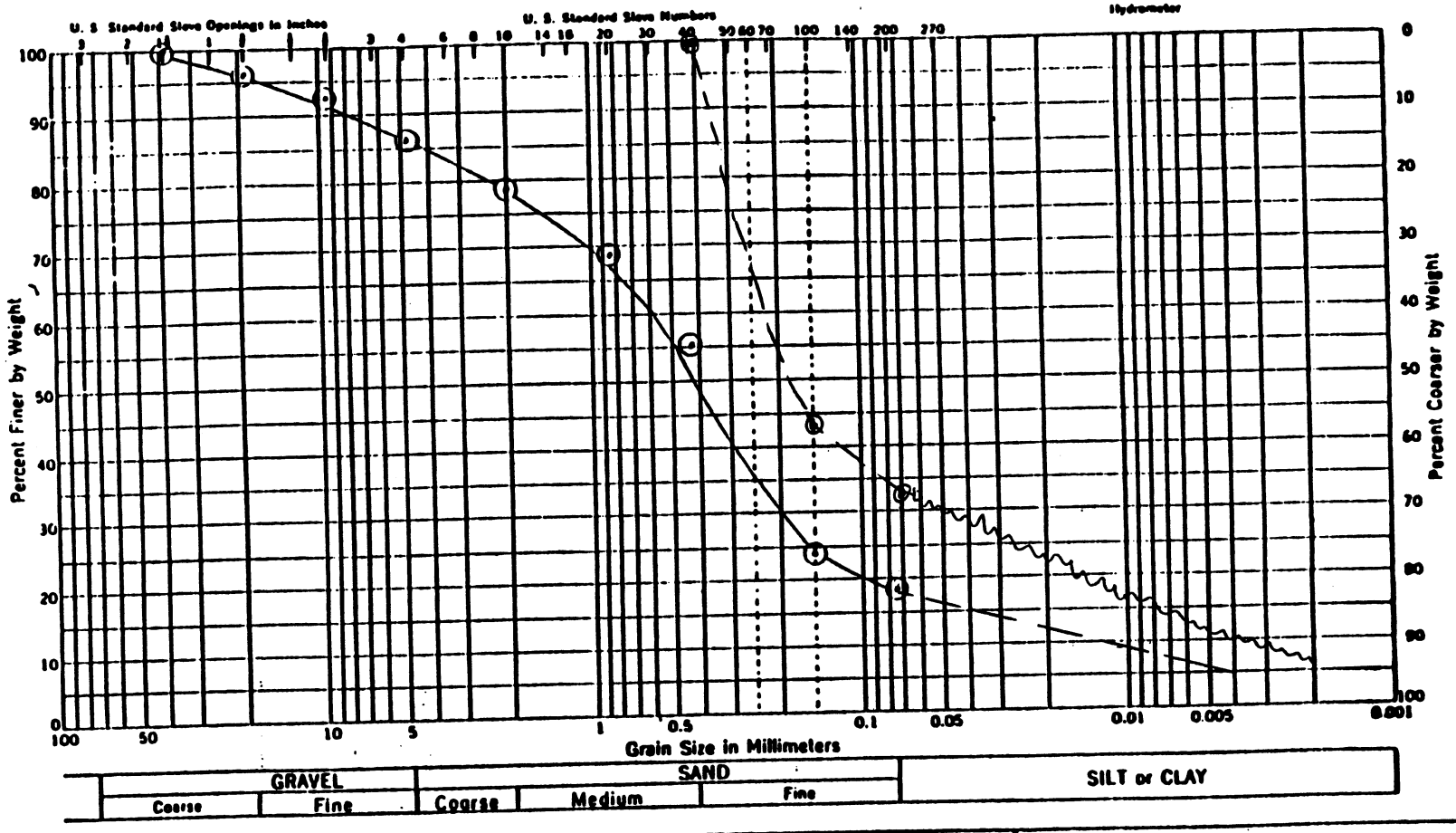
GRAIN SIZE DISTRIBUTION



COBBLES	GRAVEL		SAND			FINES	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

BORING NO.	ELEV. OR DEPTH	w_n	w_L	w_p	I_p	DESCRIPTION OR CLASSIFICATION
G41-G12 SA-1 —⊙—	0.0m-0.46m (0.0'-1.5')	-	NP	NP	NP	Red-brown, SILT, some fine to medium sand, trace clay (ML)
SA-4 --△--	4.42m-4.88m (14.5'-16.0')	$C_u = \frac{D_{60}}{D_{10}} = \frac{1.1}{0.02} = 55$	-	-	-	Red-brown, fine to coarse gravelly, fine to coarse SAND, some silt, trace clay (SM)
SA-5 --⊡--	5.94m-6.40m (19.5'-21.0')	$C_u = \frac{D_{60}}{D_{10}} = \frac{0.9}{0.01} = 90$	-	-	-	Red-brown, fine to coarse gravelly, fine to coarse SAND, some silt, trace clay (SM)

FIGURE 28



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
G41 H9					Silty fine to coarse sand (SM)
SA-3					
21-22.5'					$C_u = \frac{D_{60}}{D_{10}} = \frac{0.6}{0.01} \approx 60$
					$C_u \approx \frac{.22}{.005} \approx 44$

EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
SMD	JAS	5-18-84	12959

@ 55%

100: $\frac{24}{55} = 43.6\%$

200: $\frac{18}{55} = 32.7\%$

.005: $\frac{5}{55}$

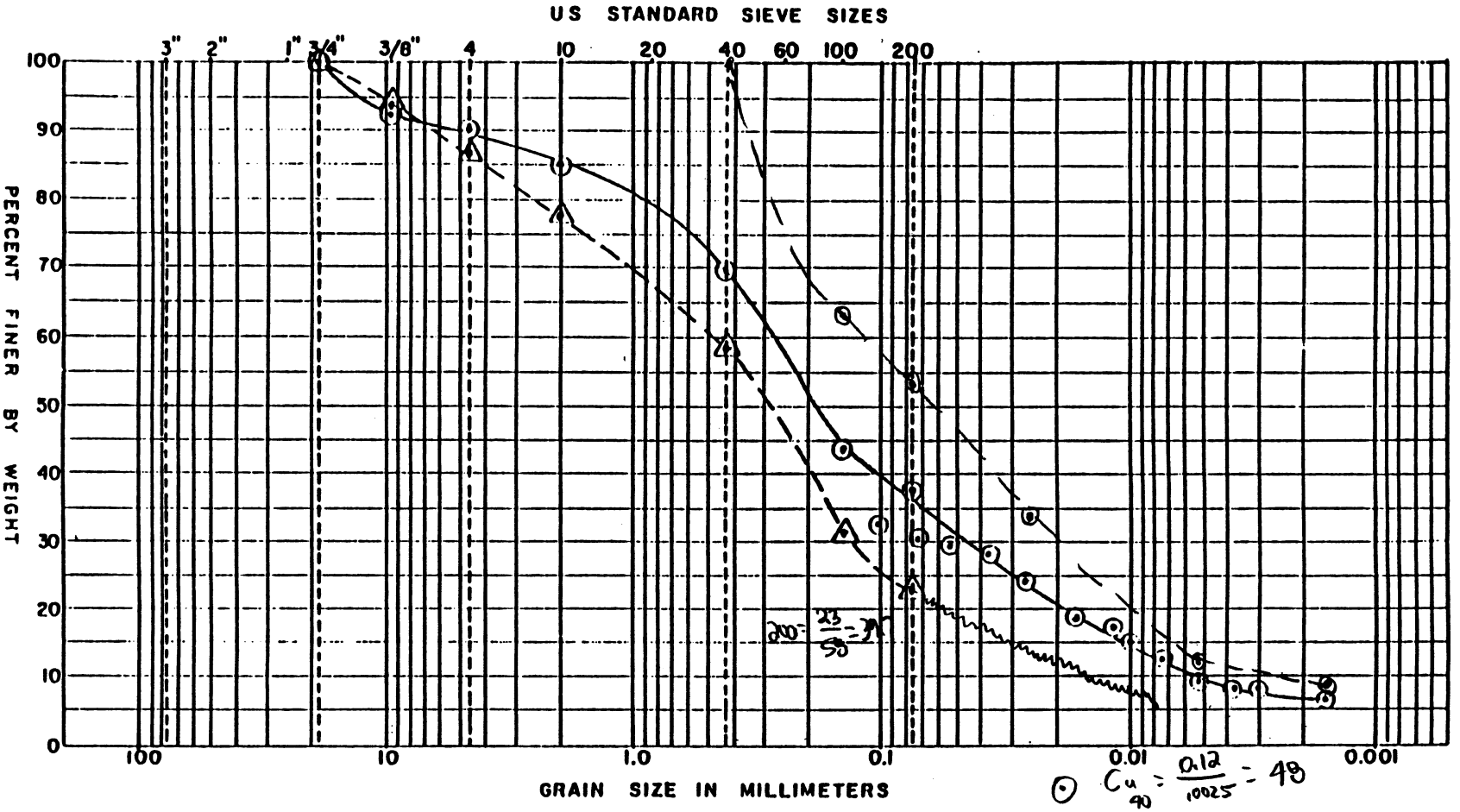
3.5-21-72

9302

29

Date 5/30/79
Job No 786035

GRAIN SIZE DISTRIBUTION



COBBLES	GRAVEL		SAND			FINES	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

BORING NO.	ELEV. OR DEPTH	W_n	W_L	W_p	I_p	DESCRIPTION OR CLASSIFICATION
G41-1113 SA-1 —⊙—	0.0m-0.46m (0.0'-1.5')	$C_u = \frac{D_{60}}{D_{10}}$	$\frac{0.28}{.0055}$	= 50.9	-	Brown to dark brown, silty fine to coarse SAND, some fine gravel, trace clay (SM)
SA-7 --△--	8.84m-9.30m (29'-30.5')	$C_u = \frac{D_{60}}{D_{10}}$	$= \frac{0.49}{.015}$	= 32.7	-	Brown, silty fine to coarse SAND, some fine gravel, trace clay (SM)

Golder Associates 3.5-17-91

Drawn AST
Checked JFC
Approved JFC

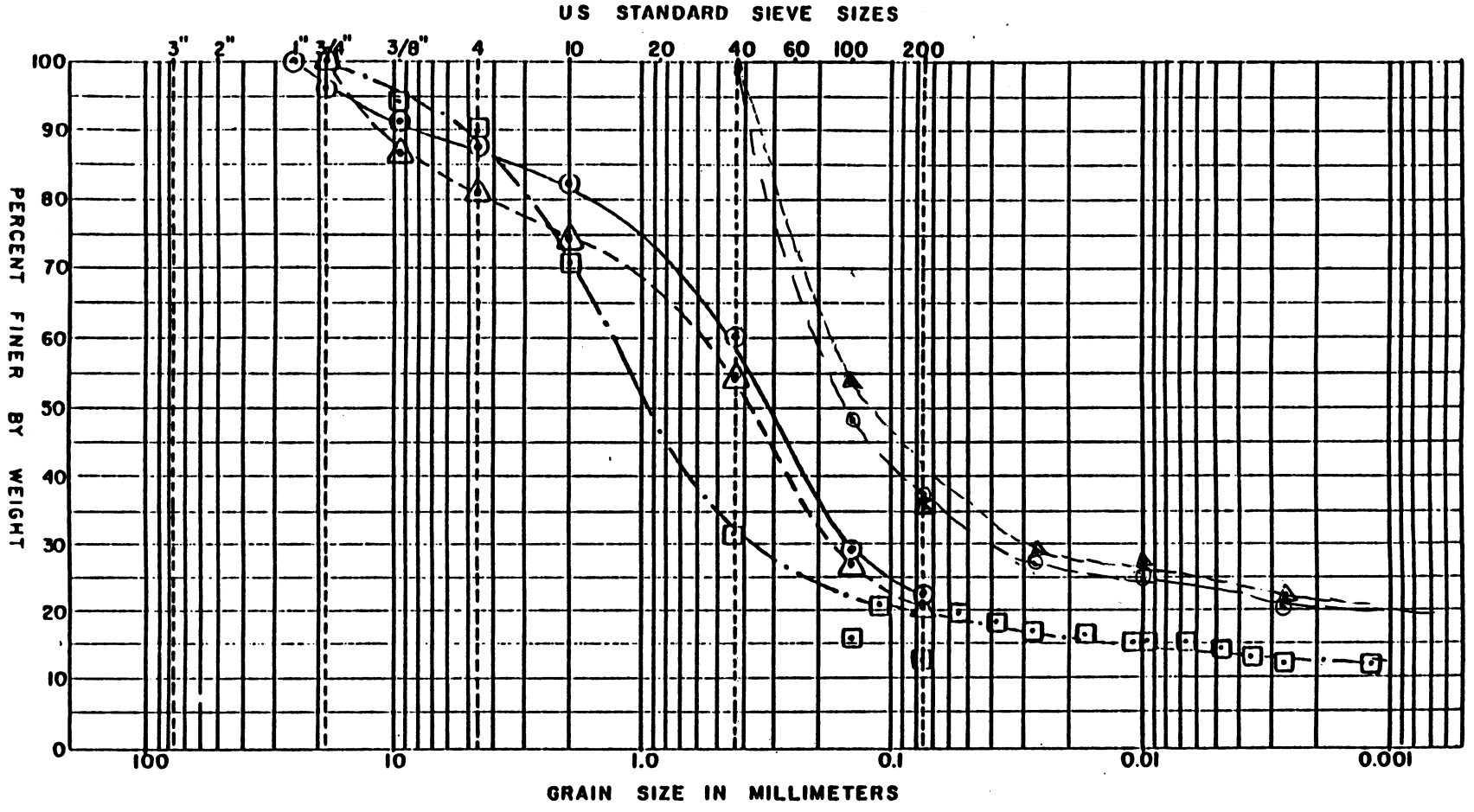
FIGURE 30

Date 5/30/79
Job No. 786085

Golder Associates 3.5-17-107

Drawn AST
Checked JFC
Approved JFC

GRAIN SIZE DISTRIBUTION



COBBLES	GRAVEL		SAND			FINES	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

BORING NO.	ELEV. OR DEPTH	w_n	w_L	w_p	I_p	DESCRIPTION OR CLASSIFICATION
G41-K13A SA-2 ○	1.52m-1.98m (5'-6.5')	$C_u = \frac{D_{60}}{D_{10}}$			420	Red-brown, fine to coarse SAND, some fine to coarse gravel, some silt, trace clay (SM)
SA-8 △	10.67m-10.76m (35'-35.3')	$C_u = \frac{D_{60}}{D_{10}}$			580	Brown, fine to coarse SAND, some fine gravel, some silt, trace clay (SM)
SA-13 □	18.29m-18.47m (60'-60.6')	-	-	-	-	Red-brown, fine to coarse SAND, some fine gravel, some clay, trace silt (SM)

○ $C_u = \frac{0.2}{.001} \approx > 200$

△ $C_u = \frac{0.19}{.001} = > 190$ say > 200

5'-6.5'
○ 60%
100 = 29/60 = 48.3
200 = 22.5/60 = 37.5
.02 = 16/60 = 26.7
.01 = 15/60 = 25
0.005 = 13/60 = 21.7

△ 55%
100 = 27/55 = 49
200 = 20/55 = 36.3
0.02 = 13/55 = 24
.01 = 12/55 = 21.8
.005 = 11/55 = 20

FIGURE 31

Foth & Van Dyke

Client: CRANDON Mining Co. Scope I.D.: 930049
Project: TMA TILL Page: 32
Prepared by: JBH1 Date: 2/8/96
Checked by: N x P Date: 2-13-96

GRADATION REQUIREMENTS

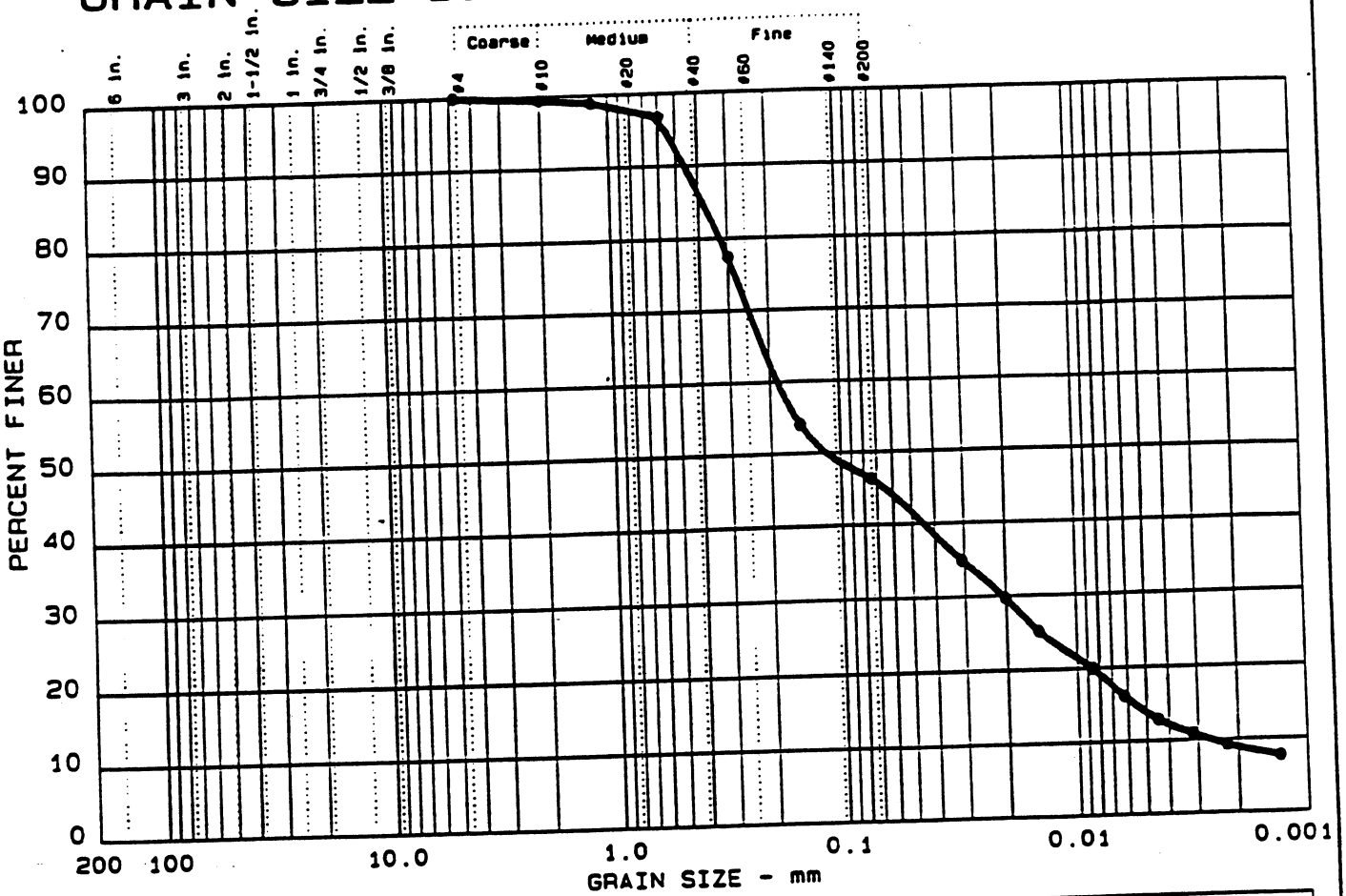
BASED UPON The results of the analysis of the 14 soil samples obtained within the area of the TMA, the following can be seen:

- Only sample EX-9, 4 to 6 ft was found to be too coarse after screening to be estimated to have a permeability greater than 1×10^{-4} cm/s.
- The soil surrounding EX-9, to a depth of 10' consists of approximately 20,000 to 30,000 cy.
- The existing WLT that will be excavated has permeabilities ranging from 4×10^{-2} cm/s (EX 9, 4 to 6') TO 1.4×10^{-6} cm/s as estimated by the HAZEN FORMULA
- The recalculated gradation curves based on sieving the WLT Through a #40 sieve, show an almost doubling of the D60 percentage within the modified soil as compared to the original soil.
- The recalculated gradation curves also show a drop in permeability by one to two orders of magnitude based on the Hazen formula
- The recalculated permeabilities based on the Hazen formula varied from $< 1 \times 10^{-6}$ cm/s TO 2×10^{-5} cm/s (if EX-9, 4 to 6' is excluded.
- All the soil samples, except for EX 9, 4 to 6' had Cu values greater than 6 which indicates a generally well graded material.

AS A CHECK ON PERMEABILITIES, A QUICK REVIEW OF DATA EXISTING FROM ONSITE SOIL SAMPLES WAS PERFORMED. TWO soil gradation curves WERE FOUND that closely resembled the gradation curve shape and size distribution were found and the data is attached:

Soil Sample		Measured permeability
CMC-BO-101B	4 to 6'	1.0×10^{-6} TO 1.2×10^{-6} cm/s
CMC-SL-104	4 to 6'	1.7×10^{-6} TO 1.8×10^{-6} cm/s

GRAIN SIZE DISTRIBUTION TEST REPORT



Symbol	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
•	0.0	0.0	53.7	32.5	13.8

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
•	19	5	0.38	0.18	0.12	0.020	0.0056	0.0026	0.85	70.8

MATERIAL DESCRIPTION	USCS
• Brown silty, clayey fine to medium SAND	SC-SM

Project No.: 4E05140
Project: CRANDON MINING CO
• Sample: CMC-BO-101B, 4-6'

Date: APRIL 14, 1994

GRAIN SIZE DISTRIBUTION TEST REPORT
WOODWARD-CLYDE CONSULTANTS

Remarks:

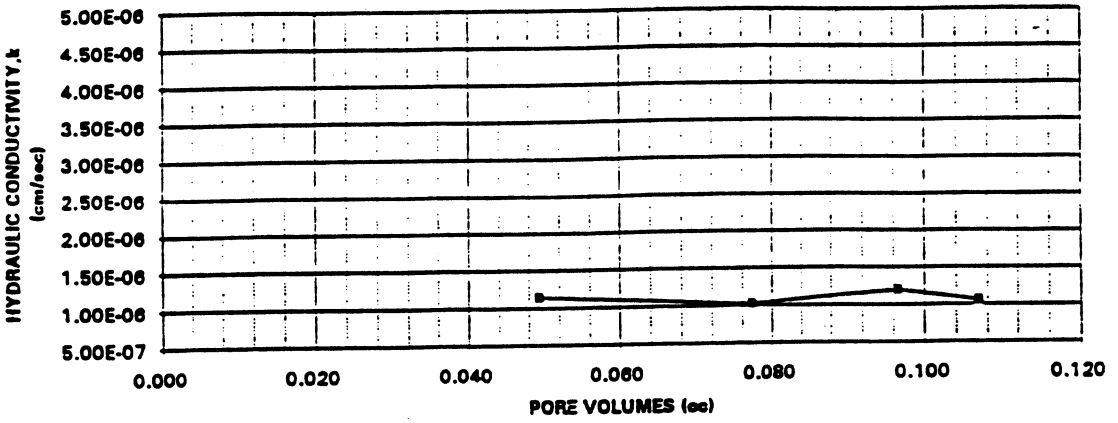
Tested by: NL

Checked by: GTS

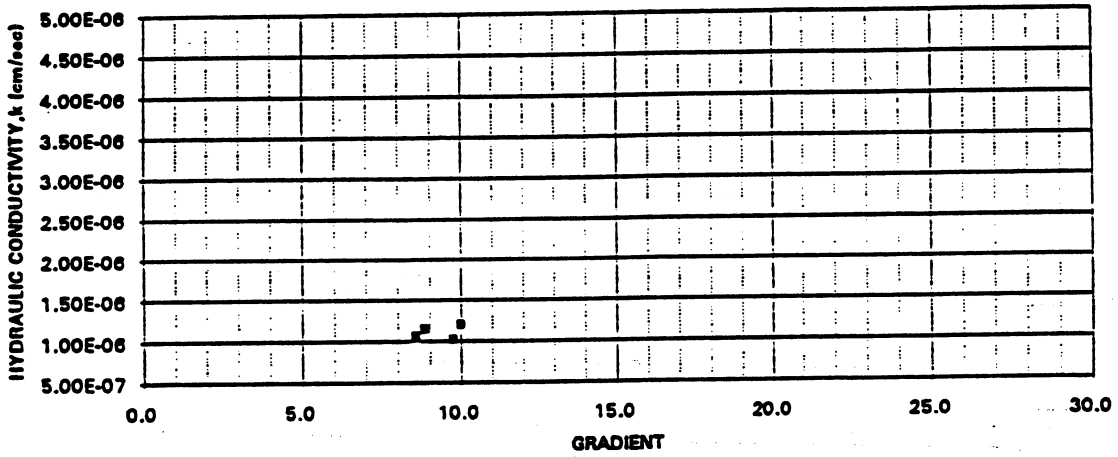
Sheet No. _____

TEST REPORT

HYDRAULIC CONDUCTIVITY VS. PORE FLOW



HYDRAULIC CONDUCTIVITY VS. GRADIENT



SPECIMEN NO: BO - 101B 4'-5'

SPECIMEN DESCRIPTION: Brown silty clayey fine to medium SAND

	INITIAL	FINAL		
SPECIMEN DIAMETER (cm)	7.18	7.18	AVERAGE BACKPRESSURE (psi)	50.0
SPECIMEN AREA, A (cm)	40.49	40.49	MAXIMUM EFFECTIVE CONFINING STRESS (psi)	5.04
SPECIMEN LENGTH, L (cm)	6.35	6.30	MINIMUM EFFECTIVE CONFINING STRESS (psi)	4.06
SPECIMEN VOLUME,V (cc)	257.11	255.08	CUMULATIVE PORE VOLUMES FLOW	0.11
WATER CONTENT (%)	16.4	16.3	PERMEANT	WATER
DRY DENSITY (pcf)	115.7	116.0		
SATURATION,n (%)	97.0	97.2	AVERAGE HYDRAULIC CONDUCTIVITY,k (cm/sec)	1.1E-06

PROJECT: CRANDON MINING CO.

PROJECT NUMBER: 4E05140

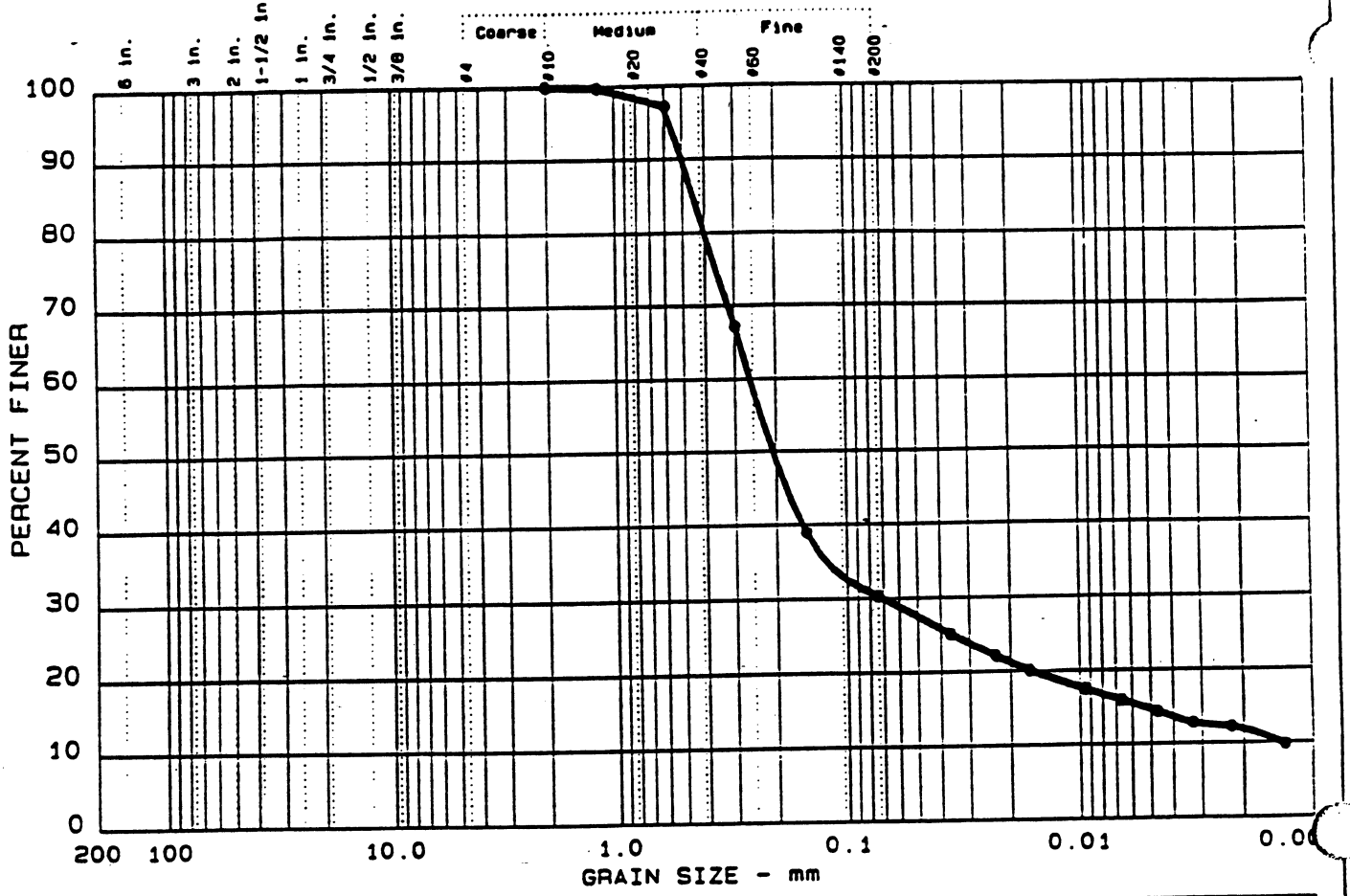
FLEXIBLE WALL HYDRAULIC CONDUCTIVITY

Woodward-Clyde Consultants

CHECKED BY: GB REVIEWED BY: JM DATE: 19-Apr-94

File:BO101B46.XLS

GRAIN SIZE DISTRIBUTION TEST REPORT



Symbol	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.0	69.7	15.6	14.7

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_C	C_U
●	16	4	0.45	0.26	0.21	0.071	0.0052	0.0014	14.26	188.8

MATERIAL DESCRIPTION	USCS
● Brown silty clayey fine to medium SAND	SC-SM

Project No.: 4E05140
Project: CRANDON MINING CO
● Sample: CMC-SL-104, 4-6'

Date: APRIL 14, 1994

GRAIN SIZE DISTRIBUTION TEST REPORT

WOODWARD-CLYDE CONSULTANTS

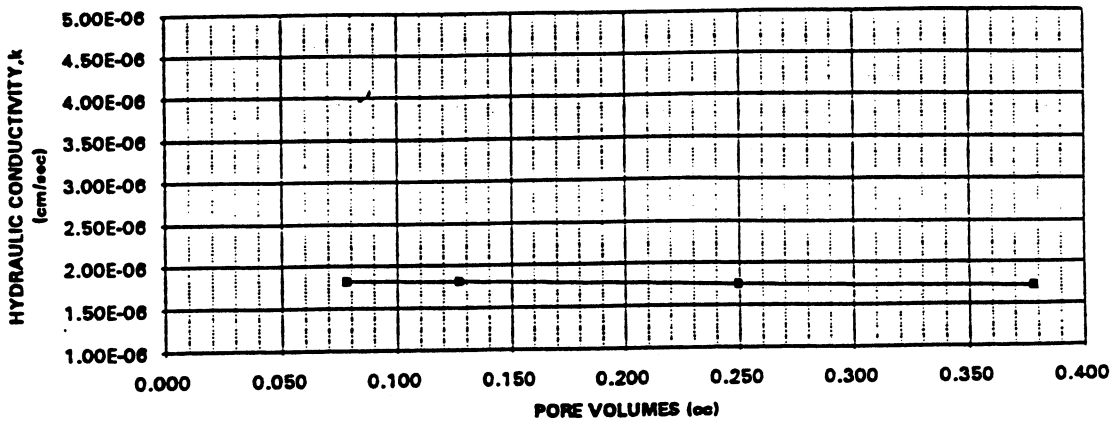
Remarks:

Tested by: NL

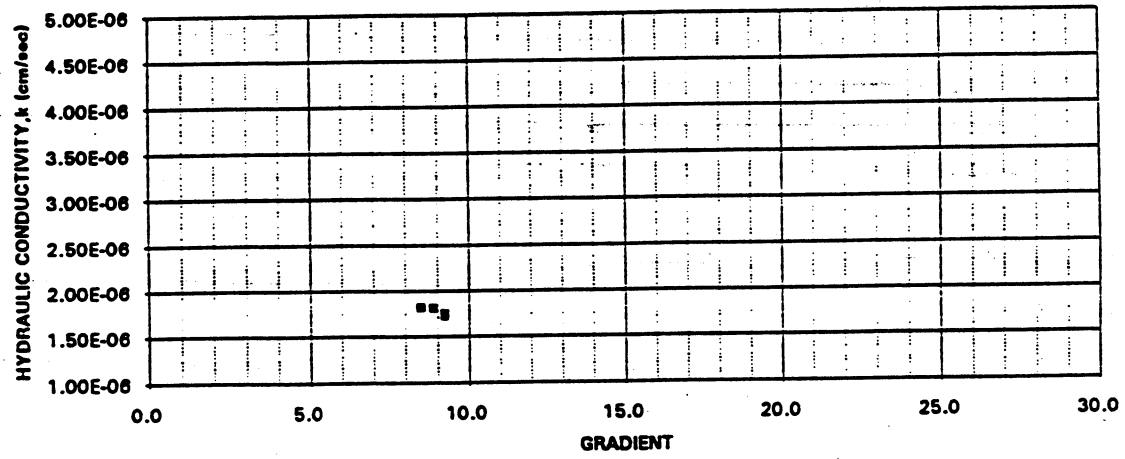
Checked by: CJS

Sheet No. _____

HYDRAULIC CONDUCTIVITY VS. PORE FLOW



HYDRAULIC CONDUCTIVITY VS. GRADIENT



SPECIMEN NO: SL - 104 4'-5'

SPECIMEN DESCRIPTION: Brown silty clayey fine to medium SAND

	INITIAL	FINAL		
SPECIMEN DIAMETER (cm)	7.18	7.18	AVERAGE BACKPRESSURE (psi)	50.0
SPECIMEN AREA, A (cm)	40.49	40.49	MAXIMUM EFFECTIVE CONFINING STRESS (psi)	5.0
SPECIMEN LENGTH, L (cm)	6.30	6.19	MINIMUM EFFECTIVE CONFINING STRESS (psi)	5.0
SPECIMEN VOLUME,V (cc)	255.08	250.63	CUMULATIVE PORE VOLUMES FLOW	0.50
WATER CONTENT (%)	14.1	15.1	PERMEANT	WATER
DRY DENSITY (pcf)	116.2	117.9		
SATURATION,n (%)	84.7	95.0	AVERAGE HYDRAULIC CONDUCTIVITY,k (cm/sec)	1.8E-06

PROJECT: CRANDON MINING CO.

PROJECT NUMBER: 4E05140

FLEXIBLE WALL HYDRAULIC CONDUCTIVITY

Woodward-Clyde Consultants

CHECKED BY: GJS REVIEWED BY: JM DATE: 14-

File:SL10446.XLS

Foth & Van Dyke

Client: CRANDON Mining Co. Scope I.D.: 93C049
Project: TMA TILL Page: 37
Prepared by: JBH1 Date: 2/8/96
Checked by: N & P Date: 2-13-96

GRADATION REQUIREMENT

BASED ON known data and existing conditions of the TMA site, the following specifications are recommended to be used to construct the one foot thick, geosynthetic subsoil layer:

Soil shall consist of LWT with the following characteristics:

p #40 sieve	100%
p200	>10%
Cu valve	>6

Compaction Requirements

The one foot thick, geosynthetic subsoil layer shall be constructed in 6" lifts and compacted to 95% modified proctor.

Attachment 12

Derivations for Upper and Lower Decision Boundaries for Liner Sequential Testing for the Crandon Project

Derivations of Upper and Lower Decision Boundaries for Liner Sequential Testing for the Crandon Project

The upper and lower decision boundaries in Figure 12 of the text were established using sequential test statistics. To accomplish this it was necessary to construct decision boundaries under two sets of hypotheses. The first hypothesis was that the true mean defects per acre is less than or equal to four, with the alternative being the true mean defects per acre is greater than four. The second hypothesis was that the true mean defects per acre is less than or equal to six, with the alternative being the true mean defects per acre is greater than six.

The two sets of hypotheses were used to construct decision boundaries capable of determining whether the true mean is less than or equal to four, less than or equal to six but greater than four, or greater than six. The Type I error rate (false positive) for the upper decision boundaries under both sets of hypotheses was set at 0.05. For the first hypothesis, (i.e., the average number of defects per acre is less than or equal to four) this implies that a 5 percent or smaller chance exists of concluding quality assurance procedures need adjustment, when in fact the average number of defects per acre is less than or equal to four. For the second hypothesis (i.e., the average number of defects per acre is less than or equal to six) this implies that a 5 percent or smaller chance exists of concluding the entire liner needs monitoring when in fact the average number of defects per acre is less than six.

The Type II error rate (false negative) for the lower decision boundary under both sets of hypotheses was also set a 0.05. For the first hypothesis this implies that only a 5 percent or smaller chance exists of accepting the integrity of the liner without adjusting quality assurance procedures when in fact quality assurance procedures should be adjusted. For the second hypothesis this implies that only a 5 percent or smaller chance exists of accepting the integrity of the liner with adjusted quality assurance procedures when in fact the entire liner should be tested.

In constructing the decision boundary plot (Figure 12) for use in the field, the two tests (i.e., two sets of hypotheses) were combined. The lower decision boundary in Figure 12 was developed from the lower boundary calculated under the first hypothesis. Dropping below this decision boundary indicates that the true mean is less than or equal to four. The upper decision boundary in Figure 12 was developed from the upper boundary calculated under the second hypothesis. Therefore, going above this boundary indicates that the true mean is greater than six. The "wedge" which appears after sample number 16 in Figure 12 was constructed from the upper boundary of the first hypothesis and the lower boundary of the second hypothesis. Therefore, falling into this "wedge" implies the true mean is greater than four, but less than or equal to six.

Foth & Van Dyke

Client: CMC Scope I.D.: 93C049
Project: FML Page: 1/5
Prepared by: SGL Date: 2/6/96
Checked by: XXC Date: 2/6/96

Likelihood Ratio (Poisson Distribution)

$$\frac{L_{1n}}{L_{on}} = \frac{\prod_{i=1}^{n} e^{-\mu_1} \frac{\mu_1^{x_i}}{x_i!}}{\prod_{i=1}^{n} e^{-\mu_0} \frac{\mu_0^{x_i}}{x_i!}}$$

Hoel, Port, Stone Pg. 62

$$= \left[\frac{e^{-n\mu_1} \mu_1^{\Sigma x_i}}{\prod_{i=1}^{n} x_i!} \right] \left[\frac{\prod_{i=1}^{n} x_i!}{e^{-n\mu_0} \mu_0^{\Sigma x_i}} \right]$$

$$= \frac{e^{-n\mu_1} \mu_1^{\Sigma x_i}}{e^{-n\mu_0} \mu_0^{\Sigma x_i}}$$

$$= e^{n(\mu_0 - \mu_1)} \left(\frac{\mu_1}{\mu_0} \right)^{\Sigma x_i}$$

α = Type I Error

β = Type II Error

μ_0 = Mean under Null Hypothesis

μ_1 = Mean under Alternative Hypothesis

Lower Decision Boundary

If $\frac{L_{1n}}{L_{0n}} \leq \frac{\beta}{1-\alpha}$ Accept H_0 (Null Hypothesis)

Hoel, Port, Stone

Pg. 75

$$\Rightarrow e^{n(\mu_0-\mu_1)}\left(\frac{\mu_1}{\mu_0}\right)^{\sum x_i} \leq \frac{\beta}{1-\alpha}$$

$$\Rightarrow \ln\left(e^{n(\mu_0-\mu_1)}\left(\frac{\mu_1}{\mu_0}\right)^{\sum x_i}\right) \leq \ln\left(\frac{\beta}{1-\alpha}\right)$$

$$\Rightarrow n(\mu_0-\mu_1) + \sum x_i \ln\left(\frac{\mu_1}{\mu_0}\right) \leq \ln\left(\frac{\beta}{1-\alpha}\right)$$

Since $\mu_1 > \mu_0$

$$\Rightarrow \sum x_i \leq \frac{\ln\left(\frac{\beta}{1-\alpha}\right)}{\ln\left(\frac{\mu_1}{\mu_0}\right)} + \frac{n(\mu_1-\mu_0)}{\ln\left(\frac{\mu_1}{\mu_0}\right)}$$

$\therefore$ Lower Boundary

$$= \frac{\ln\left(\frac{\beta}{1-\alpha}\right)}{\ln\left(\frac{\mu_1}{\mu_0}\right)} + \frac{(\mu_1-\mu_0)}{\ln\left(\frac{\mu_1}{\mu_0}\right)} \cdot n$$

Upper Decision Boundary

If $\frac{L_{1n}}{L_{0n}} \geq \frac{1-\beta}{\alpha}$ Accept H_1 (Alternative Hypothesis)

Hoel, Port, Stone
pg 75

$$\Rightarrow e^{n(\mu_0-\mu_1)}\left(\frac{\mu_1}{\mu_0}\right)^{\sum x_i} \geq \frac{1-\beta}{\alpha}$$

$$\Rightarrow \ln\left(e^{n(\mu_0-\mu_1)}\left(\frac{\mu_1}{\mu_0}\right)^{\sum x_i}\right) \geq \ln\left(\frac{1-\beta}{\alpha}\right)$$

$$\Rightarrow n(\mu_0-\mu_1) + \sum x_i \ln\left(\frac{\mu_1}{\mu_0}\right) \geq \ln\left(\frac{1-\beta}{\alpha}\right)$$

Since $\mu_1 > \mu_0$

$$\Rightarrow \sum x_i \geq \frac{\ln\left(\frac{1-\beta}{\alpha}\right)}{\ln\left(\frac{\mu_1}{\mu_0}\right)} + \frac{n(\mu_1-\mu_0)}{\ln\left(\frac{\mu_1}{\mu_0}\right)}$$

$\therefore$ Upper Boundary

$$= \frac{\ln\left(\frac{1-\beta}{\alpha}\right)}{\ln\left(\frac{\mu_1}{\mu_0}\right)} + \frac{(\mu_1-\mu_0)}{\ln\left(\frac{\mu_1}{\mu_0}\right)} \cdot n$$

Two Tests will be constructed:

First Test: $H_0 : \mu \leq 4$

$H_1 : \mu > 4$

Second Test: $H_0 : \mu \leq 6$

$H_1 : \mu > 6$

In <u>both</u> tests set Type I and Type II error rates at 0.05.

<u>Construct Boundaries for First Test</u>

$\mu_0 = 4$ $\alpha = 0.05$

$\mu_1 = 5$ $\beta = 0.05$

$$\text{Lower Boundary} = \frac{\ln\left(\frac{.05}{1-.05}\right)}{\ln\left(\frac{5}{4}\right)} + \frac{(5-4)}{\ln\left(\frac{5}{4}\right)} \cdot n$$

$$= \boxed{-13.195 + 4.481\, n}$$

$$\text{Upper Boundary} = \frac{\ln\left(\frac{1-.05}{.05}\right)}{\ln\left(\frac{5}{4}\right)} + \frac{(5-4)}{\ln\left(\frac{5}{4}\right)} \cdot n$$

$$= \boxed{13.195 + 4.481\, n}$$

Foth & Van Dyke

Client: CMC Scope I.D.: 93C049
Project: EMC Page: 5/5
Prepared by: SGL Date: 2/6/96
Checked by: SVH Date: 2/19/96

Construct Boundaries for Second Test

$p_0 = 6$ $\alpha = 0.05$

$p_1 = 7$ $\beta = 0.05$

$$\text{Lower Boundary} = \frac{\ln\left(\frac{.05}{1-.05}\right)}{\ln\left(\frac{7}{6}\right)} + \frac{(7-6)}{\ln\left(\frac{7}{6}\right)} \cdot n$$

$$= \boxed{-19.101 + 6.487\, n}$$

$$\text{Upper Boundary} = \frac{\ln\left(\frac{1-.05}{.05}\right)}{\ln\left(\frac{7}{6}\right)} + \frac{(7-6)}{\ln\left(\frac{7}{6}\right)} \cdot n$$

$$= \boxed{19.101 + 6.487\, n}$$

Crandon Mining Company

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

April 4, 1996

Mr. Bill Tans
Mr. Christopher Carlson
Mr. Robert Grefe
Wisconsin Department of Natural Resources
101 South Webster Street
P.O. Box 7921
Madison, WI 53707-7921

Dear Mr. Tans, Mr. Carlson, and Mr. Grefe:

Re: Crandon Project - CMC Response to WDNR's January 4, 1996 TMA Completeness Letter

At the March 25, 1996 meeting with the Wisconsin Department of Natural Resources (WDNR), Crandon Mining Company (CMC) discussed its responses to the remaining comments contained in the WDNR's January 4, 1996 TMA completeness letter. The responses were previously forwarded to the WDNR as "Addendum No. 2 to the May 1995 Crandon Project Tailings Management Area Feasibility Report/Plan of Operation".

With this letter CMC is submitting an update to Addendum No. 2 to the May 1995 Tailings Management Area Feasibility Report/Plan of Operation. The update has been prepared on behalf of CMC by Foth & Van Dyke and Associates Inc. and contains the clarifications and additional information relating to Addendum No. 2 which were requested by the WDNR at the March 25, 1996 meeting. The update has been provided to the individuals on the carbon copy list to this letter.

Also enclosed is a reference list with information indicating where to insert the revised pages in the three ring notebook for the Tailings Management Area Addenda to the Feasibility Report/Plan of Operation previously provided. The list has been prepared to both facilitate insertion of the additional information, and to serve as a log and reference identifying changes made to the document by CMC throughout the permitting process. If subsequent revisions are made, they will be added to the attached list in sequential order and the list will be forwarded with the changes.

The clarifications and additional information addressed by the update are as follows:

- Provide specific ownership information within the TMA and the TMA compliance boundary.

MLD2\93C049\GBAPP\30093\4000

RHINELANDER BUSINESS OFFICE
7 N. BROWN ST., 3RD FLOOR
RHINELANDER, WI 54501-3161
TEL.: (715) 365-1450 FAX: (715) 365-1457

CRANDON FIELD OFFICE
P.O. BOX 336 104 W. MADISON
CRANDON, WI 54520-0336
TEL.: (715) 478-3393 FAX: (715) 478-3641

- Provide land ownership information for the outlet of Little Sand Lake.
- Provide a formal description of the bedrock drill cuttings from the January and February 1996 TMA drilling program.
- Provide an expanded discussion of the use of the 1984 and 1994 data used for flow net development.
- Describe the effect of cutoff grades within the ore body (e.g., is it dispersed or in distinctive blocks).
- Provide a discussion of the available techniques for handling wastewater treatment plant solids and treating TMA leachate during the post-closure period.

At the March 25, 1996 meeting two additional related questions were asked for which the responses are provided below.

Comment 1: Provide information describing how tailings were added to the waste characterization humidity cells.

Response 1: *The tailings were placed in the cells in a very damp to wet state. The were not placed as a slurry.*

Comment 2: Describe what meteorological data has been used for the project and the reason for using data from multiple stations.

Response 2: *The North Pelican Lake weather observation station was selected as the primary climatological data source for the project given its near (11 to 12 miles) proximity to the project site and since it provides an extensive historical climatological record with respect to precipitation and temperature, both of which are used in project work. The South Pelican Lake weather observation station, although slightly closer to the site, only provides data on precipitation. Note that the two stations are very close to each other, with the North Pelican Lake station residing on the north side of Pelican Lake and the South Pelican Lake Station residing on the south side of Pelican Lake. The North Pelican Lake data was used, when required, for all Environmental Impact Report and Tailings Management Area Feasibility Report/Plan of Operation work with the exception of the groundwater modeling studies. Based on the following factors, the South Pelican Lake precipitation data were used in the groundwater modeling studies to calculate precipitation and runoff to the lakes and to estimate the duration and magnitude of the drought in the late 1980's.*

- *Early on in the project several regulatory reviewers requested that the groundwater modeling studies use the closest available precipitation records. The South Pelican Lake station is slightly closer to the project site than North Pelican Lake station.*

- *South Pelican Lake precipitation data was used in previous lake modeling studies completed by the USGS.*

The precipitation records of the two stations very only slightly and the use of one or the other will not alter the overall analysis of environmental impacts.

If you have any questions regarding the enclosure or the above responses, please contact me at (715) 365-1450.

Sincerely,

D. E. Moe

Don Moe
Technical/Permitting Manager
Crandon Mining Company

DEM:mld2

cc: Mr. Archie Wilson, Wisconsin Department of Natural Resources
Mr. Larry Lynch, Wisconsin Department of Natural Resources
Mr. Dave Siebert, Wisconsin Department of Natural Resources
Mr. Robert Jaeger, U.S. Department of the Interior
Mr. Philip Shopodock, Forest County Potawatomi
Mr. Daniel Santos, Horsley & Witten, Inc.
Mr. Arlyn Ackley, Sokaogon Chippewa Community
Mr. John Teller, Menominee Indian Tribe of Wisconsin
Ms. M. Catherine Condon, Greene, Meyer & McElroy
Mr. Dan Cozza, U.S. Environmental Protection Agency
Mr. John Coleman, University of Wisconsin-Madison
Mr. David Ballman, U.S. Army Corps of Engineers
Mr. Mark Meyers, U.S. Army Corps of Engineers
Mr. Kim Lapakko
Mr. Andy Robertson, A. MacG. Robertson and Associates, Inc.
Mr. Jerry Sevick, Foth & Van Dyke

Crandon Project Addendum No. 2 to the Tailings Management Area Feasibility Report/Plan of Operation

Log of Revisions and Additional Information

Entry Number	Date of Revision	Page(s)	Document Section Number	Description
1	04/04/96	10	Page 2, Response 6	Added reference to new figure and reference to property ownership by the outlet of Little Sand Lake.
2	04/04/96	11	Page 2, Response 8	Added description of rock cuttings.
3	04/04/96	12-12a	Page 2, Response 10	Added discussion of the use of non-contemporaneous data in the development of flow nets.
4	04/04/96	22	Page 3, Response 1	Added description of the location of mineralization below the cutoff grade.
5	04/04/96	32-32a	Page 5, Response 25	Added discussion of post-closure leachate and solids management.
6	04/04/96	Attachment 3	Figure 2-3A	New Figure.
7	04/04/96	Attachment 6	Boring Logs	Revised boring logs for CMC-TMA-101, -102, -104, -105, -107.

Addendum No. 2 to the May 1995 Crandon Project Tailings Management Area Feasibility Report/Plan of Operation Crandon Mining Company Responses to Requests for Clarification and Additional Information From the February 22, 1996 WDNR TMA Meeting and Responses to the Remaining Comments Contained in the Wisconsin Department of Natural Resources January 4, 1996 Completeness Determination Letter

Introduction

Crandon Mining Company (CMC) prepared a February 21, 1996 document titled "Addendum No. 1 to the May 1995 Crandon Project Tailings Management Area Feasibility Report/Plan of Operation" which presented responses to selected comments raised in the Wisconsin Department of Natural Resources (WDNR) January 4, 1996 TMA Completeness Determination Letter. This document was provided to the WDNR at a February 22, 1996 TMA meeting with the WDNR and the U.S. Army Corps of Engineers (USCOE). At this meeting, WDNR requested clarification of and additional information for some of the responses contained in Addendum No. 1.

This document titled "Addendum No. 2 to the May 1995 Crandon Project Tailings Management Area Feasibility Report/Plan of Operation" (Addendum No. 2) has been prepared both to respond to the clarifications and additional information requested at the February 22, 1996 TMA meeting and to respond to the remaining comments contained within the WDNR's January 4, 1996 TMA Completeness Determination Letter.

Purpose and Scope

The purpose of this document is to provide information required by NR 182, Wis. Admin. Code, including:

I) RESPONSES TO THE FOLLOWING INFORMATION REQUESTS MADE DURING THE FEBRUARY 22, 1996 TMA MEETING

A) F15 Setback Alternative Approximate Borrow Material Estimate.

B) Surface Water Model Validation Using 1995 Climatological Information.

C) Provide Additional Information Pertaining to Contaminant Resistant Clay.

D) Revise Language Regarding Polyethylene Geomembrane Use.

E) Provide a Reference for the Sequential Test Procedure Used for the Proposed Statistical Analyses for Monitoring of the Constructed Geomembrane Liner.

II) RESPONSES TO THE REMAINING COMMENTS IN THE JANUARY 4, 1996 WDNR LETTER

A) INFORMATION NECESSARY FOR A COMPLETENESS DETERMINATION

Page 1, Comment 1	Page 2, Comment 6	Page 2, Comment 10
Page 2, Comment 2	Page 2, Comment 7	Page 3, Comment 13
Page 2, Comment 3	Page 2, Comment 8	Page 3, Comment 17

B) ADDITIONAL INFORMATION REQUIRED FOR A FEASIBILITY DETERMINATION

Page 3, Comment 1	Page 4, Comment 13	Page 5, Comment 20
Page 4, Comment 2	Page 4, Comment 14	Page 5, Comment 21
Page 4, Comment 3	Page 5, Comment 15	Page 5, Comment 22
Page 4, Comment 4	Page 5, Comment 17	Page 5, Comment 23
Page 4, Comment 5	Page 5, Comment 18	Page 5, Comment 25
Page 4, Comment 6		

C) DESIGN, OPERATIONAL OR PERFORMANCE CONCERNS AND COMMENTS

Page 6, Comment 8	Page 6, Comment 10	Page 6, Comment 11

The format used in this document is to first list WDNR's comment and immediately follow it with CMC's response. For clarity, both the comment and response numbers are listed for each item.

I) Responses to Information Requests Made During the February 22, 1996 TMA Meeting

Comment A: Provide an estimate of the approximate site borrow needs for the F15 Setback Alternative.

Response A: *CMC has completed an order of magnitude estimate of borrow needs for the F15 Setback Alternative. The analysis showed that approximately the same borrow material is needed for both the TMA North and the F15 Setback Alternatives. A more rigorous estimation could be used to refine the difference, but in the interest of moving forward with the siting analysis, CMC has decided to assume that the borrow needs for the TMA North and F15 Setback Alternatives are essentially equivalent. As a result, CMC has provided on the following pages a revised Table 10.2-2 from the May 1995 Tailings Management Area Feasibility Report/Plan of Operation (Feasibility Report) (Foth & Van Dyke, 1995a) that does not include a reference to borrow material needs. The change to the table does not result in a change in the conclusion as stated in Section 10.2.3.2 of the Feasibility Report that the TMA North Alternative is still the TMA footprint with the least overall impact on the environment.*

Table 10.2-2

Comparative Impact Assessment
Alternatives TMA North and F15 Setback

Environmental Parameter	Comparative Assessment	Parameter Weight	Rating		Total	
			N	F15	N	F15
Historical-Archeology-Cultural Resources	• No significant difference.	3	--	--	--	--
Transportation & Utilities	• No significant difference.	1	--	--	--	--
Climatology - Air Quality	• No significant difference.	1	--	--	--	--
Geology - Soils - Groundwater	• Soil permeabilities - no significant difference.	1	--	--	--	--
	• Groundwater separation - no significant difference.	3	--	--	--	--
Surface Water	• TMA North results in less significant impact on Duck Lake watershed and Deep Hole Lake watershed.	2	0	-2	0	-4
	• F15 Setback decreases disturbance in F15 watershed.	3	-2	0	-6	0
Biology	• F15 increases disturbance of F66, F65, I8, F27 which have greater biological diversity.	3	0	-2	0	-6
	• TMA North increases indirect disturbance within F15 watershed containing bur oak community.	3	-2	0	-6	0
	• Number of state endangered species: TMA North - 1 species F15 Setback - 1 species	3	--	--	--	--
	• Number of other species of concern: TMA North - 6 species F15 Setback - 6 species	2	--	--	--	--
Wetlands	• F15 increases direct disturbance to wetlands. TMA North - 23 acres F15 Setback - 28 acres	3	0	-2	0	-6
Noise	• No significant difference.	2	--	--	--	--

Table 10.2-2 *(Continued)*

Environmental Parameter	*Comparative Assessment*	*Parameter Weight*	*Rating*		*Total*	
			N	*F15*	*N*	*F15*
Land Use - Zoning	• *No significant difference.*	*2*	--	--	--	--
Aesthetics	• *Increased TMA exposure for F15.*	*1*	*0*	*-1*	*0*	*-1*
Socioeconomics	• *No significant difference.*	*1*	--	--	--	--
Native American Communities	• *No significant difference.*	*2*	--	--	--	--
	Total Score				***-12***	***-17***

Notes:

1. *Environmental Parameters Consistent with Section 3.0.*
2. *Rating is comparative between TMA North (N) and F15 Setback (F15) only*
   -- = equal impact for both alternatives
   0 = baseline (site with least impact)
   -1 = minor difference
   -2 = moderate difference
   -3 = significant difference
3. *Parameter Weight x Ratings = Total Score*

Prepared by: PAE
Checked by: JWS

Comment B: Rerun the surface water hydrology model using 1995 climatological data to determine if model results compare to field observations during the wet fall.

Response B: *Using the surface water hydrology model, an analysis of existing conditions in the wetland F15 watershed has been completed with 1995 precipitation and temperature data from the North Pelican Lake weather station. This is the weather station used previously for the surface water hydrology modeling.*

To be able to use the 1995 data in lieu of the average data conditions (years 1961 through 1990), two model data files were modified. The ATMOS.2 and the ATMOS.3 basic data were changed at the North Pelican Lake NOAA station to include 1995 information. In the ATMOS.2 file, average temperature values for each month and the annual average for 1995 were entered. The North Pelican Lake NOAA station data is located on line 62 of the temperature data field. The ATMOS.3 file contains precipitation data. Line 62 of this file was also modified to include the 1995 precipitation data. After creating these files, the model was run for the F15 watershed and basin runoff values were obtained. Model outputs and the 1995 data sets entered into the model are contained in Attachment 1.

Figure 1-1 in Attachment 1 presents a graph of precipitation/runoff versus month of the year for average precipitation (the 1961 through 1990 interval) and 1995 precipitation. As shown on the figure, there is a direct correlation between changes in precipitation and runoff when comparing 1995 events to the averages. The figure shows that during the months of August and October 1995, significant rainfall occurred which resulted in increased modeled runoff when compared to the average conditions. This matches observed field conditions when water was noted in F15 during the fall of 1995. The figure also shows that the August and October 1995 runoff compares favorably to the average spring peak runoff period. It is during the spring when water has been noted in wetland F15 in the past.

The cumulative basin runoff calculated by the model for 1995 also shows a correlation between the spring high runoff period and August and October. The cumulative basin runoff for August and October of 1995, which has been calculated to be 7.46 and 7.57 acre-feet, respectively, is comparable to the 9.35 acre-feet calculated for April 1995. For information purposes, the long-term annual average cumulative basin runoff for April, August, and October is 9.68, 5.79, and 2.65 acre-feet, respectively.

Comment C: Provide additional information pertaining to contaminant resistant clay.

Response C: *VOLCLAY® contaminant resistant clay (CRC) is a specially mined, processed, and treated granular sodium bentonite used for the containment of liquids. This material is especially resistant to degradation by calcium, magnesium, and other ubiquitous cations, as well as organic chemicals. CRC is primarily (approximately 90 percent) montmorillonite, a 2:1 dioctahedral smectite whose chemical formulation is approximately:* $(Al\ Fe_{1.67}\ Mg_{0.33})\ Si_4\ O_{10}\ (OH_2)\ Na^+\ Ca^{++}_{0.33}$

CRC is a product that has been extensively researched from the selection of the base clays to the means by which it is processed and treated. A unique blend of several base clays, a series physical processes (patent pending), and additives that would maximize the performance of the clay in contaminated environments, backed by compatibility tests conducted by Colloid Environmental Technology Company (CETCO), make CRC a dependable containment liner for contaminated liquids. The results of compatibility tests performed by CETCO are reproduced in Table 1 below.

Table 1

Compatibility Test Results for VOLCLAY® CRC and Other Bentonites

Type of Test	Clay Sample				
	VOLCLAY® CRC	Bentonite A	Bentonite B	GCL A	GCL B
Fluid Loss (ml):					
In D.I. Water	8.0	11.6	13.8	9.7	18.0
In 1000 ppm $CaCl_2$	7.5	21.2	23.1	12.1	19.7
In 30,000 ppm, acetic acid	7.5	18.8	24.7	17.0	—
In 10,000 ppm sea water salt	9.7	40.1	58.0	25.2	—
Rigid Wall Permeability of Clay/Sand Mixtures (cm/sec):					
Tap water as permeant	$6.0x10^{-8}$	$3.1x10^{-9}$	$7.5x10^{-8}$		
10,000 ppm $CaCl_2$ as permeant[1]	$9.4x10^{-9}$	$1.3x10^{-7}$	$1.3x10^{-6}$		
Flexible-Wall Permeability (cm/sec):					
Tap water as permeant	$3.6x10^{-10}$	$8.0x10^{-10}$		$1.0x10^{-9}$	
10,000 ppm $CaCl_2$ as permeant[1]	$3.8x10^{-10}$	$1.8x10^{-8}$		$2.1x10^{-8}$	
Free Swell (ml/2g):					
Pre-permeability testing	28	32		33	
Post-permeability testing[1]	25	7		8	
Exchangeable Cations Ratio (meq/100g of $Na^+/Ca^{++}/Mg^{++}$):					
Pre-permeability testing	57/15/5	—		—	
Post-permeability testing[1]	47/14/6	15/67/8		19/59/4	

[1] *Samples were prehydrated with 1,000 ppm calcium chloride and then permeated with 10,000 ppm calcium chloride. Free swell and exchangeable cations tests were performed on samples of the clay obtained from the flexible-wall permeameters after 30-60 days of exposure to the calcium chloride solution.*

Source: CETCO, 1994.

"Typical" bentonites are suitable for most bentonite-based lining projects. When the concentrations of soluble metallic cations or organic compounds are greater than several hundred parts per million, CRC is considered for use in lieu of typical bentonites. To establish which bentonite to use for an application with higher concentrations of soluble metallic cations, a three-tiered approach to compatibility testing is used. The first tier is a simple review of existing analytical data. If the data indicates the potential presence of higher concentrations of soluble metallic cations, then in the second tier, fluid loss or top-loading filter press (TLFP) tests are performed. If these test results are inconclusive or inconsistent, an extended permeability test is performed as the third tier. A 30-day permeability test is typically sufficient for evaluating a GCL. Final selection of the GCL product to use for the TMA, including required testing, will occur during plan of operation preparation.

Comment D: Revise language regarding polyethylene geomembrane use in Addendum No. 1 to the May 1995 Tailings Management Area Feasibility Report/Plan of Operation.

Response D: *An update to page 10 of Addendum No. 1 to the May 1995 Crandon Project Tailings Management Area Feasibility Report/Plan of Operation has been provided to the WDNR with the cover letter to Addendum No. 2.*

Comment E: Provide a reference for the sequential test procedure used for the proposed statistical analyses for monitoring of the constructed geomembrane liner.

Response E: *The requested reference is: Hoe, Port and Stone, 1971. Introduction to Statistical Theory. Houghton Mifflin Company, Boston. pp. 73-76.*

II) Responses to the Remaining Comments in the January 4, 1996 WDNR Letter

A) Information Necessary For a Completeness Determination

Page 1, Comment 1: Include feasibility information for the two proposed waste-rock storage areas, the pre-production ore pad, and the associated leachate/runoff management facilities or develop a new feasibility report for those facilities. In accordance with ss. NR 182.01 and 182.02, Wis. Adm. Code, these storage facilities will be regulated under ch. NR 182. Therefore the proposed design and operation of these facilities must be proposed in a feasibility report prior to the master hearing, to be followed by a plan of operation prior to construction and licensure.

Page 1, Response 1: *As stated in Section 4.8.5.9, pages 50 and 51 of the Crandon Project Mine Permit Application (MPA) (Foth & Van Dyke, 1995b), 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 stated in Section 4.8.5.9 of the MPA, 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 4.5 of the MPA. Section 4.8.5.9 further states that the Type II waste rock to be placed on the lined pre-production ore storage pad will be used in the TMA for riprap or as other construction material within the TMA facility.

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 our 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.

Based on the above discussion, CMC believes that the information requested in Comment 1 is not required as part of the additional information identified by the Wisconsin Department of Natural Resources as needed for a TMA Feasibility Report completeness determination, or for the ultimate review and approval of the Feasibility Report.

Page 2, Comment 2: Provide a detailed discussion of the bedrock mineralization beneath the TMA. Note the drill holes and depths used to assess the bedrock in this area. Include a map at the same scale as the site conditions map, Drawing 3, showing the location and trace of all drill holes in the area of the TMA. [s. NR 182.07(1)(g)]

Page 2, Response 2: *There have been three programs within and adjacent to the Crandon Project TMA to evaluate the presence of bedrock mineralization. Seven diamond drill holes, totaling 12,278 feet, were drilled in 1978. Three combined air hammer - core holes, totaling 778 feet, were drilled into bedrock between 1979 and 1981 and five additional air-rotary holes, totaling 1,327 feet were bottomed in bedrock in February 1996. The first two drilling programs indicated that there is no significant sulfide mineralization to a depth of at least 1,500 vertical feet beneath the TMA. The recent 1996 program showed no evidence of mineralization in the upper level of the bedrock in which the holes were drilled. Based on this work, the area has been determined to have no mineral potential. A discussion of the drilling is presented in the following paragraphs.*

A generally north-south 8-hole fence of shallow vertical and deeper inclined holes, 203, 205, 204, TMA 105, 199, 206, TMA 107, and TMA 104 were drilled into bedrock along the east edge of the area. A second generally north-south 6-hole fence of shallow vertical and one deeper inclined hole, G41-E19A, G41-E17, 200, G41-E13, TMA-101 and TMA-102 were drilled along the western side of the TMA. Additionally, one short vertical hole, 207, was drilled further east of the eastern 8-hole fence. Location, bearing, inclination, depth and other information on these bedrock holes is provided in Table 2.

The vertical depth drilled ranged from the upper bedrock, i.e., the subcrop, some 200 to 300 feet below surface, to in excess of 1,400 feet in the deeper holes. Core recovery in the diamond drill holes was excellent. The core is stored in Rhinelander, Wisconsin.

Rocks intersected in the drilling were typical Precambrian greenstones, i.e., meta-volcanics and some thin volcanisclastic sediments. Lithologies consist of thin to thick tuffs, lapilli tuffs, crystal tuffs, tuff breccias as well as thin to thick flows and associated sediments. Near the bedrock and glacial sediment interface, the rocks are weathered, i.e., generally argillized, iron oxide stained, and occasionally leached. These surficial effects are thin and decrease rapidly as the holes passed into fresh generally unaltered greenstones.

Sulfide mineralization throughout the area is extremely weak, consisting almost entirely of fine grained disseminated, or occasionally a thin veinlet, of pyrite and rare traces of chalcopyrite. The most common sulfide estimates usually are in the nil to trace range (<0.5 percent), or <1 percent range, with occasional thin zones of no real significance containing slightly higher amounts.

The rocks in the TMA area have not been subjected to any significant hydrothermal alteration effects which commonly accompany the introduction of sulfide mineralization. This lack of alternation is typical for unmineralized areas. Thin carbonate and locally quartz veining was observed in most of

Table 2

TMA Bedrock Drilling

Hole No.	Northing	Easting	Bearing	Inclination	Elevation	TD	Date
			Exploration Core Holes				
199	113412	2,286,407	Due N	-55°	1718'	1951'	4Q78
200	112753	2,283,365	Due S	-55°	1676'	1991'	4Q78
203	110489	3,387,173	S15°E	-55°	1664'	2005'	4Q78
204	112717	2,286,264	Due S	-55°	1704'	2055'	4Q78
205	111575	2,286,710	S20°E	-60°	1694'	2004'	4Q78
206	113751	2,278,904	Due S	-55°	1698'	1991'	4Q78
207	113742	2,290,048	NA	-90°	1596'	281'	1Q79
7 holes					**Total Ft.**	**12,278**	
			Environmental Borings Air Hammer with NX Core Completion				
G41-E13	114395	2,282,894	NA	-90°	1627'	251'	1Q79
G41-E17	112385	2,283,005	NA	-90°	1666'	260'	1Q79
G41-19A	110260	2,283,290	AA	-90°	1646'	267'	2Q81
3 holes					**Total Ft.**	**778**	
			Environmental Borings Air Rotary				
TMA 101	116701	2,283,073	NA	-90°	1645'	175'	1Q96
TMA 102	118180	2,283,980	NA	-90°	1638'	260'	1Q96
TMA 104	116551	2,286,501	NA	-90°	1710'	278'	1Q96
TMA 105	112723	2,286,269	NA	-90°	1685'	312'	1Q96
TMA 107	114674	2,286,757	NA	-90°	1710'	302'	1Q96
5 holes					**Total Ft.**	**1327**	
15 holes					**Total Ft.**	**14,383**	

the holes but there is no sulfide commonly associated with the veinlets. Thin cherts are locally noted. Finally, the area was covered by an IP (induced polarization) geophysical survey which indicated no significant sulfide concentrations in the bedrock beneath the TMA. Subsequent drilling as discussed above confirmed the geophysical work.

Figure 2-1 in Attachment 2 shows the location of the 15 core holes and borings and the bedrock geology in the TMA area. Cross-sections (Figures 3.5-16 and -17) from Section 3.5 of the project's EIR showing the trace of the deep bedrock holes, the weathering, and the fresh bedrock are also included in Attachment 2.

Page 2, Comment 3: Complete waste characterization information is necessary. The Department recognizes that a new waste characterization report was received on December 18, 1995, as a part of the EIR, but is not included in this review. More complete information with appropriate referencing to the EIR must be included in the FR. [s. NR 182.08(2)(b)]

Page 2, Response 3: *CMC is currently in the process of preparing the final waste characterization report for the project. Once it has been completed, it will be submitted to the WDNR for review.*

Page 2, Comment 6: Discussion must be provided covering identification of adjacent landowners, zoning, present land uses, and present or proposed road restrictions. Include maps at a uniform scale covering a five mile radius from the TMA for the first three items.
[ss. NR 182.08(2)(c)7-10]

Page 2, Response 6: *Figure 3.2-1a, derived from plat maps, shows property ownership within a 5-mile radius of the TMA. The plat maps do not include CMC land purchase options, leases, or easements. Figures 2-2 and 2-3 from the project's MPA (Foth & Van Dyke, 1995b) showing all CMC land ownership as of May 1995 are included in Attachment 3. The extent of CMC's property ownership along the outlet from Little Sand Lake is also shown on Figure 2-3. Figure 2-3A, also in Attachment 3, shows property ownership within the TMA and its compliance boundary. It is CMC's intent to exercise the land purchase options near the TMA after permits are granted.*

Land use and zoning is discussed in Section 3.12, Land Use and Zoning of the project's Environmental Impact Report (EIR) (Foth & Van Dyke, 1995c). A reproduction of this section of the EIR is presented in Attachment 4. Attachment 4 also includes a consolidated zoning map for the Town of Ainsworth, Langlade County, the Town of Lincoln, Forest County, and the Town of Nashville, Forest County. The map was prepared from the best available information obtained from the Langlade County zoning office and the North Central Regional Planning Commission.

The land ownership, present land use, and zoning figures are provided at scales that best depict the requested information in a readable, usable format within an approximate 5-miles radius from the project plant site using available documents.

Road restrictions are discussed in Section 3.3.2, Roads, of the project's EIR (Foth & Van Dyke, 1995c). This section is reproduced in Attachment 5 for reference.

Page 2, Comment 7: Revise the existing conditions plan sheet (Drawing 3) to clearly show existing property lines with existing owners identified; proposed borrow and staging areas, as well as the proposed footprint and compliance boundary; all operational/inactive/abandoned wells, as well as borings; the proposed utility and pipeline corridors; the proposed reclaim water pond; and the proposed TMA water supply well. Clearly delineate wells from borings and active, inactive and abandoned wells. [s. NR 182.08(2)(d)1]

Page 2, Response 7: *An update to the existing conditions plan sheet (Drawing 3) showing proposed borrow and staging areas, the proposed footprint and compliance boundary, all*

operational/inactive/abandoned wells, borings, the proposed utility and pipeline corridors, the proposed reclaim water pond, and the proposed TMA water supply well is included in this addendum. Land ownership is shown on Figure 3.2-1a and on Figures 2-2 and 2-3 in Attachment 3.

Page 2, Comment 8: Provide information from additional new borings to characterize areas of the proposed facility and compliance zone where no information is available. The number of borings and their depth and location should be proposed to the Department at least two weeks in advance of the expected start of drilling. The drilling must be done in accordance with ch. NR 141 and ss. NR 182.08(2)(d)3-5. The Department's Rhinelander office must be notified at least 48 hours in advance of the initiation of drilling. [s. NR 182.08(2)(d)2]

Page 2, Response 8: *On January 16, 1996, CMC discussed with the WDNR the contents of the requested drilling and notified the WDNR that drilling would begin on January 22, 1996. Based on this discussion, CMC provided to the WDNR on January 19, 1996 a letter describing the boring program to corroborate glacial stratigraphy depicted on the TMA geologic cross-sections. The proposed boring program consisted of 10 borings. The borings were completed between January 23 and February 10, 1996 using rotary mud and dual tube drilling techniques. Boreholes were abandoned in accordance with NR 141. Table 3 summarizes the completed borings. The location of each boring is shown on Drawings 3 and 5. Revised TMA cross-sections incorporating the new borings are depicted on Drawing Numbers 5A through 12D. Boring logs (WDNR Form 4400-122) and abandonment forms (WDNR Form 3300-5W) are provided in Attachment 6. The logs contain a description of rock cuttings for CMC-TMA-101, -102, -104, -105, and -107 which penetrated bedrock. The rock cuttings corroborate the absence of significant sulfide mineralization in the vicinity of the TMA.*

Table 3

1996 Crandon Project TMA Boring Program Summary

Boring	*Target*	*Completed*
CMC-TMA-101	*Lower Till*[1]	*Bedrock*
CMC-TMA-102	*Bedrock*	*Bedrock*
CMC-TMA-103	*Lower Till*[1]	*Lower Till*
CMC-TMA-104	*Bedrock*	*Bedrock*
CMC-TMA-105	*Bedrock*	*Bedrock*
CMC-TMA-106	*5' Into Water Table*	*>5' Below Water Table*
CMC-TMA-107	*Bedrock*	*Bedrock*
CMC-TMA-108	*25' Below TMA Base Grades*	*>25' Below TMA Base Grades*
CMC-TMA-109	*5' Below Water Table*	*>5' Below Water Table*
CMC-TMA-110	*5' Below Water Table*	*>5' Below Water Table*

[1]*Lower Till = Pre- to Early Wisconsinan Till.*

Prepared by: SVD1
Checked by: SGL1

Page 2, Comment 10: Provide flow nets drawn on geologic cross sections following the most direct route for each of the following, or propose similar alternate locations:

a. EX-10 to WP-7
b. EX-10 to DMA-32
c. G41-K13 to DMA-4
d. G41-K13 to DMA-12

Page 2, Response 10: *On February 23, 1996, Steve Donohue of Foth & Van Dyke and Christopher Carlson of the WDNR discussed alternative locations for the requested flow nets. The parties agreed that two flow nets would be drawn with the first flow net transect running northwest to southeast from DMA-12 to DMA-32A. The second flow net was proposed to run northeast to southwest from WP-6 and EX-7 to DMA-4. By constructing the flow nets in this fashion, both flow nets would intersect EX-10 in the center of the TMA and capture the groundwater divide.*

Drawings 12C and 12D display the flow nets on new geologic cross-sections R"-R‴ and S"-S‴ that are incorporated into the set of revised TMA geologic cross-sections. The flow nets display the vertical profile of head along approximate flow paths from the TMA groundwater high and divide situated in the vicinity of EX-10. The flow nets have been developed primarily using water elevations from October 1984 with additional resolution with respect to vertical gradients provided by 1994 data. Consequently, the equipotential lines represent the approximate distribution of head for October 1984.

1984 represents the year with the greatest amount of groundwater level data for construction of the flow nets. With respect to precipitation and historical groundwater levels, October of 1984 represents near steady state groundwater water conditions that were also used as calibration targets for the regional groundwater model. To provide additional resolution of the flow nets with respect to vertical gradients, non-contemporaneous data was used for wells CMC-01, -01P, -01R, -03RR, -03P, STS-DL-1, G41-C15B, and G41-C15C. These groundwater level monitoring points represent wells that were installed in 1994 and points that were installed for limited monitoring programs in the mid 1980's. Consequently, the water level records from these wells are limited in comparison to the majority of the site wells.

Attempts were made to adjust the non-contemporaneous data based on correlation to wells measured in 1984. However, water level records were insufficient to make this adjustment. Consequently, the non-contemporaneous data was used primarily as an indicator of the prevailing vertical gradients at the above referenced monitoring points. For example, the water levels from October 1994 at well nest CMC-03RR and CMC-03P show slight downward vertical gradients and there is no reason to believe that the direction of the vertical gradients change in this area over time. Based on this data the flow net on Drawing 12C was drawn to indicate downward vertical gradients in the vicinity of CMC-03RR and CMC-03P. Similar interpretations were used for other non-contemporaneous groundwater level data. Overall the use of non-contemporaneous data does not significantly affect the pattern of groundwater flow depicted on the flow nets.

Along cross-section R"-R‴, groundwater recharging the system moves vertically into the glacial deposits and laterally beneath Skunk Lake and toward the wetland complex immediately west of Ground Hemlock Lake. Skunk Lake functions as a head dependent recharge lake. The wetland just east of Ground Hemlock Lake functions as a local groundwater discharge point with deep groundwater flowing beneath the wetland. Along cross-section S"-S‴ groundwater recharging the system in the vicinity of the groundwater divide moves vertically down into the glacial deposits and laterally towards discharge points such as Hemlock Creek and beneath Duck Lake which functions as a head dependent recharge boundary. Near discharge points such as Hemlock Creek and the

wetland east of Ground Hemlock Lake, groundwater flows laterally and upwards into the creek resulting in upward gradients. In the vicinity of head dependent recharge lakes, strong downward gradients exist between the lake beds and the groundwater system with water moving vertically out of the lake beds and then laterally through the glacial outwash and till along flow paths governed by the regional hydraulic gradient.

Page 3, Comment 13: Provide a detailed assessment of the changes in groundwater quality that may occur at or beyond the limits of waste using the results of an acceptable solute transport modeling effort. [s. NR 182.08(2)(e)9]

Page 3, Response 13: *At the November 1, 1995 groundwater modeling meeting, the WDNR requested that CMC consider developing a three-dimensional contaminant transport model to evaluate potential groundwater quality changes in the vicinity of the TMA. At the November 13, 1995 groundwater modeling meeting, CMC presented a proposed approach to accommodate the WDNR's request. In a letter dated December 7, 1995, the WDNR indicated that the concepts, if implemented appropriately, should provide an acceptable resolution to the TMA solute transport work. Upon resolution of the outstanding regional groundwater flow modeling issues, CMC will complete the three-dimensional solute transport modeling in accordance with the approach proposed on November 13, 1995 and considering WDNR's December 7, 1995 comments. Upon completion of this work CMC will provide to the WDNR a revised assessment of potential groundwater quality changes in the vicinity of the TMA.*

Page 3, Comment 17: The alternatives analysis must consist, at a minimum, of the following: site selection (including footprint location on the sites), site design, and site operations. The discussion must include an economic analysis of the final sites. In addition, all data on all alternative sites and designs must be submitted. [s. NR 182.08(2)(k)]

Page 3, Response 17: *A discussion of TMA site selection, including footprint locations within Area 41 was provided in a February 19, 1996 update to the Feasibility Report (Foth & Van Dyke, 1995a). This update included a discussion of the advantages of Area 41 (Section 10.1.4), TMA siting criteria (Section 10.2.1), an evaluation of footprints within Area 41 (Section 10.2.2), and a comparative impact assessment (Section 10.2.3). An economic analysis of the three alternatives (listed below) identified in the alternatives evaluation (Section 10.2.2) follows.*

- *TMA South Alternative;*
- *TMA North Alternative (the selected alternative); and*
- *TMA F15 Setback Alternative.*

A plan view of each of these alternatives is provided on Figures 10.2-2, 10.2-3, and 10.2-4, respectively, of the Feasibility Report (Foth & Van Dyke, 1995a).

Table 4 contains the basis for the cost estimates, including the unit cost for each item and the source of the unit costs. The unit costs provided in Table 4 are used in Tables 5, 6, and 7 to estimate the total approximate costs for construction and closure of the TMA South Alternative, the TMA North Alternative, and the TMA F15 Setback Alternative, respectively. In preparing these tables, the following was assumed:

- *the liner system is modified to be consistent with CMC's present proposal (i.e., a composite liner and cap consisting of a geosynthetic clay liner (GCL) over 12 inches of P40 processed on-site till soil).*
- *for the TMA North Alternative, configuration of the cells and the leachate collection system is per the May 1995 Feasibility Report;*
- *all quantities are in-place quantities;*
- *for the TMA South Alternative and the TMA F15 Setback Alternative the quantities for liner, leachate collection system and final cover are the same as for the TMA North Alternative; and*

The earthwork balances for the quantities for the TMA South Alternative and the F15 Setback Alternative were estimated, whereas the earthwork balance for the TMA North Alternative (the selected alternative) was calculated during preparation of the Feasibility Report. A difference between the alternatives is the quantity of borrow material required from outside the TMA footprint. In Table 6.12-3 of the Feasibility Report (Foth & Van Dyke, 1995a), the amount of borrow material required from outside the TMA North Alternative footprint, including a 15 percent contingency, was calculated as approximately 107,400 cubic yards. The additional borrow material outside the TMA footprint for the other two alternatives was estimated assuming that the same quantity of soil will be required for manufacturing the components of the liner, leachate collection system, and final cover for all alternatives. The quantities estimated for the additional borrow material required are 121,000 cubic yards for the F15 Setback Alternative and 2,726,000 for the TMA South Alternative.

Table 4

Basis for Cost Estimate for TMA Alternatives Analysis

Item/Description	Unit Cost/Units	Source
Earthwork		
Clear and Grub	$1500/acre	1
Wetland, Clear and Grub	$6000/acre	1
Excavate and Stockpile	$1.25/cubic yard	1
Excavate, Haul and Compact	$2/cubic yard	1
Final Reclamation Excavate and Haul from Borrow Area		
TMA South Alternative	$0.35/cubic yard	1
TMA North Alternative	$0.10/cubic yard	1
F15 Setback Alternative	$0.15/cubic yard	1
Liners		
Subgrade Preparation	$2000/acre	1,2
12" P40 Till	$7/cubic yard	4,5
Geosynthetic Clay Liner (GCL)	$0.40/square foot	3
60 mil HDPE	$0.40/square foot	3
Geotextile (8 oz/yd^2 or >)	$1.10/square yard	3
18" Protective Soil (-¾" Till)	$4/cubic yard	4,5
Leachate Collection System		
Drainage Layer (Sand)	$6/cubic yard	4,5
Geocomposite (Geocomposite Drain and Geomembrane)	$0.82/square foot	3
Drainage Layer (Gravel)	$7/cubic yard	4,5
Internal Leachate Collection Piping	$25/lineal foot	1
Sideslope Risers and Pumps	$50,000 each	1
Leachate Piping Forcemain	$5/lineal foot	1
Final Cover		
Soil Grading Layer (thickness varies)	$2/cubic yard	1
12" P40 Till	$7/cubic yard	4,5
Geosynthetic Clay Liner (GCL)	$0.40/square foot	3
60 mil HDPE	$0.40/square foot	3
Drainage Layer (Sand)	$6/cubic yard	4,5

Table 4 *(Continued)*

Item/Description	*Unit Cost/Units*	*Source*
3' Protective Soil (Unprocessed Till)	*$2/cubic yard*	*1*
6" Topsoil	*$2/cubic yard*	*1*
Seed, Fertilize and Mulch	*$1500/acre*	*1*

[1]Typical construction cost for Wisconsin landfills or large earth work projects.
[2]Includes scarifying, removal of boulders, cobbles, etc., proof rolling and recompacting yielding areas.
[3]Manufacturer/Supplier 1995 quote.
[4]Assumes on-site processing of these soils from till and outwash soils. Includes soil processing costs, loading, hauling, placing and compacting (if required).
[5]All unit costs are cost in-place, which includes shrinkage and construction loss.

Table 5

Cost Estimate for TMA South Alternative[1]

Item/Description	Estimated Quantity	Unit Cost/ Units	Total Cost[2] ($ x 10^6)
Earthwork			
Clear and Grub	*350 ac*	*$1500/ac*	*0.53*
Wetland - Clear and Grub	*40 ac*	*$6000/ac*	*0.24*
Excavate and Stockpile	*4.5 mil cy*	*$1.25/cy*	*5.63*
Excavate, Haul and Compact	*5.7 mil cy*	*$2/cy*	*11.40*
Final Reclamation Excavate and Haul from Borrow Area	*2.73 mil cy*	*$0.35/cy*	*0.96*
Subtotal			*18.76*
Liners			
Subgrade Preparation	*235 ac*	*$2000/ac*	*0.47*
12" P40 Till	*385,000 cy*	*$7/cy*	*2.70*
Geosynthetic Clay Liner (GCL)	*10.3 mil sf*	*$0.40/sf*	*4.12*
60 mil HDPE	*10.3 mil sf*	*$0.40/sf*	*4.12*
Geotextile (8 oz/yd or >)(Cushioning)	*1.14 mil sy*	*$1.10/sy*	*1.25*
18" Protective Soil (Sideslopes Only)	*328,000 cy*	*$2/cy*	*0.66*
Geotextile (4 oz/yd or >)(Filtering)	*474,000 sy*	*$0.60/sy*	*0.28*
18" Protective Soil (Base Only)	*156,000 cy*	*$2/cy*	*0.31*
6" Till Fines	*78,000 cy*	*$7/cy*	*0.55*
Subtotal			*14.46*
Leachate Collection System			
24" Drainage Layer (Sand)	*313,000 cy*	*$6/cy*	*1.88*
Geocomposite[3]	*2.1 mil sf*	*$0.82/sf*	*1.72*
Internal Leachate Collection Perforated Piping	*11,910 lf*	*$25/lf*	*0.30*
Leachate Cleanout Piping	*9,500 lf*	*$25/lf*	*0.24*
Sideslope Risers and Pumps	*4*	*$50,000 ea*	*0.20*
Leachate Forcemain	*14,100 lf*	*$5/lf*	*0.07*
Leachate Collection System Stone	*4,000 cy*	*$7/cy*	*0.03*
Subtotal			*4.44*

Table 5 *(Continued)*

Item/Description	*Estimated Quantity*	*Unit Cost/ Units*	*Total Cost[2] ($ x 10^6)*
Final Cover			
Soil Grading Layer (thickness varies)	*1.60 mil cy*	*$2/cy*	*3.20*
12" P40 Till	*359,000 cy*	*$7/cy*	*2.51*
Geosynthetic Clay Liner (GCL)	*9.91 mil sf*	*$0.40/sf*	*3.96*
60 mil HDPE	*9.91 mil sf*	*$0.40/sf*	*3.96*
12" Drainage Layer (Sand)	*362,000 cy*	*$6/cy*	*2.17*
36" Rooting Layer	*1.06 mil cy*	*$2/cy*	*2.12*
6" Topsoil	*182,000 cy*	*$2/cy*	*0.36*
Seed, Fertilize and Mulch	*228 ac*	*$1500/ac*	*0.34*
Subtotal			*18.62*
Borrow Area Development and Reclamation			
Clear and Grub	*135 ac*	*$1500/ac*	*0.20*
Excavate and Stockpile Topsoil	*145,200 cy*	*$1.25/cy*	*0.18*
6" Topsoil	*108,900 cy*	*$2/cy*	*0.22*
Seed, Fertilize and Mulch	*135 ac*	*$1500/ac*	*0.20*
Subtotal			*0.80*
Totals			
Earthwork			*18.76*
Liners			*14.46*
Leachate Collection			*4.44*
Final Cover			*18.62*
Borrow Area			*0.80*
Subtotal			*57.08*
With 10 Percent Contingency			*5.71*
Grand Total			*62.78*

[1]Cost estimate does not include costs for appurtenant structures such as roadways, decant system, monitoring equipment, etc.
[2]All costs rounded to the nearest $10k.
[3]Geocomposite consists of a geocomposite drain with an additional geomembrane constructed halfway up the sideslope of the initial stage (i.e., stages I, III, V, and VII).

ac	=	*acre*
cy	=	*cubic yard*
mil	=	*million*
sf	=	*square foot*
sy	=	*square yard*
lf	=	*lineal foot*
ea	=	*each*
$ x 10^6	=	*millions of dollars*

Table 6

Cost Estimate for TMA North Alternative[1]

Item/Description	Estimated Quantity	Unit Cost/ Units	Total Cost[2] ($ x 10^6)
Earthwork			
Clear and Grub	*355 ac*	*$1500/ac*	*0.53*
Wetland - Clear and Grub	*23 ac*	*$6000/ac*	*0.14*
Excavate and Stockpile	*5.8 mil cy*	*$1.25/cy*	*7.25*
Excavate, Haul and Compact	*5.3 mil cy*	*$2/cy*	*10.60*
Final Reclamation Excavate and Haul from Borrow Area	*107,400 cy*	*$0.10/cy*	*0.01*
Subtotal			*18.53*
Liners			
Subgrade Preparation	*235 ac*	*$2000/ac*	*0.47*
12" P40 Till	*385,000 cy*	*$7/cy*	*2.70*
Geosynthetic Clay Liner (GCL)	*10.3 mil sf*	*$0.40/sf*	*4.12*
60 mil HDPE	*10.3 mil sf*	*$0.40/sf*	*4.12*
Geotextile (8 oz/yd or >)(Cushioning)	*1.14 mil sy*	*$1.10/sy*	*1.25*
18" Protective Soil (Sideslopes Only)	*328,000 cy*	*$2/cy*	*0.66*
Geotextile (4 oz/yd or >)(Filtering)	*474,000 sy*	*$0.60/sy*	*0.28*
18" Protective Soil (Base Only)	*156,000 cy*	*$2/cy*	*0.31*
6" Till Fines	*78,000 cy*	*$7/cy*	*0.55*
Subtotal			*14.46*
Leachate Collection System			
24" Drainage Layer (Sand)	*313,000 cy*	*$6/cy*	*1.88*
Geocomposite[3]	*2.1 mil sf*	*$0.82/sf*	*1.72*
Internal Leachate Collection Perforated Piping	*11,910 lf*	*$25/lf*	*0.30*
Leachate Cleanout Piping	*9,500 lf*	*$25/lf*	*0.24*
Sideslope Risers and Pumps	*4*	*$50,000 ea*	*0.20*
Leachate Forcemain	*14,100 lf*	*$5/lf*	*0.07*
Leachate Collection System Stone	*4,000 cy*	*$7/cy*	*0.03*
Subtotal			*4.44*

Table 6 *(Continued)*

Item/Description	*Estimated Quantity*	*Unit Cost/ Units*	*Total Cost[2] ($ x 10^6)*
Final Cover			
Soil Grading Layer (thickness varies)	*1.60 mil cy*	*$2/cy*	*3.20*
12" P40 Till	*359,000 cy*	*$7/cy*	*2.51*
Geosynthetic Clay Liner (GCL)	*9.91 mil sf*	*$0.40/sf*	*3.96*
60 mil HDPE	*9.91 mil sf*	*$0.40/sf*	*3.96*
12" Drainage Layer (Sand)	*362,000 cy*	*$6/cy*	*2.17*
36" Rooting Layer	*1.06 mil cy*	*$2/cy*	*2.12*
6" Topsoil	*182,000 cy*	*$2/cy*	*0.36*
Seed, Fertilize and Mulch	*228 ac*	*$1500/ac*	*0.34*
Subtotal			*18.62*
Borrow Area Development and Reclamation			
Clear and Grub	*16 ac*	*$1500/ac*	*0.02*
Excavate and Stockpile Topsoil	*17,200 cy*	*$1.25/cy*	*0.02*
6" Topsoil	*12,900 cy*	*$2/cy*	*0.03*
Seed, Fertilize and Mulch	*16 ac*	*$1500/ac*	*0.02*
Subtotal			*0.09*
Totals			
Earthwork			*18.53*
Liners			*14.46*
Leachate Collection			*4.44*
Final Cover			*18.62*
Borrow Area			*0.09*
Subtotal			*56.14*
With 10 Percent Contingency			*5.61*
Grand Total			*61.75*

[1]Cost estimate does not include costs for appurtenant structures such as roadways, decant system, monitoring equipment, etc.
[2]All costs rounded to the nearest $10k.
[3]Geocomposite consists of a geocomposite drain with an additional geomembrane constructed halfway up the sideslope of the initial stage (i.e., stages I, III, V, and VII).

ac = *acre*
cy = *cubic yard*
mil = *million*
sf = *square foot*
sy = *square yard*
lf = *lineal foot*
ea = *each*
$ x 10^6 = *millions of dollars*

Table 7

Cost Estimate for TMA F15 Setback Alternative[1]

Item/Description	Estimated Quantity	Unit Cost/ Units	Total Cost[2] ($ x 10^6)
Earthwork			
Clear and Grub	*360 ac*	*$1500/ac*	*0.54*
Wetland - Clear and Grub	*28 ac*	*$6000/ac*	*0.17*
Excavate and Stockpile	*5.8 mil cy*	*$1.25/cy*	*7.25*
Excavate, Haul and Compact	*5.3 mil cy*	*$2/cy*	*10.60*
Final Reclamation Excavate and Haul from Borrow Area	*121,000 cy*	*$0.15/cy*	*0.02*
Subtotal			*18.58*
Liners			
Subgrade Preparation	*235 ac*	*$2000/ac*	*0.47*
12" P40 Till	*385,000 cy*	*$7/cy*	*2.70*
Geosynthetic Clay Liner (GCL)	*10.3 mil sf*	*$0.40/sf*	*4.12*
60 mil HDPE	*10.3 mil sf*	*$0.40/sf*	*4.12*
Geotextile (8 oz/yd or >)(Cushioning)	*1.14 mil sy*	*$1.10/sy*	*1.25*
18" Protective Soil (Sideslopes Only)	*328,000 cy*	*$2/cy*	*0.66*
Geotextile (4 oz/yd or >)(Filtering)	*474,000 sy*	*$0.60/sy*	*0.28*
18" Protective Soil (Base Only)	*156,000 cy*	*$2/cy*	*0.31*
6" Till Fines	*78,000 cy*	*$7/cy*	*0.55*
Subtotal			*14.46*
Leachate Collection System			
24" Drainage Layer (Sand)	*313,000 cy*	*$6/cy*	*1.88*
Geocomposite[3]	*2.1 mil sf*	*$0.82/sf*	*1.72*
Internal Leachate Collection Perforated Piping	*11,910 lf*	*$25/lf*	*0.30*
Leachate Cleanout Piping	*9,500 lf*	*$25/lf*	*0.24*
Sideslope Risers and Pumps	*4*	*$50,000 ea*	*0.20*
Leachate Forcemain	*14,100 lf*	*$5/lf*	*0.07*
Leachate Collection System Stone	*4,000 cy*	*$7/cy*	*0.03*
Subtotal			*4.44*

Table 7 *(Continued)*

Item/Description	*Estimated Quantity*	*Unit Cost/ Units*	*Total Cost[2] ($ x 10^6)*
Final Cover			
Soil Grading Layer (thickness varies)	*1.60 mil cy*	*$2/cy*	*3.20*
12" P40 Till	*359,000 cy*	*$7/cy*	*2.51*
Geosynthetic Clay Liner (GCL)	*9.91 mil sf*	*$0.40/sf*	*3.96*
60 mil HDPE	*9.91 mil sf*	*$0.40/sf*	*3.96*
12" Drainage Layer (Sand)	*362,000 cy*	*$6/cy*	*2.17*
36" Rooting Layer	*1.06 mil cy*	*$2/cy*	*2.12*
6" Topsoil	*182,000 cy*	*$2/cy*	*0.36*
Seed, Fertilize and Mulch	*228 ac*	*$1500/ac*	*0.34*
Subtotal			*18.62*
Borrow Area Development and Restoration			
Clear and Grub	*18 ac*	*$1500/ac*	*0.03*
Excavate and Stockpile Topsoil	*19,400 cy*	*$1.25/cy*	*0.02*
6" Topsoil	*14,500 cy*	*$2/cy*	*0.03*
Seed, Fertilize and Mulch	*18 ac*	*$1500/ac*	*0.03*
Subtotal			*0.11*
Totals			
Earthwork			*18.58*
Liners			*14.46*
Leachate Collection			*4.44*
Final Cover			*18.62*
Borrow Area			*0.11*
Subtotal			*56.21*
With 10 Percent Contingency			*5.62*
Grand Total			*61.83*

[1]Cost estimate does not include costs for appurtenant structures such as roadways, decant system, monitoring equipment, etc.
[2]All costs rounded to the nearest $10k.
[3]Geocomposite consists of a geocomposite drain with an additional geomembrane constructed halfway up the sideslope of the initial stage (i.e., stages I, III, V, and VII).

ac	=	*acre*
cy	=	*cubic yard*
mil	=	*million*
sf	=	*square foot*
sy	=	*square yard*
lf	=	*lineal foot*
ea	=	*each*
$ x 10^6	=	*millions of dollars*

B) Additional Information Required for a Feasibility Determination

Page 3, Comment 1: Provide a discussion of the adequacy of the TMA volume contingency of 13%. Include information on how the changes in ore volume from 75+ million tons in the late 70s/early 80s, to 67 million tons in the mid 80s, to 55 million tons in the current proposal should be viewed with respect to the volume contingency. Provide an examination of the effects that lower mining costs or higher metals prices would have on the grade of ore that could be mined profitably and the volume of waste that would be produced. Additionally, discuss the options for disposal of additional tailings after reaching the design capacity of the currently proposed facility (i.e. expansion, new facility, additional backfill, etc.).

Page 3, Response 1: *The change in the mineable reserves from 75 million tons in the 1970s to 55 million tons for the proposed project is a function of the mineable cutoff grade used in the economic analysis. The proposed 1995 permit application (Foth & Van Dyke, 1995b) uses a higher cutoff grade than previously used to account for changes in metal values, operating costs, metallurgical recoveries, and transportation and changes in anticipated smelter returns. The higher cutoff grade results in a total mineable reserve of 55 million tons of ore. This is the basis on which the entire facility has been designed and for which permits are sought. The remaining mineralization containing metal concentrations below the cutoff grade exists in both isolated, discrete areas that will not be mined and in areas spacially distributed throughout the planned development.*

Decreases in the ore reserve could be accommodated by the current TMA design through a reduction in the size of TMA 4 at the time of its construction. Minor increases in the ore reserve could be accommodated by the current TMA design through the planned 13 percent contingency. Significant increases in the ore reserves would impact the capacity of the TMA as it is currently designed. Any design capacity changes beyond that currently proposed to the TMA facilities would require a permit modification addressing an expansion or new facility.

A decrease in mining costs or an increase in metal prices could result in a decrease in the ore cutoff grade. A decrease in the zinc ore cutoff grade to 2 percent would increase the amount of tailings to be placed in the TMA by approximately 7 percent, which is well within the 13 percent contingency. A decrease in cutoff grade to the 1970's or 1980's levels would result in the need for TMA capacity beyond that included in the current design. An increase in needed capacity could be addressed by an expansion to the proposed facility or the development of a new facility. The first option would require a revision to the permit for the proposed facility. The second option would require the permitting of a new facility.

Page 4, Comment 2: Include the portion of EIR Cross Section E-E' from G41-A23 to DMA-31 on the western edge of the compliance boundary in the feasibility report.

Page 4, Response 2: *Drawing 5 shows a revised geologic cross-section location map. Revised geologic cross-sections are provided on Drawings 5A through 12D. The requested portion of regional cross-section E-E' is provided on Drawing 5A as TMA geologic cross-section E"-E"'.*

Page 4, Comment 3: Develop two new geologic cross sections that include the following borings or wells or propose a similar alternative:

a. E-W on the southern edge of the compliance boundary: DMA-4, G41-D18, CMC-05/EX-13, CMC-04/G41-H18, G41-J18, G41-L19, G41-P18, DMA-32A
b. N-S on the eastern edge of the compliance boundary: G41-N21, G41-P18, G41-M15, DMB-8, EX-8/G41-M11, DMB-3, WP-6

Page 4, Response 3: *The requested two new geologic cross-sections are presented as cross-sections P"-P"" and Q"-Q"" on Drawings 12A and 12B.*

Page 4, Comment 4: Include all new borings on at least one geologic cross section.

Page 4, Response 4: *The new borings, CMC-TMA-101 through CMC-TMA-110, completed in January and February of 1996 are included on the revised geologic cross-sections displayed on Drawings 5 through 12D. As shown by the cross-sections, the borings corroborate previous interpretations of the glacial stratigraphy.*

Page 4, Comment 5: Provide revised geologic cross sections that include all wells or borings within the proposed facility footprint. Label the bedrock formations on all FR geologic cross sections.

Page 4, Response 5: *All borings within the TMA facility boundaries have been included on the revised geologic cross-sections provided as Drawings 5 through 12D. Also displayed on the cross-sections are the bedrock formations.*

Page 4, Comment 6: Provide a bedrock contour map for the TMA vicinity showing the same area and at the same scale as the Existing Conditions Map, Drawing 3.

Page 4, Response 6: *A bedrock contour map is provided as Drawing 12E. The map includes data from environmental borings that encountered bedrock. Also included is approximate bedrock surface elevation data from exploration holes 199 and 205, based on the depth at which bedrock coring began. Of the exploration holes, these were the only two where the start of coring correlated with other bedrock data. It should be noted that coring for exploration holes does not always start at the till/bedrock interface. The start of coring is typically dictated by the degree of weathering and recovery. The bedrock contour map depicts a surface of considerable relief with an east west trending bedrock ridge beneath the center of the TMA. From the ridge, the bedrock surface slopes to the north. To the south a local bedrock depression exists.*

Page 4, Comment 13: Provide a detail for the reclaim water pump station construction. Include information on the foundation, protection from weather, and power supply.

Page 4, Response 13: *Three alternatives for the reclaim pond pump station are under consideration. The alternatives include a sideslope intake structure, piping draining to an exterior wetwell, and a central barge with a suction lift pump mounted on the pond's exterior berm. Each alternative is briefly described below.*

- *The central barge with a berm mounted suction lift pump, which is the preferred option, would be similar to the system proposed for decanting water from the TMA. A typical view of this system is shown as detail 3/30 on Drawing 30 of the Feasibility Report. For this alternative, a barge with an intake would be located in the pond with the suction lift pump located on the top of the berm. The main advantages of this system are that liner penetrations are avoided and the ease of servicing the pump.*

- *The sideslope intake structure would be similar to the sideslope riser planned for leachate extraction in the TMA. It would consist of a small diameter manhole or large diameter pipe lying on top of the liner, most likely on an interior sideslope in the corner of the reclaim pond. A typical view of this system is shown as detail 1/30 on Drawing 30 of the Feasibility Report. A submersible pump would be provided at the bottom of the intake*

structure which will have sufficient capacity to pump water from the reclaim pond to the mill. The sideslope intake structure would lay on top of the liner's protective cover and be designed with suitable padding to prevent damage to the liner. The main advantage of this system is that no liner penetration is required.

- *The reclaim pond could be fitted with a series of intake pipes at different elevations so that the reclaim pond could be drawn down to the level desired by manually operating a valve at the top of the berm. Each intake pipe would penetrate the liner through a booted liner joint and discharge into a wetwell located on or outside the reclaim pond exterior berm slope. A typical view of a geomembrane pipe boot is shown as detail 5/29 on Drawing 29 of the Feasibility Report. The wetwell would be equipped with a submersible pump of sufficient size to pump water to the mill. The major advantage of this system is that the pump is located outside the pond for easy access.*

Power to the pump for each of the alternatives would be provided from the power line to be installed along the TMA access road and tailings pipeline route corridor. A decision on which alternative will be used will be made during final engineering design.

Page 4, Comment 14: In consultation with the Department, develop a lab-scale physical drainage test of the proposed filter layer design using representative materials and a realistic head. Provide the results to the Department.

Page 4, Response 14: *The design of the filter system was performed using the NAVFAC DM 7-1 filter criteria. These criteria were developed by Terzaghi based on experiments conducted by Bertram (1940). The Waterways Experiment Station, U.S. Army Corps of Engineers (1941, 1942) have investigated the validity of the criteria. The criteria have been used the world over ever since.*

The use of the above criteria is considered appropriate for the design of the filter over the drainage layer placed on the TMA base for the following reasons:

- *The criteria have been developed and validated for particle sizes ranging from plastic clay with low permeability to non-plastic silt, rock flour, and varved silt. The tailings are coarser than clays and are characterized as sandy silt or rock flour.*

- *The proposed filter system has layers with successively increasing hydraulic conductivities from the base of the tailings to the drainage layer. This, in turn, will lead to a continually decreasing seepage force as the tailings pore water drains.*

CMC would like to point out that the column tests conducted to characterize the TMA tailings are very similar to a test set up that would be required to perform a lab-scale physical drainage test of the filter layer design. Since the column test setup is scheduled to be dismantled shortly, this will provide a good opportunity for the WDNR staff to make observations of the presence or absence of tailings fines in the filter zone. In view of the above, CMC requests that this comment be withdrawn in lieu of the WDNR observation of the dismantling of the column test setup.

Page 5, Comment 15: Provide more information on earth work balances and stockpile sizing through the life of the facility. Revise the discussion of the processing of native soils to provide more detail on methods and procedures. It is not clear how or where excess soil will be stored between cells.

Page 5, Response 15: *The Feasibility Report (Foth & Van Dyke, 1995a) contains Table 6.12-3 (Waste Volumes and Earthwork Balance for TMA Cells) and Table 6.12-4 (TMA Construction - Stockpile Sequence). Table 6.12-3 contains an accounting of the earthwork balance and soils required for processing over the life of the facility. These quantities are based on the design presented in the Feasibility Report which included importing approximately 743,000 cubic yards of clay from off-site locations. At the present time, the soil liner type and thickness is under review by WDNR, as are other factors which could impact the earthwork balance. As a result, CMC proposes to finalize the earthwork balance when all factors influencing it have been resolved.*

Table 6.12-4 contains a description of the stockpiling sequencing, including the approximate time period, the stockpile size, and the purpose of each stockpile. The stockpiling of soils for future processing into granular materials, fines, or for general fill will conform to the following general principles:

- *With the exception of the construction and closure of TMA 4, stockpiles will be located only in areas which have already been disturbed or that will be disturbed by future activities (i.e., future cell construction or soil borrow activities). Stockpiling during the construction and closure of TMA 4 will occur in the closure borrow area.*

- *Stockpiles will be located as close as practicable to either the construction staging area or the portion of the site in which the soil will be used.*

- *Stockpiles will be confined to the smallest possible area. The size, shape, and construction of stockpiles will depend on the equipment used by the contractor, the soil type, and other factors.*

- *The management of surface water and the construction and/or installation of erosion control devices will be the first step in either stockpile construction or borrow area development. Surface water will be diverted away from disturbed areas by constructing diversion berms or ditches. Runoff from disturbed areas will be routed to a temporary or permanent sedimentation pond located within the disturbed area prior to discharge. The project's erosion control plan outlined in Section 4.10 of the MPA (Foth & Van Dyke, 1995b) and the Wisconsin Construction Site Best Management Practice Handbook will be used for guidance in the selection, design, construction, operation, and maintenance of erosion and sedimentation control structures.*

Figures 6.12-1 through 6.12-5 provide the typical locations of the soil stockpiles and the construction staging area during various phases of TMA construction. The contractor will determine the exact stockpile location, size, shape, etc., based on haul distance, equipment type, logistics, and other factors. Note that the construction staging area will be located in the same location until approximately year 24 of TMA operation when TMA 4, Stage VII construction is started. This will enable the contractor to use the same area for the processing of soils and deployment of the liner and leachate collection system materials. The construction staging area is estimated to be approximately 10 acres in size through the first 24 years. When it is relocated for the construction of the final cell (TMA 4), it is estimated to be approximately 6 acres in size. The construction staging area will be used to locate the equipment (e.g., screening plant, washing plant, conveyors, etc.) for soil processing. Material processed for use in TMA construction will be temporarily stored in the construction staging area, typically for only a short period of time prior to placement in the TMA cell under construction. It is possible that there would be periods of time when the contractor may need to stockpile soils outside the construction staging area. A separate stockpile area has been shown on the figures for this purpose.

Gradational requirements for some of the materials to be employed in construction do not match the gradation of the native till or outwash soils. Therefore, processing of these soils which could include screening, crushing and/or washing of the till or outwash soils may be required. Table 6.12-2 from the Feasibility Report (Foth & Van Dyke, 1995a), provides a summary and description of the processes needed to produce the various required gradations. Figure 6.12-6 shows a typical flow path for processing of till to achieve the required soil and aggregate products. Following is a description of typical equipment which could be used in these processes.

- *Vibrating grizzly feeders are mechanically actuated, self-cleaning feeders which regulate the flow of material from material handling equipment.*

- *Screens separate aggregate particles into various sizes. The types of screens typically used include vibrating inclined, stationary inclined, vibrating grizzly, vibrating horizontal, and rotary.*

- *Washing equipment may consist of rinsing materials over vibrating screens with one to three gallons per minute of water. If screen washing described above is inadequate, screw washers, log washers, and rotary scrubbers can be used to clean aggregates to the required P200 limits.*

- *Belt conveyors, typically used to keep material moving through the aggregate processes, are typically located between processes and at the end of process lines to pile finished materials.*

Page 5, Comment 17: Provide a more detailed discussion on amendments to/alterations of the tailings mass to reduce acid production. Include more information on oxidation barriers (i.e. a layer of organic material on top of the tails and beneath the grading layer), adding buffering capacity to the system both above and below the tails, and thickening the tails. Discuss the longevity and constructability of these amendments/alterations.

Page 5, Response 17:

Amendment and Alteration to Tailings Mass

Liner and cover systems have been widely used in the forest products industry and in municipal and industrial waste disposal. During the last 10 to 15 years, the mining industry has focused its attention on the use of low permeability covers and oxygen consuming materials that will limit diffusion of oxygen through the interstitial pores of a tailings mass.

An Evaluation of Alternate Dry Covers for the Inhibition of Acid Mine Drainage from Tailings was conducted under the MEND Program (MEND, 1994). The report classified dry covers primarily as oxygen transport barriers, oxygen consuming barriers, or reaction inhibiting barriers. A discussion of these and other applications follows.

- *Oxygen Transport Barriers. Liner systems typically act to retain moisture and hence provide a low diffusion barrier to atmospheric oxygen.*

    - *The primary mode of oxygen transport to the surfaces of sulfide tailings is by molecular diffusion through interstitial pore spaces. The degree of oxygen diffusion through tailings pore space is a strong function of the moisture content and/or the type and thickness of the final cover.*

- *The degree of saturation within the tailings mass will cause the diffusion coefficient to vary as much as five orders of magnitude (MEND Project 2.20.1 Appendix A, Nicholson, 1994).*

- *Field evaluation of composite covers at Waite Amulet indicates that oxygen fluxes through covers may be reduced by as much as 90 to 99 percent over non-covered sites (Yanful, et al., 1993).*

- *An evaluation of a composite liner at Heath Steele indicate that oxygen concentrations in the waste rock pile was reduced to less than 1 percent two years after placement of cover (Bell, et al., 1995).*

• *Oxygen Consuming Barriers. The primary function of these cover materials is to reduce the oxygen concentration at the tailings/cover interface by consuming oxygen. The reduction of oxygen is achieved by biological degradation through the use of a cover material that contains organic matter (such as wood chips, wood waste, peat, hay, silage, paper mill and/or sewage sludges).*

- *The efficiency of these organic covers depend on their oxygen demand. Using an average consumption rate of $1.9x10^{-6}$ mol of O_2 per square foot per second, the average life span of 3.3 feet of organic cover is 10.7 years if anaerobic degradation is neglected.*

- *Anaerobic fermentation processes produce organic acids which can mobilize metals and provide energy for oxidation. Bench scale work by Yanful and Payant (1992) suggests that wood may have accelerated the rate of acid production by about 60 percent in the laboratory and by 500 percent in the field.*

- *Incorporating organic matter into a reactive tailings mass makes use of sulfate reduction. This reduction process will occur under anoxic and near neutral conditions but does not limit acid generation and it causes precipitation of metal ions as sulfides as the pore water migrates through the organic rich-zone (Blowes, et al., 1988).*

- *Results to date indicate that a relatively thin wood bark cover is not a good technique for reducing acid generation in reactive waste rock (St. Arnaud, 1994).*

• *Reaction Inhibiting Barriers. These types of covers provide an environment which results in a significant reduction of the sulfide oxidation rate by biological and chemical processes.*

- *The controlling parameter in the field is pore water pH. At pH values above 4.5, biological activity is negligible. Materials such as ground phosphate have been used as reaction inhibitors by reacting with the surface of the pyrite crystals forming a coating.*

- *Fly ash, lime kiln dust, etc., provide alkalinity which controls pH which then controls biological activity as discussed above.*

- *There are a number of organic and inorganic compounds (surfactants) which are bactericides that will inhibit biological activity. Those substances that are economical*

have been shown to biodegrade rapidly in a tailings environment. Research into the use of such surfactant compounds to inhibit acid generation from pyritic material has shown that control is temporary.

- *Other Applications. Synthetic covers, including asphalt, spray-on sealing agents, waxes, and polymers have not been tested and have been discounted because of their potential for cracking which would increase the oxygen flux rate.*

Included in Attachment 7 is Table 3.1 from the MEND (1994) report. The table provides a summary of potential dry cover materials describing sources and quantities, perceived benefits and concerns, experience related to tailings sites, etc.

Thickened Tailings

The air/oxygen permeability of drained thickened tailings is not significantly less than that applicable to tailings that will reside in the TMA due to the natural loading which will occur as the ponds fill. Hence, drained thickened tailings would not reduce the entry of oxygen into the tailings by diffusion in the long term. Under the proposed design, the tailings cells themselves will behave like a larger thickener eliminating the need for a thickener at concentrator.

Page 5, Comment 18: Provide a more detailed discussion on the distinction between Type I and Type II waste rock. Determination of the cutoff chemistry and description of the methodology for field assessment is needed. In addition, the FR is inconsistent in several areas in the proposed use/disposal of Type I and Type II waste rock. Clarification is necessary.

Page 5, Response 18: *The distinction between Type I and Type II waste rock, determination of cutoff chemistry, and a description of the methodology for field assessment will be included in the project's final waste characterization report, referenced in the response to comment 3 above. The requested clarification regarding the proposed use of Type I and Type II waste rock is provided by rewriting the last sentence of the last paragraph of Section 4.1.1.1, Waste Rock, of the Feasibility Report to read as follows: "This material will be brought to the surface during the preproduction phase of mine development and will be used for erosion control on the TMA interior slopes."*

Page 5, Comment 20: Revise the discussion on sulfide mineral removal in the alternatives section to include an analysis of the creation of a segregated high-sulfide waste disposal facility and an assessment of the low-sulfide waste disposal options.

Page 5, Response 20: *The separation of tailings into high and low-sulfide components would offer no environmental or operational advantage for the Crandon Project. Both high and low-sulfide tailings are potentially acid generating. Even if pyrite removal were to be employed, a residual of 1 to 2 percent would remain assuming a 90 percent sulfide removal efficiency. If segregated high and low-sulfide disposal were implemented, two separate lined facilities would need to be operated simultaneously requiring two separate pumping and transport lines.*

Page 5, Comment 21: Revise the discussion of geomembrane and geotextiles to identify the resin or resins most likely to be used and the rationale for selection. Include a discussion of why the selection of a specific membrane type should be delayed until a pre-construction report just prior to cell construction. All geotextiles proposed to be used should be described at least generically as woven or non-woven with a given weight and type of production. Include a discussion of the potential longevity of the membranes to be used in the liner and final cover systems.

Page 5, Response 21: *In response to comment 19 on page 3, CMC has already identified HDPE as the resin most likely to be used for the geomembrane and polypropylene as the resin most likely to be used for the geotextiles, if the construction were to be done today. The reasons for this selection, as well as the basis for selection in the future, are:*

- *Compatibility with the tailings and anticipated leachate from the facility.*
- *Longevity of the liner and geotextile materials.*
- *Experience in the industry from the perspective of manufacture and installation including manufacturing quality control (MQC) and manufacturing quality assurance (MQA).*
- *Experience in the engineering community from the perspective of construction quality control (CQC) and construction quality assurance (CQA).*
- *Availability and competitive pricing of the liner and geotextiles.*

Of the above reasons, the most compelling ones are the superior chemical resistance in the case of HDPE and availability in the case of polypropylene for geotextiles. This stems from the primary purpose of the geomembranes and the geotextiles. For the geomembrane, the primary purpose is to remain as an effective hydraulic barrier for a very long period of time. This can be achieved only if the liner material is compatible with the materials it comes into contact with at anticipated field conditions and if the liner installation practices are conducive to a long service life. The superior chemical resistance of HDPE makes it the liner material of choice in containment applications. Coupled with this, the design and installation experience gained during the past five to ten years makes it possible to practically eliminate the potential for defects during the construction and operation of a containment facility. Quality control and quality assurance practices, monitoring of the constructed liner using techniques such as leak location surveys, and sound engineering design methods to identify possible loading (stressing) conditions and providing an adequate factor of safety under those conditions make HDPE an excellent choice for the TMA liner at this time.

In the TMA design, geotextiles are to provide cushioning and filtration functions. The resin needs to be compatible with the environment in which it is situated, including the liquids with which it comes in contact. Polypropylene satisfies this criteria. Because of its availability at competitive prices, polypropylene has been selected for application in the TMA. Descriptions of the geotextiles proposed for use in the TMA can be found in Section 6.3.5 and 6.4.3.1 of the Feasibility Report. All geotextiles would be non-woven polypropylene.

The reasons why the selection of a specific membrane type should be delayed until a pre-construction report just prior to cell construction are discussed below.

- *The TMA is proposed to consist of four independent cells to be constructed sequentially.*
- *The cells will be constructed during a period spanning close to three decades. Technology is likely to change during this period, potentially resulting in the development of other materials equal to or superior to those currently available.*
- *Maintaining flexibility to use different materials and methods of construction if the same environmental protection can be achieved at a lower cost, or if the same cost can achieve better environmental protection, is desirable.*

- *Materials available today may no longer be available if replaced with new materials.*

Because of the factors listed above, it is prudent to permit a design with materials meeting performance requirements with respect to stress conditions and permeability conditions.

The design requirement for the longevity of the geomembrane in the base liner should be a function of the time that the percolation from the TMA site is controlled by the final cover placed over the facility or when the percolation from the site becomes negligible. Once the tailings have consolidated and drained to their field capacity, percolation from the base of the site is limited to the percolation of precipitation through the final cover. The importance of the base liner diminishes when the performance of the facility is governed by the final cover system alone.

Based on the above criterion, the time for the draining the tailings from their initial water content to their field capacity is the factor that determines the required longevity of the base liner geomembrane. Field capacity is a function of the density which varies with depth. The rate of drainage will depend on the hydraulic conductivity(s) of the tailings layers located at lower depths. As a result, the tailings within a TMA cell will reach field capacity at different times. Given this fact, the appropriate way to determine the time of drainage for the tailings mass is to use the HELP model results to assess when the soil water in the system reaches equilibrium conditions. Based on the model, this time has been determined to range from approximately 20 to 50 years. Therefore, a conservative design requirement set at 50 years for the longevity of the geomembranes in the liner is appropriate.

Available geomembranes, HDPE for example, have been described as non-degradable. It is known that the longevity of the polymer used to manufacture geomembranes can be affected by 1) thermal-oxidative degradation, 2) ultraviolet degradation, 3) chemical degradation, 4) environmental stress cracking, and 5) biological degradation. The use of geomembranes in facilities such as the TMA cells for the Crandon Project will not be conducive to these types of degradation mechanisms. Therefore, an argument can be made that geomembrane longevity should not be a concern. Accelerated aging tests conducted on HDPE have resulted in the predictions that geomembrane polymers may last for centuries. Based on the available information relating to geomembrane polymers and their intended application for the Crandon Project, it is concluded that HDPE will meet the longevity requirements for the liner of the Crandon Project's TMA.

Page 5, Comment 22: Provide clarification to the discussion of leachate management addressing the following items:

a. Projected period of active dewatering/leachate generation.
b. Projected periods of leachate pumping and criteria for determining when pumping should end.
c. Expected impact on percolation volumes and rates due to periods of non-pumping.
d. Expected head on liner system during periods of non-pumping.

Page 5, Response 22: *As presented in the Feasibility Report, the approach CMC used to design its TMA leachate management system consisted of the following five principal steps.*

- *Assume that leachate collection will continue for the full length of the 40-year post-closure care period.*

- *Model the water balance in the system using the HELP model to obtain the tailings water content at the end of 40 years.*

- *Inputting the tailings water content as obtained above into the HELP model without leachate removal, run the model for 200 years.*

- *Using the data from the above two separate models representing the two separate periods to determine the percolation from the site for the complete post-closure period. It should be noted that CMC had conservatively assumed the geomembrane component of the composite liner to be ineffective 100 years after the cessation of pumping, resulting in the soil component alone as a hydraulic barrier. This results in a transient increase in the percolation from the site.*

- *Once the percolation from the site was estimated, input the quantities into the solute groundwater transport model to assess compliance with the groundwater standards, which is the goal of the design.*

The results of CMC's analysis of the TMA leachate management design can be found in Section 6.4, Leachate Management System, of the Feasibility Report (Foth & Van Dyke, 1995a). Section 6.4.7.1 contains information on leachate generation during the post-closure period. Appendix J of the Feasibility Report lists the expected leachate quantities from closed cells as a function of time. Appendix J also shows the results from HELP model runs where the TMA cells have been modeled with final cover and an active drainage system at the base.

Based on the analysis described above, CMC has demonstrated that the TMA design complies with groundwater standards. The analysis performed evaluates the TMA system as a whole rather than evaluating individual aspects such as referred to in items a. through d. of WDNR's comment. However, in an effort to be responsive, the requested information is provided below.

a. *Projected period of active dewatering/leachate generation.*

   Based on the HELP model output, approximately 80 percent of the total soil water in the tailings is drained within 20 years after closure. At this point, the rate of estimated soil water drainage has decreased significantly. Also at this time, the leachate generation rate is about 2 percent of the peak leachate generation rate during the first year after closure. As shown in Appendix J of the Feasibility Report (Foth & Van Dyke, 1995a), the leachate generation rate becomes practically negligible in approximately 50 years.

b. *Projected period of leachate pumping and criteria for determining when pumping should end.*

   CMC projected the period of leachate pumping to be 40 years to coincide with the post-closure care period. The criteria used was a back check to determine if groundwater criteria are met with this pumping period.

c. *Expected impact on percolation volumes and rates due to periods of non-pumping.*

   Table 6.7-19 of the Feasibility Report (Foth & Van Dyke, 1995a) shows that percolation rates will increase when leachate pumping is stopped (see the percolation rate at the base for years 36 to 40 versus the later years). However, the important aspect of the analysis is that cessation of pumping does not impact compliance with groundwater standards.

d. *Expected head on liner system during periods of non-pumping.*

As with the percolation rates, the head on the liner will also increase gradually after leachate pumping is stopped (from 0 to 0.074 inches in 100 years). However, also as with percolation rates, CMC's analysis has shown that the increase in heads does not impact compliance with groundwater standards.

Page 5, Comment 23: Provide results from TCLP testing on samples of high sulfide waste rock and tailings.

Page 5, Response 23: *A report regarding TCLP testing is in preparation and will be forwarded to the WDNR when it is completed.*

Page 5, Comment 25: Include a section on the disposal of wastewater treatment plant solids after the closure of the final TMA cell.

Page 5, Response 25: *After CMC has ceased the mining and processing of ore, and the final TMA cell has been closed, the wastewater treatment plant will see a significant decrease in the volume of water it is expected to treat. This will result in an equally significant decrease in the production of solids. At such time, CMC will be required to identify an approved disposal site, other than the TMA, for the wastewater treatment system solids (e.g., a landfill licensed to handle such materials). The actual flow of leachate from the TMA may become so small that taking the leachate to an alternate treatment facility, licensed to handle such waters, may become the selected alternative.*

Because the date when off-site disposal of leachate could occur is many years in the future, it is not possible to state exactly which method(s) and location(s) will be used for treatment and disposal. However, there are presently several waste disposal companies operating in Wisconsin, such as, Peoria Disposal Company, Waste Management Inc., Browning Ferris Industries, Inc., etc., which provide transportation, treatment, and/or disposal of liquid wastes from industrial facilities. These companies typically use one of the following options for treatment and disposal of liquids similar in quality to that anticipated for the TMA leachate:

- *Pretreatment and discharge to a municipal sanitary sewer system. For this option, the leachate would be pretreated to meet the standards for discharge into a municipal sanitary sewer system. The pretreated wastewater would then be monitored prior to discharge. If solids are produced by pretreatment, they would be dewatered or stabilized and disposed of in a landfill licensed to accept them.*

- *Stabilization and disposal as a solid material. For this option, a stabilization process would be used to incorporate the liquid into a solid material to produce a solid waste suitable for disposal in a landfill. The landfill selected would be based on the characteristics of the solid waste produced and whether the landfill was licensed to accept the solid waste. Such a landfill could exist in Wisconsin, or a landfill outside of Wisconsin may be used.*

Following closure of the final TMA cell, the solids produced by the project's wastewater treatment system will be dewatered on-site and then transported for off-site disposal. There are presently several waste disposal companies operating in Wisconsin, such as those listed above, which provide transportation and disposal of solids from industrial facilities. These companies will haul materials similar to those expected for the wastewater treatment system solids to an off-site landfill for disposal. The solids would likely be classified as a special waste and, as such, if they would meet the special waste criteria in place at the time of disposal, they could be delivered to any landfill in Wisconsin licensed to accept special waste of this nature. If at the time of disposal a Wisconsin landfill was not licensed to accept this material, it would be transported out-of-state to a landfill licensed to accept it.

C) Design, Operational or Performance Concerns and Comments

Page 6, Comment 8: Provide a wetland-by-wetland overall impact assessment (including both "indirect" and "direct" impacts) for all wetlands to be affected by the TMA.

Page 6, Response 8: *An update to Section 4.2.7 of the project's EIR addressing this comment will be provided to the WDNR shortly.*

Page 6, Comment 10: Provide a comparison of the wetland water budget model results for the Duck Lake wetlands to the Duck Lake spreadsheet water budget model using the same drainage basin.

Page 6, Response 10: *Attachment 8 contains a technical memorandum addressing this comparison.*

Page 6, Comment 11: Provide an update to EIR Appendix 4.2-5 Table 4, taking into account the changes that occur to the drainage basin due to capping of the TMA.

Page 6, Response 11: *The primary component of the response to Comment 11 was included in Addendum No. 1 to the May 1995 Tailings Management Area Feasibility Report/Plan of Operation. Attachment 9 contains a February 26, 1996 technical memorandum describing the results of the investigation to determine if fragipans influence the hydrology of the Burr Oak Swamp. The investigation concluded that while there is some evidence that fragipans exist in some areas along the proposed TMA's northwest ridge, the soils on the ridge are well drained, indicating that fragipans do not influence the hydrology of Burr Oak Swamp in that area.*

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Figures and Drawings for Addendum No. 2 to the Crandon Project Tailings Management Area Feasibility Report/Plan of Operation



N

LEGEND

PROPOSED TMA FACILITY

0 4300' 8600'

APPROXIMATE SCALE

NOTES

1. MAP DERIVED FROM LAND ATLAS & PLAT BOOK, LANGLADE COUNTY 1992 & FOREST COUNTY 1989.
2. REPRODUCED WITH PERMISSION OF ROCKFORD MAP COMPANY, ROCKFORD, IL.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: MAR. '96	
APPROVED BY:	REM	DATE: MAR. '96	
APPROVED BY:	GWS	DATE: MAR. '96	

Crandon Mining Company

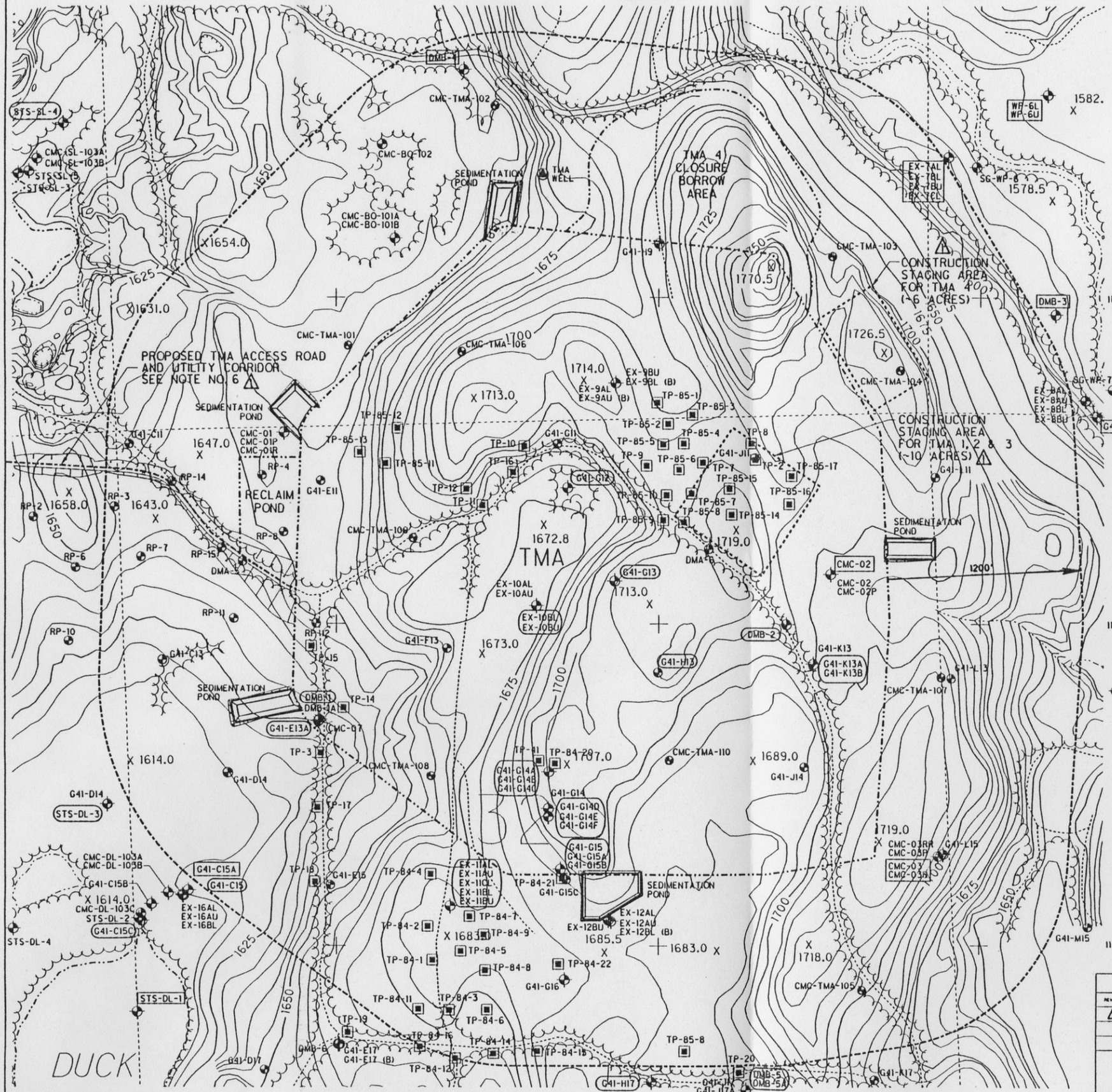
FIGURE 3.2-1A

PROPERTY OWNERSHIP

Scale:	AS SHOWN	Date:	MARCH, 1996
Prepared By:	Foth & Van Dyke	By:	JRB2

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93C049



LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- —1675— EXISTING CONTOUR
- 1692.0 X SPOT ELEVATION
- SECTION LINE
- PERIMETER OF MINE WASTE SITE (AS PER NR182)
- COMPLIANCE BOUNDARY
- SOIL BORING LOCATION (SEE NOTE 5)
- MONITORING WELL LOCATION (SEE NOTE 5)
- ⚠ WP-7L — ABANDONED WELLS NUMBER AND LOCATION
- ⚠ DMB-2 — TEMPORARILY ABANDONED WELLS NUMBER AND LOCATION
- TEST PIT LOCATION (SEE NOTE 5)
- PROPOSED TMA WATER SUPPLY WELL LOCATION (SEE NOTE 5)

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. SOIL BORING, TEST PIT, WATER SUPPLY WELL & MONITORING WELL NUMBERS ADJACENT TO SYMBOL.
6. ⚠ UTILITY CORRIDOR INCLUDES TAILINGS PIPELINE, RECLAIM WATER PIPELINE, AND ELECTRICAL.
7. ⚠ ADDED THE FOLLOWING: ABANDONED WELLS, TEMPORARILY ABANDONED WELLS, CONSTRUCTION STAGING AREAS, BORROW AREA, UTILITY CORRIDOR AND SEDIMENTATION PONDS.

0 300' 600'
SCALE

REVISED	DATE	BY	DESCRIPTION
⚠	3/13/96	REM	SEE NOTE 7

TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

Foth & Van Dyke

Crandon Mining Company

TITLE: EXISTING CONDITIONS - TMA

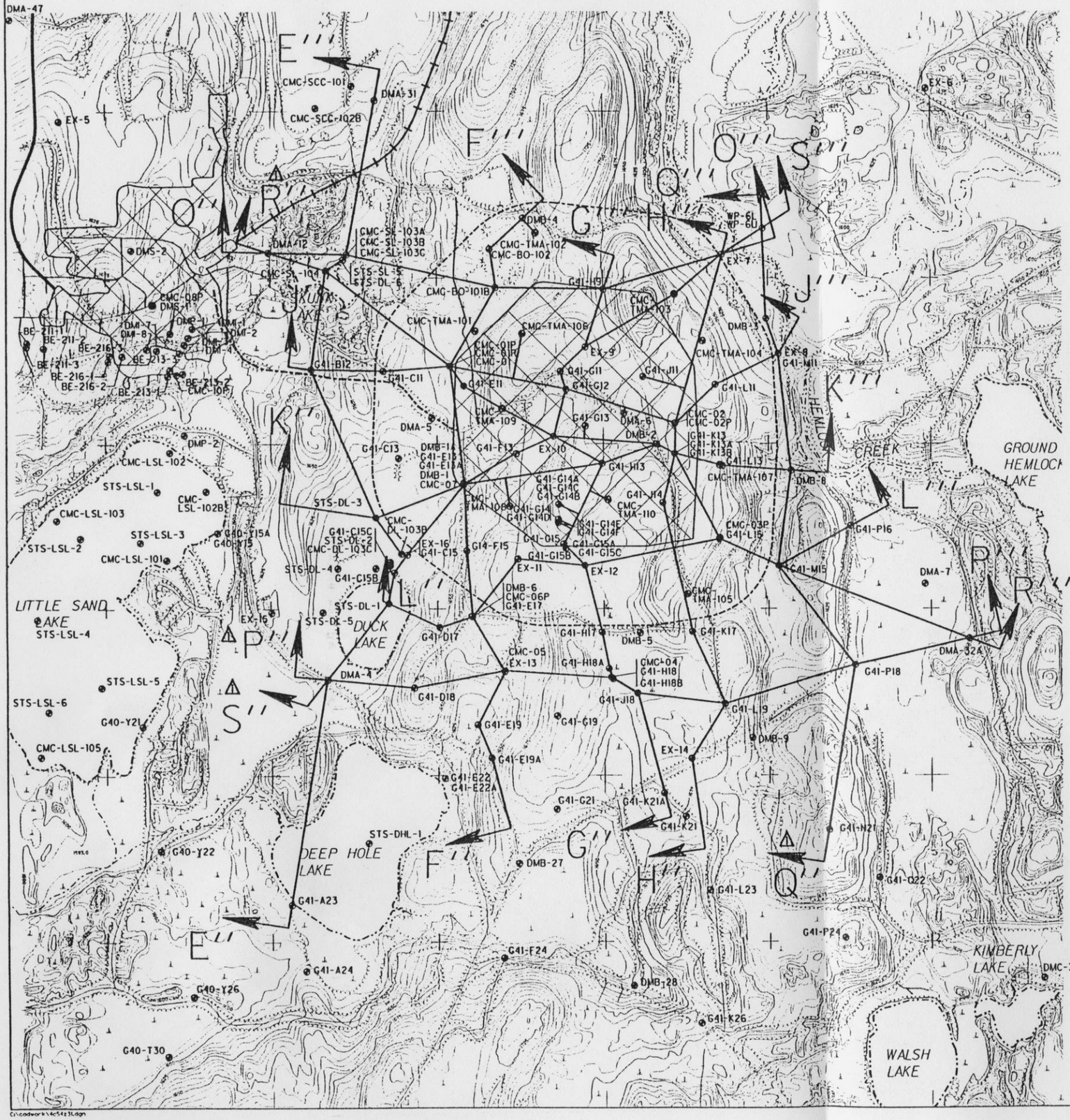
SCALE AS SHOWN	STATE: WISCONSIN	COUNTY: FOREST	
DRAWN BY: GAM, JPRI	DATE: 5/95	CHECKED BY: JKSI	DATE: 5/95
APPROVED BY: REM	DATE: 5/95	APPROVED BY: NXP	DATE: 5/95
APPROVED BY: GWS	DATE: 5/95	CRANDON MINING COMPANY: DEM	DATE: 5/95
DRAWING NO. 3		SHEET 3 OF 1	REVISION NO.

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03/15/96 JRB2

2,277,500 E | 2,280,000 E | 2,282,500 E | 2,285,000 E | 2,287,500 E | 2,290,000 E

120,000 N | 117,500 N | 115,000 N | 112,500 N | 110,000 N | 107,500 N



LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- EXISTING CONTOUR
- TREE LINE
- SPOT ELEVATION
- SECTION LINE
- PROPOSED ACCESS ROAD
- PROPOSED HAUL ROAD
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- EX-9 SOIL BORING
- G41-J11 SOIL BORING PROJECTED ONTO CROSS SECTION

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. ⚠ MODIFIED EXISTING SECTIONS AND ADDED SECTIONS P'''-P''', Q'''-Q''', R'''-R''', S'''-S'''.

SCALE
0 800' 1600'

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION
⚠	3/96	SVDI	SEE NOTE NO. 5

TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

Crandon Mining Company

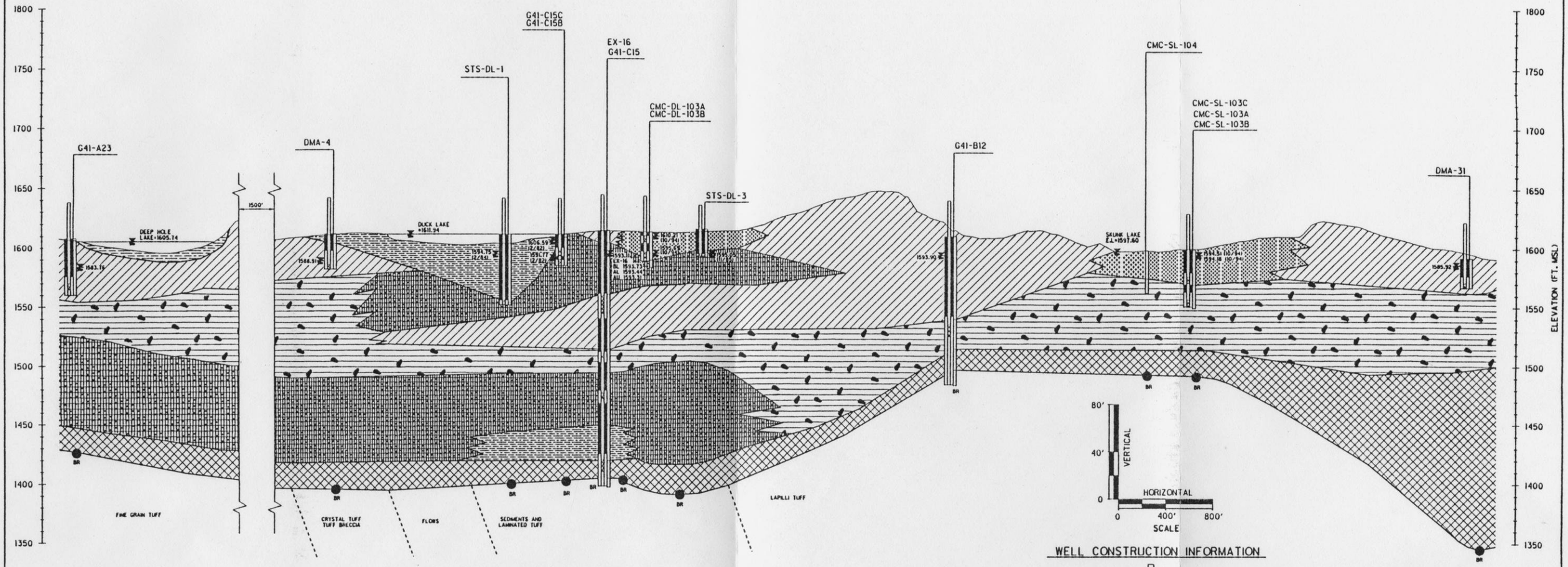
TITLE
GEOLOGIC CROSS SECTION LOCATION MAP

SCALE AS SHOWN	STATE WISCONSIN		COUNTY FOREST		
DRAWN BY GAM, JPRI	DATE 5/95	CHECKED BY JKSI	DATE 5/95		
APPROVED BY REM	DATE 5/95	APPROVED BY NXP	DATE 5/95		
APPROVED BY GWS	DATE 5/95	CRANDON MINING COMPANY DEM	DATE 5/95		
DRAWING NO. 5		SHEET 5 OF 31	REVISION NO. 1		

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SECTION E''-E'''



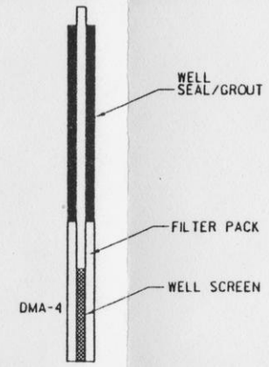
LEGEND

- Qtl UNDIFFERENTIATED LATE WISCONSIN TILL — NASHVILLE MEMBER, COPPER FALLS FORMATION AND THE MAPLEVILLE MEMBER, HORICON FORMATION
- Qte UNDIFFERENTIATED EARLY-WISCONSIN-TILL AND PRE-WISCONSIN TILL — MARATHON AND LINCOLN FORMATIONS, MAY INCLUDE MASSIVE SAPROLITE
- Qowf FINE-GRAINED OUTWASH DEPOSITS — GLACIAL FLUVIAL STRATIFIED SAND AND SILT OF WISCONSINAN AGE
- Qowl COARSE-GRAINED OUTWASH DEPOSITS — GLACIAL FLUVIAL STRATIFIED SAND AND GRAVEL OF WISCONSINAN AGE
- INFERRED GEOLOGIC CONTACT
- 1594.58 (EX-128L) WATER LEVEL ELEVATION (10/84)* UNLESS INDICATED
- LL LIQUID LIMIT
- PI PLASTICITY INDEX
- P200 PERCENT FINES
- USCS UNIFIED SOIL CLASSIFICATION SYSTEM
- KL LABORATORY HYDRAULIC CONDUCTIVITY IN CM/SEC.
- Ql LACUSTRINE DEPOSITS — GLACIO-LACUSTRINE, BEDDED, SILT AND CLAY WITH MINOR AMOUNTS OF SAND OF WISCONSINAN, HOLOCENC AND RECENT AGE.
- Qhlc ICE-CONTACT DEPOSITS — ABLATION TILL, FLOW TILL, GLACIO-FLUVIAL SILT, CLAY AND SAND OF WISCONSINAN AGE
- BR PCu UNDIFFERENTIATED BEDROCK — PRECAMBRIAN METAVOLCANIC BEDROCK, FINE GRAIN TUFF, CRYSTAL TUFF, TUFF BRECCIA, FLOWS, SEDIMENTS AND LAMINATED TUFF, LAPILLI TUFF, MAY INCLUDE STRUCTURED SAPROLITE
- BR INFERRED UNDIFFERENTIATED BEDROCK ELEVATION BASED UPON STS 1984 BEDROCK ELEVATION MAP
- •Kff FIELD PERMEABILITY - FALLING HEAD TEST IN CM/SEC.
- •Kfr FIELD PERMEABILITY - RISING HEAD TEST IN CM/SEC.
- •(Kff) •(Kfr) WELL ABANDONED
- INFERRED BEDROCK LITHOLOGIC CONTACT

Boring ID	Sample	Depth	% Gravel	% Sand	P200	% Silt	% Clay	USCS	Other
CMC-DL-103A	S-1	4-6	11.8	53.5	34.7	21	13.7	SC-SM	KL=9.3x10-8
CMC-DL-103B	S-12	20-22	0	67.4	32.6	27.6	5	SM	
DMA-4	S-1	4	0	50	50	--	--	ML	
	S-4	8.5	17	58	25	--	--	SM	
G41-A23	S-7	30-31.6	5	89	6	--	--	SP	
	S-9	40-42	7	91	2	--	--	SP	
G41-B12	S-5	40-41.5	13	61	26	--	--	SM	
	S-9	80-81.9	20	73	17	--	--	SP-SM	
	S-12	110-111	8	64	28	25	3	SM	
G41-C15	S-3	7.5-9	0	98	2			SP	
	S-8	28-29.5	0	80	20	18	2	SM	
	S-11	43-44.5	0	27	73	63	10	ML	
	S-14	58-59.5	41	46	13			GM-SM	
	S-20	90-90.8	15	65	20	--	--	SM	
	25	130-131	3	89	8	--	--	SP-SM	
	S-31	190-190.7	0	5	95	88	7	ML	
	S-32	200-200.7	21	69	10	--	--	SP-SM	
EX-16	S-1	68-70	12	67	21	--	--	SM	
	S-2	110-112	45	46	9			SM-SP	
	S-3	140-142	5	89	6			SM-SP	

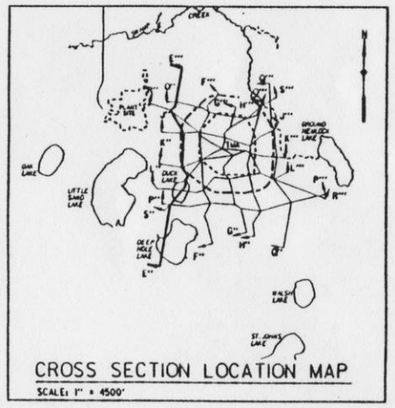
See cross-sections with common points for additional soils data.

WELL CONSTRUCTION INFORMATION



NOTES:

1. WELLS ARE LOCATED IN INDIVIDUAL BORINGS, THE FILTER PACK IS SILICA SAND, AND THE ANNULAR SPACE AROUND THE WELL CASING WAS BACKFILLED WITH BENTONITE PELLETS AND CEMENT/BENTONITE GROUT AND CONCRETE.
2. THIS CROSS SECTION DERIVED FROM THE REGIONAL CROSS SECTION E-E' OF THE EIR, 1995.



Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

Crandon Mining Company

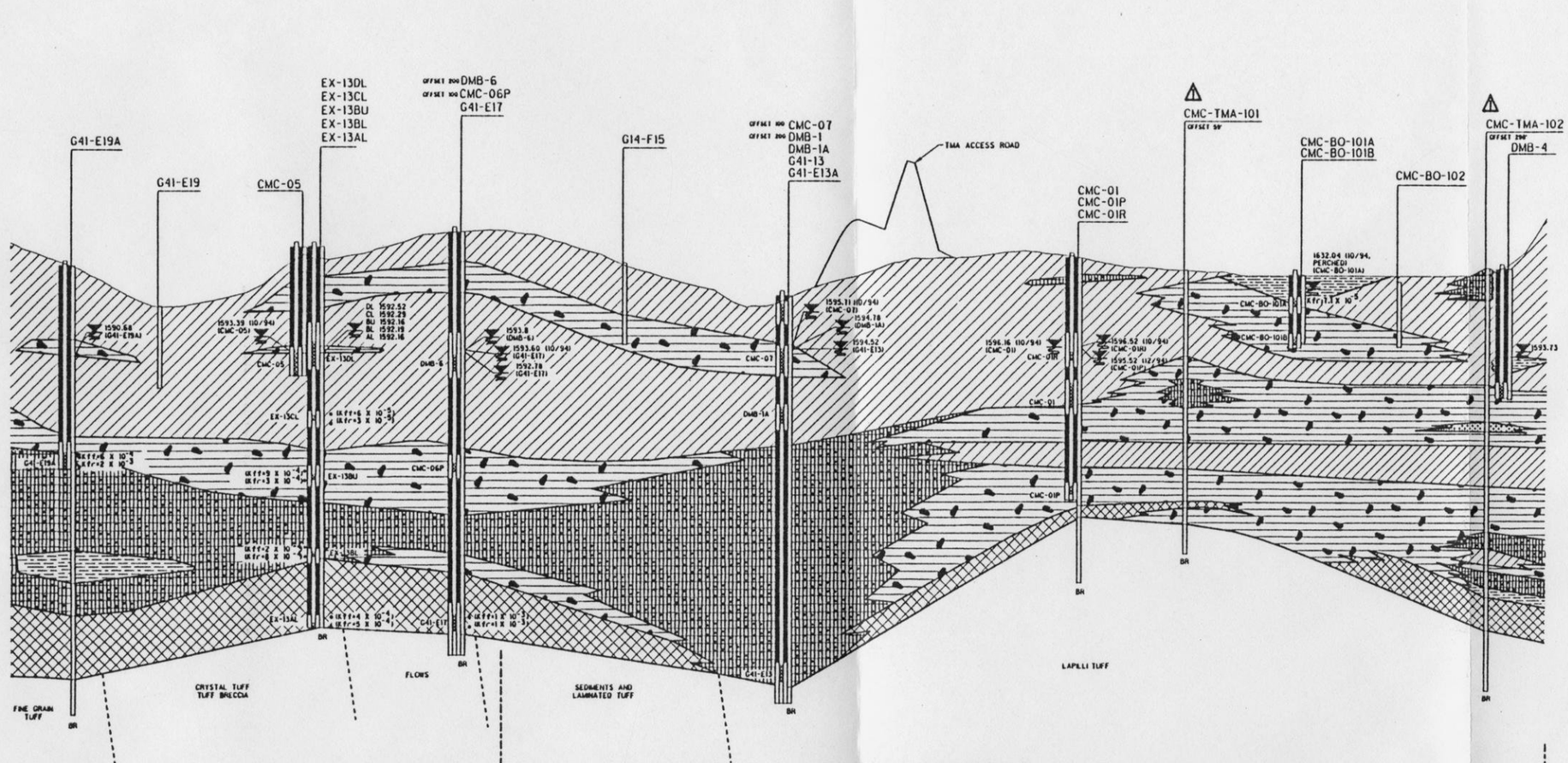
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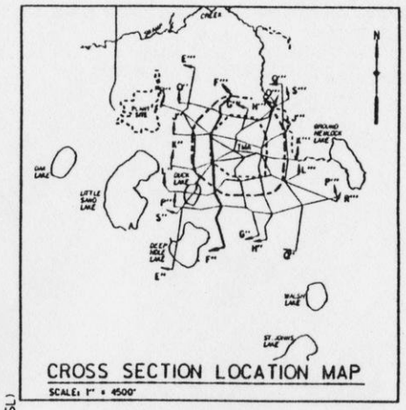
SCALE VERT. 1" = 40' HOR. 1" = 400'	STATE: WISCONSIN		COUNTY: FOREST		
DRAWN BY: GAM	DATE: 3/96	CHECKED BY: JKSI	DATE: 3/96		
APPROVED BY: SVDI	DATE: 3/96	APPROVED BY: REM	DATE: 3/96		
APPROVED BY: GWS	DATE: 3/96	CRANDON MINING COMPANY: DEM	DATE: 3/96		
DRAWING NO.: 5A	SHEET: 6 OF 31	REVISION NO.: 0			

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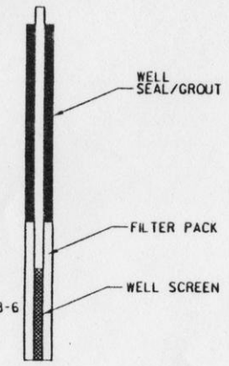
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SECTION F''-F'''



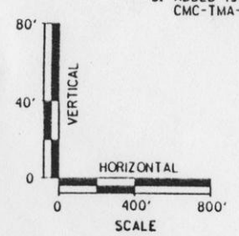


WELL CONSTRUCTION INFORMATION



NOTES:

1. WELLS ARE LOCATED IN INDIVIDUAL BORINGS, THE FILTER PACK IS SILICA SAND, AND THE ANNULAR SPACE AROUND THE WELL CASING WAS BACKFILLED WITH BENTONITE PELLETS AND CEMENT/BENTONITE GROUT AND CONCRETE.
2. THIS CROSS SECTION DERIVED FROM THE REGIONAL CROSS SECTION F-F' OF THE EIR, 1995.
3. ADDED 1996 TMA VERIFICATION BORINGS CMC-TMA-101, CMC-TMA-102.



LEGEND

- Qtl UNDIFFERENTIATED LATE WISCONSIN TILL — NASHVILLE MEMBER, COPPER FALLS FORMATION AND THE MAPLEVILLE MEMBER, HORICON FORMATION
- Qte UNDIFFERENTIATED EARLY-WISCONSIN-TILL AND PRE-WISCONSIN TILL — MARATHON AND LINCOLN FORMATIONS, MAY INCLUDE MASSIVE SAPROLITE
- Qowf FINE-GRAINED OUTWASH DEPOSITS — GLACIAL FLUVIAL STRATIFIED SAND AND SILT OF WISCONSINAN AGE
- Qowl COARSE-GRAINED OUTWASH DEPOSITS — GLACIAL FLUVIAL STRATIFIED SAND AND GRAVEL OF WISCONSINAN AGE
- INFERRED GEOLOGIC CONTACT
- 1594.58 (EX-12BL) WATER LEVEL ELEVATION (10/84)* UNLESS INDICATED
- LL LIQUID LIMIT
- PI PLASTICITY INDEX
- P200 PERCENT FINES
- USCS UNIFIED SOIL CLASSIFICATION SYSTEM
- KL LABORATORY HYDRAULIC CONDUCTIVITY IN CM/SEC.
- Ql LACUSTRINE DEPOSITS — GLACIO-LACUSTRINE, BEDDED, SILT AND CLAY WITH MINOR AMOUNTS OF SAND OF WISCONSINAN, HOLOCENIC AND RECENT AGE.
- Qhlc ICE-CONTACT DEPOSITS — ABLATION TILL, FLOW TILL, GLACIO-FLUVIAL SILT, CLAY AND SAND OF WISCONSINAN AGE
- BR PCu UNDIFFERENTIATED BEDROCK — PRECAMBRIAN METAVOLCANIC BEDROCK, FINE GRAIN TUFF, CRYSTAL TUFF, TUFF BRECCIA, FLOWS, SEDIMENTS AND LAMINATED TUFF, LAPILLI TUFF, MAY INCLUDE STRUCTURED SAPROLITE
- BR INFERRED UNDIFFERENTIATED BEDROCK ELEVATION BASED UPON STS 1984 BEDROCK ELEVATION MAP
- Kff FIELD PERMEABILITY - FALLING HEAD TEST IN CM/SEC.
- Kfr FIELD PERMEABILITY - RISING HEAD TEST IN CM/SEC.
- (Kff) (Kfr) WELL ABANDONED
- INFERRED BEDROCK LITHOLOGIC CONTACT

Crandon Mining Company - TMA Laboratory Soil Data

Boring ID	Sample #	Depth(ft.)	% Gravel	% Sand	P200	% Silt	% Clay	USCS	Other
G41-E18	S-3	7.5-8.5	7	65	28			SM	
G41-E19A	S-3	20-21.5	11	72	17			SM	
	S-4	30-31.5	23	51	28			SM	
	S-10	90-91.5	18	65	17			SM	
	S-12	110-111	32	60	8			SW-SM	
	S-18	170-171.3	1	96	3			SP	
	S-19	180-182	2	68	30			SM	
	S-24	232-233	31	62	7			SW-SM	
EX-13	S-2	15-16.5	61	35	4			GW	
	S-3	20-22	12	42	46			SM	
	S-4	25-27	28	60	12			SW-SM	
	S-5	30-32	42	46	12			SW-SM	
EX-13B	S-6	35-37	4	78	18			SM	
	S-7	41-42.5	7	75	18	15	3	SM	
	S-8	51-52.5	16	63	21			SM	
	S-10	71-72.5	11	74	15	12	3	SM	
	S-12	92-93.5	12	65	23	19	4	SM	
	S-13	102-103.5	14	73	13			SM	
	S-14	110-111.5	19	65	16			SM	
	S-16	131-132.5	35	58	7			SW-SM	
EX-13C	S-1	152-153.5	67	26	7	6	1	GP-GM	
	S-2	162-163.5	12	82	6			SW-SM	
	S-3	172-173.5	3	90	7			SW-SM	
	S-4	183-184.5	7	86	7			SW-SM	
	S-5	194-195	32	41	27	20	7	SM	
	S-6	205-206	12	63	25	21	4	SM	
	S-7	215.6-216.5	6	88	6			SW-SM	
	S-8	226-226.5	18	10	72	53	19	CL	
CMC-05	S-14	73.4-74.2	5.9	74.4	19.7			SM	
CMC-06P	S-26	145-147	34.1	55.5	10.2			SP-SM	
G41-E17	S-2	12-13.5	31	54	15			SM	
	S-7	40-41.5	7	68	25	18	7	SM	
	S-16	86-87.5	6	71	23			SM	
	S-24	153.5-155	37	54	9	3	6	SP-SM	
	S-28	185-186	6	82	12			SW-SM	
	S-30	214-215.5	0	10	90			ML	
	S-31	224.5-226	0	1	99	51	12	ML	
	S-32a	234-235	3	34	63	39	24	ML	
	S-32b	234-235	7	35	58	46	12	ML	
	S-33	245.5-246.5	31	49	20			SM	
CMC-07	S-8	40-42	9.8	71.5	18.7			SM	
	S-9	45-47	1.2	70.2	28.6	26.2	8.4	SC	
G41-E13	S-3	10-11.8	31	73	16			SM	
	S-5	30-31.5	7	71	22	20	2	SM	
	S-9	60-61.8	35	52	13			SM	
	S-13 & 14	65-65.5	23	59	18			SM	
	S-21	100-100.8	2	81	17			SM	
	S-22	110-111	3	84	13			SM	
	S-25	140-141	1	95	4			SM	
	S-30	190-191	0	95	5			SP-SM	
	S-34	230-231	0	93	7			SP-SM	
CMC-01	S-2	82.5-84.5	8.2	69.1	22.7			SM	
CMC-01A	S-1	46-46.7	11.9	62.2	25.9	17.5	8.4	SC	
	S-2	53-55	15.3	61.6	23.1			SM	
CMC-01P	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	13.4	6.0	[illegible]	
CMC-BO-101AS-1		14-16	0.4	23.3	73.3	53.6	22.7	CL	LL:28 PI: 8
CMC-BO-101BS-3		4-6	0	53.7	46.3	32.5	13.8	SC-SM	KL:1.1X10-6 LL:19 PI: 8
	S-7	12-14	0	4.4	95.6	73.3	22.3	CL	KL:2.9X10-9 LL:28 PI: 8
	S-16	36-38	1.8	95.6	2.6			SP	
CMC-BO-102S-9		16-18	17.6	62.4	20			SC	
	S-16	35-37	0	82.9	17.1			SM	
DMB-4	2	6.5	14	66	20			SM-SM	
	5	20.5	13	82	5			SP	
	8	35.0	9	74	17			SM	
	12	55.0	4	41	55			ML	

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION
1	3/96	SVDI	SEE NOTE NO. 3

TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

Crandon Mining Company

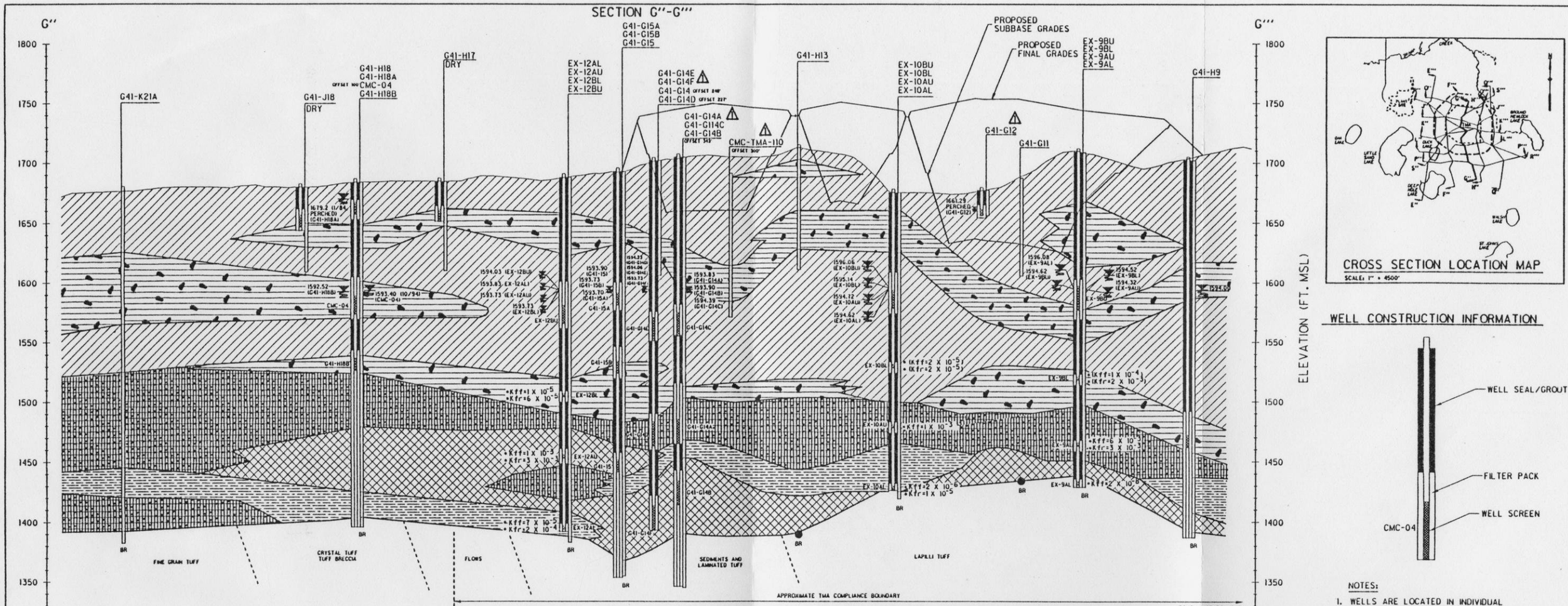
TITLE: GEOLOGIC CROSS SECTION F''-F'''

SCALE VERT: 1" = 40' HOR: 1" = 400'	STATE: WISCONSIN	COUNTY: FOREST	
DRAWN BY: GAM	DATE: 5/95	CHECKED BY: JKSI	DATE: 5/95
APPROVED BY: REM	DATE: 5/95	APPROVED BY: NXP	DATE: 5/95
APPROVED BY: GWS	DATE: 5/95	CRANDON MINING COMPANY: DEM	DATE: 5/95
DRAWING NO.: 6	SHEET 6 OF 31	REVISION NO.: 1	

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SECTION G''-G'''

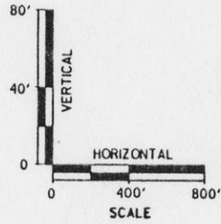


CROSS SECTION LOCATION MAP

WELL CONSTRUCTION INFORMATION

NOTES:

1. WELLS ARE LOCATED IN INDIVIDUAL BORINGS, THE FILTER PACK IS SILICA SAND, AND THE ANNULAR SPACE AROUND THE WELL CASING WAS BACKFILLED WITH BENTONITE PELLETS AND CEMENT/BENTONITE GROUT AND CONCRETE.
2. THIS CROSS SECTION DERIVED FROM THE REGIONAL CROSS SECTION G-G' OF THE EIR, 1995.
3. ADDED BORINGS G41-G14A, B, C, D, E, F, G41-G12 AND 1996 TMA VERIFICATION BORING CMC-TMA-110



LEGEND

- Qtl UNDIFFERENTIATED LATE WISCONSIN TILL — NASHVILLE MEMBER, COPPER FALLS FORMATION AND THE MAPLEVILLE MEMBER, HORICON FORMATION
- Qte UNDIFFERENTIATED EARLY-WISCONSIN-TILL AND PRE-WISCONSIN TILL — MARATHON AND LINCOLN FORMATIONS, MAY INCLUDE MASSIVE SAPROLITE
- Qowf FINE-GRAINED OUTWASH DEPOSITS — GLACIAL FLUVIAL STRATIFIED SAND AND SILT OF WISCONSINAN AGE
- Qowl COARSE-GRAINED OUTWASH DEPOSITS — GLACIAL FLUVIAL STRATIFIED SAND AND GRAVEL OF WISCONSINAN AGE
- INFERRED GEOLOGIC CONTACT
- 1594.56 (EX-12BL) (10/84)* WATER LEVEL ELEVATION — UNLESS INDICATED
- LL LIQUID LIMIT
- PI PLASTICITY INDEX
- P200 PERCENT FINES
- USCS UNIFIED SOIL CLASSIFICATION SYSTEM
- KL LABORATORY HYDRAULIC CONDUCTIVITY IN CM/SEC.
- Ql LACUSTRINE DEPOSITS — GLACIO-LACUSTRINE, BEDDED, SILT AND CLAY WITH MINOR AMOUNTS OF SAND OF WISCONSINAN, HOLOCENC AND RECENT AGE.
- Qhlc ICE-CONTACT DEPOSITS — ABLATION TILL, FLOW TILL, GLACIO-FLUVIAL SILT, CLAY AND SAND OF WISCONSINAN AGE
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- BR INFERRED UNDIFFERENTIATED BEDROCK ELEVATION BASED UPON STS 1984 BEDROCK ELEVATION MAP
- *Kff FIELD PERMEABILITY - FALLING HEAD TEST IN CM/SEC.
- *Kfr FIELD PERMEABILITY - RISING HEAD TEST IN CM/SEC.
- *(Kff) *(Kfr) WELL ABANDONED
- INFERRED BEDROCK LITHOLOGIC CONTACT

Crandon Mining Company - TMA Laboratory Soil Data

Boring ID	Sample *	Depth(ft.)	% Gravel	% Sand	P200	% Silt	% Clay	USCS
G41-H18	S-5	20-21.5	23	65	12			SW
	S-9	40-41	18	78	4			SP
G41-H18A	S-2	13-14.5	0	39	61	54	7	SM
	S-3	16.5-18	11	51	38	30	8	SM
	S-4	20-21.5	31	66	3			SP
CMC-04	S-22	108-110	2.5	86.6	10.9			SP-SM
G41-H17	S-3	9-10.5	30	66	4			SP
	S-6	24-25.5	43	54	3			SP
	S-13	54-54.5	32	53	15			SW
	S-16	69-69.5	7	58	35			SM
EX-12	S-1	18-18	9	83	8			SW-SM
	S-2	20-22	18	82	30	23	7	
	S-4	41-43	75	6	19	18	1	GW
	S-5	48-49	44	52	4			GW
	S-6	59-60	50	47	3			SW-GW
	S-7	69-70.5	20	36	44			SM
	S-8	80-81.5	42	38	16	13	3	SM
	S-9	90-91.5	7	78	15			SW
	S-11	110.5-112	6	69	25			SM
	S-14	141-142.5	26	60	14	12	2	SM
	S-15	192-192.5	47	46	7			SW-SM
	S-20	203-204.5	1	93	6			SW-SM
	S-21	213-214.5	10	67	23	21	2	SM
	S-22	223.5-225	13	63	18			SM
	S-24	244.2-245.5	1	81	18			SM
	S-27	274.5-276.5	9	75	21	4		SM
	S-28	285-287	0	48	52	45	7	ML
	S-29	295-297	0	4	96	84	12	ML
G41-G15A	S-3	18-19	24	53	23	12	11	SM
	S-4	23-24	34	66	20			SM
	S-7	38-38.5	43	28	29			SM
	S-9	183.5-186.5	18	70	27			SM
	S-10	111.5-113	7	70	23			SM
G41-H13	S-1	0-1.5	10	52	38	31	7	SM
	S-7	29-30.5	14	63	23			SM
	S-15	71-72.5	2	84	14			SM
	S-22	104-104.8	25	59	16			SM
EX-10	S-1	18.5-12.5	6	55	41	8		SM
	S-2	20.5-22.5	24	72	4			SW-SM
	S-4	41.5-43.5	24	70	6			SW
	S-5	51.5-53.5	8	68	24	19	5	SM
	S-6	62-64	11	65	24	18	6	SM
	S-9	92.5-94.5	6	70	24	20	4	SM
	S-10	103-105	7	78	14			SM
	S-13	133.5-135.5	15	65	20			SM
	S-17	174.5-176.5	5	90	5			SW-SM
	S-18	183-184.5	1	93	6			SW-SM
	S-21	215.5-217	2	61	37	35	2	ML
	S-22	228-229	0	7	93	81	12	ML
	S-23	236-237	0	8	92	80	12	ML
	S-24	246.5-250.5	3	85	6			SW-SM
G41-G11	S-1	0-1.5	15	53	32	20	12	SM
	S-4	10-11.5	23	59	18			SM
	S-6	20-21.5	25	57	18			SM
	S-14	60-61	14	76	10			SM
	S-15	65-66	16	63	21	17	4	SM
	S-17	75-76	30	52	18			SM
EX-9	S-1	4-6	5	90	5			SW-SM
	S-2	20-22	27	61	12			SM
	S-3	30-31.5	25	59	17	13	4	SM
	S-5	50-52	32	57	11			SM
	S-7	70.5-72	17	77	6			SW-SM
	S-9	91-93	16	79	5			SW-SM
	S-10	101.5-103.5	24	56	18	2		SW
	S-12	123-124.5	12	69	19	17	2	SM
	S-13	133.5-135	27	65	8			SW-SM
	S-14	142.5-144	0	85	9			SW-SM
	S-16	163-165	11	67	22	20.5	1.5	SM
	S-18	183-184.5	29	58	13			SW-SM
	S-20	203-205	12	75	13			SM
	S-25	255-256	1	81	18			SM
G41-H9	S-3	21-22.5	14	68	18			SM
	S-5	40-41	26	62	12			SM
	S-8	70-71.5	26	58	16			SM
	S-10	90-91	49	44	7			SW-SM
	S-15	140-141.5	17	63	20			SM
	S-16	150-151.5	14	64	22			SM
	S-21	200-200.6	0	93	7			SW-SM
	S-22	210.5-211.4	14	64	22			SM

Boring ID	Sample	Depth	% Gravel	% Sand	P200	% Silt	% Clay	USCS
G41-G14A	S-1	100.0-100.5	24	70	6			SP-SM
	S-2	110-111	16	78	6			SP-SM
	S-3	120-121.5	9	70	21			SM
	S-4	130-131	7	63	30			SM
	S-5	140-141	11	63	26			SM
	S-6	150-150.8	12	73	15			SM
	S-7	160-161	9	76	15			SM
	S-8	170-171	7	77	16			SM
	S-9	180-181	8	78	14			SM
	S-10	190-191	8	77	15			SM
	S-11	200-200.5	0	68	32			SM
	S-12	210-211	0	68	32			SM
	S-13	220-221	0	63	37			SM
	S-14	230-231	0	63	37			SM
	S-15	240-241	0	63	37			SM
	S-16	250-251	0	73	27			SM
G41-G14B	S-1	245-246.5	0	73	27			
	S-2	250-251.5	0	73	27			
	S-3	255-256.5	0	60	40			
	S-4	260-261	0	68	32			
	S-5	265-266	0	68	32			
	S-6	270-271.5	0	68	32			
	S-7	275-276	0	68	32			
	S-8	280-281.5	0	68	32			
	S-9	285-286.5	0	68	32			
	S-10	290-291.5	0	68	32			
	S-11	295-296.5	0	68	32			
	S-12	300-301.5	0	68	32			
	S-13	305-306.5	0	68	32			
	S-14	310-310.5	0	54	46			
	S-15	320-320.5	0	54	46	42	10	
	S-16	330-330.5	14	48	38			

See cross-sections with common points for additional soils data.

TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

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REVISED	DATE	BY	DESCRIPTION
1	3/96	SVDI	SEE NOTE NO. 3

Crandon Mining Company

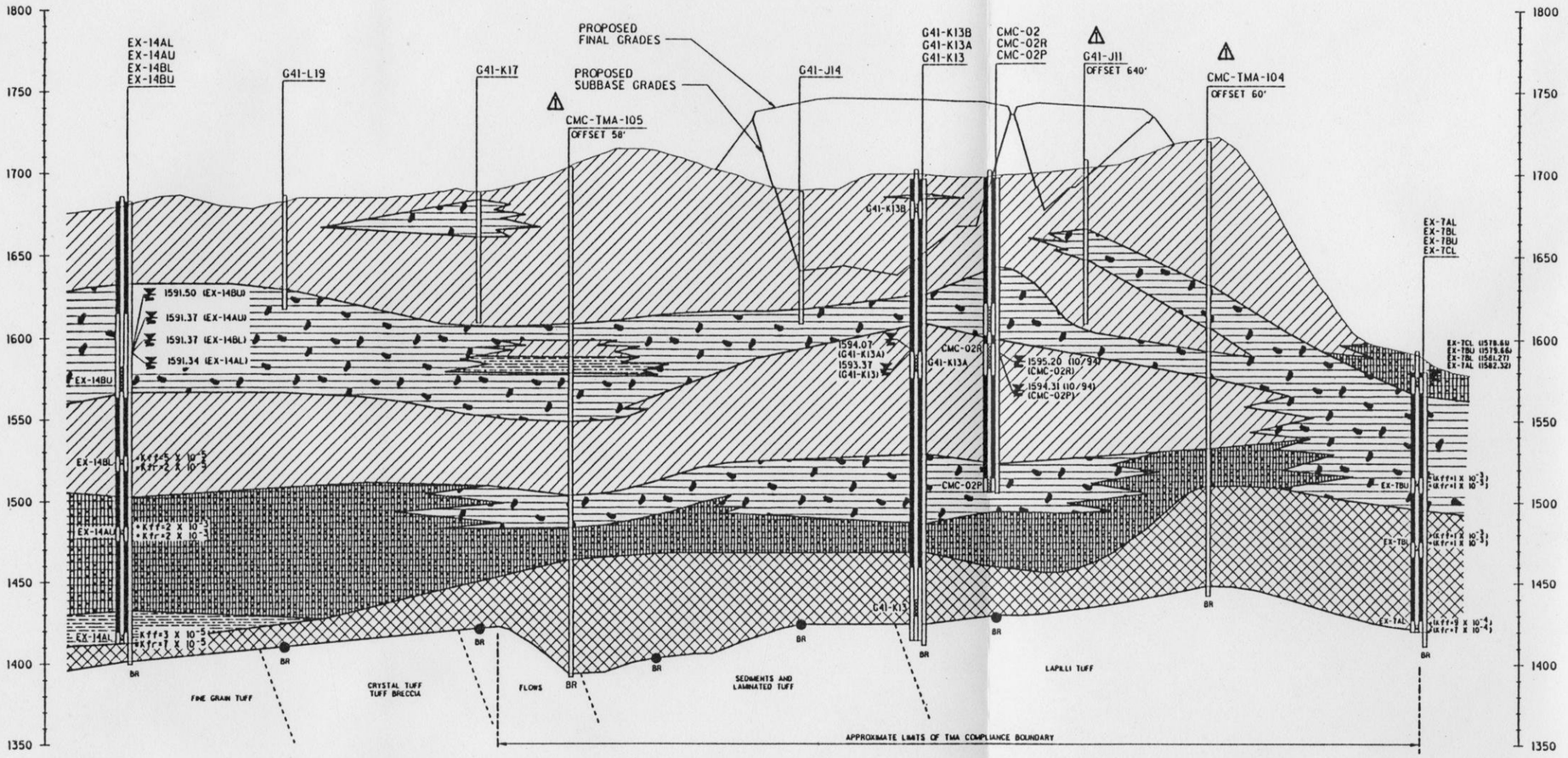
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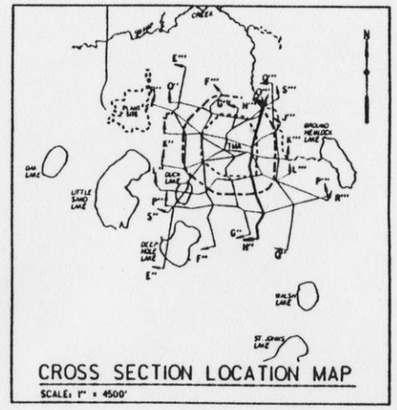
SCALE VERT: 1" = 40' HOR: 1" = 400'	STATE: WISCONSIN		COUNTY: FOREST		
DRAWN BY: GAM	DATE: 5/95	CHECKED BY: JKSI	DATE: 5/95		
APPROVED BY: REM	DATE: 5/95	APPROVED BY: NXP	DATE: 5/95		
APPROVED BY: GWS	DATE: 5/95	CRANDON MINING COMPANY: DEM	DATE: 5/95		
DRAWING NO. 7	SHEET 7 OF 31	REVISION NO. 1			

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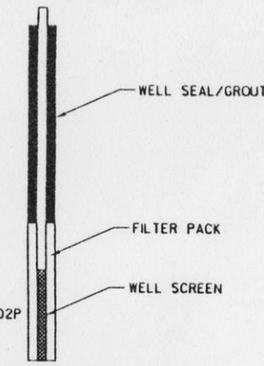
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SECTION H''-H'''





WELL CONSTRUCTION INFORMATION



NOTES:

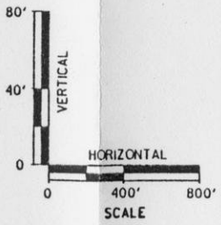
1. WELLS ARE LOCATED IN INDIVIDUAL BORINGS, THE FILTER PACK IS SILICA SAND, AND THE ANNULAR SPACE AROUND THE WELL CASING WAS BACKFILLED WITH BENTONITE PELLETS AND CEMENT/BENTONITE GROUT AND CONCRETE.
2. THIS CROSS SECTION DERIVED FROM THE REGIONAL CROSS SECTION H-H' OF THE EIR, 1995.
3. ADDED BORING G41-J11, AND 1996 TMA VERIFICATION BORINGS CMC-TMA-104, CMC-TMA-105.

LEGEND

- Qtl UNDIFFERENTIATED LATE WISCONSIN TILL — NASHVILLE MEMBER, COPPER FALLS FORMATION AND THE MAPLEVILLE MEMBER, HORICON FORMATION
- Qte UNDIFFERENTIATED EARLY-WISCONSIN-TILL AND PRE-WISCONSIN TILL — MARATHON AND LINCOLN FORMATIONS, MAY INCLUDE MASSIVE SAPROLITE
- Qowf FINE-GRAINED OUTWASH DEPOSITS — GLACIAL FLUVIAL STRATIFIED SAND AND SILT OF WISCONSINAN AGE
- Qowl COARSE-GRAINED OUTWASH DEPOSITS — GLACIAL FLUVIAL STRATIFIED SAND AND GRAVEL OF WISCONSINAN AGE
- INFERRED GEOLOGIC CONTACT
- 1594.58 (EX-12BL) WATER LEVEL ELEVATION (10/84)* UNLESS INDICATED
- LL LIQUID LIMIT
- PI PLASTICITY INDEX
- P200 PERCENT FINES
- USCS UNIFIED SOIL CLASSIFICATION SYSTEM
- KL LABORATORY HYDRAULIC CONDUCTIVITY IN CM/SEC.
- Ql LACUSTRINE DEPOSITS — GLACIO-LACUSTRINE, BEDDED, SILT AND CLAY WITH MINOR AMOUNTS OF SAND OF WISCONSINAN, HOLOCENC AND RECENT AGE.
- Qhlc ICE-CONTACT DEPOSITS — ABLATION TILL, FLOW TILL, GLACIO-FLUVIAL SILT, CLAY AND SAND OF WISCONSINAN AGE
- BR PCu UNDIFFERENTIATED BEDROCK — PRECAMBRIAN METAVOLCANIC BEDROCK, FINE GRAIN TUFF, CRYSTAL TUFF, TUFF BRECCIA, FLOWS, SEDIMENTS AND LAMINATED TUFF, LAPILLI TUFF, MAY INCLUDE STRUCTURED SAPROLITE
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- •Kfr FIELD PERMEABILITY - RISING HEAD TEST IN CM/SEC.
- •(Kff) •(Kfr) WELL ABANDONED
- INFERRED BEDROCK LITHOLOGIC CONTACT

Crandon Mining Company - TMA Laboratory Soil Data

Boring ID	Sample *	Depth (ft.)	% Gravel	% Sand	P200	% Silt	% Clay	USCS	Other
EX-14	S-1	2-4	0	31	69	61	8	ML	--
	S-2	10-12	27	56	17	14	3	SW	--
	S-3	21-22	42	50	8	--	--	SW-SP	--
	S-4	30-31.5	15	67	18	16	2	SW	--
	S-5	40-41.5	24	62	14	--	--	SW	--
	S-6	50.5-51.9	29	63	8	--	--	SW-SP	--
	S-7	60.5-62.0	18	76	6	--	--	SW-SP	--
	S-8	71-73	45	49	6	--	--	SW-SP	--
	S-9	81-82	35	57	8	--	--	SW-SP	--
	S-11	101.5-103.5	15	69	6	--	--	SW-SP	--
	S-13	122-124	12	70	18	--	--	SW	--
	S-15	142.5-144.5	16	70	14	--	--	SW	--
	S-18	173.175	18	69	13	12	1	SW	--
	S-19	183.5-185.5	0	94	6	--	--	SW-SP	--
	S-22	214-215.5	10	79	11	--	--	SW-SP	--
	S-23	224.5-226	1	76	23	--	--	SW	--
	S-25	245-246	0	47	53	52	1	ML	--
	S-27	264.5-266	10	75	15	--	--	SW	--
	S-28	276-277.5	25	57	18	--	--	SW	--
G41-L19	S-2	9-10.5	22	62	16	13	3	SW	--
	S-5	24-24.5	16	70	14	--	--	SW	--
G41-K17	S-6	24-25.5	27	66	7	--	--	SW-SP	--
	S-12	54-54.5	2	88	12	--	--	SW-SP	--
	S-16	74-74.4	8	73	19	--	--	SW	--
G41-K13	S-1	120-120.9	6	75	19	10	9	SW	--
	S-3	142-142.5	8	71	21	--	--	SW	--
	S-6	172-173	26	65	9	--	--	GW-SW	--
	S-14	254-254.7	22	61	17	--	--	SW	--
G41-K13A	S-2	5-6.5	12	65	23	--	--	SW	--
	S-8	35-35.3	20	60	20	--	--	SW	--
	S-13	60-60.6	10	70	20	7	13	SW	--
	S-15	70-70.3	41	45	14	--	--	GW-SW	--
	S-16	75-75.5	33	57	10	2	8	SP-SW	--
	S-20	95-96	10	70	20	--	--	SW	--
	S-23A	116-116.3	8	82	10	--	--	SP-SW	--
G41-K13B	S-1	1-2.5	0	27	63	56	7	ML	--
	S-3	9.5-11	0	13	87	78	9	CL-ML	LL:22 PI: 4
	S-5	19.5-20	20	64	16	--	--	SW	--
CMC-02P	S-31	191-193	30	53.6	16.4	--	--	SW	--
EX-7	S-1	61.5-63.5	11	80	9	--	--	SW-SP	--
	S-2	120-122	7	52	41	39	2	SW	--
	S-3	162-163	61	27	12	10	2	GP-SW	--



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REVISED	DATE	BY	DESCRIPTION
1	3/96	SVDI	SEE NOTE NO. 3

TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

Crandon Mining Company

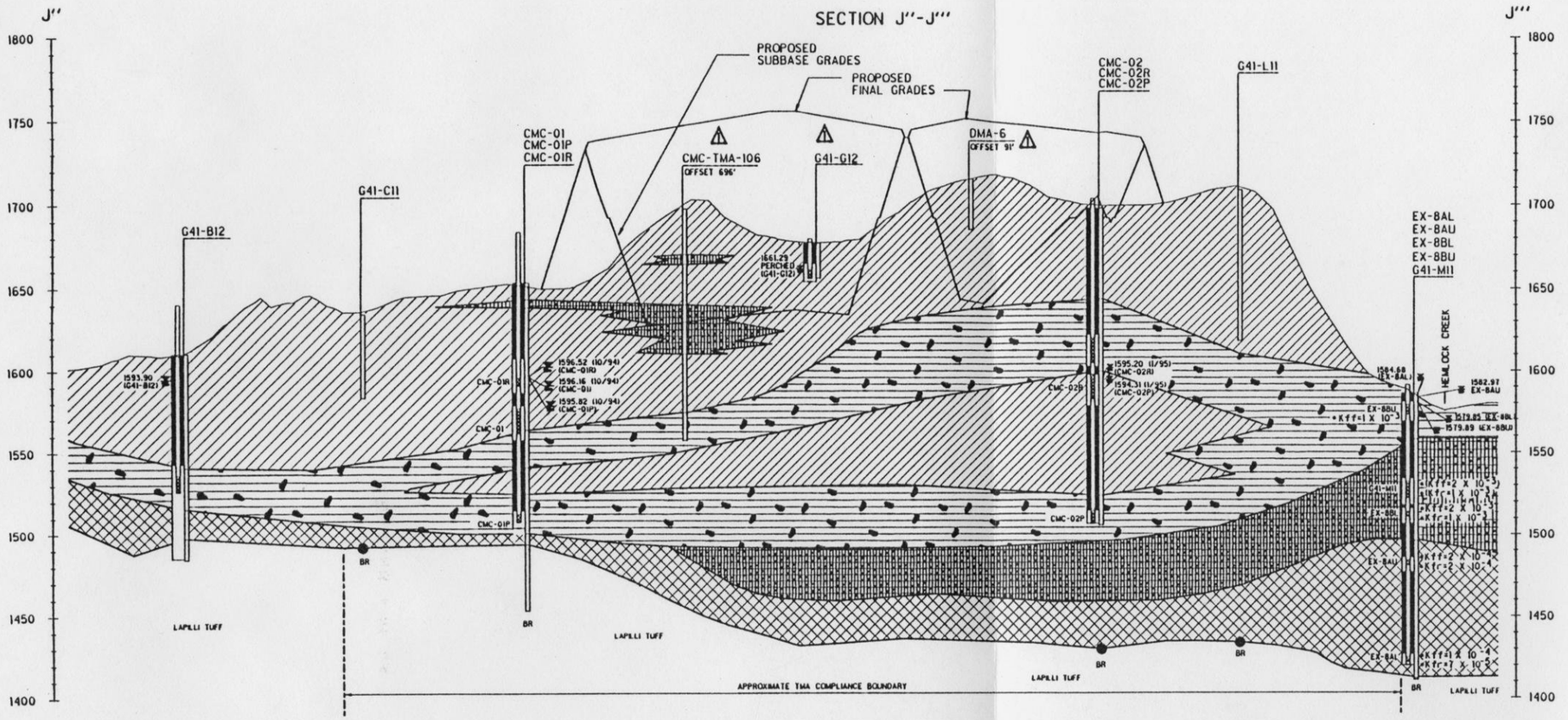
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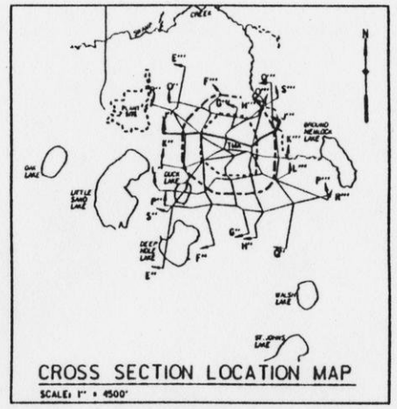
SCALE VERT: 1" = 40' HOR: 1" = 400'	STATE: WISCONSIN	COUNTY: FOREST	
DRAWN BY: GAM	DATE: 5/95	CHECKED BY: JKSI	DATE: 5/95
APPROVED BY: REM	DATE: 5/95	APPROVED BY: NXP	DATE: 5/95
APPROVED BY: GWS	DATE: 5/95	CRANDON MINING COMPANY: DEM	DATE: 5/95
DRAWING NO.: 8		SHEET 8 OF 31	REVISION NO.: 1

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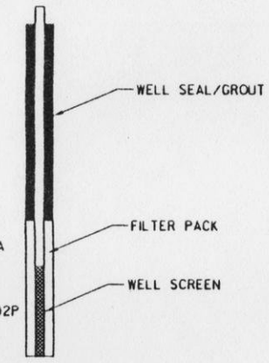
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SECTION J''-J'''





WELL CONSTRUCTION INFORMATION



NOTES:

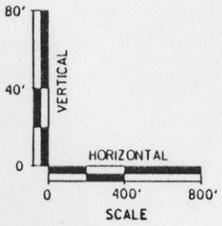
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2. THIS CROSS SECTION DERIVED FROM THE REGIONAL CROSS SECTION J-J' OF THE EIR, 1995.
3. ADDED BORINGS DMA-6, G41-G12, AND 1996 TMA VERIFICATION BORING CMC-TMA-106.

LEGEND

- Qtl UNDIFFERENTIATED LATE WISCONSIN TILL — NASHVILLE MEMBER, COPPER FALLS FORMATION AND THE MAPLEVILLE MEMBER, HORICON FORMATION
- Qte UNDIFFERENTIATED EARLY-WISCONSIN-TILL AND PRE-WISCONSIN TILL — MARATHON AND LINCOLN FORMATIONS, MAY INCLUDE MASSIVE SAPROLITE
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- INFERRED GEOLOGIC CONTACT
- 1594.58 (EX-12BL) WATER LEVEL ELEVATION (10/84)* UNLESS INDICATED
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- PI PLASTICITY INDEX
- P200 PERCENT FINES
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- Ql LACUSTRINE DEPOSITS — GLACIO-LACUSTRINE, BEDDED, SILT AND CLAY WITH MINOR AMOUNTS OF SAND OF WISCONSINAN, HOLOCENC AND RECENT AGE.
- Qhlc ICE-CONTACT DEPOSITS — ABLATION TILL, FLOW TILL, GLACIO-FLUVIAL SILT, CLAY AND SAND OF WISCONSINAN AGE
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- •Kff FIELD PERMEABILITY - FALLING HEAD TEST IN CM/SEC.
- •Kfr FIELD PERMEABILITY - RISING HEAD TEST IN CM/SEC.
- •(Kff) •(Kfr) WELL ABANDONED

Crandon Mining Company - TMA Laboratory Soil Data

Boring ID	Sample #	Depth(ft.)	% Gravel	% Sand	P200	% Silt	% Clay	USCS	Other
G41-C11	S-4	10-11.5	16	60	24			SM	
	S-9	35-36.5	13	67	20			SM	
CMC-01	S-2	82.5-84.5	8.2	69.1	22.7			SM	
CMC-01R	S-1	48-48.7	11.9	62.2	25.9	17.5	8.4	SC	
CMC-01P	S-2	53-55	15.3	61.6	23.1			SM	
	S-24	138-140	6.3	74.3	19.4	13.4	6.0	SC	
	S-25	143-145	3.1	83.9	13.0			SM	
CMC-02P	S-31	191-193	30	53.6	16.4			SM	
G41-L11	S-2	5-6.5	13	63	24			SM	
	S-4	10-11.5	11	65	24	20	4	SM	
	S-6	20-21.5	28	52	20			SM	
	S-10	40-40.5	36	48	16			SM	
	S-12	50-50.5	10	68	22			SM	
	S-14	60-61	8	67	25			SM	
	S-16	70-71	10	70	20			SM	
	S-18	80-80.5	44	44	12			GM-SM	
G41-M11	S-2	10-12	11	87	2			SM	
	S-5	38.5-40	0	98	2			SP	
EX-8	S-8	68-70	0	63	37			SM	
	S-1	1-1.3	1	96	3			SP	
	S-3	20-22	22	68	10			SM-SP	
	S-5	40-42	0	96	4			SP	
	S-8	71-73	1	87	12	10	2	SM	
	S-10	92-94	22	51	27	21	6	SM	
	S-12	112-114	18	71	11	10	1	SM-SP	
	S-14	133-135	29	60	11			SM-SP	
	S-15	143-145	16	63	21	17	4	SM	
	S-17	164-166	31	50	19			SM	
DMA-6	S-2	6.5	15	60	20			SM	
	S-4	13.5	10	70	20			SM	



Crandon Mining Company

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REVISED	DATE	BY	DESCRIPTION
1	3/96	SVDI	SEE NOTE NO. 3

TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

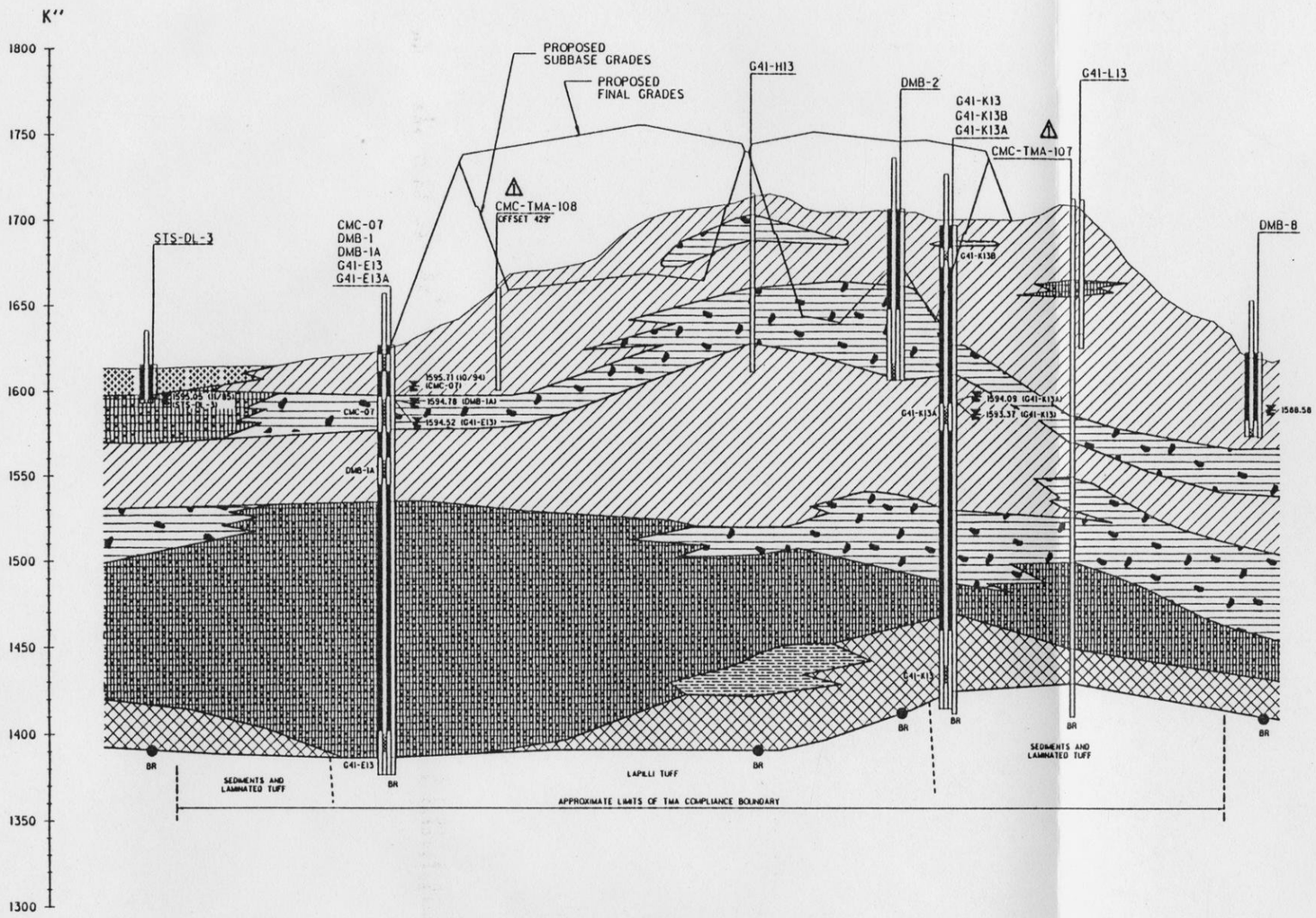
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DRAWN BY: GAM	DATE: 5/95	CHECKED BY: JKSI	DATE: 5/95
APPROVED BY: REM	DATE: 5/95	APPROVED BY: NXP	DATE: 5/95
APPROVED BY: GWS	DATE: 5/95	CRANDON MINING COMPANY: DEM	DATE: 5/95
DRAWING NO.: 9	SHEET 9 OF 31	REVISION NO.: 1	

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SECTION K''-K'''



LEGEND

- Qtl UNDIFFERENTIATED LATE WISCONSIN TILL — NASHVILLE MEMBER, COPPER FALLS FORMATION AND THE MAPLEVILLE MEMBER, HORICON FORMATION
- Qte UNDIFFERENTIATED EARLY-WISCONSIN-TILL AND PRE-WISCONSIN TILL — MARATHON AND LINCOLN FORMATIONS, MAY INCLUDE MASSIVE SAPROLITE
- Qowf FINE-GRAINED OUTWASH DEPOSITS — GLACIAL FLUVIAL STRATIFIED SAND AND SILT OF WISCONSINAN AGE
- Qowl COARSE-GRAINED OUTWASH DEPOSITS — GLACIAL FLUVIAL STRATIFIED SAND AND GRAVEL OF WISCONSINAN AGE
- Ql LACUSTRINE DEPOSITS — GLACIO-LACUSTRINE, BEDDED, SILT AND CLAY WITH MINOR AMOUNTS OF SAND OF WISCONSINAN, HOLOCENC AND RECENT AGE.
- Qhlc ICE-CONTACT DEPOSITS — ABLATION TILL, FLOW TILL, GLACIO-FLUVIAL SILT, CLAY AND SAND OF WISCONSINAN AGE
- PCu UNDIFFERENTIATED BEDROCK — PRECAMBRIAN METAVOLCANIC BEDROCK, FINE GRAIN TUFF, CRYSTAL TUFF, TUFF BRECCIA, FLOWS, SEDIMENTS AND LAMINATED TUFF, LAPILLI TUFF, MAY INCLUDE STRUCTURED SAPROLITE
- BR INFERRED UNDIFFERENTIATED BEDROCK ELEVATION BASED UPON STS 1984 BEDROCK ELEVATION MAP
- INFERRED GEOLOGIC CONTACT
- 1594.58 (EX-12BL) WATER LEVEL ELEVATION (10/84)• UNLESS INDICATED
- •Kff FIELD PERMEABILITY - FALLING HEAD TEST IN CM/SEC.
- •Kfr FIELD PERMEABILITY - RISING HEAD TEST IN CM/SEC.
- •(Kff) •(Kfr) WELL ABANDONED
- INFERRED BEDROCK LITHOLOGIC CONTACT

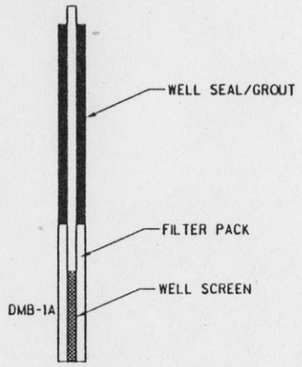
LL LIQUID LIMIT
PI PLASTICITY INDEX
P200 PERCENT FINES
USCS UNIFIED SOIL CLASSIFICATION SYSTEM
KL LABORATORY HYDRAULIC CONDUCTIVITY IN CM/SEC.

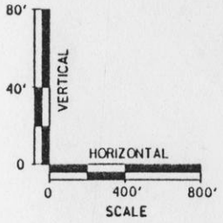
ELEVATION (FT. MSL)

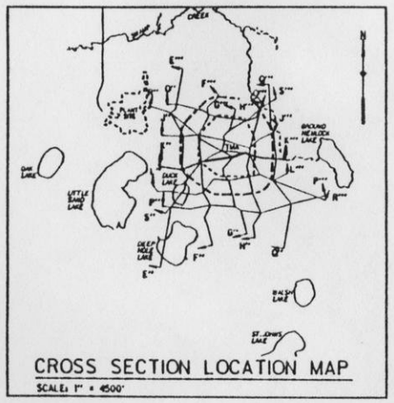
Crandon Mining Company - TMA Laboratory Soil Data

Boring ID	Sample #	Depth(ft.)	% Gravel	% Sand	P200	% Silt	% Clay	USCS	Other
G41-E13	S-3	10-11.5	11	73	16				
	S-5	20-21.5	7	71	22	20	2	SM	
	S-9	40-41.5	35	52	13			SM	
	S-13 & 14	65-65.5	23	59	18			SM	
	S-21	100-100.8	2	81	17			SM	
	S-22	110-111	3	84	13			SM	
	S-25	140-141	1	95	4			SP	
	S-30	190-191	0	95	5			SP-SM	
	S-34	230-231	0	93	7			SP-SM	
CMC-07	S-8	40-42	9.8	71.5	18.7			SM	
	S-9	45-47	1.2	70.2	28.6	2.4	26.2	SM	
G41-H13	S-1	0-1.5	10	52	38	31	7	SM	
	S-7	29-30.5	14	63	23			SM	
	S-15	71-72.2	2	84	14			SM	
	S-22	104-104.8	25	59	16			SM	
G41-K13	S-1	120-120.9	6	75	19	10	9	SM	
	S-3	142-142.5	8	71	21			SM	
	S-6	172-173	26	65	9			GM-SM	
	S-14	254-254.7	22	61	17			SM	
G41-K13A	S-2	5-6.5	12	65	23			SM	
	S-8	35-35.3	20	60	20			SM	
	S-13	60.60.6	10	70	20	7	13	SM	
	S-15	70-70.3	41	45	14			GM-SM	
	S-16	75-75.5	33	57	10	2	8	SP-SM	
	S-20	95-96	10	70	20			SM	
	S-23A	116-116.3	8	82	10			SP-SM	
G41-K13B	S-1	1-2.5	0	27	63	56	7	ML	
	S-3	9.5-11	0	13	87	78	9	CL-ML	LL:22 PI: 4
	S-5	19.5-20	20	64	16			SM	

WELL CONSTRUCTION INFORMATION







CROSS SECTION LOCATION MAP
SCALE: 1" = 4500'

NOTES:

1. WELLS ARE LOCATED IN INDIVIDUAL BORINGS, THE FILTER PACK IS SILICA SAND, AND THE ANNULAR SPACE AROUND THE WELL CASING WAS BACKFILLED WITH BENTONITE PELLETS AND CEMENT/BENTONITE GROUT AND CONCRETE.
2. THIS CROSS SECTION DERIVED FROM THE REGIONAL CROSS SECTION K-K' OF THE EIR, 1995.
3. ADDED 1996 TMA VERIFICATION BORINGS CMC-TMA-107, CMC-TMA-108.

TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION
1	3/96	SVDI	SEE NOTE NO. 3

Crandon Mining Company

TITLE: GEOLOGIC CROSS SECTION K''-K'''

SCALE VERT: 1" = 40' HOR: 1" = 400' | STATE: WISCONSIN | COUNTY: FOREST

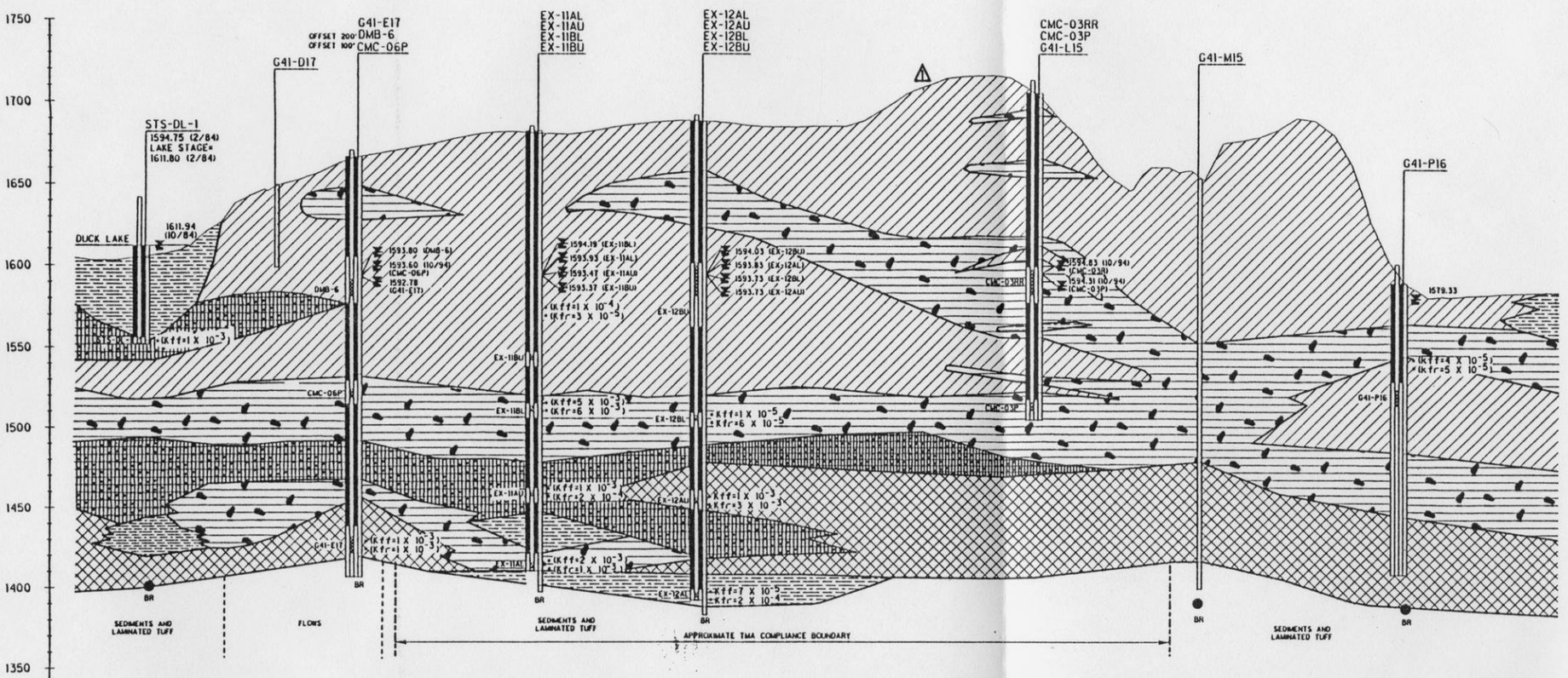
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APPROVED BY	GWS	DATE 5/95	CRANDON MINING COMPANY	DEM	DATE 5/95

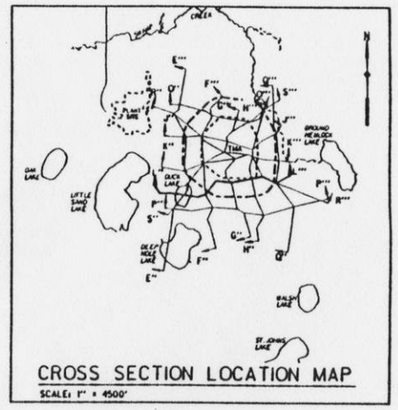
DRAWING NO. 10 | SHEET 10 OF 31 | REVISION NO. 1

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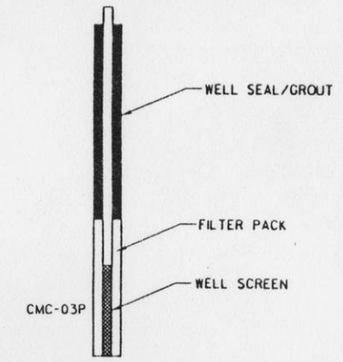
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SECTION L'' - L'''





WELL CONSTRUCTION INFORMATION



NOTES:

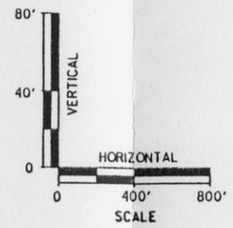
1. WELLS ARE LOCATED IN INDIVIDUAL BORINGS, THE FILTER PACK IS SILICA SAND, AND THE ANNULAR SPACE AROUND THE WELL CASING WAS BACKFILLED WITH BENTONITE PELLETS AND CEMENT/BENTONITE GROUT AND CONCRETE.
2. THIS CROSS SECTION DERIVED FROM THE REGIONAL CROSS SECTION L-L' OF THE EIR, 1995.
3. REVISED BASED ON CROSS CORRELATION TO H''-H''' W/CMC-TMA-105.

LEGEND

- Qtl UNDIFFERENTIATED LATE WISCONSIN TILL — NASHVILLE MEMBER, COPPER FALLS FORMATION AND THE MAPLEVILLE MEMBER, HORICON FORMATION
- Qte UNDIFFERENTIATED EARLY-WISCONSIN-TILL AND PRE-WISCONSIN TILL — MARATHON AND LINCOLN FORMATIONS, MAY INCLUDE MASSIVE SAPROLITE
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- Qowl COARSE-GRAINED OUTWASH DEPOSITS — GLACIAL FLUVIAL STRATIFIED SAND AND GRAVEL OF WISCONSINAN AGE
- INFERRED GEOLOGIC CONTACT
- 1594.58 (EX-12BL) WATER LEVEL ELEVATION (10/84)• UNLESS INDICATED
- LL LIQUID LIMIT
- PI PLASTICITY INDEX
- P200 PERCENT FINES
- USCS UNIFIED SOIL CLASSIFICATION SYSTEM
- KL LABORATORY HYDRAULIC CONDUCTIVITY IN CM/SEC.
- Ql LACUSTRINE DEPOSITS — GLACIO-LACUSTRINE, BEDDED, SILT AND CLAY WITH MINOR AMOUNTS OF SAND OF WISCONSINAN, HOLOCENC AND RECENT AGE.
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- •Kff FIELD PERMEABILITY - FALLING HEAD TEST IN CM/SEC.
- •Kfr FIELD PERMEABILITY - RISING HEAD TEST IN CM/SEC.
- •(Kff) •(Kfr) WELL ABANDONED
- INFERRED BEDROCK LITHOLOGIC CONTACT

Crandon Mining Company - TMA Laboratory Soil Data

Boring ID	Sample #	Depth (ft.)	% Gravel	% Sand	P200	% Silt	% Clay	USCS	Other
STS-DL-1	10	25.5-28	0	22	78	69	9	CL	KL:1.3X10-6 LL:30.4
	15	38-40	0	7	93	83	10	CL	KL:1.0X10-7 PI:9.1
G41-D17									
G41-E17	S-2	12-13.5	31	54	15			SW	
	S-7	40-41.5	7	68	25	18	7	SW	
	S-14	86-87.5	6	71	23			SW	
	S-24	153.5-155	37	54	9	3	6	SP-SW	
	S-28	195-196	6	82	12			SW-SP	
	S-30	214-215.5	0	10	90			ML	
	S-31	224.5-226	0	1	99	51	12	ML	
	S-32a	234-235	3	34	63	39	24	ML	
	S-32b	234-235	7	35	58	46	12	ML	
	S-33	245.5-246.5	31	49	20			SW	
CMC-06P	S-24	145-147	34.3	55.5	10.2			SP-SW	
EX-11	S-1	4-6	9	71	20			SW	
	S-2	10-12	17	60	23			SW	
	S-3	20.4-22.6	21	61	18			SW	
	S-4	30.5-32.5	9	65	26	22	4	SW	
	S-5	41-45	12	66	22			SW	
	S-6	45-49	14	64	22	18	4	SW	
	S-7	50-54	6	70	24			SW	
	S-8	55-57	9	69	22			SW	
	S-9	60-64	9	71	20			SW	
	S-30	65-69	34	50	16	13	3	SW	
	S-32	82.5-84.5	7	67	26	22	4	SW	
	S-34	123.5-125.5	20	67	13	11	2	SW	
	S-35	154-156	13	71	16			SW	
	S-20	164.5-166.5	37	56	7			SW-SP	
	S-22	185-187	8	86	6			SW-SP	
	S-24	205.5-207.5	1	95	4			SP	
	S-27	236-237	0	77	23			SW	
	S-29	256.5-258.5	0	4	96	74	22	CL	
	S-30	267-269	21	77	12			SW-SP	
	S-31	277-278.5	0	2	98	86	12	CL	
EX-12	S-1	10-12	9	82	8			SW-SP	
	S-2	20-22	18	52	30	23	7	SW	
	S-4	41-43	75	6	19	18	1	GW	
	S-5	48-49	66	32	2			GW	
	S-6	59-60	50	47	3			SW-GW	
	S-7	69-70.5	20	36	44			SW	
	S-8	80-81.5	48	36	16	13	3	SW	
	S-9	90-91.5	7	78	15			SW	
	S-11	110.5-112	6	69	25			SW	
	S-14	141-142.5	26	60	14	12	2	SW	
	S-19	192-192.5	47	46	7			SW-SP	
	S-20	203-204.5	1	93	6			SW-SP	
	S-21	213-214.5	10	67	23	21	2	SW	
	S-22	223.5-225	13	69	18			SW	
	S-24	244.2-245.8	1	81	18			SW	
	S-27	274.5-276.5	9	66	25	21	4	SW	
	S-28	285-287	0	48	52	45	7	ML	
	S-29	295-297	0	4	96	84	12	ML	
G41-L15	S-2	4.5-5	14	66	20	15	5	SW	
	S-7	29-30.5	37	48	15			SW	
	S-9	39-40.5	11	79	10			SP-SW	
CMC-03RR	S-3	133-135	22.5	58.8	18.7			SW	
CMC-03P	S-37	190-191	33.6	54.1	12.3			SW	
G41-M15	S-5	46-47	42	50	8			SW-SP	
	S-30	90-91.5	2	61	37	31	6	SW	
	S-33	121-122.5	14	78	8			SW-SP	
	S-36	150-151.5	29	63	8			SW-SP	
	S-38	170-171.5	26	64	10			SW-SP	
G41-P16	S-4	30-31.5	62	34	4			GP	
	S-6	50-51.5	11	72	17			SW	
	S-9	80-81.5	20	69	11			SW-SP	
	S-10	90-91.5	19	65	16			SW	
	S-36	148.5-149.5	28	52	20			SW	



Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION
⚠	3/96	SVDI	SEE NOTE NO. 3

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

Crandon Mining Company

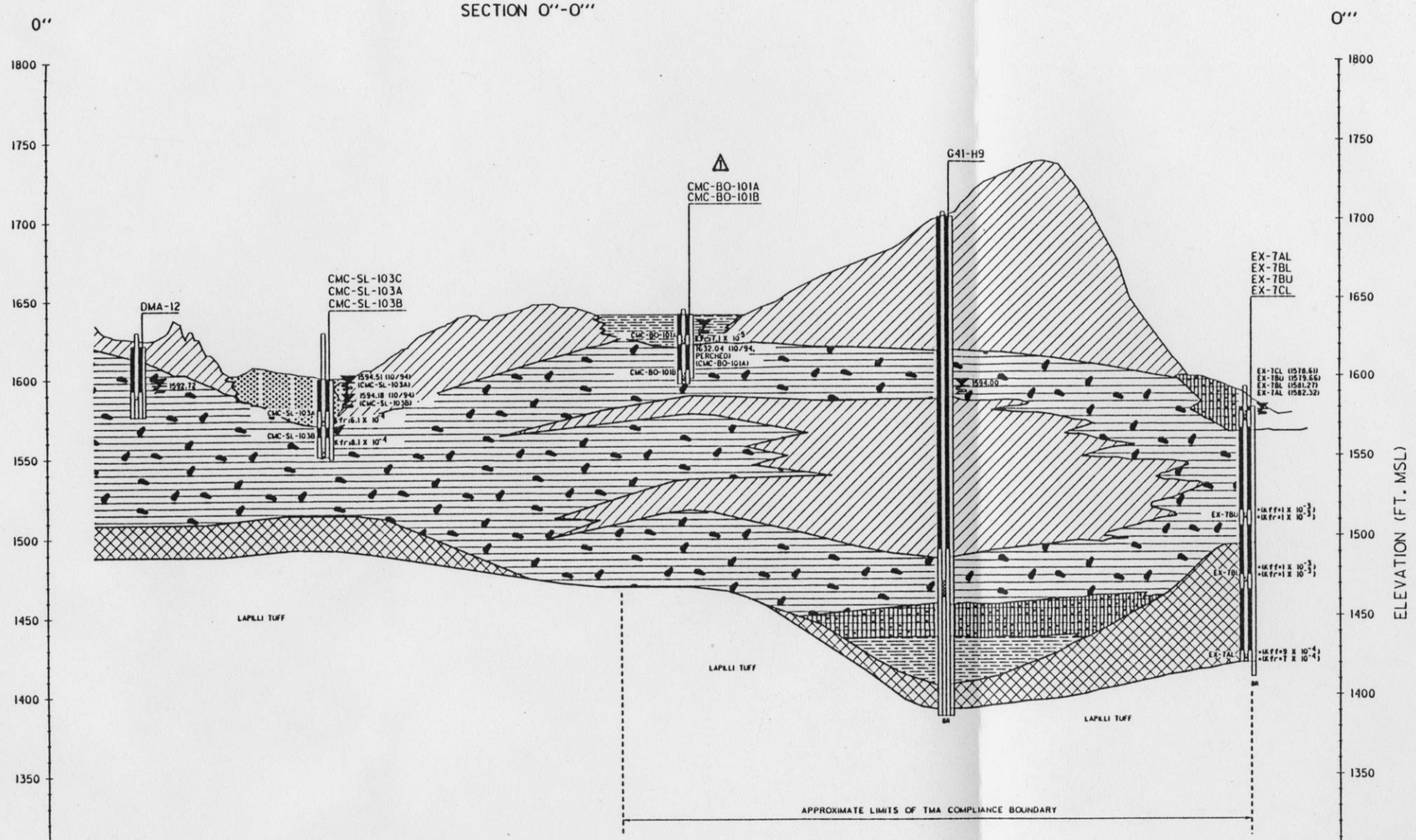
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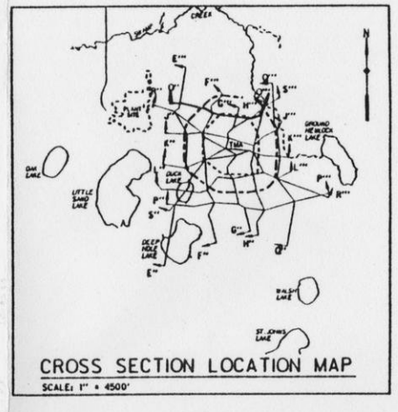
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APPROVED BY: REM	DATE: 5/95	APPROVED BY: NXP	DATE: 5/95
APPROVED BY: GWS	DATE: 5/95	CRANDON MINING COMPANY: DEM	DATE: 5/95
DRAWING NO.: 11	SHEET 11 OF 31	REVISION NO.: 1	

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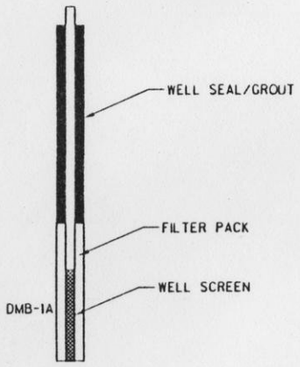
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SECTION O''-O'''



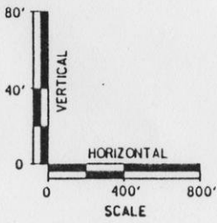


WELL CONSTRUCTION INFORMATION



NOTES:

1. WELLS ARE LOCATED IN INDIVIDUAL BORINGS, THE FILTER PACK IS SILICA SAND, AND THE ANNULAR SPACE AROUND THE WELL CASING WAS BACKFILLED WITH BENTONITE PELLETS AND CEMENT/BENTONITE GROUT AND CONCRETE.
2. REVISED TO CORRELATE WITH SECTION F''-F''' DUE TO 1996 TMA VERIFICATION BORINGS.



LEGEND

- Qti UNDIFFERENTIATED LATE WISCONSIN TILL — NASHVILLE MEMBER, COPPER FALLS FORMATION AND THE MAPLEVILLE MEMBER, HORICON FORMATION
- Qte UNDIFFERENTIATED EARLY-WISCONSIN-TILL AND PRE-WISCONSIN TILL — MARATHON AND LINCOLN FORMATIONS, MAY INCLUDE MASSIVE SAPROLITE
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- Qowl COARSE-GRAINED OUTWASH DEPOSITS — GLACIAL FLUVIAL STRATIFIED SAND AND GRAVEL OF WISCONSINAN AGE
- INFERRED GEOLOGIC CONTACT
- 1594.36 (EX-12BL) (10/84)• WATER LEVEL ELEVATION UNLESS INDICATED
- LL LIQUID LIMIT
- PI PLASTICITY INDEX
- P200 PERCENT FINES
- USCS UNIFIED SOIL CLASSIFICATION SYSTEM
- KL LABORATORY HYDRAULIC CONDUCTIVITY IN CM/SEC.
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- • Kff FIELD PERMEABILITY - FALLING HEAD TEST IN CM/SEC.
- • Kfr FIELD PERMEABILITY - RISING HEAD TEST IN CM/SEC.
- • (Kff) • (Kfr) WELL ABANDONED

Crandon Mining Company - TMA Laboratory Soil Data

Boring ID	Sample #	Depth(ft.)	% Gravel	% Sand	P200	% Silt	% Clay	USCS	Other
CMC-SL-103A	S-4	6-8.5	0.1	57.4	42.5	19.6	22.9	SC-SM	KL: 4.2 X 10^-7
CMC-SL-103B	ST-4	26-28	0.0	14.8	85.2	61.1	24.1	CL	KL: 3.5 X 10^-6
	S-9	38-40	25.5	70.1	4.4	—	—	SP	
CMC-BO-101AS-1		14-16	0.4	23.3	73.3	53.6	22.7	CL	LL:28 PI: 8
CMC-BO-101BS-3		4-6	0	53.7	46.3	32.5	13.8	SC-SM	KL:1X10-6 LL:19 PI: 5
	S-7	12-14	0	4.4	95.6	73.3	22.3	CL	KL:2.9X10-9 LL:28 PI: 8
	S-18	36-38	1.8	95.6	2.6			SP	
G41-H9	S-3	21-22.5	14	68	18			SM	
	S-5	40-41	26	62	12			SM	
	S-8	70-71.8	28	58	14			SM	
	S-10	90-91	49	44	7			SM-SP	
	S-15	140-141.5	17	63	20			SM	
	S-16	150-151.3	14	64	22			SM	
	S-21	200-200.8	1	92	8	101.0		SM-SP	
	S-22	210.5-211.4	14	64	22			SM	
EX-7	S-1	61.5-63.5	11	80	9	--	--	SM-SP	--
	S-2	120-122	7	52	41	39	2	SM	--
	S-3	162-163	61	27	12	10	2	GP-SM	--

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION
1	3/96	SVDI	SEE NOTE NO. 2

TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

Crandon Mining Company

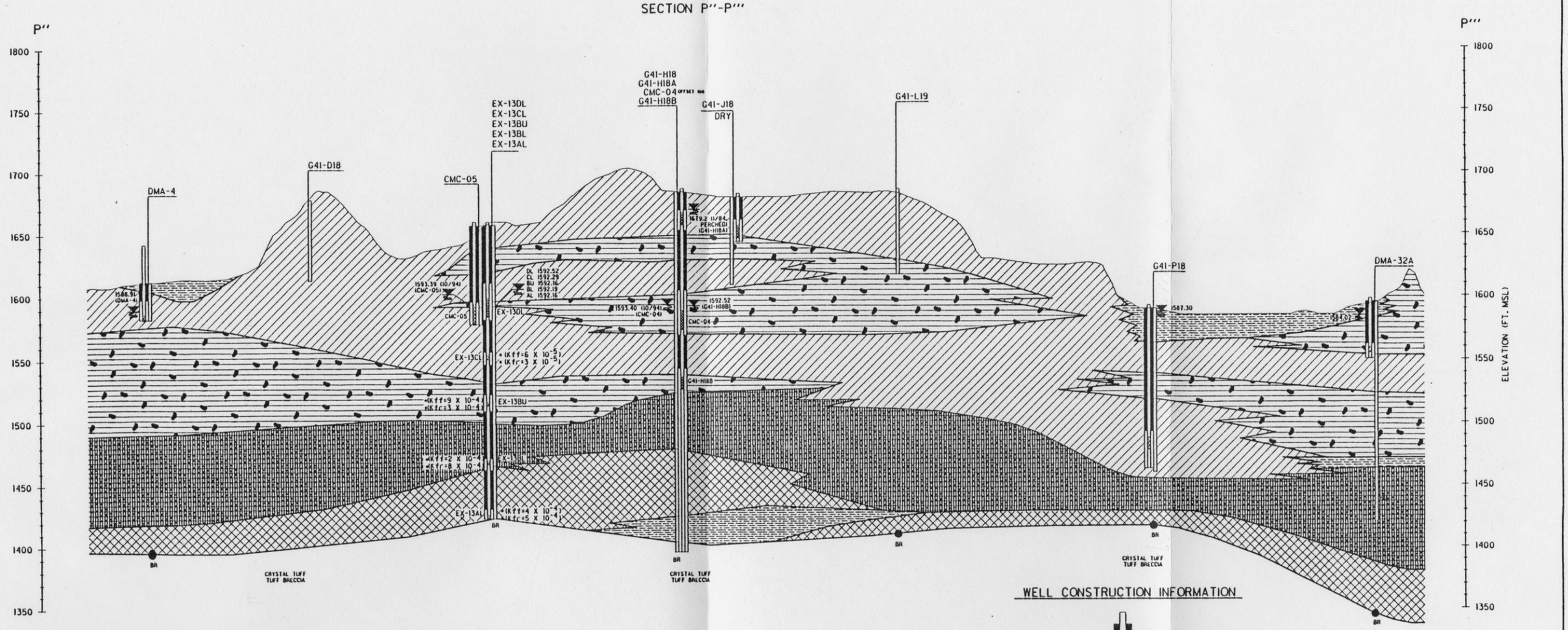
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SCALE VERT: 1" = 40' HOR: 1" = 400'	STATE: WISCONSIN		COUNTY: FOREST		
DRAWN BY: GAM	DATE: 5/95	CHECKED BY: JKSI	DATE: 5/95		
APPROVED BY: REM	DATE: 5/95	APPROVED BY: NXP	DATE: 5/95		
APPROVED BY: GWS	DATE: 5/95	CRANDON MINING COMPANY: DEM	DATE: 5/95		
DRAWING NO.: 12	SHEET 12 OF 31	REVISION NO.: 1			

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SECTION P''-P'''

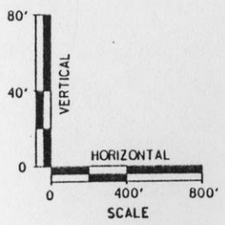


LEGEND

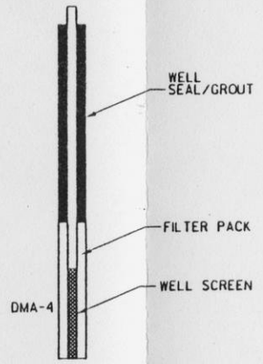
- Qtl UNDIFFERENTIATED LATE WISCONSIN TILL — NASHVILLE MEMBER, COPPER FALLS FORMATION AND THE MAPLEVILLE MEMBER, HORICON FORMATION
- Qte UNDIFFERENTIATED EARLY-WISCONSIN-TILL AND PRE-WISCONSIN TILL — MARATHON AND LINCOLN FORMATIONS, MAY INCLUDE MASSIVE SAPROLITE
- Qowf FINE-GRAINED OUTWASH DEPOSITS — GLACIAL FLUVIAL STRATIFIED SAND AND SILT OF WISCONSINAN AGE
- Qowl COARSE-GRAINED OUTWASH DEPOSITS — GLACIAL FLUVIAL STRATIFIED SAND AND GRAVEL OF WISCONSINAN AGE
- INFERRED GEOLOGIC CONTACT
- 1594.58 (E41-12BL) WATER LEVEL ELEVATION (10/84)• UNLESS INDICATED
- LL LIQUID LIMIT
- PI PLASTICITY INDEX
- P200 PERCENT FINES
- USCS UNIFIED SOIL CLASSIFICATION SYSTEM
- KL LABORATORY HYDRAULIC CONDUCTIVITY IN CM/SEC.
- Ql LACUSTRINE DEPOSITS — GLACIO-LACUSTRINE, BEDDED, SILT AND CLAY WITH MINOR AMOUNTS OF SAND OF WISCONSINAN, HOLOCENC AND RECENT AGE.
- Qhlc ICE-CONTACT DEPOSITS — ABLATION TILL, FLOW TILL, GLACIO-FLUVIAL SILT, CLAY AND SAND OF WISCONSINAN AGE
- BR PCu UNDIFFERENTIATED BEDROCK — PRECAMBRIAN METAVOLCANIC BEDROCK, FINE GRAIN TUFF, CRYSTAL TUFF, TUFF BRECCIA, FLOWS, SEDIMENTS AND LAMINATED TUFF, LAPILLI TUFF, MAY INCLUDE STRUCTURED SAPROLITE
- BR INFERRED UNDIFFERENTIATED BEDROCK ELEVATION BASED UPON STS 1984 BEDROCK ELEVATION MAP
- •Kff FIELD PERMEABILITY - FALLING HEAD TEST IN CM/SEC.
- •Kfr FIELD PERMEABILITY - RISING HEAD TEST IN CM/SEC.
- •(Kff) •(Kfr) WELL ABANDONED

Boring ID	Sample	Depth	% Gravel	% Sand	P200	% Silt	% Clay	USCS
G41-P18	S-2	5-6.5	0	15	85			SM
	S-3	20-21.5	0	2	98	92	6	ML
	S-6	25-26.5	0	4	96	79	17	ML
	S-9	45-46.5	15	58	27			SM
	S-10	55-56.5	36	57	7			SP-SM
	S-20	95-96.5	10	72	18			SM
	S-21	100-101	21	64	15			SM
G41-D18	S-1	2.5-4	20	61	19			SM
	S-3	10-11.5	30	54	16			SM
	S-4	20-20.8	17	73	10			SP-SM
	S-8	50-51.5	12	73	15			SM
	S-11	50-50.7	20	62	18			SM

SEE CROSS SECTIONS WITH COMMON POINTS FOR ADDITIONAL SOILS DATA

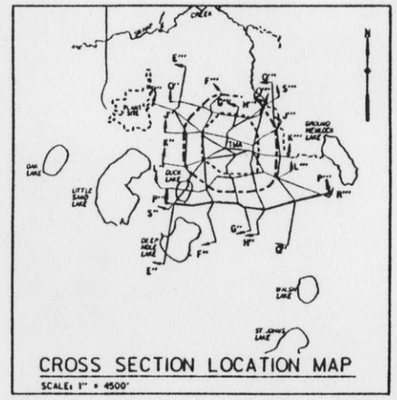


WELL CONSTRUCTION INFORMATION



NOTES:

1. WELLS ARE LOCATED IN INDIVIDUAL BORINGS, THE FILTER PACK IS SILICA SAND, AND THE ANNULAR SPACE AROUND THE WELL CASING WAS BACKFILLED WITH BENTONITE PELLETS AND CEMENT/BENTONITE GROUT AND CONCRETE.



Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

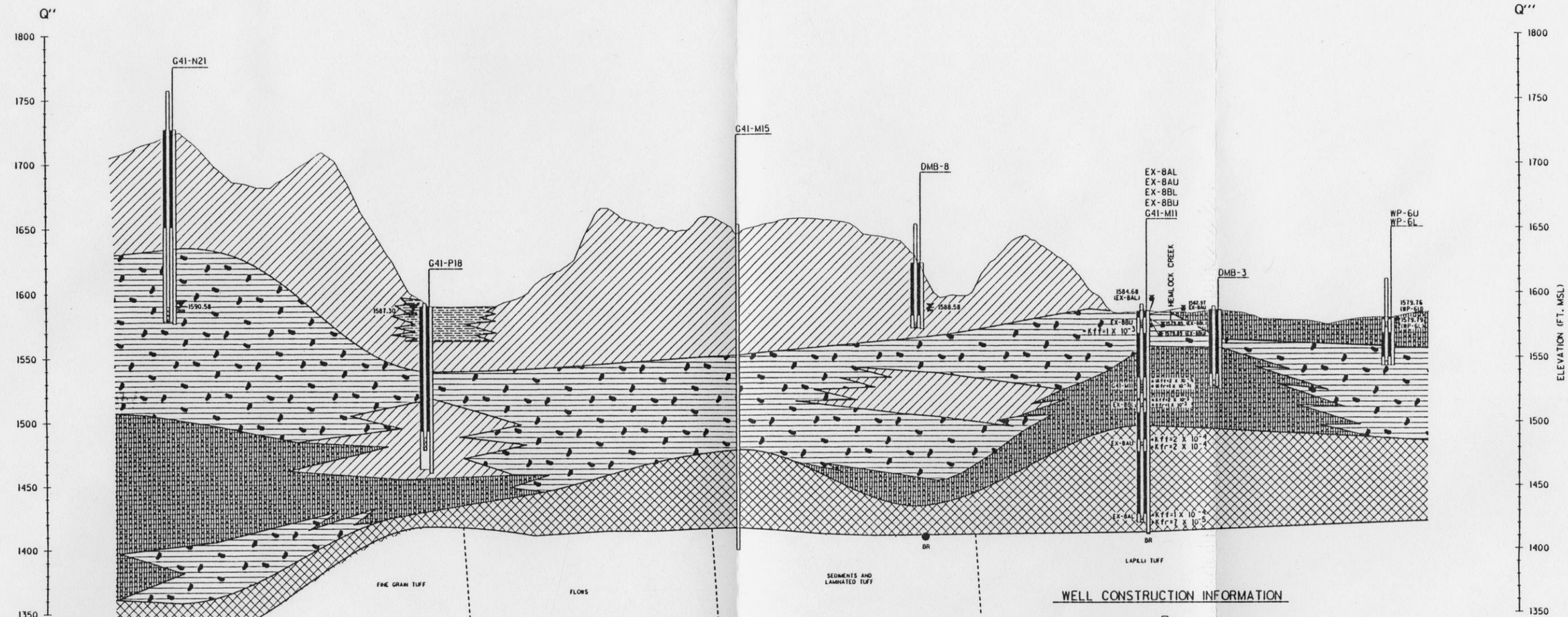
Crandon Mining Company

TITLE: GEOLOGIC CROSS SECTION P''-P'''

SCALE VERT: 1" = 40' HOR: 1" = 400'	STATE: WISCONSIN		COUNTY: FOREST		
DRAWN BY: GAM	DATE: 3/96	CHECKED BY: JKSI	DATE: 3/96		
APPROVED BY: SVDI	DATE: 3/96	APPROVED BY: REM	DATE: 3/96		
APPROVED BY: GWS	DATE: 3/96	CRANDON MINING COMPANY: DEM	DATE: 3/96		
DRAWING NO.: 12A	SHEET: 12A OF 31	REVISION NO.: 0			

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SECTION Q''-Q'''

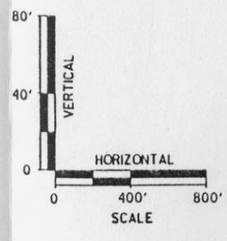


LEGEND

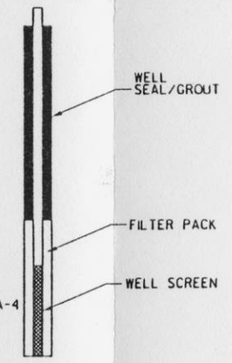
- Qtl UNDIFFERENTIATED LATE WISCONSIN TILL — NASHVILLE MEMBER, COPPER FALLS FORMATION AND THE MAPLEVILLE MEMBER, HORICON FORMATION
- Qte UNDIFFERENTIATED EARLY-WISCONSIN-TILL AND PRE-WISCONSIN TILL — MARATHON AND LINCOLN FORMATIONS, MAY INCLUDE MASSIVE SAPROLITE
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- Qowl COARSE-GRAINED OUTWASH DEPOSITS — GLACIAL FLUVIAL STRATIFIED SAND AND GRAVEL OF WISCONSINAN AGE
- INFERRED GEOLOGIC CONTACT
- 1594.58 (EX-12BL) WATER LEVEL ELEVATION (10/84)* UNLESS INDICATED
- LL LIQUID LIMIT
- PI PLASTICITY INDEX
- P200 PERCENT FINES
- USCS UNIFIED SOIL CLASSIFICATION SYSTEM
- KL LABORATORY HYDRAULIC CONDUCTIVITY IN CM/SEC.
- Ql LACUSTRINE DEPOSITS — GLACIO-LACUSTRINE, BEDDED, SILT AND CLAY WITH MINOR AMOUNTS OF SAND OF WISCONSINAN, HOLOCENE AND RECENT AGE.
- Qhlc ICE-CONTACT DEPOSITS — ABLATION TILL, FLOW TILL, GLACIO-FLUVIAL SILT, CLAY AND SAND OF WISCONSINAN AGE
- BR PCu UNDIFFERENTIATED BEDROCK — PRECAMBRIAN METAVOLCANIC BEDROCK, FINE GRAIN TUFF, CRYSTAL TUFF, TUFF BRECCIA, FLOWS, SEDIMENTS AND LAMINATED TUFF, LAPILLI TUFF, MAY INCLUDE STRUCTURED SAPROLITE
- BR INFERRED UNDIFFERENTIATED BEDROCK ELEVATION BASED UPON STS 1984 BEDROCK ELEVATION MAP
- •Kff FIELD PERMEABILITY - FALLING HEAD TEST IN CM/SEC.
- •Kfr FIELD PERMEABILITY - RISING HEAD TEST IN CM/SEC.
- •(Kff) •(Kfr) WELL ABANDONED
- INFERRED BEDROCK LITHOLOGIC CONTACT

Boring ID	Sample	Depth	% Gravel	% Sand	P200	% Silt	% Clay	USCS
DMB-3	4	15.5	10	88	2	--	--	SM

SEE CROSS SECTIONS WITH COMMON POINTS FOR ADDITIONAL DATA.

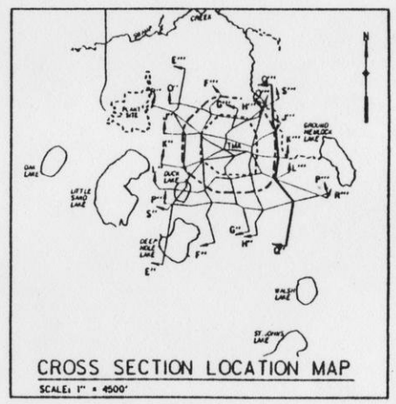


WELL CONSTRUCTION INFORMATION



NOTES:

1. WELLS ARE LOCATED IN INDIVIDUAL BORINGS, THE FILTER PACK IS SILICA SAND, AND THE ANNULAR SPACE AROUND THE WELL CASING WAS BACKFILLED WITH BENTONITE PELLETS AND CEMENT/BENTONITE GROUT AND CONCRETE.



Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

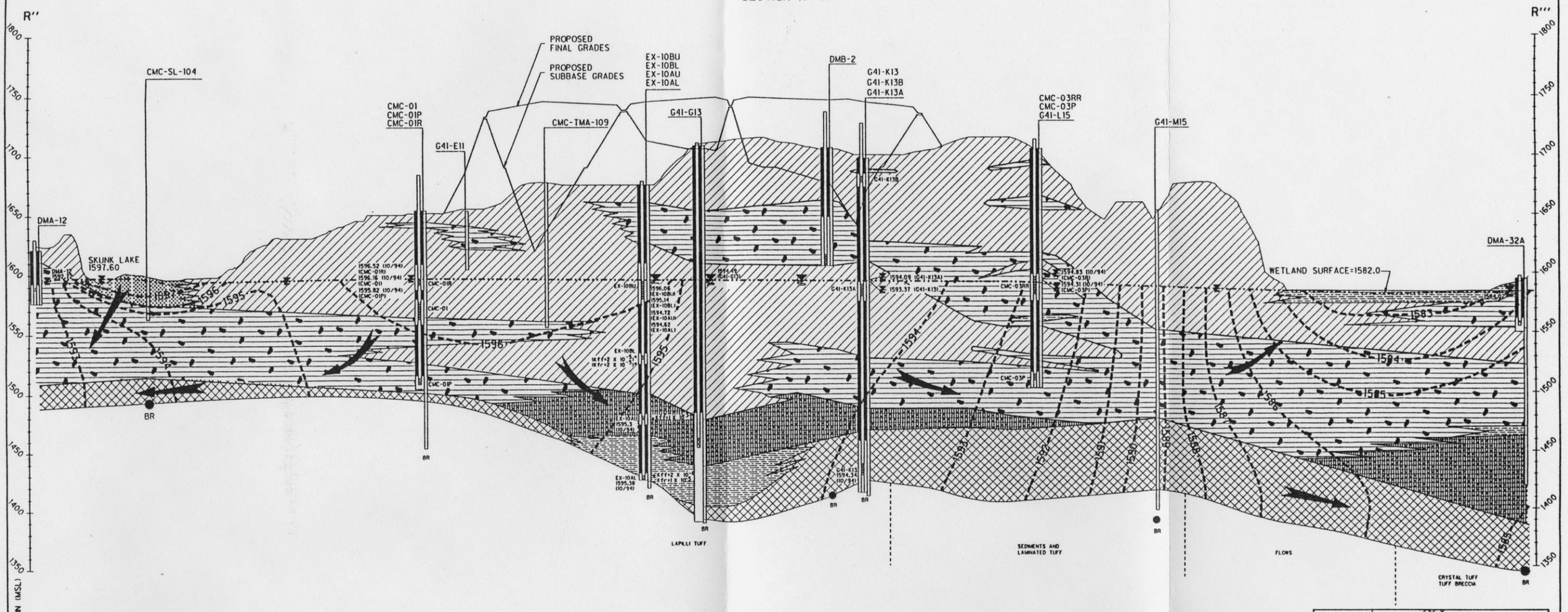
Crandon Mining Company

TITLE: GEOLOGIC CROSS SECTION Q''-Q'''

SCALE VERT: 1" = 40' HOR: 1" = 400'	STATE: WISCONSIN		COUNTY: FOREST		
DRAWN BY: GAM	DATE: 3/96	CHECKED BY: JKSI	DATE: 3/96		
APPROVED BY: SVDI	DATE: 3/96	APPROVED BY: REM	DATE: 3/96		
APPROVED BY: GWS	DATE: 3/96	CRANDON MINING COMPANY: DEM	DATE: 3/96		
DRAWING NO.: 12B	SHEET: 12B OF 31	REVISION NO.: 0			

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SECTION R''-R'''

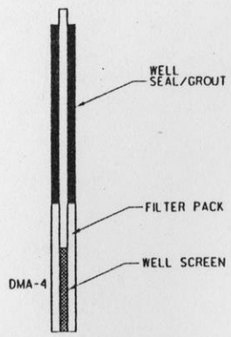


Boring ID	Sample	Depth	% Gravel	% Sand	P200	% Silt	% Clay	USCS	Other
G41-G13	S-12	110-111.8	13	79	8	--	--	SM-SP	
	S-13	120-122	14	65	21			SM	
	S-18	170-170.9	12	65	23	--	--	SM	
CMC-SL-104	S-3	4-6	0	69.7	30.3	15.6	14.7	SC-SM	KL=1.8x10-6
	S-9	16-19	0	30.5	69.5	56.0	13.5	CL-ML	KL=6.4x10-7
	S-17	34-36	16.3	74.7	9	--	--		

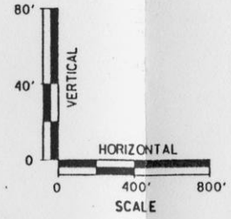
SEE CROSS SECTIONS WITH COMMON POINTS FOR ADDITIONAL SOILS DATA.

LEGEND

- Qtl UNDIFFERENTIATED LATE WISCONSIN TILL — NASHVILLE MEMBER, COPPER FALLS FORMATION AND THE MAPLEVILLE MEMBER, HORICON FORMATION
- Qte UNDIFFERENTIATED EARLY-WISCONSIN-TILL AND PRE-WISCONSIN TILL — MARATHON AND LINCOLN FORMATIONS, MAY INCLUDE MASSIVE SAPROLITE
- Qowf FINE-GRAINED OUTWASH DEPOSITS — GLACIAL FLUVIAL STRATIFIED SAND AND SILT OF WISCONSINAN AGE
- Qowl COARSE-GRAINED OUTWASH DEPOSITS — GLACIAL FLUVIAL STRATIFIED SAND AND GRAVEL OF WISCONSINAN AGE
- INFERRED GEOLOGIC CONTACT
- 1594.58 (EX-10BL) (10/84)* WATER LEVEL ELEVATION (10/84)* UNLESS INDICATED
- LL LIQUID LIMIT
- PI PLASTICITY INDEX
- P200 PERCENT FINES
- USCS UNIFIED SOIL CLASSIFICATION SYSTEM
- KL LABORATORY HYDRAULIC CONDUCTIVITY IN CM/SEC.
- Qi LACUSTRINE DEPOSITS — GLACIO-LACUSTRINE, BEDDED, SILT AND CLAY WITH MINOR AMOUNTS OF SAND OF WISCONSINAN, HOLOCENC AND RECENT AGE.
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- BR INFERRED UNDIFFERENTIATED BEDROCK ELEVATION BASED UPON STS 1984 BEDROCK ELEVATION MAP
- *Kff FIELD PERMEABILITY - FALLING HEAD TEST IN CM/SEC.
- *Kfr FIELD PERMEABILITY - RISING HEAD TEST IN CM/SEC.
- *(Kff) *(Kfr) WELL ABANDONED
- APPROXIMATE EQUIPOTENTIAL LINES FOR OCTOBER 1984, INCLUDES NON-CONTEMPORANEOUS DATA FROM CMC-03RR, CMC-03P, CMC-01, CMC-01R, CMC-01P.
- GENERAL GROUNDWATER FLOW DIRECTION, NOTE, ARROWS DEPICT GENERAL PATTERN OF GROUNDWATER FLOW AND HAVE NOT BEEN ADJUSTED FOR VERTICAL EXAGGERATION.
- GROUNDWATER TABLE

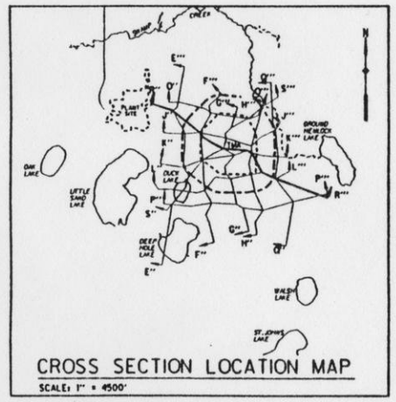


WELL CONSTRUCTION INFORMATION



NOTES:

1. WELLS ARE LOCATED IN INDIVIDUAL BORINGS, THE FILTER PACK IS SILICA SAND, AND THE ANNULAR SPACE AROUND THE WELL CASING WAS BACKFILLED WITH BENTONITE PELLETS AND CEMENT/BENTONITE GROUT AND CONCRETE.



CROSS SECTION LOCATION MAP

SCALE: 1" = 4500'

Crandon Mining Company

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

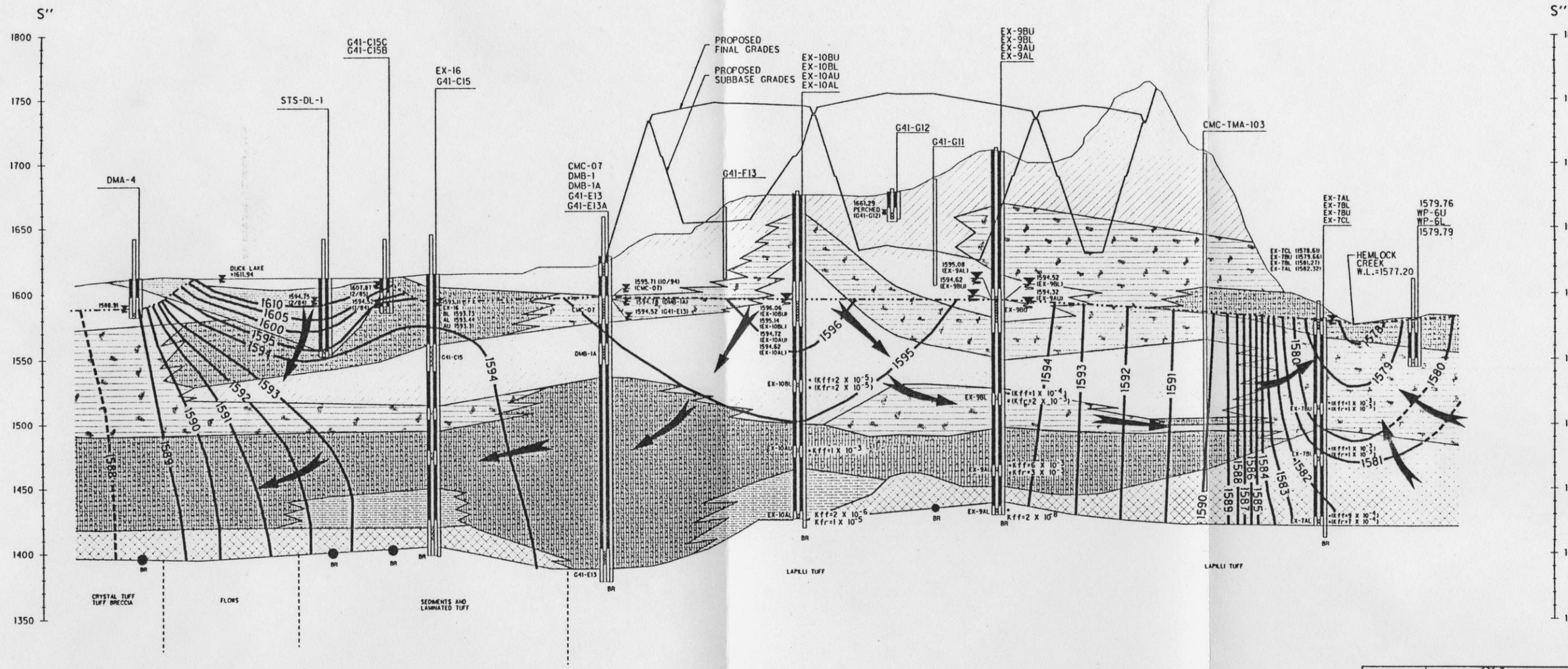
TITLE: GEOLOGIC CROSS SECTION R''-R'''

SCALE VERT: 1" = 40' HOR: 1" = 400'	STATE: WISCONSIN		COUNTY: FOREST		
DRAWN BY: GAM	DATE: 3/96	CHECKED BY: JKSI	DATE: 3/96		
APPROVED BY: SVDI	DATE: 3/96	APPROVED BY: REM	DATE: 3/96		
APPROVED BY: GWS	DATE: 3/96	CRANDON MINING COMPANY: DEM	DATE: 3/96		
DRAWING NO.: 12C	SHEET: 12C OF 31	REVISION NO.: 0			

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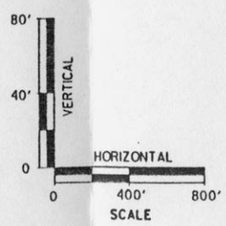
SECTION S''-S'''



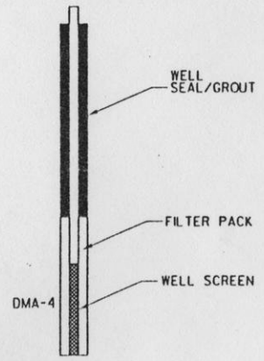
LEGEND

- Qti UNDIFFERENTIATED LATE WISCONSIN TILL — NASHVILLE MEMBER, COPPER FALLS FORMATION AND THE MAPLEVILLE MEMBER, HORICON FORMATION
- Qte UNDIFFERENTIATED EARLY-WISCONSIN-TILL AND PRE-WISCONSIN TILL — MARATHON AND LINCOLN FORMATIONS, MAY INCLUDE MASSIVE SAPROLITE
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- Qowl COARSE-GRAINED OUTWASH DEPOSITS — GLACIAL FLUVIAL STRATIFIED SAND AND GRAVEL OF WISCONSINAN AGE
- INFERRED GEOLOGIC CONTACT
- 1594.56 (EX-12BL) WATER LEVEL ELEVATION (10/84)• UNLESS INDICATED
- LL LIQUID LIMIT
- PI PLASTICITY INDEX
- P200 PERCENT FINES
- USCS UNIFIED SOIL CLASSIFICATION SYSTEM
- KL LABORATORY HYDRAULIC CONDUCTIVITY IN CM/SEC.

- Ql LACUSTRINE DEPOSITS — GLACIO-LACUSTRINE, BEDDED, SILT AND CLAY WITH MINOR AMOUNTS OF SAND OF WISCONSINAN, HOLOCENE AND RECENT AGE.
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- PCu UNDIFFERENTIATED BEDROCK — PRECAMBRIAN METAVOLCANIC BEDROCK, FINE GRAIN TUFF, CRYSTAL TUFF, TUFF BRECCIA, FLOWS, SEDIMENTS AND LAMINATED TUFF, LAPILLI TUFF, MAY INCLUDE STRUCTURED SAPROLITE
- BR INFERRED UNDIFFERENTIATED BEDROCK ELEVATION BASED UPON STS 1984 BEDROCK ELEVATION MAP
- •Kff FIELD PERMEABILITY - FALLING HEAD TEST IN CM/SEC.
- •Kfr FIELD PERMEABILITY - RISING HEAD TEST IN CM/SEC.
- •(Kff) •(Kfr) WELL ABANDONED
- EQUIPOTENTIAL LINE. INCLUDES NON-CONTEMPORANEOUS DATA AT STS-DL-1, G41-C15B AND G41-C15C.
- INFERRED EQUIPOTENTIAL LINE
- GENERAL GROUNDWATER FLOW DIRECTION. NOTE: ARROWS DEPICT GENERAL PATTERN OF GROUNDWATER FLOW AND HAVE NOT BEEN ADJUSTED FOR VERTICAL EXAGGERATION.
- GROUNDWATER TABLE

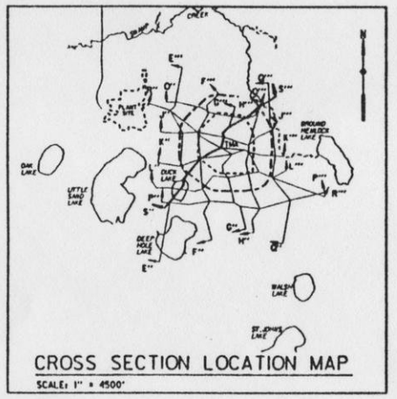


WELL CONSTRUCTION INFORMATION



NOTES:

1. WELLS ARE LOCATED IN INDIVIDUAL BORINGS, THE FILTER PACK IS SILICA SAND, AND THE ANNULAR SPACE AROUND THE WELL CASING WAS BACKFILLED WITH BENTONITE PELLETS AND CEMENT/BENTONITE GROUT AND CONCRETE.
2. SEE CROSS SECTIONS WITH COMMON POINTS FOR SOILS DATA.



Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

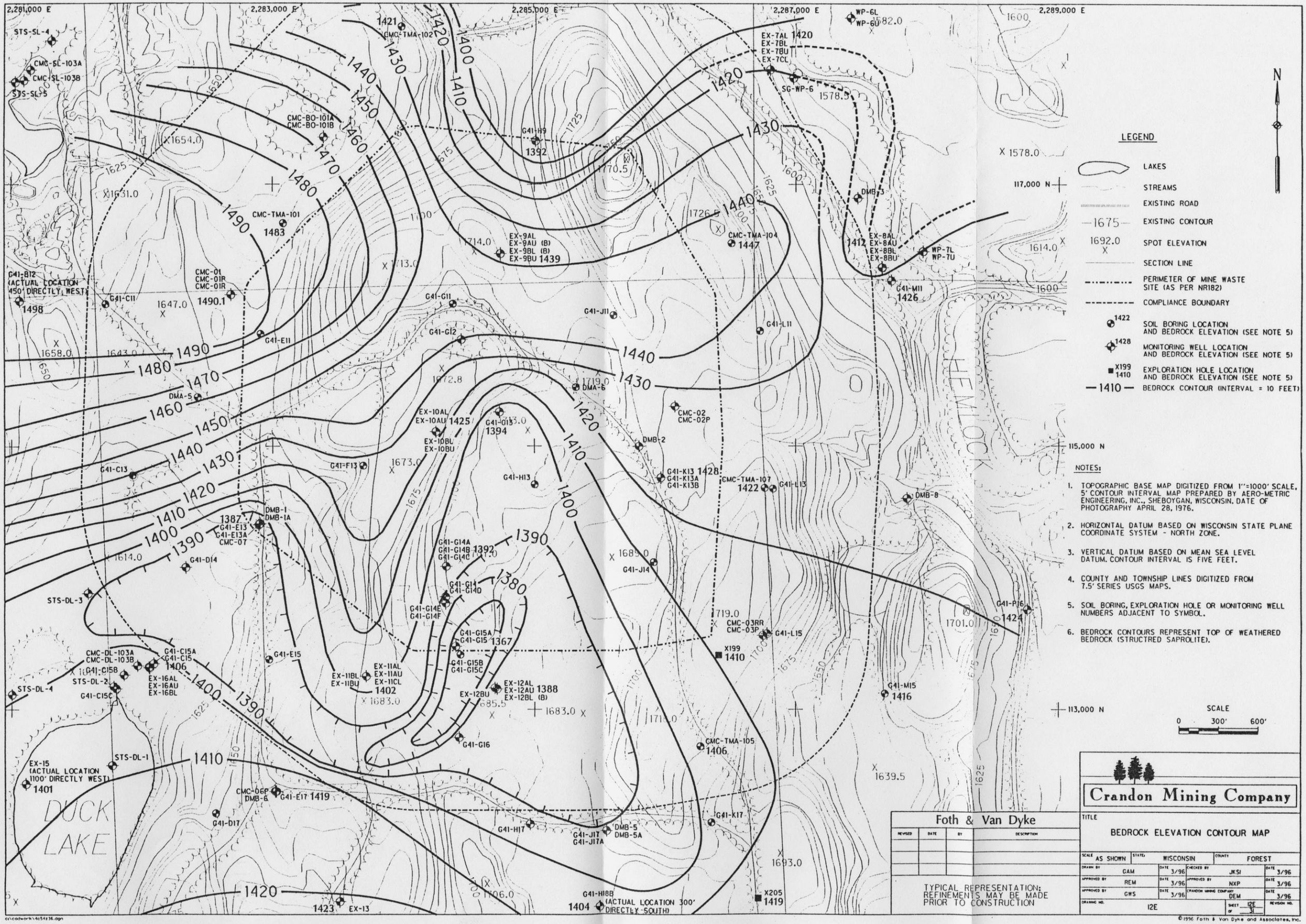
Crandon Mining Company

TITLE: GEOLOGIC CROSS SECTION S''-S'''

SCALE VERT: 1" = 40' HOR: 1" = 400'	STATE: WISCONSIN		COUNTY: FOREST		
DRAWN BY: GAM	DATE: 3/96	CHECKED BY: JKSI	DATE: 3/96		
APPROVED BY: SVDI	DATE: 3/96	APPROVED BY: REM	DATE: 3/96		
APPROVED BY: GWS	DATE: 3/96	CRANDON MINING COMPANY: DEM	DATE: 3/96		
DRAWING NO.: 12D	SHEET 12D OF 31	REVISION NO.: 0			

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03/15/96 GR2



N

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- —1675— EXISTING CONTOUR
- 1692.0 X SPOT ELEVATION
- SECTION LINE
- PERIMETER OF MINE WASTE SITE (AS PER NR182)
- COMPLIANCE BOUNDARY
- 1422 SOIL BORING LOCATION AND BEDROCK ELEVATION (SEE NOTE 5)
- 1428 MONITORING WELL LOCATION AND BEDROCK ELEVATION (SEE NOTE 5)
- X199 1410 EXPLORATION HOLE LOCATION AND BEDROCK ELEVATION (SEE NOTE 5)
- —1410— BEDROCK CONTOUR (INTERVAL = 10 FEET)

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. SOIL BORING, EXPLORATION HOLE OR MONITORING WELL NUMBERS ADJACENT TO SYMBOL.
6. BEDROCK CONTOURS REPRESENT TOP OF WEATHERED BEDROCK (STRUCTRED SAPROLITE).

SCALE
0 300' 600'

TYPICAL REPRESENTATION:
REFINEMENTS MAY BE MADE
PRIOR TO CONSTRUCTION

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

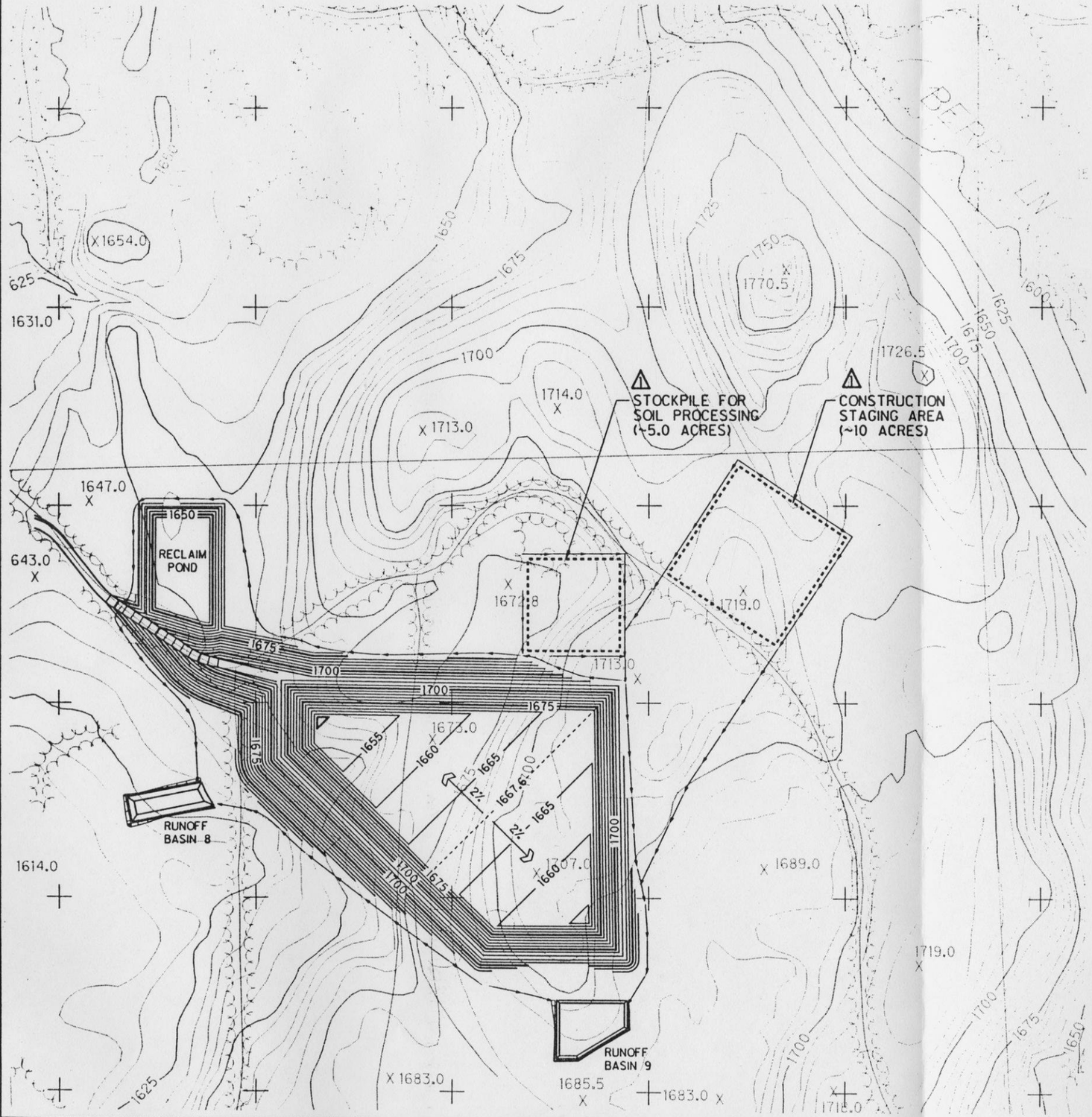
Crandon Mining Company

TITLE
BEDROCK ELEVATION CONTOUR MAP

SCALE AS SHOWN	STATE: WISCONSIN		COUNTY FOREST		
DRAWN BY GAM	DATE 3/96	CHECKED BY JKSI	DATE 3/96		
APPROVED BY REM	DATE 3/96	APPROVED BY NXP	DATE 3/96		
APPROVED BY GWS	DATE 3/96	CRANDON MINING COMPANY DEM	DATE 3/96		
DRAWING NO. I2E	SHEET I2E OF 51	REVISION NO.			

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03/15/96 JRB2



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N

LEGEND

- EXISTING ROAD
- 1675 — EXISTING CONTOUR
- 1642.0 SPOT ELEVATION
- SECTION LINE
- 1660 — PROPOSED CONTOUR
- PROPOSED DRAINAGE FLOW
- 2% PROPOSED SLOPE DIRECTION

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. ⚠ STOCKPILE AREAS SIZE AND LOCATION ARE APPROXIMATE. THE CONTRACTOR MAY VARY LOCATION AND SIZE BASED ON LOGISTICS, CONSTRUCTION EQUIPMENT AVAILABILITY AND OTHER FACTORS.
6. ⚠ CHANGED CONSTRUCTION STAGING AREA LOCATION AND ADDED STOCKPILE FOR SOIL PROCESSING.

0 300' 600'
SCALE

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

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REVISED	DATE	BY	DESCRIPTION
⚠	3/13/96	REM	SEE NOTE 6

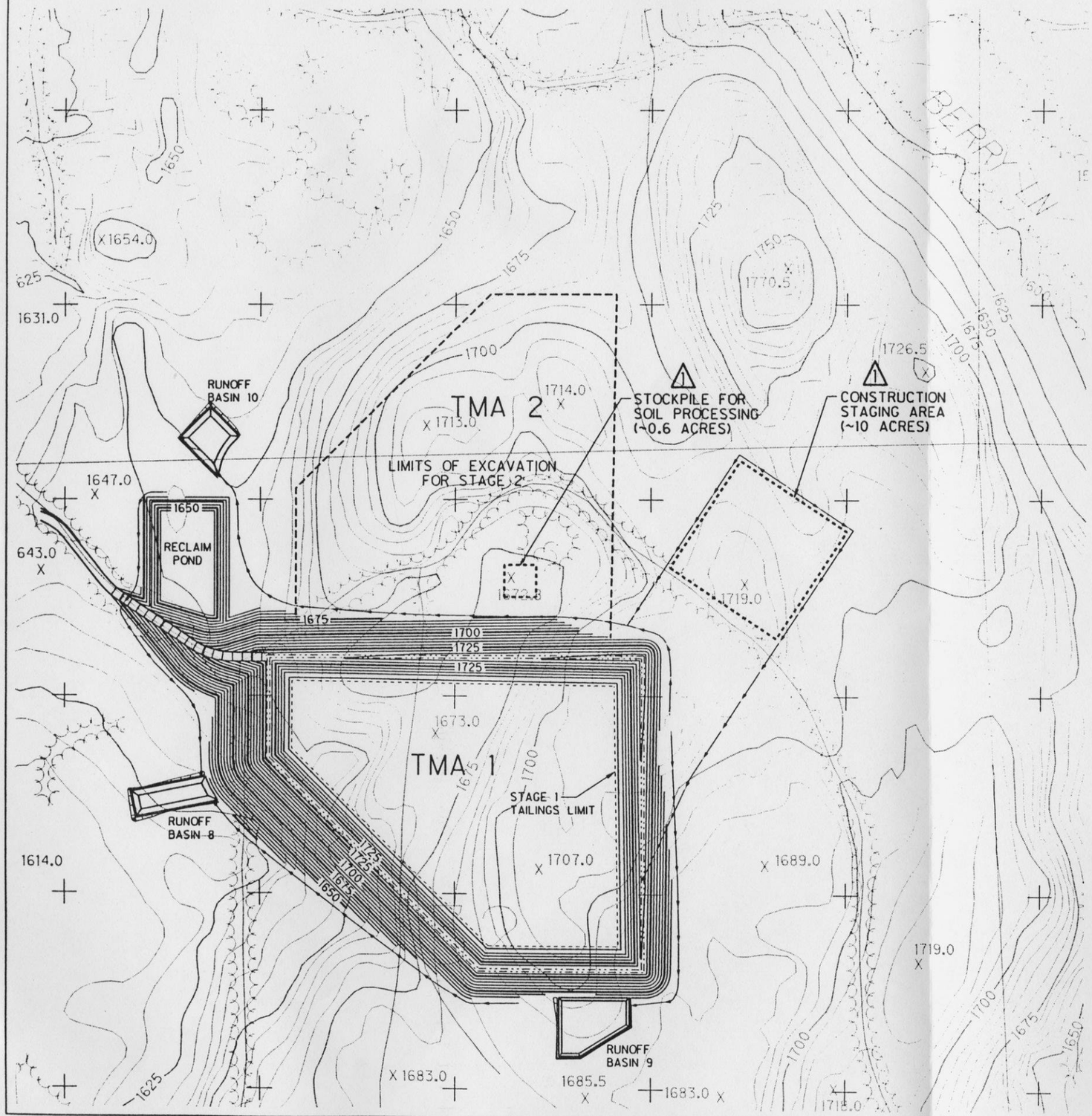
CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	REM	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

Crandon Mining Company

FIGURE 6.12-1
TMA 1
STAGE 1 CONSTRUCTION

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	JRB2

930049



LEGEND

- EXISTING ROAD
- 1675 — EXISTING CONTOUR
- X 1692.0 — SPOT ELEVATION
- SECTION LINE
- 1660 — PROPOSED CONTOUR
- 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.
5. ⚠1 STOCKPILE AREAS SIZE AND LOCATION ARE APPROXIMATE. THE CONTRACTOR MAY VARY LOCATION AND SIZE BASED ON LOGISTICS, CONSTRUCTION EQUIPMENT AVAILABILITY AND OTHER FACTORS.
6. ⚠1 CHANGED CONSTRUCTION STAGING AREA LOCATION AND ADDED STOCKPILE FOR SOIL PROCESSING.

0 300' 600'
SCALE

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION
⚠1	3/13/96	REM	SEE NOTE 6

CHECKED BY:	JKS1	DATE: MAY '95
APPROVED BY:	REM	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

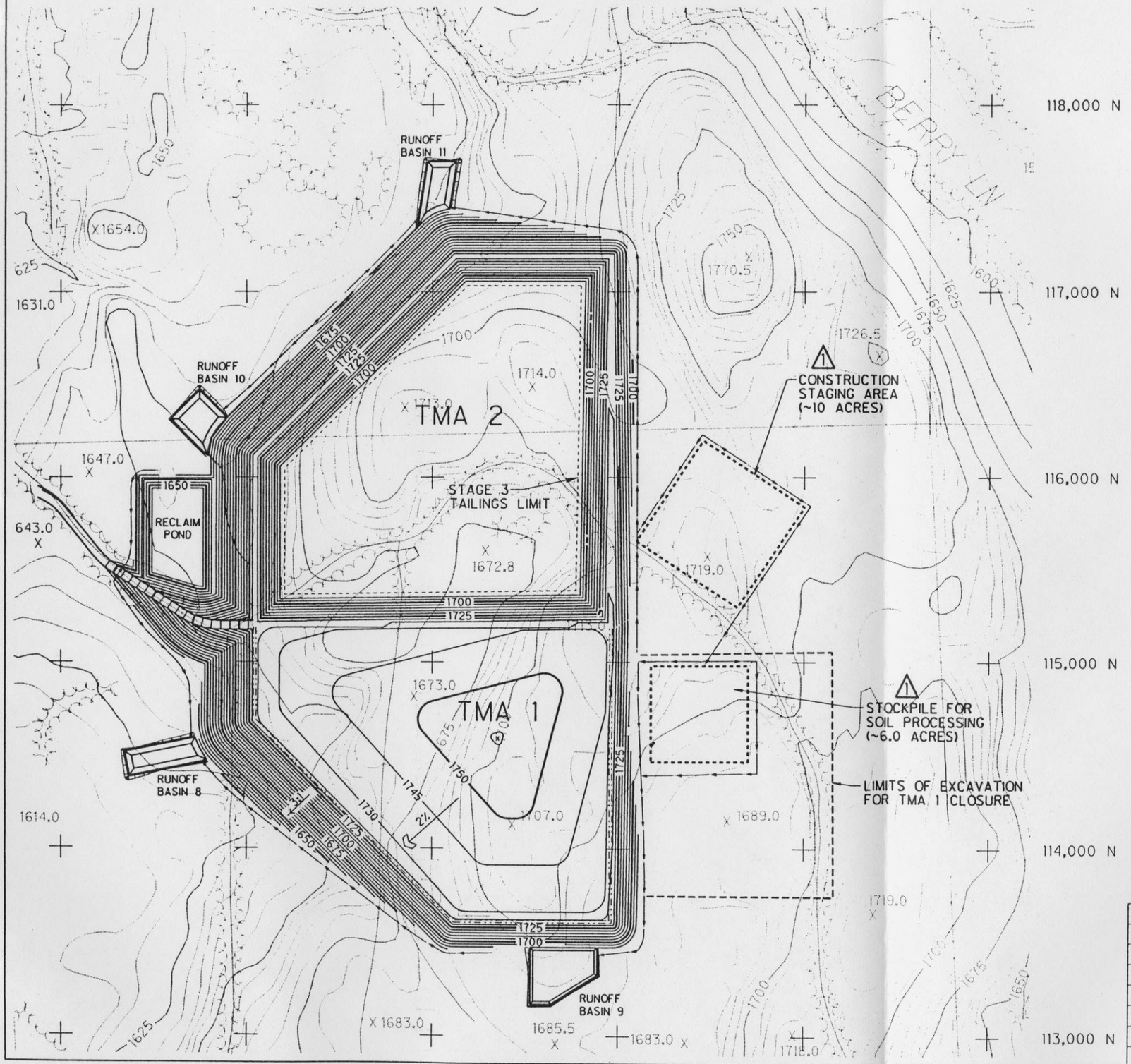
Crandon Mining Company

FIGURE 6.12-2
TMA 1 STAGE 2 CONSTRUCTION

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	JRB2

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93C049



LEGEND

- EXISTING ROAD
- 1675 — EXISTING CONTOUR
- X 1692.0 — SPOT ELEVATION
- SECTION LINE
- 1660 — PROPOSED CONTOUR
- PROPOSED DRAINAGE FLOW
- 2% — PROPOSED SLOPE DIRECTION

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. ⚠1 STOCKPILE AREAS SIZE AND LOCATION ARE APPROXIMATE. THE CONTRACTOR MAY VARY LOCATION AND SIZE BASED ON LOGISTICS, CONSTRUCTION EQUIPMENT AVAILABILITY AND OTHER FACTORS.
6. ⚠1 CHANGED CONSTRUCTION STAGING AREA LOCATION AND ADDED STOCKPILE FOR SOIL PROCESSING.

0 300' 600'
SCALE

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION
⚠1	3/13/96	REM	SEE NOTE 6

CHECKED BY:	JKS1	DATE: MAY '95
APPROVED BY:	REM	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

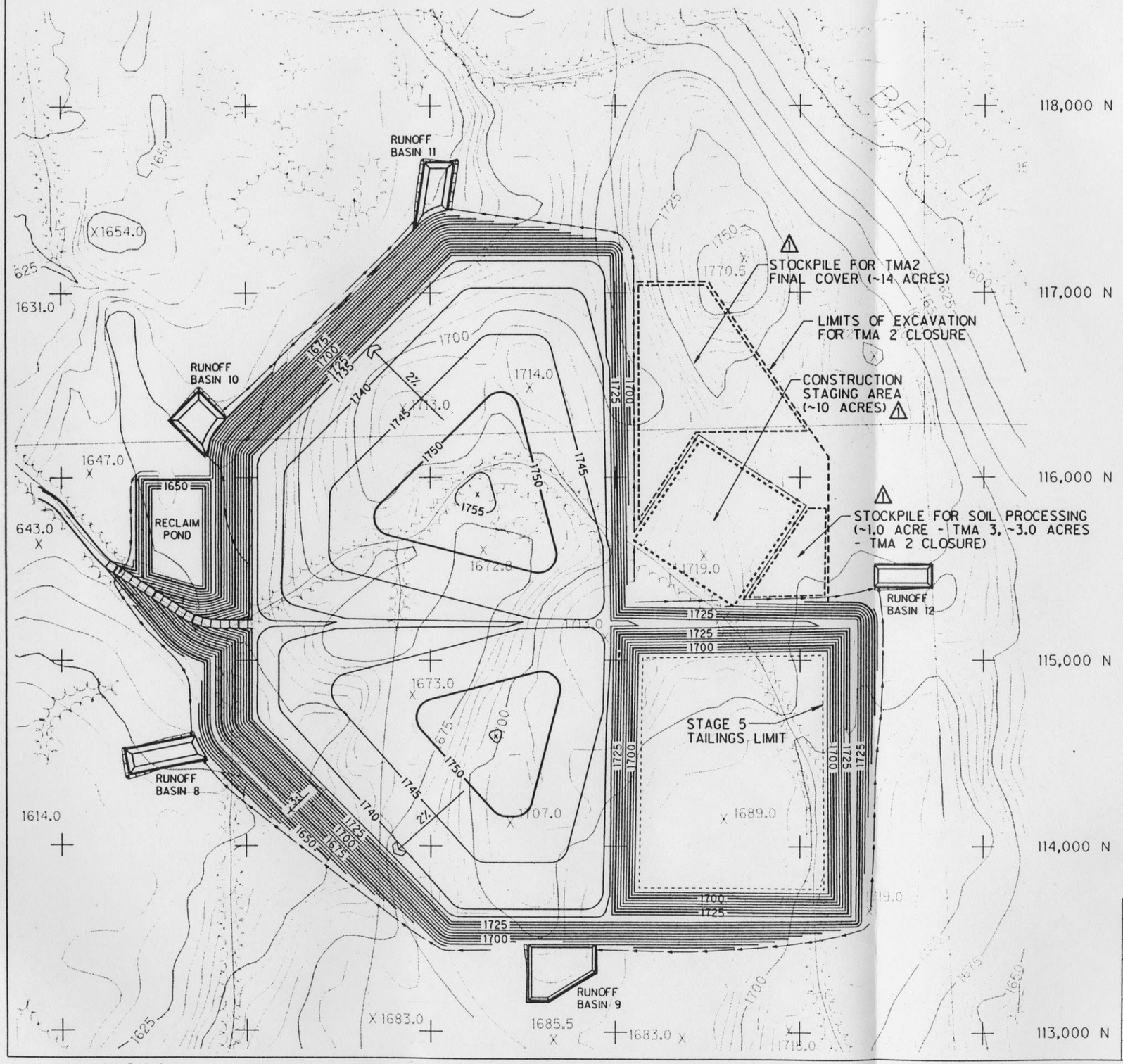
Crandon Mining Company

FIGURE 6.12-3
TMA 1 CLOSURE AND
TMA 2 CONSTRUCTION

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	JRB2

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93C049



LEGEND

- EXISTING ROAD
- 1675 — EXISTING CONTOUR
- 1692.0 — SPOT ELEVATION
- SECTION LINE
- 1660 — PROPOSED CONTOUR
- PROPOSED DRAINAGE FLOW
- 2% — PROPOSED SLOPE DIRECTION

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. ⚠1 STOCKPILE AREAS SIZE AND LOCATION ARE APPROXIMATE. THE CONTRACTOR MAY VARY LOCATION AND SIZE BASED ON LOGISTICS, CONSTRUCTION EQUIPMENT AVAILABILITY AND OTHER FACTORS.
6. ⚠1 CHANGED CONSTRUCTION STAGING AREA LOCATION AND ADDED STOCKPILE FOR SOIL PROCESSING.

0 300' 600'
SCALE

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION
⚠1	3/13/96	REM	SEE NOTE 6

CHECKED BY:	JKS1	DATE: MAY '95
APPROVED BY:	REM	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

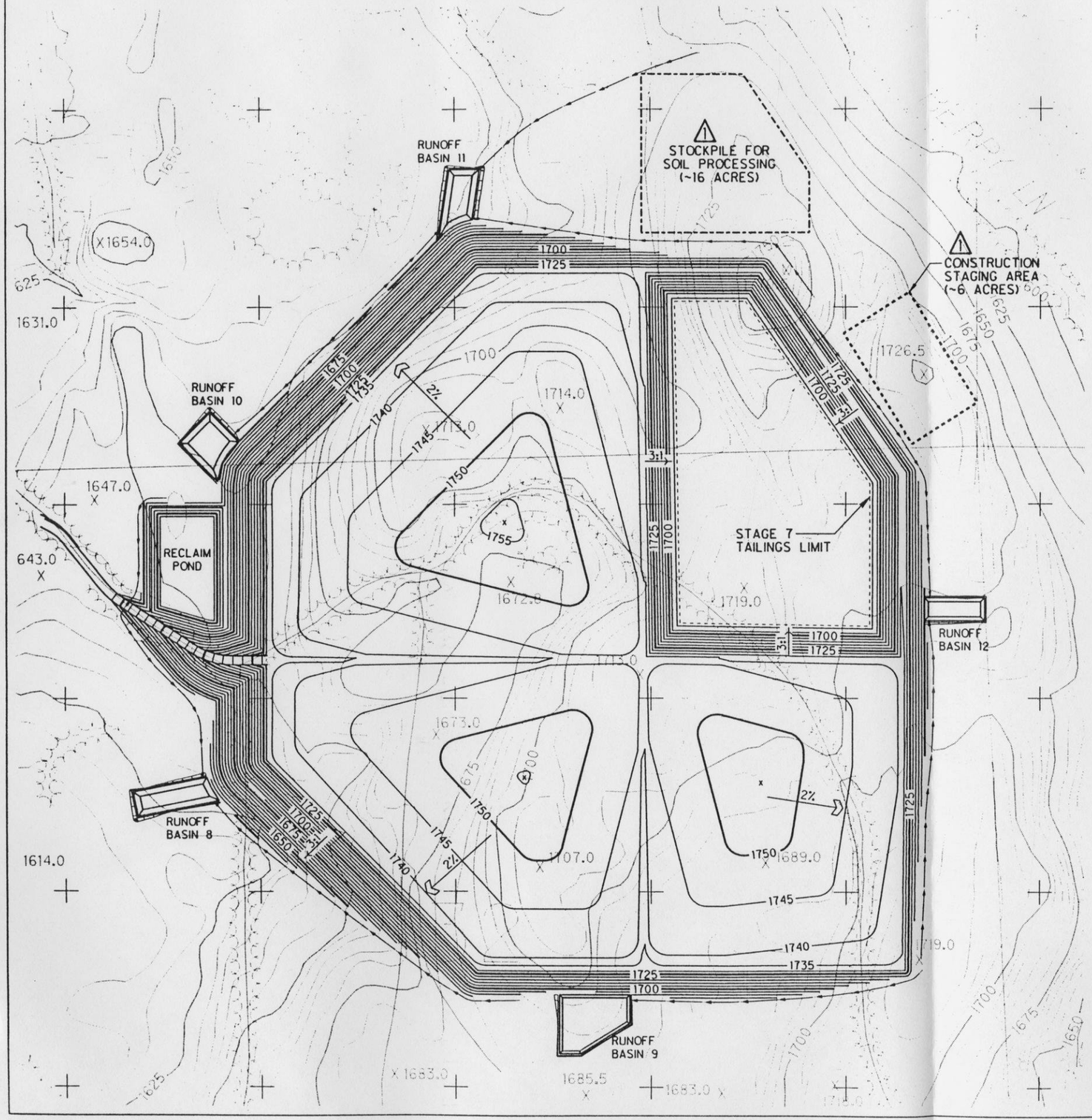
Crandon Mining Company

FIGURE 6.12-4
TMA 2 CLOSURE AND
TMA 3 CONSTRUCTION

Scale:	AS SHOWN	Date:	MAY, 1996
Prepared By:	Foth & Van Dyke	By:	JRB2

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93C049



N

LEGEND

- EXISTING ROAD
- EXISTING CONTOUR
- SPOT ELEVATION
- SECTION LINE
- 1660 — PROPOSED CONTOUR
- PROPOSED DRAINAGE FLOW
- 2% → PROPOSED SLOPE DIRECTION

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. ⚠1 STOCKPILE AREAS SIZE AND LOCATION ARE APPROXIMATE. THE CONTRACTOR MAY VARY LOCATION AND SIZE BASED ON LOGISTICS, CONSTRUCTION EQUIPMENT AVAILABILITY AND OTHER FACTORS.
6. ⚠1 CHANGED CONSTRUCTION STAGING AREA LOCATION AND ADDED STOCKPILE FOR SOIL PROCESSING.

0 300' 600'
SCALE

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION
⚠1	3/13/96	REM	SEE NOTE 6

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	REM	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

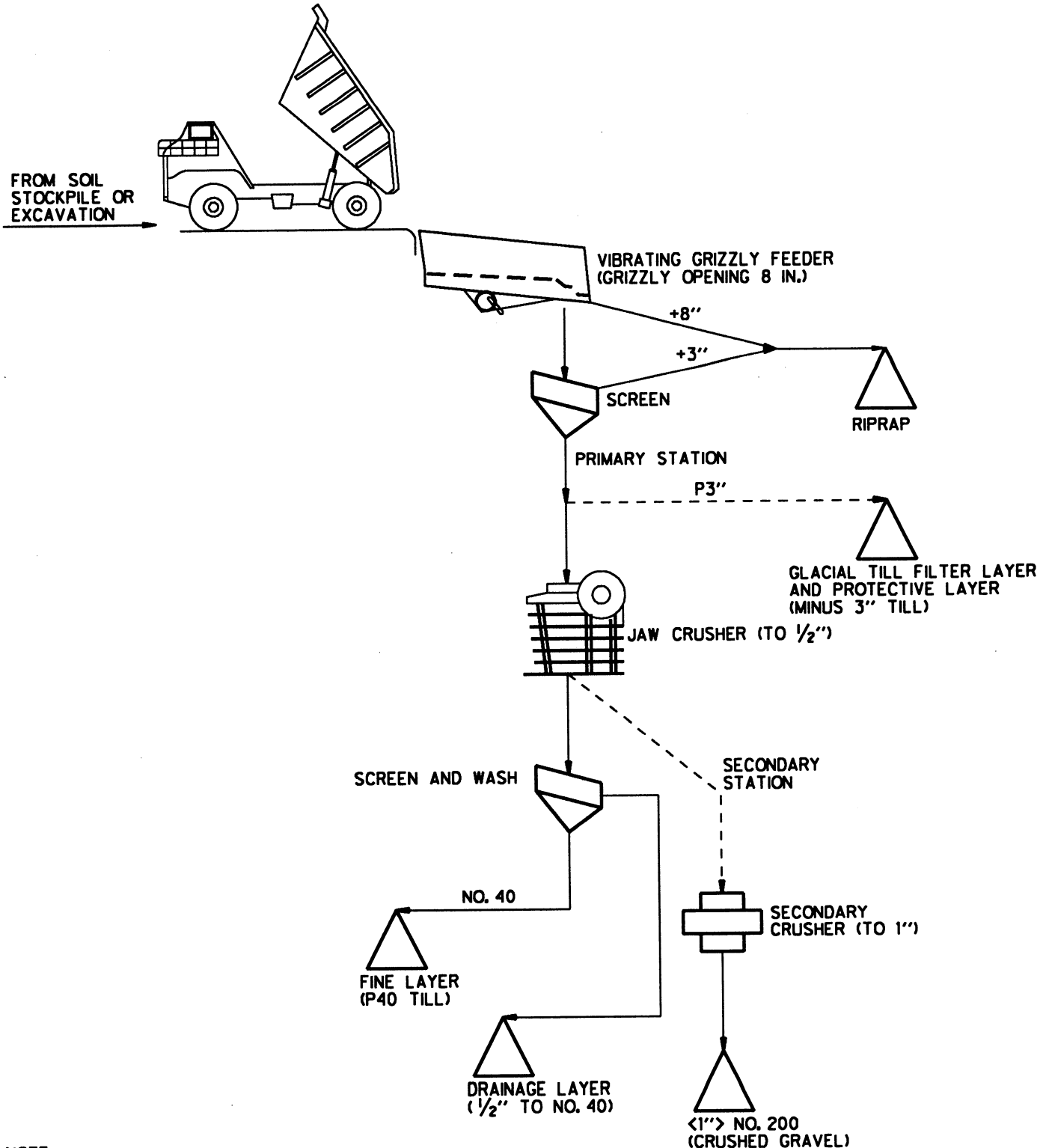
Crandon Mining Company

FIGURE 6.12-5
TMA 3 CLOSURE AND
TMA 4 CONSTRUCTION

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	JRB2

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NOTE:
BELT CONVEYORS ARE USED TO MOVE MATERIALS BETWEEN PROCESSES AND STACK MATERIALS AT THE END OF EACH PROCESS LINE.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: MAR.'96
APPROVED BY:	REM	DATE: MAR.'96
APPROVED BY:	GWS	DATE: MAR.'96

Crandon Mining Company

FIGURE 6.12-6

TMA

FLOW CHART FOR SOIL PROCESSING

Scale:	NOT TO SCALE	Date:	MARCH 1996
Prepared By:	Foth & Van Dyke	By:	JRB2

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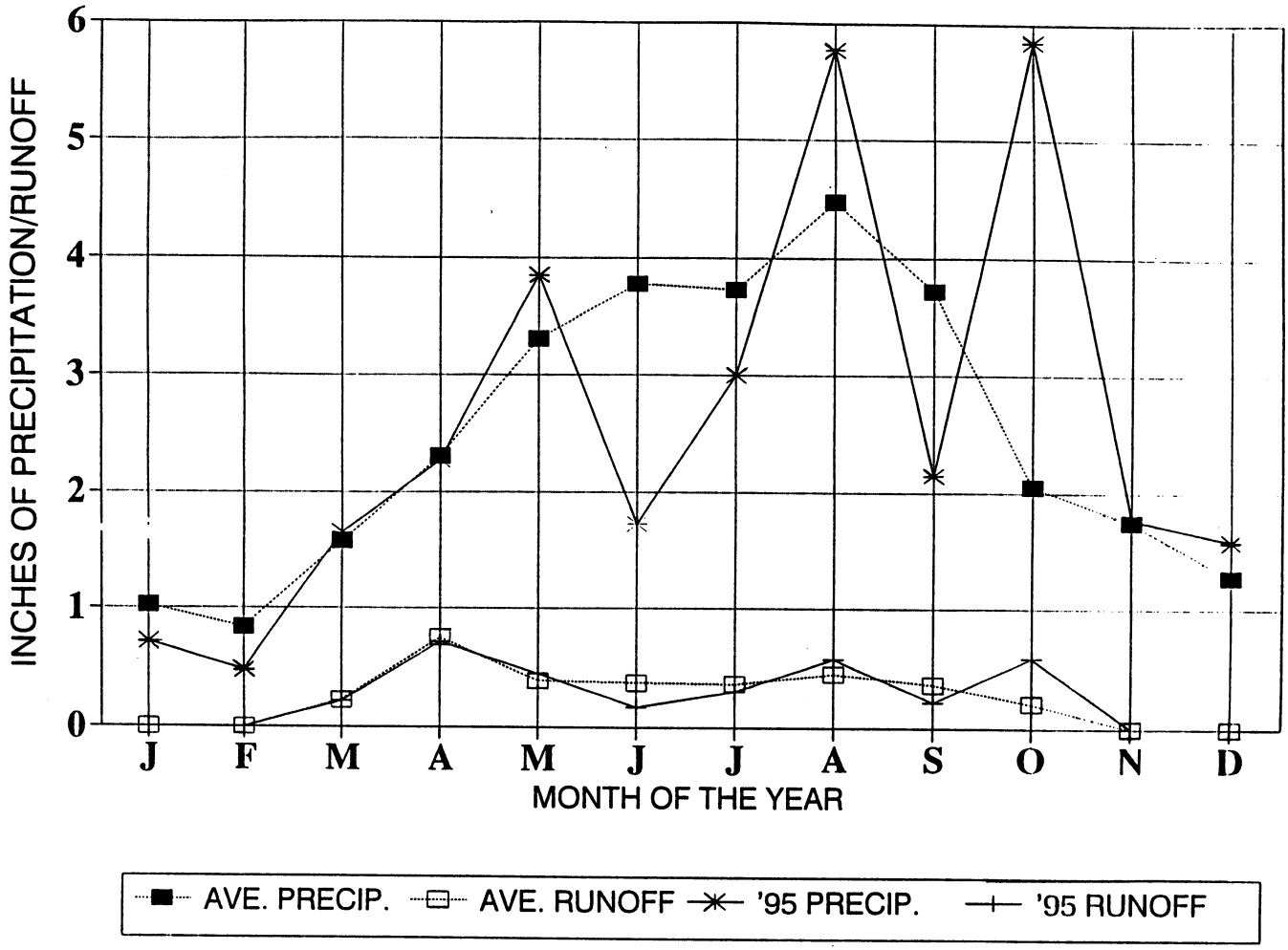
93C049

Attachment 1

- Figure 1-1 - Comparison of Average Annual to 1995 Runoff for the F15 Watershed

- Model Outputs for the Existing Conditions for the Upland and Wetland Areas Within Wetland F15 and Monthly Precipitation and Average Temperature Data Sets

CRANDON MINING COMPANY
WATER BALANCE MODELING



Foth & Van Dyke			
REVISED	DATE	BY	DESCRIPTION
CHECKED BY: JKSI			DATE: MAR. '96
APPROVED BY: PAE			DATE: MAR. '96
APPROVED BY: GWS			DATE: MAR. '96

Crandon Mining Company

FIGURE 1-1

COMPARISON OF AVERAGE ANNUAL RUNOFF TO 1995 RUNOFF FOR F15 WETLAND

Scale: AS SHOWN	Date: MARCH 1996
Prepared By: Foth & Van Dyke	By: JRB2

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93C049

WATER BALANCE PROGRAM

FOTH & VAN DYKE AND ASSOCIATES, INC.

DRAINAGE BASIN NAME: UPLAND F15 (EXISTING) DRAINAGE BASIN AREA: 119.00 ACRES

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
TEMPERATURE (F)	14.2	14.3	29.5	39.5	51.7	65.4	65.8	67.8	52.5	44.5	19.4	11.2	
MONTHLY i VALUES	0.00	0.00	0.00	0.76	3.28	7.28	7.42	8.09	3.45	1.64	0.00	0.00	31.92
UNADJUSTED POT. EVAPO-TRANSP.	0.00	0.00	0.00	0.02	0.07	0.12	0.12	0.13	0.07	0.04	0.00	0.00	
LATITUDE CORRECTION (r)	23.8	24.1	30.6	33.6	38.5	38.8	39.4	36.4	31.2	28.2	23.7	22.3	
POTENTIAL EVAPO-TRANSPIRATION	0.00	0.00	0.00	0.67	2.69	4.65	4.72	4.73	2.18	1.12	0.00	0.00	
PRECIPITATION	0.71	0.48	1.65	2.27	3.85	1.72	3.00	5.77	2.15	5.85	1.78	1.59	30.82
CUMULATIVE SNOW PACK (IN)	4.08	4.56	5.58	0.62	0.00	0.00	0.00	0.00	0.00	0.00	1.78	3.37	
CORRECTED EQUIV. PRECIP. (IN)	0.00	0.00	0.63	7.23	4.47	1.72	3.00	5.77	2.15	5.85	0.00	0.00	
RUNOFF COEFFICIENT	0.45	0.45	0.45	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.45	0.45	
MONTHLY RUNOFF (IN)	0.00	0.00	0.28	0.72	0.45	0.17	0.30	0.58	0.22	0.59	0.00	0.00	3.30
INFILTRATION (IN)	0.00	0.00	0.35	6.51	4.02	1.55	2.70	5.19	1.94	5.27	0.00	0.00	
INFILTRATION MINUS PET (IN)	0.00	0.00	0.35	5.84	1.33	-3.10	-2.02	0.46	-0.25	4.15	0.00	0.00	
ACCUMULATED WATER LOSS (IN)	0.00	0.00	0.00	0.00	0.00	-3.10	-5.12	0.00	-0.25	0.00	0.00	0.00	
SOIL MOISTURE STORAGE (IN)	2.64	2.64	2.64	2.64	2.64	0.75	0.33	0.79	0.55	2.64	2.64	2.64	
MONTHLY MOISTURE CHANGE (IN)	0.00	0.00	0.00	0.00	0.00	-1.89	-0.42	0.46	-0.25	2.09	0.00	0.00	
ACTUAL EVAPO-TRANSP. (IN)	0.00	0.00	0.00	0.67	2.69	3.44	3.12	4.73	2.18	1.12	0.00	0.00	17.95
NET PERCOLATION (IN)	0.00	0.00	0.35	5.84	1.33	0.00	0.00	-0.00	0.00	2.05	0.00	0.00	9.57
DRAINAGE BASIN RUNOFF (ACRE-FT)	0.00	0.00	2.81	7.17	4.43	1.71	2.98	5.72	2.13	5.80	0.00	0.00	32.75
CUMUL. BASIN RUNOFF (ACRE-FT)	0.00	0.00	2.81	7.17	4.43	1.71	2.98	5.72	2.13	5.80	0.00	0.00	32.75

NOTE: THE FOLLOWING CONDITIONS WERE USED IN COMPUTING THIS WATER BALANCE (PER THORNTHWAITE & MATHER / EPA 1975 METHODS).

1 THE PROPOSED SITE HAS BEEN ESTIMATED TO BE AT 45.51 DEGREES NORTH LATITUDE.

2 THE NOTED RELATIVE SITE LOCATION WAS REFERENCED FOR ATMOSPHERIC DATA BASED UPON THE NEAREST NOAA STATION(S) (1 NORTH PELICAN WHICH IS 20.2 MILES WNW THE SITE LOCATION).

3 THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA) DATA FOR PRECIPITATION AND TEMPERATURE, FOR THE YEARS 1961 THROUGH 1990 FOR THE STATION NOTED IN ITEM 2, HAS BEEN USED IN THIS ANALYSIS.

4 UNADJUSTED POTENTIAL EVAPO-TRANSPIRATION VALUES HAVE BEEN CALCULATED USING THE EQUATION DEVELOPED BY THORNTHWAITE & MATHER AND NOT EPA/1975 TABLE 3 WHICH VARIES AS MUCH AS 0.01 FROM THE DEFINING EQUATION.

5 A SNOW PACK (IN EQUIVALENT INCHES OF RAINFALL) IS ACCUMULATED FOR EACH SUB 32 DEGREE FAHRENHEIT MONTH FROM OCTOBER THROUGH SEPTEMBER. THE TOTAL SNOW PACK IS THEN DISPERSED AS EQUIVALENT PRECIPITATION DURING A SPRING MELT EVENT, STARTING WHEN TEMPERATURES APPROACH 32 DEGREES.

6 THE CORRECTED EQUIVALENT PRECIPITATION IS THE SUM OF THE MONTHLY PRECIPITATION MINUS THE AMOUNT ADDED TO THE ACCUMULATED SNOW PACK PLUS THE ESTIMATED MONTHLY SNOW MELT.

7 RUNOFF COEFFICIENTS HAVE BEEN SELECTED PER CHOW, FENN, ET AL. FOR THE TOPSOIL TYPE AND SLOPE SPECIFIC TO THIS DRAINAGE BASIN. THE SURFACE SLOPE WHICH HAS BEEN ESTIMATED AS 6.800001E-02 FEET PER FOOT.

8 SELECTING AVAILABLE MOISTURE VALUES FROM THE RANGE OF VALUES RECORDED BY SCS, THE FOLLOWING FINAL COVER SYSTEM HAS BEEN ANALYZED: THE ROOT ZONE HAS BEEN ESTIMATED AT; 24 INCHES
THE FINAL COVER WAS SET AT; 12 INCHES OF SANDY LOAM WITH 12 % AVAILABLE MOISTURE
12 INCHES OF SILTY SAND WITH 10 % AVAILABLE MOISTURE

9 FOR MONTHS WHEN POTENTIAL EVAPO-TRANSPIRATION EXCEEDS INFILTRATION, THE MOISTURE STORAGE VALUES ARE COMPUTED BY THE EQUATION USED TO GENERATE EPA/1975 TABLES 11 THROUGH 22. THE VALUES DO NOT MATCH THE EQUATION VALUES AT ALL POINTS. THESE VARIATIONS DON'T AFFECT THE MONTHLY MOISTURE CHANGE VALUES BY MORE THAN 0.01.

10 ALL COMPUTED TABLE VALUES HAVE BEEN ROUNDED TO THE NEAREST 0.01 FOR PRINTING FORMAT. COMPUTER STORAGE ACCURACY OF THESE VALUES, RESULTS IN AN ANNUAL TOTAL PERCOLATION VALUE ACCURACY OF PLUS OR MINUS 0.05.

11 THIS CODE WAS ADAPTED FROM THE CODE BY J. F. SCHARCH OF THE WISCONSIN DEPARTMENT OF NATURAL RESOURCES (1985).

WATER BALANCE PROGRAM

FOTH & VAN DYKE AND ASSOCIATES, INC.

DRAINAGE BASIN NAME: WETLAND F15 (EXISTING) DRAINAGE BASIN AREA: 36.21 ACRES

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
TEMPERATURE (F)	14.2	14.3	29.5	39.5	51.7	65.4	65.8	67.8	52.5	44.5	19.4	11.2	
MONTHLY i VALUES	0.00	0.00	0.00	0.76	3.28	7.28	7.42	8.09	3.48	1.64	0.00	0.00	31.95
UNADJUSTED POT. EVAPO-TRANSP.	0.00	0.00	0.00	0.02	0.07	0.12	0.12	0.13	0.07	0.04	0.00	0.00	
LATITUDE CORRECTION (r)	23.8	24.1	30.6	33.7	38.5	38.8	39.4	36.4	31.2	28.2	23.7	22.3	
POTENTIAL EVAPO-TRANSPIRATION	0.00	0.00	0.00	0.67	2.69	4.65	4.72	4.73	2.18	1.12	0.00	0.00	
PRECIPITATION	0.71	0.48	1.65	2.27	3.85	1.72	3.00	5.77	2.15	5.85	1.78	1.59	30.82
CUMULATIVE SNOW PACK (IN)	4.08	4.56	5.58	0.62	0.00	0.00	0.00	0.00	0.00	0.00	1.78	3.37	
CORRECTED EQUIV. PRECIP. (IN)	0.00	0.00	0.63	7.23	4.47	1.72	3.00	5.77	2.15	5.85	0.00	0.00	
RUNOFF COEFFICIENT	0.35	0.35	0.35	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.35	0.35	
MONTHLY RUNOFF (IN)	0.00	0.00	0.22	0.72	0.45	0.17	0.30	0.58	0.22	0.59	0.00	0.00	3.24
INFILTRATION (IN)	0.00	0.00	0.41	6.51	4.02	1.55	2.70	5.19	1.94	5.27	0.00	0.00	
INFILTRATION MINUS PET (IN)	0.00	0.00	0.41	5.84	1.33	-3.10	-2.02	0.46	-0.25	4.15	0.00	0.00	
ACCUMULATED WATER LOSS (IN)	0.00	0.00	0.00	0.00	0.00	-3.10	-5.12	0.00	-0.25	0.00	0.00	0.00	
SOIL MOISTURE STORAGE (IN)	6.24	6.24	6.24	6.24	6.24	3.79	2.74	3.20	2.95	6.24	6.24	6.24	
MONTHLY MOISTURE CHANGE (IN)	0.00	0.00	0.00	0.00	0.00	-2.45	-1.05	0.46	-0.24	3.29	0.00	0.00	
ACTUAL EVAPO-TRANSP. (IN)	0.00	0.00	0.00	0.67	2.69	4.00	3.75	4.73	2.18	1.12	0.00	0.00	19.14
NET PERCOLATION (IN)	0.00	0.00	0.41	5.84	1.33	0.00	0.00	-0.00	0.00	0.86	0.00	0.00	8.44
DRAINAGE BASIN RUNOFF (ACRE-FT)	0.00	0.00	0.67	2.18	1.35	0.52	0.91	1.74	0.65	1.77	0.00	0.00	9.78
CUMUL. BASIN RUNOFF (ACRE-FT)	0.00	0.00	3.48	9.35	5.78	2.23	3.89	7.46	2.78	7.57	0.00	0.00	42.53

NOTE: THE FOLLOWING CONDITIONS WERE USED IN COMPUTING THIS WATER BALANCE (PER THORNTHWAITE & MATHER / EPA 1975 METHODS).

1 THE PROPOSED SITE HAS BEEN ESTIMATED TO BE AT 45.49 DEGREES NORTH LATITUDE.

2 THE NOTED RELATIVE SITE LOCATION WAS REFERENCED FOR ATMOSPHERIC DATA BASED UPON THE NEAREST NOAA STATION(S) (1 NORTH PELICAN WHICH IS 19.3 MILES WNW THE SITE LOCATION).

3 THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA) DATA FOR PRECIPITATION AND TEMPERATURE, FOR THE YEARS 1961 THROUGH 1990 FOR THE STATION NOTED IN ITEM 2, HAS BEEN USED IN THIS ANALYSIS.

4 UNADJUSTED POTENTIAL EVAPO-TRANSPIRATION VALUES HAVE BEEN CALCULATED USING THE EQUATION DEVELOPED BY THORNTHWAITE & MATHER AND NOT EPA/1975 TABLE 3 WHICH VARIES AS MUCH AS 0.01 FROM THE DEFINING EQUATION.

5 A SNOW PACK (IN EQUIVALENT INCHES OF RAINFALL) IS ACCUMULATED FOR EACH SUB 32 DEGREE FAHRENHEIT MONTH FROM OCTOBER THROUGH SEPTEMBER. THE TOTAL SNOW PACK IS THEN DISPERSED AS EQUIVALENT PRECIPITATION DURING A SPRING MELT EVENT, STARTING WHEN TEMPERATURES APPROACH 32 DEGREES.

6 THE CORRECTED EQUIVALENT PRECIPITATION IS THE SUM OF THE MONTHLY PRECIPITATION MINUS THE AMOUNT ADDED TO THE ACCUMULATED SNOW PACK PLUS THE ESTIMATED MONTHLY SNOW MELT.

7 RUNOFF COEFFICIENTS HAVE BEEN SELECTED PER CHOW, FENN, ET AL. FOR THE TOPSOIL TYPE AND SLOPE SPECIFIC TO THIS DRAINAGE BASIN. THE SURFACE SLOPE WHICH HAS BEEN ESTIMATED AS .002 FEET PER FOOT.

8 SELECTING AVAILABLE MOISTURE VALUES FROM THE RANGE OF VALUES RECORDED BY SCS, THE FOLLOWING FINAL COVER SYSTEM HAS BEEN ANALYZED: THE ROOT ZONE HAS BEEN ESTIMATED AT; 24 INCHES
THE FINAL COVER WAS SET AT; 12 INCHES OF ORGANIC TOPSOIL WITH 22 % AVAILABLE MOISTURE
12 INCHES OF SILT LOAM WITH 30 % AVAILABLE MOISTURE

9 FOR MONTHS WHEN POTENTIAL EVAPO-TRANSPIRATION EXCEEDS INFILTRATION, THE MOISTURE STORAGE VALUES ARE COMPUTED BY THE EQUATION USED TO GENERATE EPA/1975 TABLES 11 THROUGH 22. THE VALUES DO NOT MATCH THE EQUATION VALUES AT ALL POINTS. THESE VARIATIONS DON'T AFFECT THE MONTHLY MOISTURE CHANGE VALUES BY MORE THAN 0.01.

10 ALL COMPUTED TABLE VALUES HAVE BEEN ROUNDED TO THE NEAREST 0.01 FOR PRINTING FORMAT. COMPUTER STORAGE ACCURACY OF THESE VALUES, RESULTS IN AN ANNUAL TOTAL PERCOLATION VALUE ACCURACY OF PLUS OR MINUS 0.05.

11 THIS CODE WAS ADAPTED FROM THE CODE BY J. F. SCHARCH OF THE WISCONSIN DEPARTMENT OF NATURAL RESOURCES (1985).

1995 North Pelican Lake Climatological Information[1]

	Average Monthly Temperature "ATMOS.2" (°F)	Average Monthly Rainfall "ATMOS.3" (inches)
January	14.2	0.71
February	14.3	0.48
March	29.5	1.65
April	39.5	2.27
May	51.7	3.85
June	65.4	1.72
July	65.8	3.00
August	67.8	5.77
September	52.5	2.15
October	44.5	5.85
November	19.4	1.78
December	11.2	1.59
Annual Average Temperature	39.65	—
Annual Total Rainfall	—	30.82

[1]1995 Climatological information input into water balance model.

Prepared by: SRB
Checked by: PAE

MONTHLY AND ANNUAL RAINFALL
(IN INCHES)
NORTH PELICAN LAKE

3/29/95

YEAR	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL
1961	0.06	1.71	2.42	1.12	3.03	3.79	6.57	2.94	4.66	3.13	2.45	1.08	32.96
1962	0.76	2	0.48	1.52	3.44	2.7	2.91	4.91	3.42	1.65	0.82	1.12	25.73
1963	0.61	0.54	1.09	1.56	3.04	2.59	2.57	3.23	3.25	0.87	0.94	1.05	21.34
1964	0.83	0.19	0.87	3.58	4.38	2.85	4.33	4.15	5.43	0.43	2.7	1.48	31.22
1965	0.57	0.97	1.93	3.16	4.34	3.73	2.35	3.94	5.02	1.4	3.41	1.75	32.57
1966	0.91	0.51	3.24	2.2	0.8	2.17	1.93	6.91	2.87	2.67	1.14	1.41	26.76
1967	2.82	0.68	1.3	4.84	1.73	5.93	1.93	4.43	1.52	2.89	0.44	0.56	29.07
1968	1.37	0.22	1.5	2.89	4.11	9.43	5.76	2.38	6.33	2.55	0.55	2.36	39.45
1969	2.32	0.09	0.89	1.11	3.5	5.36	2.07	0.46	1.72	3.93	1.23	1.61	24.29
1970	1.07	0.32	0.72	0.72	4.72	1.59	3.2	1.26	6.64	3.17	2.55	1.56	27.52
1971	1.86	2.22	0.79	0.5	3.12	2.35	4.12	3.29	5.71	3.79	1.68	2.19	31.62
1972	1.01	0.93	2.24	2.38	1.58	1.61	2.56	8.54	5.56	2.12	2.07	2.5	33.1
1973	0.62	0.68	3.55	3.33	6.49	2.61	3.2	3.78	2.78	1.66	1.31	1.44	31.45
1974	0.48	0.83	0.4	2.63	2.88	3.16	4.46	6.39	3.72	1.02	2.3	0.66	28.93
1975	1.83	0.91	1.22	3.43	2.1	3.47	1.74	4.5	4.2	1.47	4.37	1.85	31.09
1976	1.99	1.16	2.98	2.11	2.33	1.93	1.42	4.2	0.64	0.28	0.24	0.56	19.84
1977	0.64	0.71	3.93	4.5	2.17	3.1	3.4	5.81	4.28	1.83	2.52	1.43	34.32
1978	0.74	0.45	0.2	2.96	4.23	3.15	6.68	6.65	4	0.88	1.7	1.48	33.12
1979	1.11	1.6	3.55	1.05	3.13	4.62	2.53	3.25	0.99	4.67	2.18	0.49	29.17
1980	1.6	0.32	0.51	1.49	2.21	3.75	3.28	6.93	6.33	1.42	0.74	1.3	29.88
1981	0.19	2.16	0.47	3.16	3	11.06	1.23	1.46	1.86	2.8	0.36	1.29	29.04
1982	1.61	0.31	1.34	3.7	6.39	2.14	8.91	2.92	5.84	3.96	2.41	2.49	42.02
1983	1.52	0.7	1.75	1.61	5.63	2.01	3.47	3.33	4.05	3.94	3.85	1.1	32.96
1984	0.56	1.36	1.3	2.7	1.29	4.6	2.41	5.41	5	3.7	1.43	2.58	32.34
1985	0.3	0.95	2.12	2.5	3.88	3.8	4.46	3.9	5.06	M	M	M	26.97
1986	M	M	1.77	2.78	0.91	2.14	12.02	2.56	6.53	3.25	1.33	0.73	34.02
1987	0.87	0.11	0.83	1.6	2.79	1.97	3.05	1.79	1.57	M	M	M	14.58
1988	M	M	M	M	M	M	M	4.68	3.71	2.35	3.71	1.09	15.54
1989	1.18	0.55	1.68	1.38	2.53	1.72	1.14	4.3	0.91	M	1.44	0.73	17.56
1990	0.67	0.54	1.88	2.18	4.38	6.25	2.78	5.99	6.13	4.01	1.66	0.91	37.38
MIN. RAIN FALL	0.06	0.09	0.2	0.5	0.8	1.59	1.14	0.46	0.64	0.28	0.24	0.49	14.58
MAX. RAIN FALL	2.82	2.22	3.93	4.84	6.49	11.06	12.02	8.54	6.64	4.67	4.37	2.58	42.02
MEAN	1.075	0.84714	1.61897	2.36862	3.24586	3.64069	3.67172	4.143	3.991	2.43852	1.84036	1.38571	29.1947

* SOURCE: NATIONAL OCEANIC ATMOSPHERIC ADMINISTRATION (NOAA)
CLIMATOLOGICAL DATA 1961-1990

Attachment 2

Bedrock Geology in the Vicinity of the TMA (from EIR)

2,283,000 E

2,285,000 E

2,287,000 E

2,289,000 E

117,000 N

115,000 N

113,000 N

111,000 N

CMC-TMA-102

TMA 4 CLOSURE BORROW AREA

CMC-TMA-101

CMC-TMA-104

TMA

RECLAIM POND

LAPILLI TUFF

1200'

HEMLOCK CREEK

CMC-TMA-107

G41-E13

32

33

206

199

201

G41-C15

SEDIMENTS AND LAMINATED TUFF

200

204

CMC-TMA-105

G41-E17

DUCK LAKE

FLOWS

205

CRYSTAL TUFF TUFF BRECCIA

G41-E19A

203

FINE GRAIN TUFF

N

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- —1675— EXISTING CONTOUR
- 1692.0 X SPOT ELEVATION
- ---------- SECTION LINE
- ·-·-·-·-·- PERIMETER OF MINE WASTE SITE (AS PER NR182)
- ·-·-·-·-·- COMPLIANCE BOUNDARY
- CMC-TMA-106 ENVIRONMENTAL BORING LOCATION AND NUMBER
- 206 EXPLORATION HOLE LOCATION AND NUMBER

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.

0 450' 900'

SCALE

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: MAR. '96
APPROVED BY:	SVD1	DATE: MAR. '96
APPROVED BY:	GWS	DATE: MAR. '96

Crandon Mining Company

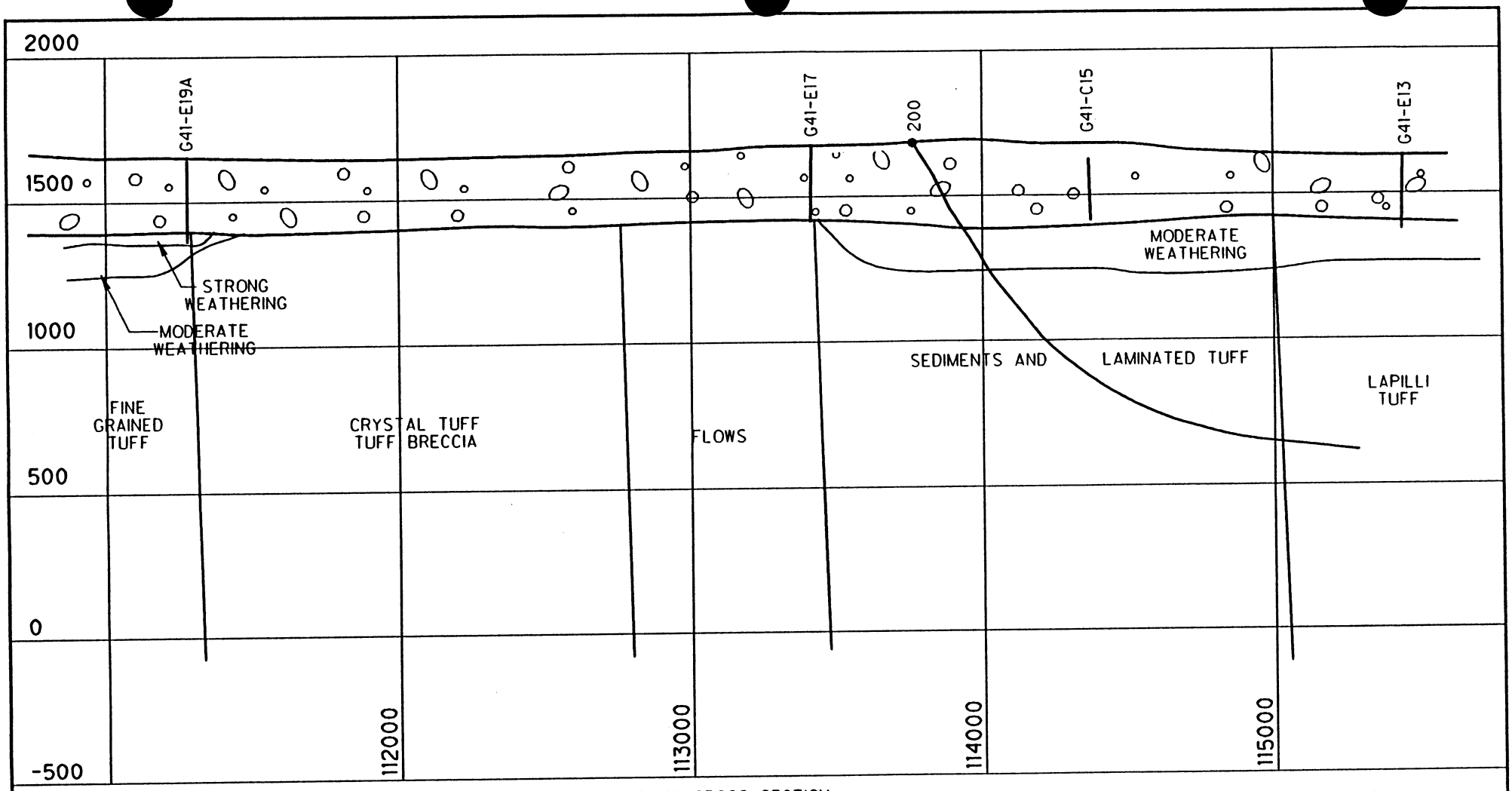
FIGURE 2-1

BEDROCK GEOLOGY IN VICINITY OF TMA

Scale:	AS SHOWN	Date:	MARCH 1996
Prepared By:	Foth & Van Dyke	By:	JRB2

C:\cadwork\4c54z2ra.dgn

93C049



NORTH-SOUTH BEDROCK CROSS SECTION
APPROXIMATELY AT 2,282,500 EAST

LEGEND

G41-E19A ENVIRONMENTAL BORING

200 CORE HOLE TRACE

SOURCE:
ROWE, 1984

Foth & Van Dyke			
REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	SVDI	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

Crandon Mining Company

FIGURE 3.5-16

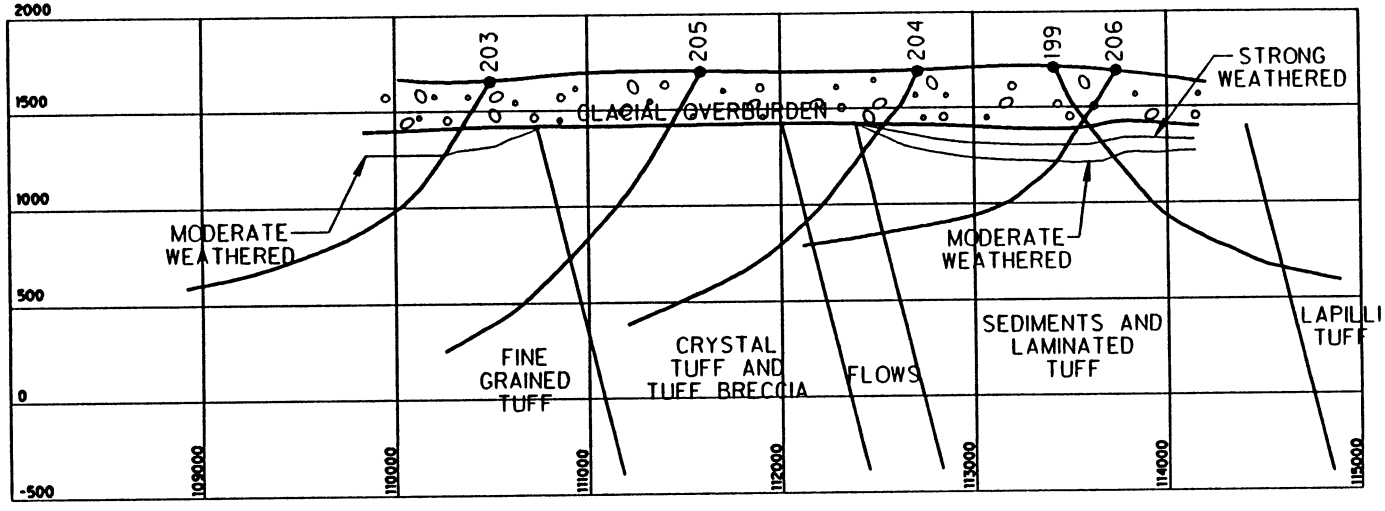
NORTH AND SOUTH BEDROCK CROSS SECTION IN THE VICINITY OF TMA

Scale:	1"=500'	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	KMP

93C049

G:\geowork\4c33f114.dgn

c:\cadwork\4c33f115.dgn



NORTH-SOUTH BEDROCK CROSS SECTION
APPROXIMATELY 2,287,000 EAST

LEGEND

203 CORE HOLE TRACE

SOURCE:
ROWE, 1984

Foth & Van Dyke			
REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	SVDI	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

Crandon Mining Company

FIGURE 3.5-17

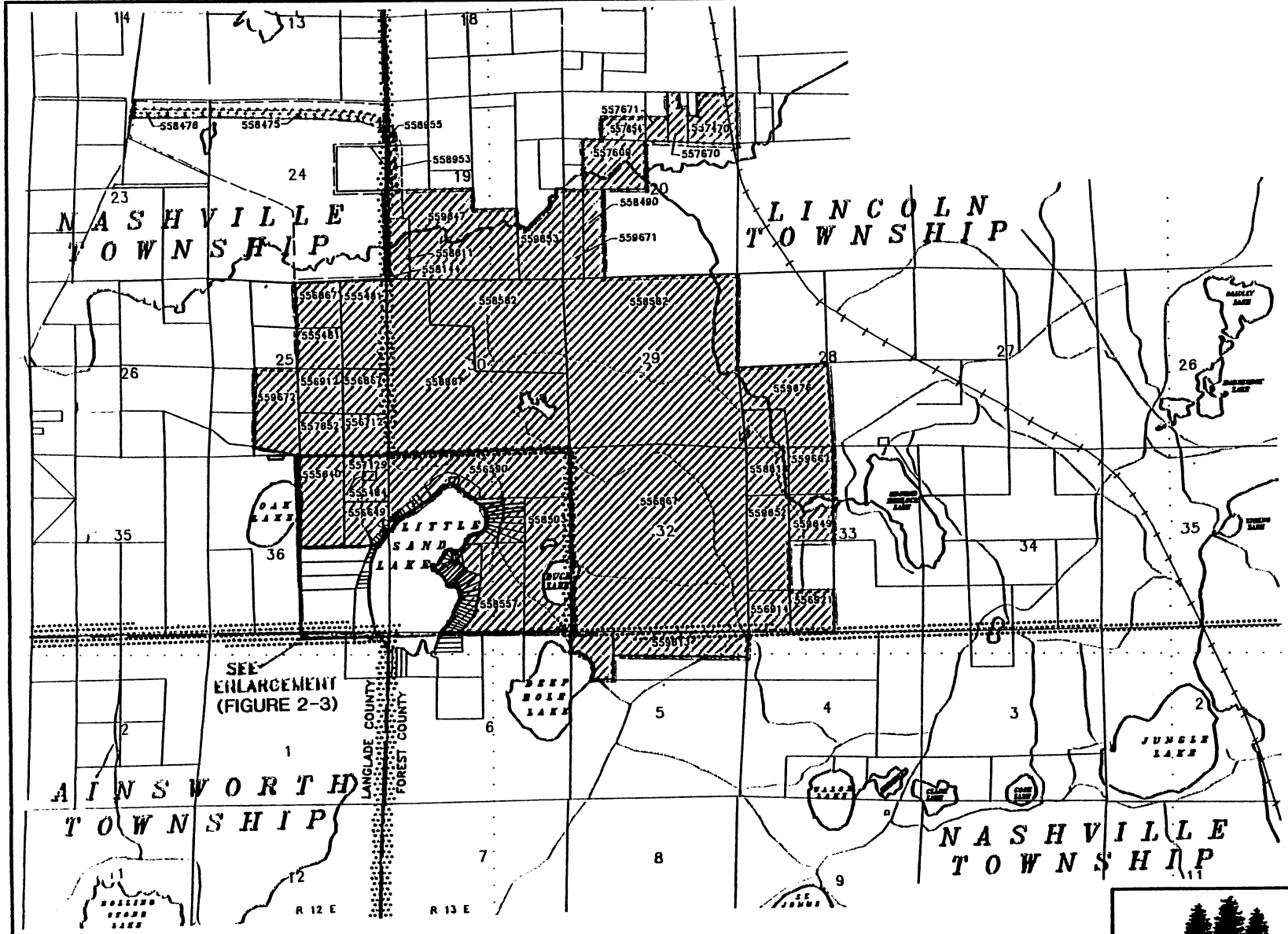
NORTH AND SOUTH BEDROCK CROSS SECTION IN VICINITY OF TMA

Scale:	1"=1000'	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	KMP

93C049

Attachment 3

CMC Property Ownership Drawings



CMC PROPERTIES (FEE, PURCHASE OPTION, MINING LEASE OR EASEMENT)

CRANDON PROJECT BOUNDARY

ROADS
STREAMS, LAKES
RAILROADS

0 1000 2000 3000 4000 5000 FT.

0 1/4 1/2 3/4 1 MILE

NORTH

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

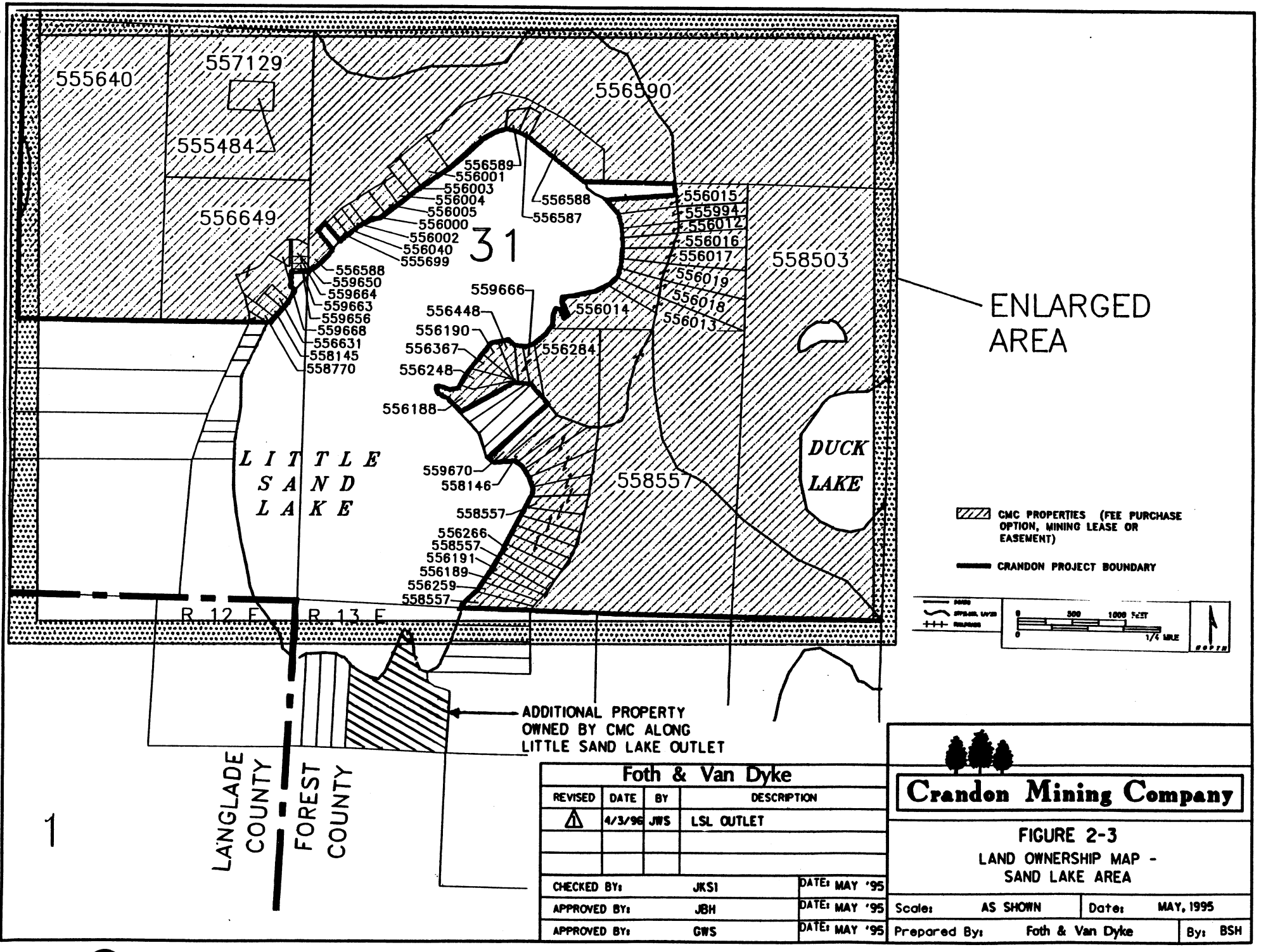
Crandon Mining Company

FIGURE 2-2
LAND OWNERSHIP MAP

Scale:	AS SHOWN	Date:	MAY. 1995
Prepared By:	Foth & Van Dyke	By:	BSH

G:\cadwork\3c49f136.dgn

93C049



Foth & Van Dyke			
REVISED	DATE	BY	DESCRIPTION
1	4/3/96	JWS	LSL OUTLET

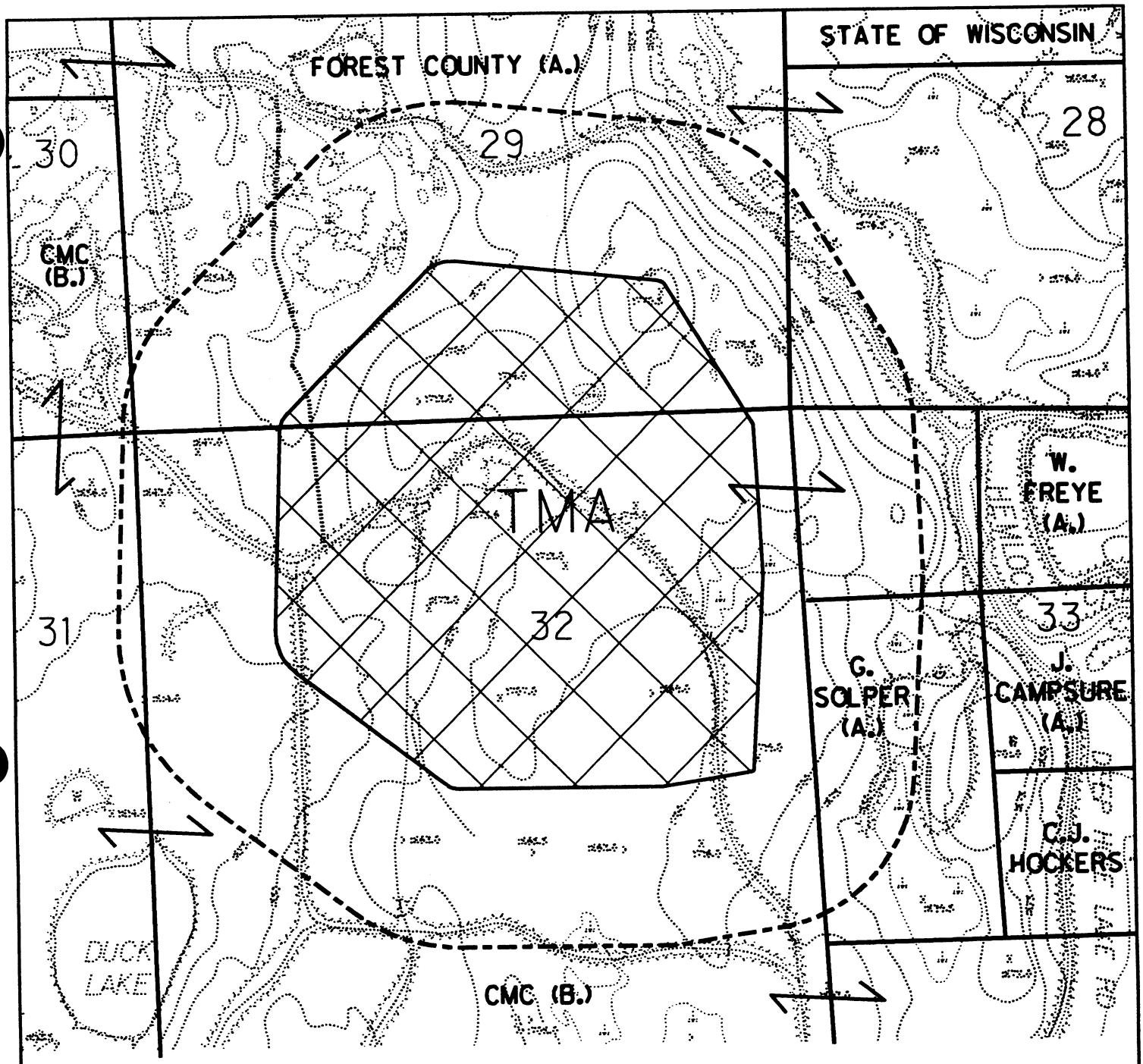
CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	JBH	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

Crandon Mining Company

FIGURE 2-3
LAND OWNERSHIP MAP -
SAND LAKE AREA

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	BSH

93C049



NOTES:

1. MAP DERIVED FROM LAND ATLAS AND PLAT BOOK FOREST COUNTY 1989.
2. REPRODUCED WITH PERMISSION OF ROCKFORD MAP COMPANY, ROCKFORD, IL.
3. PLAT MAP UPDATE TO REFLECT PROPERTY OWNERSHIP/STATUS AS OF MARCH, 1996.
   - A. CMC - PURCHASE OPTION.
   - B. CMC - FEE TITLE.

LEGEND

- PROPOSED TMA FACILITY
- COMPLIANCE BOUNDARY
- PROPERTY LINES (APPROXIMATE)
- 32 SECTION NUMBER IN T.35N., R.13E.

0 1100' 2200'

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: APR. '96
APPROVED BY:	REM	DATE: APR. '96
APPROVED BY:	GWS	DATE: APR. '96

Crandon Mining Company

FIGURE 2-3A

TMA - PROPERTY OWNERSHIP WITH THE COMPLIANCE BOUNDARY

Scale:	SEE BAR SCALE	Date:	APRIL, 1996
Prepared By:	Foth & Van Dyke	By:	JRB2

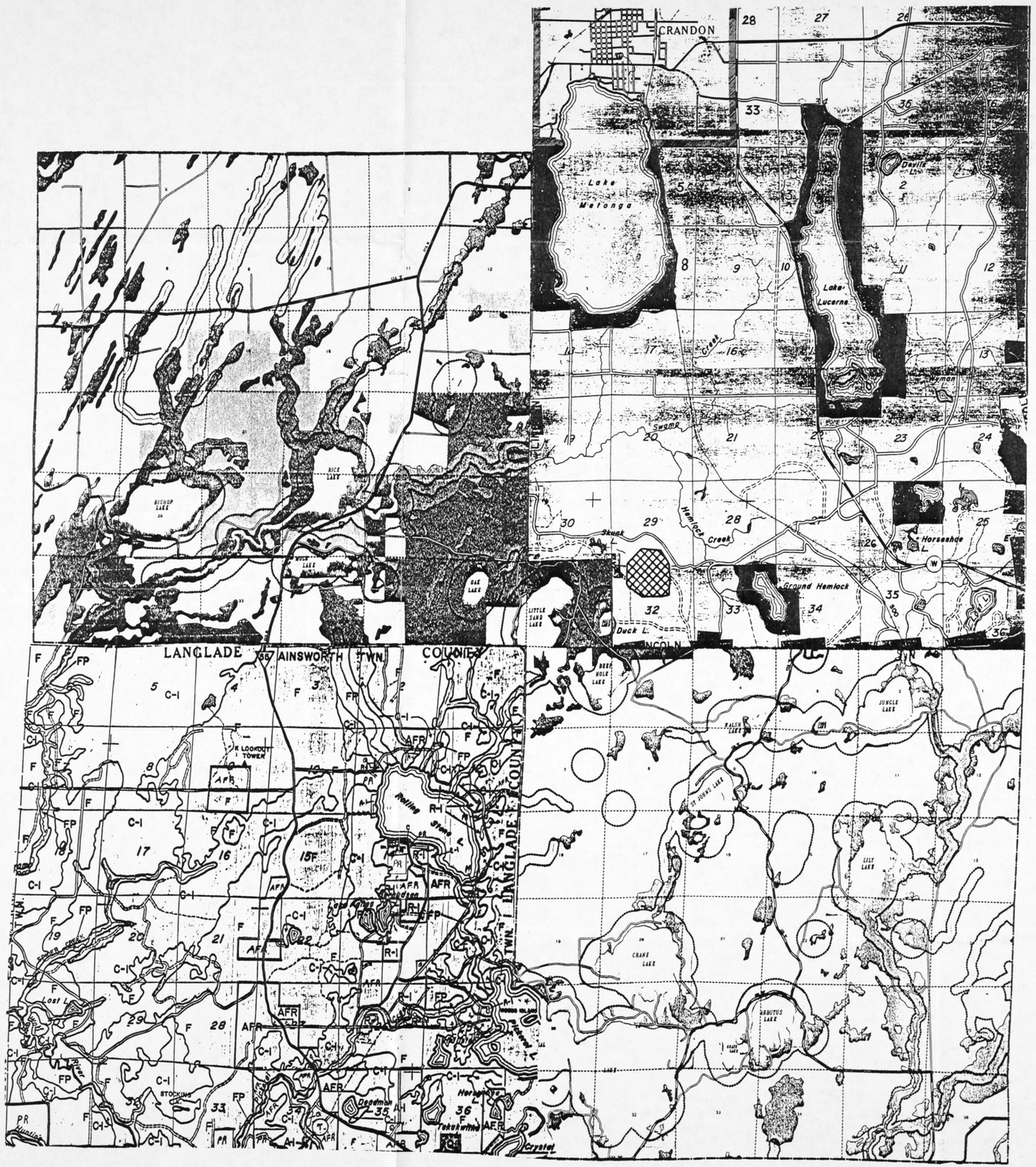
93C049

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Attachment 4

- Figure 4-1 - Zoning Map for Town of Ainsworth, Langlade County, Town of Lincoln, Forest County, and Town of Nashville, Forest County

- Section 3.12, Land Use and Zoning, from the May 1995 Crandon Project Environmental Impact Report



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
- PROPOSED TMA FACILITY

TOWN OF NASHVILLE

- CONSERVANCY
- GENERAL RURAL DISTRICT
- LAKE DEVELOPMENT DISTRICT
- TRIBAL LAND/PUBLIC
- PROPOSED CRANDON MINING CO. LANDS (FEE, EASEMENT, ETC.)
- WATER
- COUNTY SHORELAND JURISDICTION

N

TOWN OF AINSWORTH

C-1	CONSERVANCY
F	FOREST
PR	PARK & RECREATION
FP	FLOOD PLAIN
A-1	EXCLUSIVE AGRICULTURAL
AFR	AGRICULTURE/FOREST RESIDENTIAL
R-1	RESIDENTIAL SINGLE FAMILY
R-2	RESIDENTIAL MULTIPLE FAMILY & CONDOMINIUM
R-3	MOBILE HOME PARK
R-4	MOBILE HOME SUBDIVISION
C	GENERAL COMMERCIAL
I	INDUSTRIAL
Q	QUARRYING
MME	METALLIC MINING EXPLORATION
M	MINING
AH	AIRPORT HEIGHT LIMITATION

TOWN OF LINCOLN

- LAKE DISTRICT

NOTE

MAP WAS COMPILED FROM INFORMATION PROVIDED BY THE NORTH CENTRAL WISCONSIN REGIONAL PLANNING COMMISSION FOR THE TOWNS OF LINCOLN AND NASHVILLE AND THE LANGLADE COUNTY ZONING OFFICE FOR THE TOWN OF AINSWORTH.

0 4000' 8000'
APPROXIMATE SCALE

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: MAR. '96
APPROVED BY:	REM	DATE: MAR. '96
APPROVED BY:	GWS	DATE: MAR. '96

Crandon Mining Company

FIGURE 4-1

AREA ZONING

Scale:	AS SHOWN	Date:	MARCH, 1996
Prepared By:	Foth & Van Dyke	By:	JOW

c:\cadwork\3c49f177.dgn

93C049

Crandon Mining Company

Environmental Impact Report

Section 3.12

Land Use and Zoning

Crandon Mining Company
Environmental Impact Report

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3.12.3 Study Area Land Use 4
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Figures

(Note: Figures for Section 3.12 are located at the end of the text, following page 3.12-16.)

Figure 3.12-1 Land Use and Zoning Study Area
Figure 3.12-2 Land Use in the Study Area
Figure 3.12-3 Recreational Resources in the Study Area
Figure 3.12-4 Recreational Trails in the Study Area

3.12 Land Use and Zoning

This section of the EIR identifies the land use types and zoning in Forest and Langlade Counties in general, and specifically in the study area. The study area evaluated for land use and zoning includes an approximate 100 square mile area surrounding the plant site, as shown on Figure 3.12-1. The study area consists of portions of Forest and Langlade Counties including portions of the Towns of Nashville and Lincoln in Forest County, and the northeast portion of the Town of Ainsworth in Langlade County.

3.12.1 Field and Laboratory Methods

Land use investigations consisting of literature searches and field reconnaissances were first conducted for the project in 1977. Additional evaluations were completed in 1982 and 1994/1995 to update the project's database. The literature searches were conducted to obtain published information on the land use and aesthetic characteristics of Forest and Langlade Counties. The types of information obtained during the literature search included USGS 7.5 minute topographic maps, plat books, regional outdoor recreation plans, Chamber of Commerce publications, and forest management plans. An important portion of the literature search consisted of contacting governmental bodies that might have information useful to the land use investigation. The agencies contacted included, but are not limited to, the WDNR; Wisconsin DOA, Wisconsin Department of Revenue, the North Central Wisconsin Regional Planning Commission (NCWRPC), and offices of the Forest and Langlade County Clerks and Zoning Administrators.

During January and September 1978, and again in May 1982, field reconnaissances were conducted of the study area. These reconnaissances were conducted by automobile and on foot to verify the information obtained during the literature search, and from April 1976, June 1978, and April 1981 aerial photographs. The type of information recorded included the distribution of land uses, vegetation types and residences, the location of recreational resources and businesses, and aesthetic characteristics. The minimum size of any land use delineated was 40 acres. Linear land uses, such as highways and railroads, were not included in acreage calculations.

The data developed from the previous field reconnaissances were compared to the April 1994 aerial photographs, Forest (1989) and Langlade (1992) County plat maps, and 1994 Wisconsin Department of Revenue Statement of Assessments for the Towns of Ainsworth, Lincoln and Nashville by Foth & Van Dyke. Based on these comparisons, as well as input from NCWRPC (January, 1995), it was determined that land use patterns have not changed significantly in the study area over the past twelve years.

3.12.2 Regional Land Use

Land use in Langlade County consists of approximately 70 percent forest lands and 24 percent farm/agricultural lands (UW-Extension, 1992). The majority of the farmlands are located in the south central portion of the county, with the majority of the forest lands located in the northern half and northeastern portions (Langlade County, 1990). Langlade County has 867 lakes totalling more than 6,800 acres (UW-Extension, 1992). A comprehensive land use plan for Langlade County forests (1985-1995) and an outdoor recreation plan (NCWRPC, 1991) are the only current county-wide land use plans available for Langlade County (Haering, 1995;

Haakenson, 1995). Both plans expire in 1995 and will be updated (Haering, 1995; Sohasky, 1995).

Land use in the Langlade County Town of Ainsworth, which comprises the southwestern quarter of the study area is shown in Table 3.12-1. As indicated in the table, more than 80 percent of the township is in forest and swamp lands, with residential and agricultural lands occupying less than 10 percent of the total land area in the town. The remaining 10 percent of the township includes tax-exempt lands such as public hunting/fishing grounds, Boy Scout lands, etc., which are also mostly forested.

Land use in Forest County consists of 84 percent forested lands, including national and county forest lands, and five percent agricultural lands (UW-Extension, 1992). Surface water resources in Forest County include 824 lakes with a total surface area of 22,324 acres and over 317 streams with an excess of 700 miles of waterway.

There are two land use plans available for Forest County. These include a ten-year (1985-1995) comprehensive land use plan for Forest County Forests and an outdoor recreation plan (1988). Both of these plans expire at the end of 1995, however, they are currently planned to be updated prior to their expiration date (Haering, 1995; Landsverk, 1995; Ziolkowski, 1995a).

Within Forest County, the Town of Lincoln comprises the northeastern portion of the study area. Land use in the Town of Lincoln is shown in Table 3.12-2. Approximately 87 percent of the town is forested, with about 10 percent of the lands being used for agricultural or residential land as indicated in the table.

Also within Forest County portions of the Town of Nashville comprise the northwestern and southeastern quarters of the study area. A breakdown of land use for the Town of Nashville is shown in Table 3.12-3. Similar to the Town of Lincoln, approximately 87 percent of the town is in forested lands with about 12 percent of the land area in agricultural or residential land.

Table 3.12-1

1994 Land Use, Town of Ainsworth, Langlade County

Land Use Category	Acres	%
Residential	1613	3.6
Commercial	45	0.1
Manufacturing	--	0
Agricultural	1,602	3.6
Swamp Lands	1,820	4.1
Forest Lands	35,027	78.8
Other[1]	4,330	9.8
Totals	44,437	100.0

Source: Wisconsin Department of Revenue, 1994 Statement of Assessment.

[1] Includes tax-exempt lands (i.e. public hunting/fishing grounds, lands owned by religious groups, Boy Scouts, etc.).

Prepared by: GMS
Checked by: RVS

Table 3.12-2

1994 Land Use, Town of Lincoln, Forest County

Land Use Category	Acres	%
Residential	1,664	4.6
Commercial	90	0.2
Manufacturing	--	--
Agricultural	2,047	5.6
Swamp Lands	279	0.8
Forest Lands	31,580	86.9
Other[1]	699	1.9
Totals	36,359	100.0

Source: Wisconsin Department of Revenues, 1994 Statement of Assessment.

[1] Includes tax-exempt lands, (i.e. public hunting, fishing grounds; lands owned by religious groups, Boy Scouts, etc.).

Prepared by: GMS
Checked by: RVS

Table 3.12-3

1994 Land Use, Town of Nashville, Forest County

Land Use Category	Acres	%
Residential	2,775	6.6
Commercial	76	0.2
Manufacturing	--	--
Agricultural	2,217	5.3
Swamp Lands	171	0.4
Forest Lands	36,503	86.5
Other[1]	440	1.0
Totals	42,182	100.0

Source: Wisconsin Department of Revenue, 1994, Statement of Assessment.

[1] Includes tax-exempt lands (i.e. public hunting, fishing grounds,land owned by religious groups, Boy Scouts, etc.).

Prepared by: GMS
Checked by: RVS

3.12.3 Study Area Land Use

Land use within the study area has been divided into five categories, defined as follows:

Forestry - Land being used to produce forest products such as pulp wood, saw timber, wood chips and/or maple syrup. This includes all forested land capable of producing trees with a diameter at breast height of over 2.5 cm (one inch) and where canopy coverage is greater than 25 percent. It also includes clearcuts that will be left to revert to forest cover and old agricultural fields that are being allowed to revert to forest cover.

Agriculture - Land being used for agricultural purposes. This includes crop fields, hay fields, and pastures. Old agricultural fields that can potentially be used as pasture because they are fenced and are not reverting to forest cover are also included in this category.

Recreation - This land use includes those lands whose primary use is recreation. It does not include areas where recreation is a secondary use, such as Forest Crop Law lands. Lands included within this category are primarily parks and water bodies. However, this category also includes marshes and shrub swamps as recreation is probably their only major active use.

Residential/Institutional - This includes all residential areas, both permanent and seasonal, as well as any institutional uses such as churches, schools, nursing homes, and/or hospitals.

Transportation - Any lands used by transportation systems, such as roads, railroads and airports.

The distribution of the major land uses in the study area is shown on Figure 3.12-2. The percentage of each land use is shown on Table 3.12-4.

Table 3.12-4

Study Area Land Use

Land Use	Area in Square Miles	Percent of Total Area
Forestry	76.5	76.5
Recreation[1]	11.8	11.8
Residential	6.4	6.4
Agriculture	5.0	5.0
Transportation[2]	0.3	0.3
Total	100.0	100.0

[1] Includes water bodies/wetlands.
[2] Highways/railroads not included in acreage totals.

Source: EIR, Exxon Minerals Company, November, 1985.

Prepared by: GMS
Checked by: RVS

The remainder of the land use discussion will focus on the major use categories found in the study area. These include: forest lands, agriculture, recreation, and residential. Commercial land use will not be addressed since it comprises a very minor proportion of the area.

3.12.3.1 Forestry

Approximately 77 percent of the study area is forest land that could conceivably be harvested, that is, used for forestry (Table 3.12-4 and Figure 3.12-2). In addition to providing resources for lumber, pulp and associated industries these forested lands provide numerous recreation opportunities, habitat for fish and wildlife and provide a stable environment along streams and other desirable resource areas (Foth & Van Dyke, 1988).

Forest County owns over 10,800 acres of forest lands, 97 percent of which are classified as commercial forest. These lands, wholly located in the town of Lincoln, are composed of the

North Lincoln and South Lincoln units. South Lincoln is included in the study area. Aspen and northern hardwood are the two major cover types that make up over 80 percent of the total county forest lands. The aspen cover type is composed, most commonly, of stands consisting of pure aspen or aspen mixed with white birch. The northern hardwood cover type consists of sugar maple, basswood, white ash, American elm, yellow birch, and red maple. Associated species include aspen, white birch, eastern hemlock, northern red oak, bitternut hickory, butternut, and ironwood (Forest County, 1986). Approximately 2,800 acres of Forest County-owned forest lands are included in the study area (Forest County Plat Book, 1989).

Langlade County owns approximately 126,500 acres of forest lands, of which 5,000 acres are located in the southwestern quarter of the study area, in the town of Ainsworth (Langlade County, 1992). Approximately 93 percent of the Langlade County forest is considered commercial forest, with more than half of the total forest lands being composed of northern hardwood (33.2 percent) and aspen (31.9 percent) (Langlade County, 1986).

According to Forest County (1989) and Langlade County (1992) plat books, approximately 35 percent (17,200 acres) of the forest land in the study area is owned by private corporations. Publicly owned state and county forest lands account for approximately 18 percent (9,000 acres), with the remaining 47 percent in private ownership (22,700 acres). Consolidated Papers, Inc. accounts for half of the corporately owned forest lands (8,750 acres) in the study area. Six other companies account for the remaining forested lands under corporate ownership, including CMC properties, of approximately 4100 acres.

3.12.3.2 Agriculture

Information on agricultural use in Forest and Langlade Counties was obtained from the Wisconsin Agricultural Statistics Service (1994), for the 1992-1993 seasons and is shown in Table 3.12-5.

As indicated in the table, Forest County is consistently low in the rankings for agricultural products produced by Wisconsin counties. Even though Langlade County is ranked higher in agricultural production, the portion of Langlade County in the study area is much more like Forest County than the more agricultural portions of Langlade County to the south and west.

Approximately five percent, 3,200 acres, of the study area is in agricultural use which includes dairy farming, livestock production, and crops of oats, barley, wheat, alfalfa, hay and potatoes. Irregular slopes, stoniness, dryness on rises, wetness in depressions and short growing season limit agricultural use of soils in the study area.

The majority of the agricultural lands in the study area are primarily located in Forest County near Mole Lake and to the north along Highway 55, along County Trunk Highway B near Nashville and south of Lake Metonga (Figure 3.12-2). Using the average size per farm listed in Table 3.12-5, and the number of acres in agricultural lands in the study area listed in Table 3.12-4, it is estimated that there are approximately 15 farms in the study area.

Table 3.12-5

Agricultural Statistics

	Forest County		Langlade County		1993 Statewide Rank
	1992	1993	1992	1993	Forest/Langlade
No. Farms	140	140	510	500	67/50
Ave. Size (acres)	214.3	221.4	282.4	284	
Crop Yields					
Corn bu./ac.	57.5	42.0	70.5	65.7	66/59
Oats bu./ac.	58.6	45.6	68.0	42.6	66/27
Barley bu./ac.	45.0	35.7	61.3	45.9	55/13
Wheat bu./ac.	28.0	--	33.1	43.2	--/27
Soybeans bu./ac.	--	--	18.1	18.0	--/59
Hay tons/ac.	2.1	2.3	1.9	2.9	68/30
Potatoes hundredweight/ acre	--	--	306	276	--
Milk Production lbs/cow	14,300	14,300	15,000	14,900	66/51

Source: Wisconsin Agricultural Statistics - 1994, Wisconsin Agricultural Statistics Service, Madison, WI.

Prepared by: GMS
Checked by: RVS

3.12.3.3 Recreation

The extensive amount of public forest lands, lakes and streams provide an abundance of outdoor recreational opportunities in the area. Figure 3.12-3 shows the recreational resources located in the study area. Approximately 9,000 acres of publicly owned state and county lands are available in the study area. Within Forest County alone there are a total of approximately 340,000 acres of publicly owned lands including U.S. Forest Service, county and state lands (Foth & Van Dyke, 1988). These lands are open to hunting, fishing, picnicking, and camping. Other uses such as berry picking, hiking and bike riding are encouraged, although special regulations governing those uses have not yet been developed (Forest County, 1986; Langlade County, 1986).

As shown in Figure 3.12-3, three campgrounds are located within the study area. Table 3.12-6 provides information on the number of sites and facilities located at each campground. According to this information, a total of 110 campsites are available between the three campgrounds, with electricity, flush toilets and showers available at some of the sites. Public boat access is available at four lakes in the study area, as shown in Figure 3.13-3. These include Rolling Stone, Crane, Little Sand and Lily Lakes. No other facilities are available at these sites (Foth & Van Dyke, 1988; NCWRPC, 1991).

Table 3.12-6

Forest County Campgrounds in the Study Area

	No. of Camp Sites	Facilities and Services												
		Boating	Dump Station	Electricity	Fishing	Flush Toilets	Grills	Handicapped accessible	Horse shoe Pits	Hot Water	Picnic Facilities	Pit Toilets	Showers	Swim-ming	Trailer Camping
Forest County Veteran's Memorial Park (Lake Metonga)	70	yes	yes	yes	yes	no	yes	yes	yes	no	yes	yes	no	yes	yes
Lily River (Marquardt Lodge & Campground)	20	yes	yes	yes	yes	yes	no	no	yes	yes	yes	no	yes	no	yes
Sokaogon Chippewa Community Park (Mole Lake)	20	yes	no	no	yes	no	no	no	no	no	yes	yes	no	no	yes

Source: Foth & Van Dyke; Comprehensive Outdoor Recreation Plan, Forest County Forestry Department, November 1988.

Prepared by: GMS
Checked by: RVS

Suggested bicycle routes as identified in the Forest and Langlade County recreation plans are shown on Figure 3.12-4. The plans recommended proper signage to caution drivers (NCWRPC, 1991) and paved shoulders on roadways designated as bike routes (Foth & Van Dyke, 1988). The bicycle routes, however, have not been formally implemented (Frisch, 1995; Ziolokowski, 1995b).

Over 300 miles of groomed and signed snowmobile trails are available in Forest County. The specific trail segments included in the study area, and shown on Figure 3.12-4, are the 100 Mile Snow Safari Trail, Lumberjack Memorial Trail and Tombstone-Pickerel Trail (Forest County, 1994).

Forest County Forestry Department developed and maintains an eight-mile all terrain vehicle trail (ATV) on Forest County forest land off of County Trunk Highway W at the end of Duff Road, shown on Figure 3.12-4. The trail is open for year round use. A loading dock is provided to assist with loading/unloading ATVs. A parking area is also available. No other services are provided (Forest County Forestry Department, n.d.).

Due to the abundance of lakes and streams in the area, the fishing pressure in Forest County is much less than what the available resource offers, however, fishing surfaces as the number one recreation experience. *The Forest County Comprehensive Outdoor Recreation Plan* (Foth & Van Dyke, 1988) referenced a special issues and actions report, prepared by the WDNR, that indicated protecting the existing water resources and addressing acid rain were two of the top three concerns expressed for WDNR's North Central Wisconsin District, which includes Forest County.

The *Forest County Comprehensive Outdoor Recreation Plan* (Foth & Van Dyke, 1988) includes a needs assessment for recreational facilities in Forest County for the period from 1986-1991. The needs assessment was determined by: (1) area based demand analysis; (2) trends in outdoor recreation activity participation; and (3) priority of facility needs. Through the needs assessment process priorities were established for the Forest County region, which also included Vilas and Oneida Counties. The recreation activities and their priorities are indicated below:

<u>High Priority</u>
Camping
Cross-country skiing
Fishing
Off Road Vehicle:other
Organized sports
Playground activities
Swimming:beach
Walking/jogging

<u>Medium Priority</u>
Bicycling
Canoeing
Hiking/backpacking
Ice fishing
Golfing
Picnicking
Snowmobiling
Swimming pool
Tennis

<u>Low Priority</u>
Downhill skiing
Horseback riding
Ice skating/hockey
Off Road Vehicle:cycles
Sailing
Motor boating/waterskiing

From this analysis, the plan included recommendations for new and/or improved facilities. There were no new facilities recommended for development within the study area. However, the plan included several general recommendations for future facilities, including the following:

- additional river access sites for canoeing;
- designated bicycle routes along thoroughfares which are properly designed and signed;
- better fishing access accommodations/handicapped accessible fishing docks/off-road parking; and
- upgrade existing boat launch facilities/construct new launch facilities at lakes without launch facilities.

The Langlade County Outdoor Recreation Plan (NCWRPC, 1991) provided several recommendations for future recreational facilities in the county. No new facilities were recommended or identified in the study area. Among those included the following:

- development of a county/regional park in the eastern portion of the county (no site identified);
- additional improved public access to state and federal lands; and
- undertake a county-wide bicycle trail study/identify suggested bicycle routes with route signs.

Specific improvements recommended for the Town of Ainsworth facilities located at Rolling Stone Lake included:

- upgrade to be handicap accessible;
- finish boat launch with cement planks and gravel; and
- establishment of a picnic area with table/grill.

3.12.3.4 Residential/Institutional

Residential land use, estimated to include approximately 4,000 acres or six percent of the total land area in the study area, is concentrated around the larger lakes as shown in Figure 3.12-2. Permanent population totals for the Towns of Nashville, Lincoln and Ainsworth in 1990 were 871, 630, and 474, respectively (Section 3.14.3.1, Population). However, in noting the large percentage of seasonal/recreational housing units in Forest County (50 percent, Section 3.14.3.3, Housing) it can be assumed that the population in the Towns of Lincoln and Nashville increases during summer months.

As noted in Section 3.14.3.3, Housing, Langlade County has approximately 27 percent seasonal/recreational housing units. The majority of this housing can be assumed to be located in the forested portions of Langlade County which would include the Town of Ainsworth.

Within the study area most permanent residences are located in Mole Lake, along Lakes Metonga and Lucerne and along Highway 55, County Highway B, and Airport Road in the northern portion of the study area. Little Sand Lake, the closest lake to the ore body, is developed along the western, northwest and eastern shorelines. Many of these residences as well as others on lakes in the study area are one to two bedroom seasonal cottages.

There are only four institutional buildings located in the study area. These include a chapel, school and tribal building in Mole Lake and the Nashville Town Hall, which is located at the intersection of Highway 55 and County B.

3.12.3.5 Transportation

Transportation land uses in the study area include State Trunk Highway 55, County Trunk Highways "B","M", "Q", and "W", local town roads/forest roads, a Wisconsin Central Limited Railroad line and the Crandon Municipal Airport. Transportation systems are discussed in more detail in Section 3.3, Transportation and Utilities.

3.12.4 Zoning

The following discussion on zoning pertains to the lands identified for the land use assessment within the study area (Figure 3.12-1), and specifically the area to be occupied by facilities located within the mine site. Forest County, the Towns of Lincoln and Nashville, and the City of Crandon will have zoning authority over the mine site, but Langlade County and the Town of Ainsworth have also been included in the study area due to their proximity to the mine. The discussion below of zoning requirements is subject to Wis. Stats. 144.839, which allows local jurisdictions with zoning or land use authority over mining operations to enter into one or more "local agreements" with the operator for development of the mine. Local agreements provide an alternative method for local regulation of a mining operation, and could take the place of some of the zoning procedures discussed below. CMC is presently negotiating local agreements with Forest County, the Towns of Lincoln and Nashville, and the City of Crandon.

Subject to state and federal laws, counties, cities, villages and towns have the legal authority to adopt zoning ordinances to control and regulate development within their jurisdictional boundaries. Forest County and Langlade County have both adopted zoning ordinances to regulate development in unincorporated areas within their counties. The Towns of Lincoln and Nashville have both adopted their own zoning ordinances for lands within their townships. The Town of Ainsworth, in Langlade County, adopted the Langlade County zoning ordinance on September 30, 1993 (Viola, 1995). As of February, 1995, the zoning map for the town of Ainsworth is in the process of being updated, and is scheduled for adoption in the spring of 1995 (Higgins, 1995). The following discussion will address the Langlade County Zoning Ordinance as it relates to the Town of Ainsworth, and the specific individual ordinances for the Towns of Nashville and Lincoln.

According to the Langlade County Zoning Ordinance (1991), and the current zoning map for the Town of Ainsworth (1993), the area within the study area includes seven zoning districts:

Conservancy (C-1), Forest (F), Flood Plain (FP), Exclusive Agricultural (A-1), Residential Single Family (R-1), Park and Recreation (PR) and Agriculture/Forest Residential (AFR). The R-1 and AFR districts are located around Rolling Stone, Berendsen and Agnes Lakes. The remaining area of the Town of Ainsworth within the study area is zoned C-1, F, FP, or A-1. The public boat landing located on Rolling Stone Lake is zoned PR.

Residential development is a permitted use in the following districts: Forest District, on parcels of 35 or more acres or conditional use for parcels from one to 34 acres; Exclusive Agricultural, as a part of a farm operation; Residential District, minimum lot size of one acre and minimum width of 100 feet, if served by public sanitary sewers minimum lot area of 20,000 square feet and minimum lot width of 100 feet; and Agricultural/Forest District, with the same lot requirements as Residential (Langlade County, 1991).

In Langlade County, Metallic Mining Exploration (MME) is provided as an overlay district to describe an area where exploration may occur for a specified period of time. In the event metallic minerals are found, a petition for a zoning amendment to a Mining District (M) is required for the specified site for which mining is to take place. The zoning map for the Town of Ainsworth (1993) does not show any lands zoned MME or M.

On June 20, 1994 the Town of Ainsworth Town Board passed a resolution that prohibits the placement of a mining waste disposal facility in the town. In the 1980s, an alternative tailings pond location, Site 40, was considered in portions of Sections 1 and 2, T34N, in the Town of Ainworth. The resolution noted, among other reasons, that Sections 1 and 3 in T34N are designated as floodplain according to the Langlade County Zoning maps.

The zoning ordinance for the Town of Lincoln in Forest County, includes eight zoning districts. The majority of the town, however, is zoned General Rural (GR) or Lake Development (LD) which includes the residential areas located around the lakes in the town (Carter, 1995). Minimum lot sizes for the GR and LD districts are 1.5 acres and 20,000 square feet, respectively.

Most of the mine and associated facilities will be located in the Town of Lincoln. The town's zoning ordinance includes a Planned Development (PD) provision to allow flexibility in dealing with large scale developments such as the proposed mine. The Metallic Mineral Mining and Prospecting Planned Development (MPD) is permitted in GR Districts. An application for approval of any PD must be filed with the town for approval which includes specific environmental and socioeconomic information pertaining to the project. After receipt of the application by the town's Zoning Committee, a series of public hearings will be held (Town of Lincoln, 1982).

The Town of Nashville, which has been zoned since 1984, is in the process of updating its zoning ordinance and map. The update pertains mostly to LD districts and increasing the town's ability to enforce sanitary codes for residential development. Adoption of the updated map and ordinance is expected in the spring of 1995 (Marquardt, 1995).

The Town of Nashville's current zoning ordinance includes eight districts: General Rural (GR), Village Residential (VR), Village Commercial (VC), Lake Development (LD), Industrial (IN), One and Two Family Residential (R1), Multi-Family Residential (R2) and Commercial (CM). The R1, R2 and CM districts apply only to sewered areas. Minimum lot sizes for the GR district are 1.5 acres, and 20,000 square feet with a minimum lot width of 100 feet for LD

districts. Unsewered residential development is also permitted in the VR district which is intended to be more compact than in more open rural areas. Minimum lot sizes in VR districts are 1.5 acres with a minimum lot frontage of 150 feet (Town of Nashville, 1984).

In addition, as noted in the Town's zoning ordinance, the Town has adopted a Socioeconomic Impact Ordinance (1985) that is to provide for the development and implementation of an impact mitigation plan for PD projects. Developers for any PD projects must submit socioeconomic information to the Town board, including data regarding town revenues, proposed housing units, sewer and water facilities, etc.; a description of the proposed project; an analysis of the proposed development on baseline conditions, and mitigation plans to mitigate or eliminate potential negative impact.

The City of Crandon enforces a zoning ordinance for areas around the Crandon Municipal Airport. The city's Zoning and Building Commissioner administers and enforces the ordinance. Height restrictions for structures are identified for areas around the airport. As indicated in Section 21.03 of the ordinance (City of Crandon, 1980), permits are required for structures within the zones shown on the zoning map for the Crandon Municipal Airport, which includes the proposed plant structures. Plant structures cannot exceed an elevation of 2,065 feet above mean sea level according to the zoning map. The maximum elevation of the 165 foot head frame will be an elevation of 1,830 feet above mean sea leave, within the requirements of the ordinance, however, permits will still be required. Permit applications are made to the city's Zoning and Building Commissioner. In addition, no land use is permitted that may create electrical interference with radio communication between airport and aircraft, make it difficult for pilots to distinguish between airport lights and others, or result in glare in the eyes of pilots using the airport, or impair visibility in the vicinity of the airport or otherwise endanger the landing, taking off or maneuvering of aircraft (City of Crandon, 1980).

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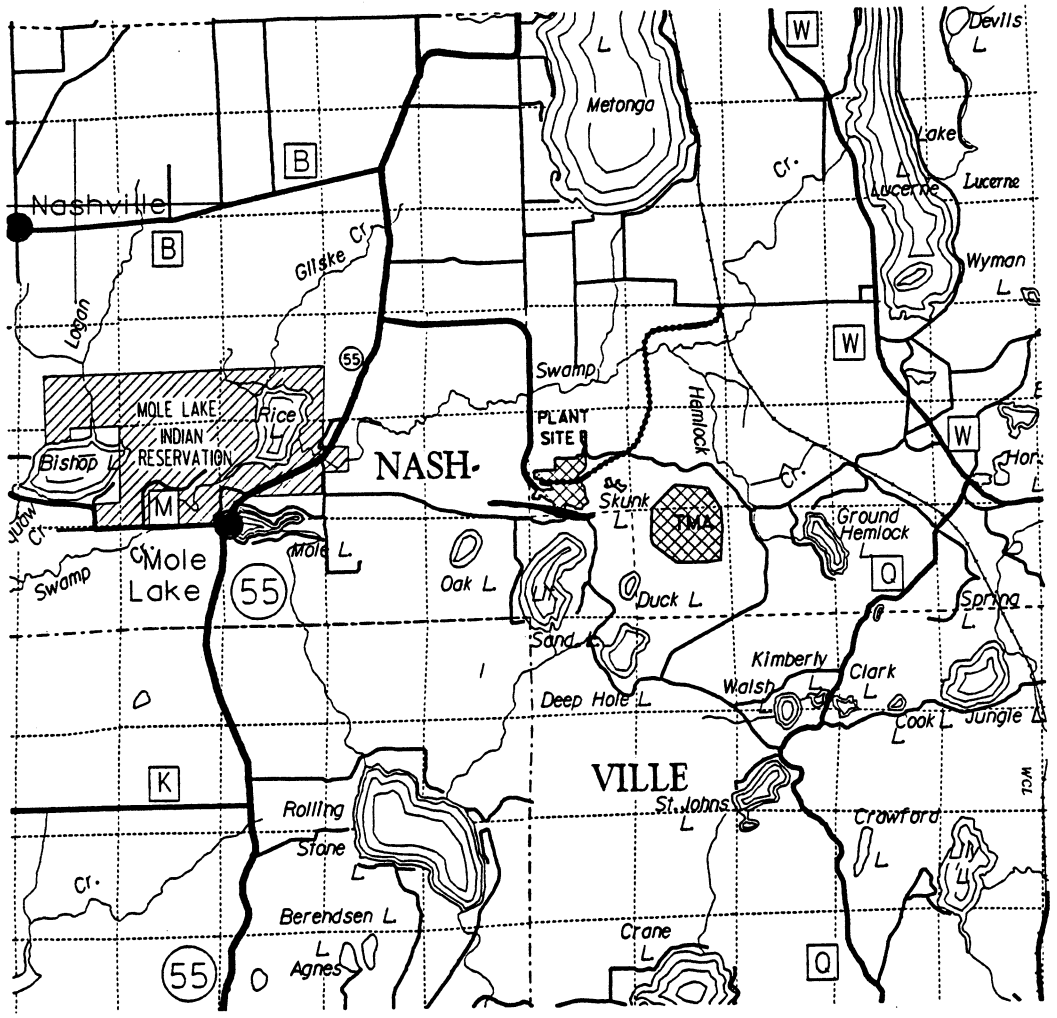
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FIGURES FOR SECTION 3.12



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 HWY LETTER
- RESERVATION LANDS
- UNINCORPORATED VILLAGE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES

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:	JKSI	DATE: MAY.'95
APPROVED BY:	GMS	DATE: MAY.'95
APPROVED BY:	GWS	DATE: MAY.'95

Crandon Mining Company

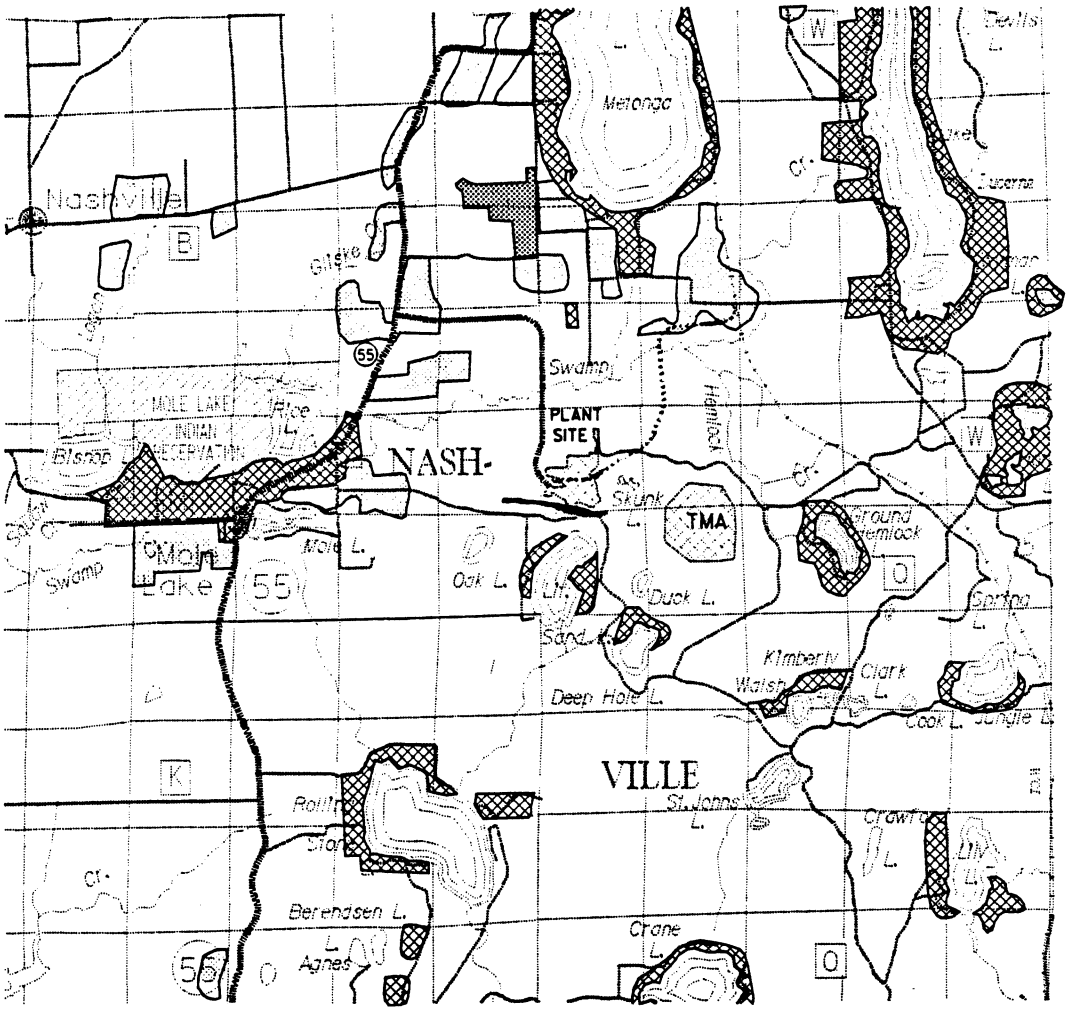
FIGURE 3.12-1
LAND USE AND ZONING
STUDY AREA

Scale: 0 10,000' 20,000' Date: MAY, 1995

Prepared By: Foth & Van Dyke By: JOW

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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 HWY LETTER
- RESERVATION LANDS
- UNINCORPORATED VILLAGE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- AGRICULTURE
- FOREST LANDS/WETLANDS
- RESIDENTAL/INSTITUTIONAL
- TRANSPORTATION

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. MINIMUM LAND USE AREA DEPICTED 40 ACRES.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE:	MAY.'95
APPROVED BY:	GMS	DATE:	MAY.'95
APPROVED BY:	GWS	DATE:	MAY.'95

Crandon Mining Company

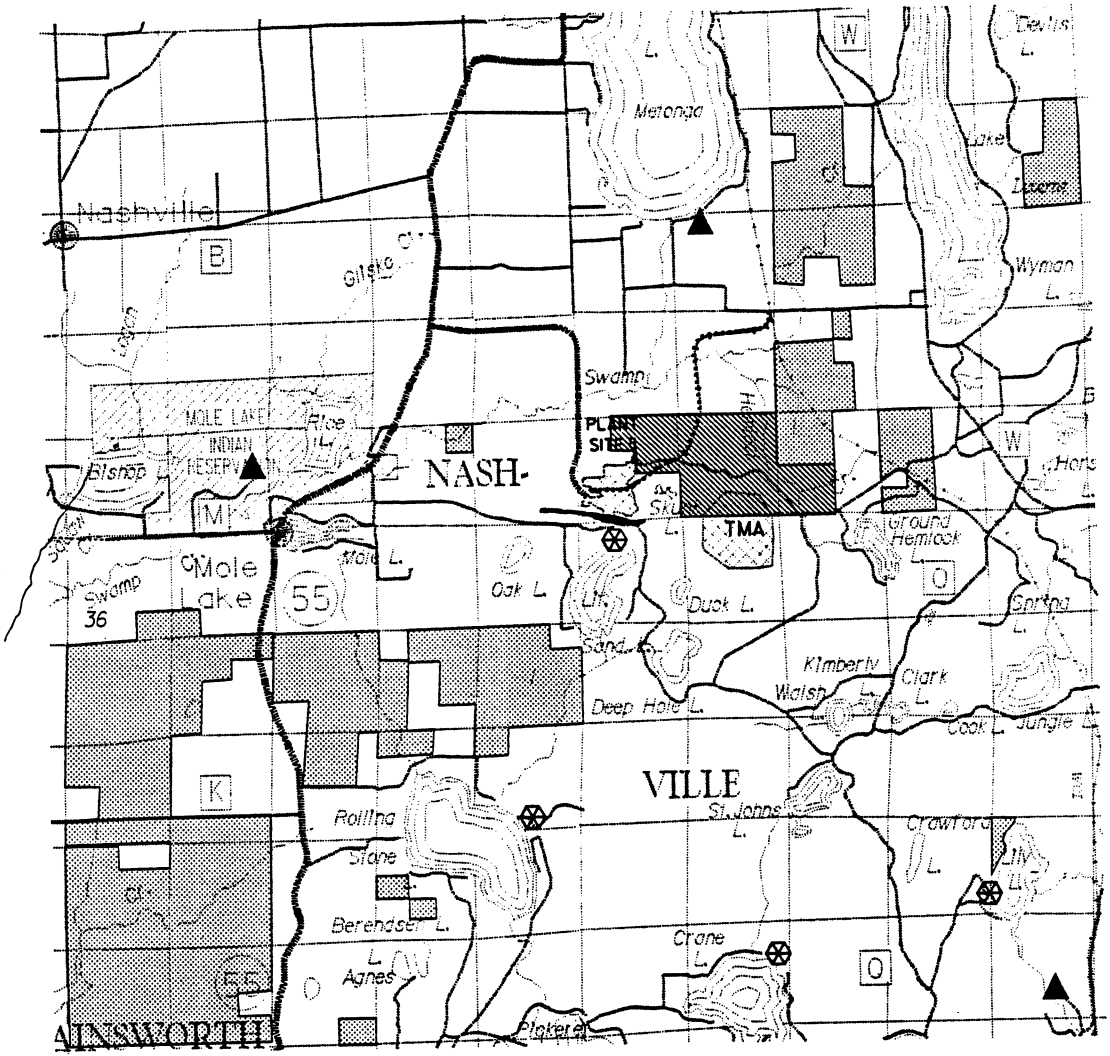
FIGURE 3.12-2
LAND USE IN THE STUDY AREA

Scale: 0 10,000' 20,000' Date: MAY, 1995

Prepared By: Foth & Van Dyke By: JOW

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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 HWY LETTER
- RESERVATION LANDS
- UNINCORPORATED VILLAGE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- BOAT ACCESS
- PARK/CAMPGROUND
- PUBLIC LANDS
- PUBLIC LANDS OPTIONED BY CMC

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. SOURCE: NORTH CENTRAL WISCONSIN REGIONAL PLANNING COMMISSION; LANGLADE COUNTY OUTDOOR RECREATION PLAN 1991-1995, JANUARY 1991; FOTH & VAN DYKE, COMPREHENSIVE OUTDOOR RECREATION PLAN, FOREST COUNTY FORESTRY DEPARTMENT, NOVEMBER, 1988; FOREST COUNTY RECREATION MAP, 1994.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: MAY.'95
APPROVED BY:	GMS	DATE: MAY.'95
APPROVED BY:	GWS	DATE: MAY.'95

Crandon Mining Company

FIGURE 3.12-3

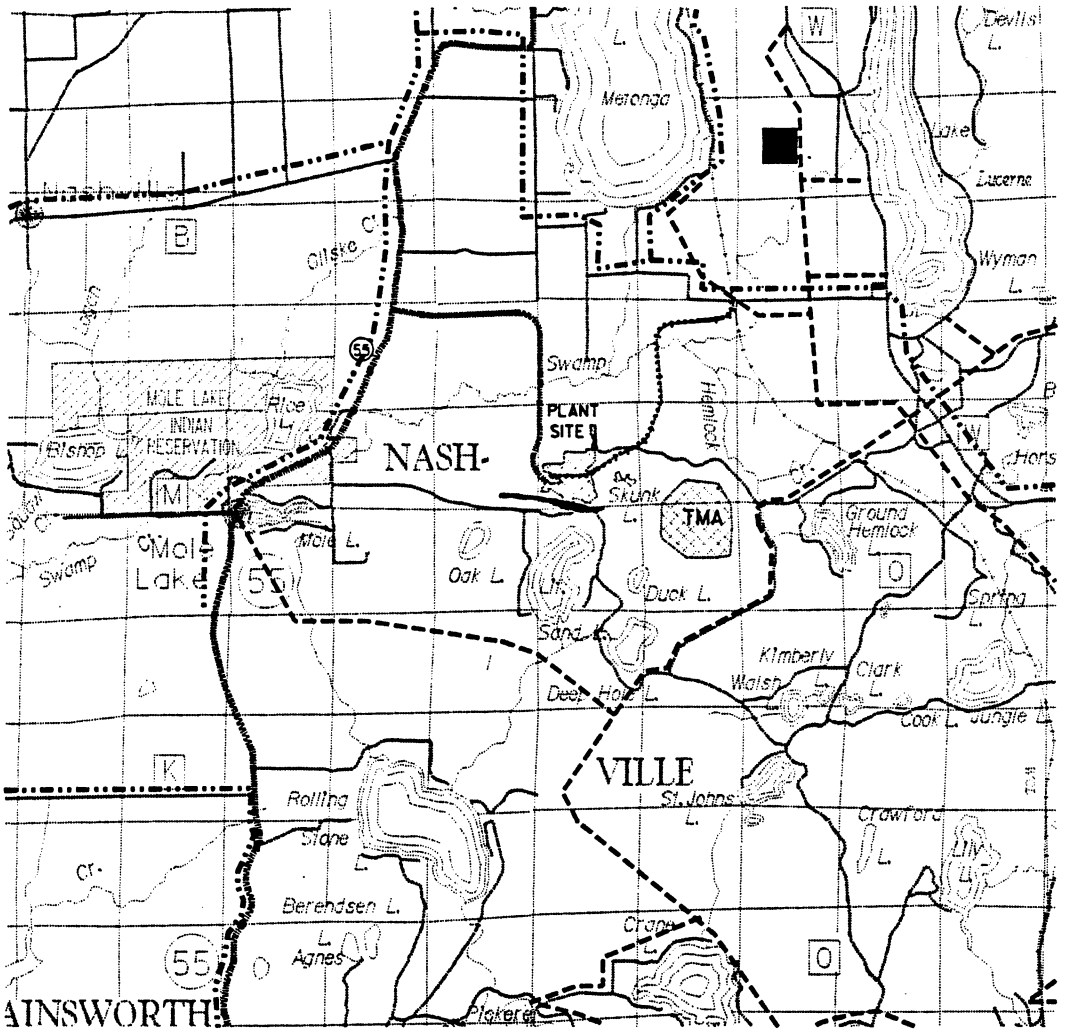
RECREATIONAL RESOURCES IN THE STUDY AREA

Scale: 0 10,000' 20,000' Date: MAY, 1995

Prepared By: Foth & Van Dyke By: JOW

93C049

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LEGEND

- U.S. OR STATE HWY
- COUNTY TRUNK ROAD
- TOWN ROAD
- COUNTY BOUNDARY
- CIVIL TOWN BOUNDARY
- SECTION LINE
- U.S. HWY NO.
- STATE HWY NO.
- COUNTY HWY LETTER
- RESERVATION LANDS
- UNINCORPORATED VILLAGE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- ALL TERRAIN VEHICLE (ATV) TRAILS
- SNOWMOBILE TRAILS
- SUGGESTED BICYCLE ROUTES

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: MAY.'95
APPROVED BY:	GMS	DATE: MAY.'95
APPROVED BY:	GWS	DATE: MAY.'95

Crandon Mining Company

FIGURE 3.12-4

RECREATIONAL TRAILS IN THE STUDY AREA

Scale: 0 10,000' 20,000' Date: MAY, 1995

Prepared By: Foth & Van Dyke By: JOW

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Attachment 5

Section 3.3.2, Roads, from the May 1995 Crandon Project Environmental Impact Report

Step 3: Using the directional distribution from the collected peak-hour volumes, the base AM and PM (K_{30}) peak-hour volumes were determined.

The base volumes are shown in Figure 3.3-4.

3.3.2 Roads

For northern Wisconsin, the study area has a well-developed system of federal, state, and county highways. All lands within the study area are within two to three miles of a county highway. Additional access is provided by numerous town roads (Figure 3.3-1).

The primary roadway that will service the plant site is STH 55. This roadway is a north-south arterial consisting of one lane in each direction. The most immediate population centers on STH 55 are the city of Crandon, north of the proposed plant site, and Mole Lake, west of the plant site. The speed limit on STH 55 in the vicinity of the proposed plant site entrance is 55 miles per hour.

United States Route 8 (USR 8) is an east-west major arterial consisting of one lane in each direction. The majority of traffic traveling east to the plant site from the Rhinelander area and west to the plant site from the Laona area will use USR 8. The posted speed limit of USR 8 in the city of Crandon is 35 miles per hour, outside of the city the posted speed limit is 55 miles per hour.

County Trunk Highway S (CTH S) is a north-south collector consisting of one lane in each direction. The majority of traffic entering the site from the west on USH 8, and exiting the site traveling west will use this segment of CTH S, rather than traveling on STH 55 to the city of Crandon and connecting with USR 8. The posted speed limit on CTH S is 55 miles per hour. Other major collectors in the study area include County Highways M, B, W and Q.

Based on the January, 1995 traffic counts the weekday morning peak hour of traffic occurred from 7:30 to 8:30 a.m., and the evening peak hour from 4:00 to 5:00 p.m.. Figure 3.3-2 illustrates the existing peak hour traffic counts. Additional AADT volume data was gathered from the WisDOT. These traffic volumes, based on WisDOT data collected during 1994, are shown on Figure 3.3-3.

Seasonal traffic levels fluctuate in the region because of tourist traffic. According to WisDOT the average daily traffic in the summer months may range from 30 to 45 percent greater than average annual daily traffic volumes (WisDOT, 1991).

According to Chapter 348 Wisconsin Statutes, the statewide highway weight limit is 80,000 pounds per vehicle. However, this may vary depending upon conditions. During the spring thaw, for instance, reduced weight limits are often imposed at the county and town level. In Langlade and Forest Counties, the posted spring weight limits are 36,000 and 24,000 pounds gross weight, respectively (Monnot, 1995; Campbell, 1995). In the towns of Lincoln and Nashville, Forest County, the spring posted weight limits are 7,500 and 14,000 pounds gross weight, respectively (Hobbs, 1995; Vollmar, 1995).

The County Highway Improvement Program for Forest County (NCWRPC, 1993) assessed the county highway system by describing and analyzing existing conditions and identifying highway

improvement priorities for budgeting purposes. The report indicated that the surface condition on 48 percent (approximately 52 miles) of the Forest County highways were rated a "6" or below on a 1-10 rating system, with "10" being excellent (new construction), and "1" being failed (total reconstruction necessary). The additional 52 percent (approximately 57 miles) were rated "7" or above. The highest priority roadway improvement project identified in the study area was segments of CTH "Q" (approximately 5.5 miles) which were recommended for seal coating. No roadways were recommended for total reconstruction.

3.3.3 Airports

The only airport in the study area was the Crandon Municipal Airport, located approximately three miles north of the plant site. It is classified as a small utility airport and does not have commercial service. The longest runway is asphalt surfaced, 3,100 feet long, and oriented west-northwest to east-southeast. A second runway consists of turf, and is 2,700 feet in length oriented in a north-south direction. The main asphalt runway is open year round, while the turf runway is open from April 1 to December 1. The main runway has low intensity lighting. There is no regularly scheduled passenger service to the Crandon Municipal Airport (WisDOT, 1993).

The closest commercial airport offering regularly scheduled passenger service is in Rhinelander, located 35 to 40 miles west of the plant site.

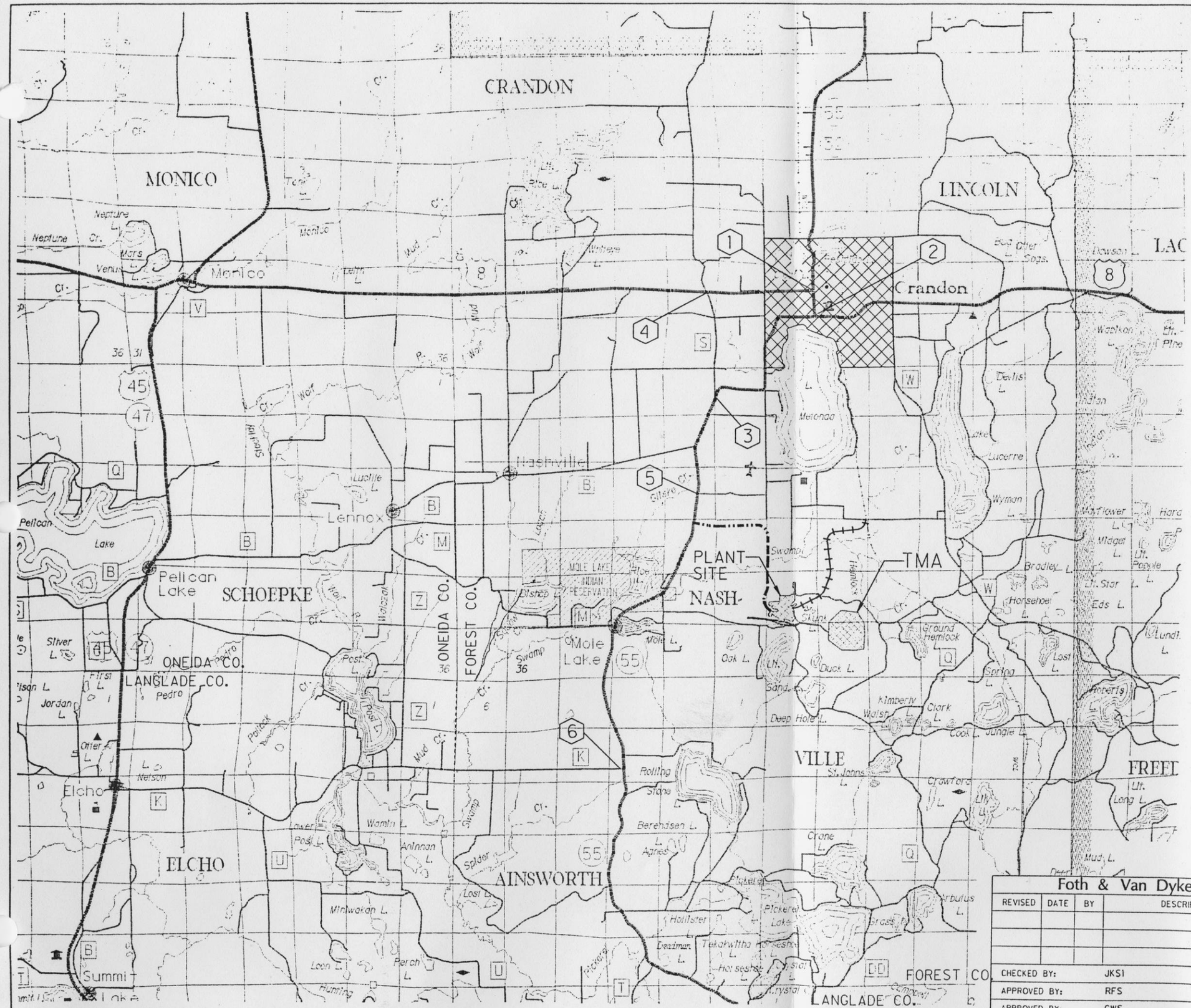
3.3.4 Railroad

The only railroad within the study area is a main line branch of the Wisconsin Central Limited Railroad, located 2.5 miles northeast of the ore body. This line begins at Wisconsin Junction, five miles north of the city of Crandon, passes through the city, extends south to Milwaukee, and ultimately Chicago. The track is estimated to handle five to seven million tons of freight per year. The line had one train a day in each direction in 1994. Plans for 1995 are to increase the number to two trains per day. This line also provides access to Upper Michigan and the cities of Superior and Minneapolis. At Wisconsin Junction, this railroad track joins another branch of the Wisconsin Central Limited Railroad that traverses Wisconsin from east to west (Tebell, 1995).

3.3.5 Utilities

Electrical and natural gas distribution service is provided in the study area by Wisconsin Public Service Corporation (WPSC). Electric is the only utility currently supplied to the Crandon Project site. This is supplied from the 115 kV Venus Substation located approximately one-mile south of Monico,Wisconsin. ANR Pipeline Company owns a six-inch natural gas transmission pipeline that is located approximately two miles north of Crandon, where it extends easterly to Laona and westerly to Rhinelander. WPSC provides local natural gas distribution.

The project and immediate surrounding area is served by individual private water supply wells and on-site sanitation systems. The City of Crandon maintains the nearest public water supply and municipal wastewater treatment facility. Telephone service is supplied by Crandon Telephone Company in Crandon, Wisconsin. Although no telephone service is currently supplied to the plant site, overhead lines exist along Little Sand Lake Road.



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

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.

TRAFFIC COUNT LOCATIONS

1. STH 55 AT USR 8 (WEST)
2. STH 55 AT USR 8 (EAST)
3. STH 55 AT CTH S
4. USR 8 AT CTH S
5. STH 55 AT AIRPORT ROAD
6. STH 55 AT CTH K

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: MAY '95
APPROVED BY:	RFS	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

Crandon Mining Company

FIGURE 3.3-1
REGIONAL TRANSPORTATION SYSTEM AND SURVEY LOCATIONS

Scale: 0 5000' 10,000' Date: MAY, 1995

Prepared By: Foth & Van Dyke By: BSH

/d3/dl/users/low/4c60f22.dgn

93C049

Attachment 6

WDNR Form 4400-122 (Boring Logs) and Form 3300-5W (Abandonment Forms)

State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☑ Other: Mining

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
Crandon Project - TMA Drilling Program		CMC-TMA-101

Boring Drilled by (Firm name and name of crew chief)	Date Started	Date Completed	Drilling Method
TD Drilling, Inc. James Meyers	MM/DD/YY 02/06/96	MM/DD/YY 02/06/96	Dual Tube

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
NA	NA	NA	NA	1643.64	5⅞ inches

Boring Location
State Plane 116701.38 N, 2283073.56 E S/C/N Lat
SE 1/4 of SW 1/4 of Section 29, T35N, R13E Long

Local Grid Location (if applicable)
____ N ____ E
Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Lincoln

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/Comm
DT-0	0-2			Dk. brown (7.5YR3/4) damp, sandy clay w/minor subangular gravel till	CL									Blow counts = rate of penetration min/5' interval
DT-1	5-7	5	5	Brown (7.5YR4/4) wet, silty sand w/5% subround-to-round gravel till	SM									
DT-2	10-12	5	10	Strong brown (7.5YR5/6) damp, coarse grained sand w/minor gravel, coarse outwash	SP									Bit plugged at 10', frequent plugging slowed penetration
DT-3	15-17	5	15	As above w/increased gravel 5-10%, rounded to subrounded coarse outwash	SP									
DT-4	20-22	5	20	As above, grading to medium texture sand w/minor gravel (4.5YR4/6)	SP									Rec = sampled interval depth below ground surface (ft)
DT-5	25-27	2.5	25	As above, coarse outwash	SP									
DT-6	30-32	3.0	30	Dk. brown (7.5YR4/4) silty sand, fine to medium texture w/gravel angular to subrounded, till	SM									
DT-7	35-37	2.0	35	As above, till	SM									
DT-8	40-42	4.0	40	As above, grading to fine silty sand, color grading to light yellow brown (2.5YR6/3) due to boulders till	SM									
DT-9	45-47	4.0	45	Lt. brown (7.5YR6/3) fine silty sand w/5% angular gravel, boulders, till	SM									

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: Stephen A. Wood
Firm: Foth & Van Dyke

This form is authorized by Chapters 114.147 and 162, Wis. Stats. Completion of this report is mandatory.
Penalties: Forfeit not less than $10 nor more then $5,000 for each violation. Fined not less than $10 or more than $100 or imprisoned not less than 30 days, or both for each violation. Each day of continued violation is a separate offense, pursuant to ss 114.06, Wis. Stats.

State of Wisconsin | Route to: | SOIL BORING LOG INFORMATION

Department of Natural Resources | Form 4400-122 | 7-91

BORING NUMBER: CMC-TMA-101 |

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
DT-10	50-52	2.3	50	As above w/increased gravel 10-15%, till	SM									
DT-11	55-57	2.3	55	Strong brown (7.5YR4/6) medium to coarse textured sand w/10-15% gravel, subangular to rounded coarse outwash	SM									
DT-12	60-62	2.3	60	As above w/increased gravel 15-20%	SP-GP									
DT-13	65-67	1.3	65	As above, grading to dk. grayish brown (2.5YR4/2) coarse outwash	SP									
DT-14	70-72	1.5	70	Brown (7.5YR5/4) fine sand, fine outwash	SP									
DT-15	75-77	1.0	75	As above w/gravel, rounded to subrounded 10% fine outwash	SP									
DT-16	80-82	1.3	80	As above, grading to stronger brown (7.5YR5/6) and coarser, textured, fine to coarse outwash	SP									
DT-17	85-87	1.0	85	Grayish brown (7.5YR5/4) med. to coarse textured sand w/gravel 15% subrounded course outwash	SP									
DT-18	90-92	1.0	90	As above, coarse outwash	SP									
DT-19	95-97	1.0	95	As above, grading to sandy gravel, coarse outwash	GP									
DT-20	100-102	1.0	100	As above, grading to (7.5YR4/2) grayish brown, coarse outwash	GP									
DT-21	105-107	1.5	105	As above, grading brown (7.5YR4/4), coarse outwash	SP									
DT-22	110-112	1.5	110	Reddish brown (5YR4/6) silty sand med. texture, oxidized till 5-10% subangular gravel	SM-SP									
DT-23	115-117	1.5	115	As above w/increased fines and gravel 10-15% grading to brown (7.5YR4/4), till	SM									
DT-24	120-122	1.5	120	Yellowish brown (10YR4/6) silty clayey sand, till, washed w/water	SM									Water wash to unplug bit and rods.

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
DT-25	125-127	2.5	125	Yellowish brown (10YR5/6) coarse sand w/gravel 10-20% coarse outwash	SP									
DT-26	130-132	1.5	130	As above grading med. texture gravels, sand coarse outwash	SP									
DT-27	135-137	2.0	135	As above	SP									
DT-28	140-142	2.0	140	As above	SP									
DT-29	145-147	3.8	145	Strong brown (7.5YR4/6) silty sand w/gravel subrounded to angular till	SM									
DT-30	150-152	4.0	150	Light brown (7.5YR5/4) med. texture sand w/minor gravel, coarse outwash	SP									
DT-31	155-157	3.6	155	As above	SP									
DT-32	160-162	3.8	160	160-175 unweathered bedrock Abandoned w/bentonite grout Topped off w/hole plug Supplemental Bedrock, AJE Jr. 2/17/96 160-162. Tan stained weakly weathered "greenstone". Fine grained metatuff. Rare trace pyrite. 162-177. Mixed tan weakly weathered tuff and grey-green unweathered metatuff. "Greenstone" - rare trace pyrite and trace white-clear quartz veinlets. No significane sulfides in bedrock.	BR									

State of Wisconsin
Department of Natural Resources

WELL/DRILLHOLE/BOREHOLE ABANDONMENT

Form 3300-5W 11-89

All abandonment work shall be performed in accordance with the provisions of Chapters NR 111, NR 112 or NR 141, Wis. Admin. Code, whichever is applicable. Also, see instructions on back.

(1) GENERAL INFORMATION

Well/Drillhole/Borehole Location | County: Forest

SE ¼ of SW ¼ of Sec. 29 ; T. 35 N R. 13 ☑ E ☐ W

(If applicable) _____ Gov't Lot _____ Grid Number

Grid Location: 116701.38 ft. ☑ N. ☐ S., 2283073.56 ft. ☑ E. ☐ W.

Civil Town Name: Lincoln

Street Address of Well: NA

City, Village: NA

(2) FACILITY NAME

Original Well Owner (If Known): Crandon Mining Company

Present Well Owner: Crandon Mining Company

Street or Route: 7 North Brown Street, 3rd Floor

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

Facility Well No. and/or Name (If applicable): CMC-TMA-101

WI Unique Well No.: _ _ _ _ _

Reason For Abandonment: Boring Completion

Date of Abandonment: 02/06/96

WELL/DRILLHOLE/BOREHOLE INFORMATION

(3) Original Well/Drillhole/Borehole Construction Completed On (Date) 02/06/96

☐ Monitoring Well
☐ Water Well
☐ Drillhole
☑ Borehole

Construction Report Available? ☐ Yes ☐ No

Construction Type:
☑ Drilled ☐ Driven (Sandpoint) ☐ Dug
☐ Other (Specify) _____

Formation Type:
☑ Unconsolidated Formation ☐ Bedrock

Total Well Depth (ft.) 162 (From groundsurface) Casing Diameter (ins.) ____

Casing Depth (ft.) _____

Was Well Annular Space Grouted? ☐ Yes ☐ No ☐ Unknown
If Yes, To What Depth? _____ Feet

(4) Depth to Water (Feet) _____

Pump & Piping Removed?	☐ Yes	☐ No	☑ Not Applicable
Liner(s) Removed?	☐ Yes	☐ No	☑ Not Applicable
Screen Removed?	☐ Yes	☐ No	☑ Not Applicable
Casing Left in Place?	☐ Yes	☐ No	

If No, Explain _____

Was Casing Cut Off Below Surface?	☐ Yes	☐ No
Did Sealing Material Rise to Surface?	☑ Yes	☐ No
Did Material Settle After 24 Hours?	☑ Yes	☐ No
If Yes, Was Hole Retopped?	☑ Yes	☐ No

(5) Required Method of Placing Sealing Material
☐ Conductor Pipe-Gravity ☑ Conductor Pipe-Pumped
☐ Dump Bailer ☐ Other (Explain)

(6) Sealing Materials — For monitoring wells and monitoring well boreholes only
☐ Neat Cement Grout
☐ Sand-Cement (Concrete) Grout
☐ Concrete
☐ Clay-Sand Slurry
☑ Bentonite-Sand Slurry
☑ Chipped Bentonite
☐ Bentonite Pellets
☐ Granular Bentonite
☐ Bentonite - Cement Grout

(7)

Sealing Material Used	From (Ft.)	To (Ft.)	No. Yards, Sacks Sealant or Volume	Mix Ratio or Mud Weight
Bentonite Grout/⅜" Hole Plug	Surface	162	2 bags Gel	150 gallons H_2O/100 lb gel
			3 bags granular	150 lb grannular
			8 bags H.P.	

(8) Comments: Borehole tapped off with ⅜" hole plug after 24 hours.

(9) Name of Person or Firm Doing Sealing Work
Total Drilling - Luisier Drilling

Signature of Person Doing Work Date Signed

Street or Route: 7391 S Porcupine Lake Road
Telephone Number: (414) 829-5690
City, State, Zip Code: Lena, WI 54139

(10) FOR DNR OR COUNTY USE ONLY

Date Received/Inspected | District/County

Reviewer/Inspector

Follow-up Necessary

DNR/COUNTY

REASONS FOR WELL/DRILLHOLE/BOREHOLE ABANDONMENT

Wis. Adm. Code (NR 111, NR 112, & NR 141) requires well owners to permanently abandon unused wells/drillholes/boreholes on their property. The reasons for this requirement are:

- To prevent contamination from entering the well/drillhole/borehole at the surface or through corroded well casings and moving downward to an aquifer used by other wells, and
- To prevent vertical movement of water between different geologic formations of differing water quality.

Most licensed well drillers and pump installers have the equipment, knowledge and experience needed to permanently abandon wells/drillholes/boreholes. We recommend that these licensed contractors be hired to do this work.

PROCEDURE

1. Remove any pump, pump piping, debris or other obstacles that could interfere with the sealing operation. In most situations the well casing should be left in place. When the casing is removed it should be pulled during the abandonment process so the drillhole does not collapse.
2. The sealing material must be placed with a conductor (tremie) pipe either by pumping or by gravity, (except when approved chipped bentonite is used according to written department instructions and restrictions).
3. The bottom end of the conductor pipe must initially reach the bottom of the well and must be kept submerged in the sealing material as it is placed.
4. Unconsolidated formation wells should be sealed with the materials listed in item (6) on the form. When clay or sodium bentonite slurry is used to fill wells, the top 20 feet must be sealed with neat cement grout, concrete grout, concrete, or bentonite chips. Bedrock formation wells should be filled with neat cement grout, concrete grout, concrete, or bentonite chips. Monitoring wells must be filled with the materials specified by NR 141, Wis. Adm. Code.
5. Fill the entire well column from the bottom to the top with the required sealing material.
6. When using concrete or cement grout, any standing water in the hole will be forced out by the concrete or cement grout (it is more dense) resulting in an entire column of cement to seal the well. The sealing material must flow at the surface with the same consistency as it is being pumped in.
7. The casing may be cut off several feet below the ground surface.
8. To abandon flowing wells, the flow must be stopped or greatly reduced. This can be accomplished by extending the well casing to an elevation higher than the artesian head, or inserting a seal or packer in the casing. Once the flow has been stopped or reduced, the well can be abandoned the same as other wells.
9. For a municipal well, information regarding drillhole diameter and depths and geologic formations should be submitted on a separate sheet.
10. For use of alternative methods and materials, especially for deep, multi-formation wells contact DNR.

TEMPORARY ABANDONMENT

- A well may be temporarily abandoned if it is planned to place the well back in service within a time specified by administrative rule.
- Temporary abandonment is accomplished by threading or welding a watertight cover to the casing or by filling the well with a clean clay slurry and then placing a cover over the well.
- If the well is not placed back into service, it should be permanently abandoned unless a written extension is granted by DNR.

REPORT TO DNR

The Well/Drillhole/Borehole Abandonment Form 3300-5W, on the front, must be completed by the owner (or agent) and submitted to the appropriate DNR district office or delegated county office within 30 days.

This form is authorized by chapters 144, 147 and 162, Wis. Stats. Completion of this report is mandatory. Penalties: Forfeit not less than $10.00 nor more than $5,000.00 for each violation. Fined not less than $10.00 or more than $100.00 or imprisoned not less than 30 days, or both for each violation. Each day of continued violation is a separate offense, pursuant to ss. 144.99 and 162.06, Wis. Stats.

State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☑ Other: Mining

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
Crandon Mining Company - Crandon TMA Site		CMC-TMA-102

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
TD Drilling, Inc. James Meyers	01/23/96	02/05/96	Rotary Mud/Dual Tube

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
NA	NA	NA	NA	1646.61	5⅞ inches

Boring Location
State Plane 118180.57 N, 2283980.35 E S/C/N Lat
NW 1/4 of SE 1/4 of Section 29, T24N, R13E Long

Local Grid Location (if applicable)
____ N ____ E
Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Lincoln

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
SS-1	12	Air hammer	0	0-4 Dk. brown (7.5YR4/2) to brown (7.5YR4/4) poorly graded med.-fine texture sand occasional round pebbles	SP									Drilled to 140 w/mud rotary. 140 to EOB w/dual tube.
SS-2	24	Air hammer	10	As above, thin laminations of silty sand, fine outwash	SP									
SS-3	20	Air hammer	20	As above w/coarse gravel lense at 20' & abundant round & angular pebbles, coarse is wet, rest is damp	SP									
SS-4	10	Air hammer	30	Yellow-brown (7.5YR5/4) silty sand w/gravel, massive to weak coarse blocky structure, damp, hard, no evident stratification (till)	SM									
SS-5	16	Air hammer	40	As above w/minor sand inclusions around coarser gravel	SM									2 bags of sample
SS-6	24	Air hammer	50	As above, dense, slight color change to 7.5YR4/6 dk. yellow-brown, slightly less gravel	SM									2 bags of sample
SS-7	21	Air hammer	60	As above, very damp, oxidized, more gravel, some cobbles	SM									2 bags of sample
SS-8	20	Air hammer	70	As above, at base very sandy Drilling much easier from 72-80	SM SM-SP									
SS-9	24	Air hammer	80	Lt. brown (7.5YR6/4) gravelly med.-coarse sand w/silt, very damp to wet, dense, structureless, minor oxidation, gravel subrounded to rounded (coarse outwash) Spoon lost down hole	SP									
			90											

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature [signature] Firm Foth & Van Dyke

This form is authorized by Chapters 114.147 and 162, Wis. Stats. Completion of this report is mandatory.
Penalties: Forfeit not less than $10 nor more then $5,000 for each violation. Fined not less than $10 or more than $100 or imprisoned not less than 30 days, or both for each violation. Each day of continued violation is a separate offense, pursuant to ss 114.06, Wis. Stats.

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
S-10	14	Air hammer		Yellow-brown (10YR6/6) fine sandy silt w/fine sand lenses, oxidized, deformed stratification, mod. fine prismatic to platy structure, wet, soft (ice marginal - lacustrine)	ML									
S-11	17	Air hammer	100	100-101 As above										
				101-102 Brown (7.5YR5/6) fine-coarse sand w/minor silt, weakly stratified, structureless, wet, soft, (coarse outwash)	SP									
S-12	24	Air hammer	110	110-112 Yellow-brown (7.5YR5/8) silty sand w/gravel, massive, wet, sl. firm, oxidized in sandier portions (till)	SM									
S-13	16	Air hammer	120	Brown (7.5YR4/3) silty sand w/gravel, massive, wet, firm (washed till)	SM-SP									
S-14	18	Air hammer	130	7.5YR5/8 coarse to med. texture silty sand w/gravel, loose to firm, wet, locally oxidized till, no evident stratification	SM									
S-15	20	Air hammer	140	7.5YR4/4 dk. brown structureless, loose to firm, weak stratification, med.-coarse texture sand, locally oxidized, w/round pebbles, coarse outwash	SP									
				Switch to dual tube at 140'										Switch to dual tube at 140'.
DT-16	145-147	1.0	145	As above w/ residual mud	SP									
DT-17	150-152	1.0	150	As above w/residual mud	SP									Blow counts = rate of penetration min/5' interval.
DT-18	155-157	1.0	155	As above, clean sample w/o mud, poorly graded, brown (7.5YR5/6) med.-coarse texture sand, ozidized, occasional pebbles, coarse outwash	SP									Rec = sample interval depth below ground surface (ft)
DT-19	160-162	1.0	160											
DT-20	165-167	1.0	165	Brown (7.5YR5/6) poorly graded fine texture sand, very few pebbles, round fine outwash	SP									
DT-21	170-172	1.0	170	As above, sl. darker brown (7.5YR4/6)	SP									
DT-22	175-177	1.0	175	Brown (7.5YR4/6) silty sand w/subangular to subrounded gravel, till	SM									
DT-23	180-182	1.0	180	As above, sl. finer sand, sl. less gravel	SM									
														Bit plugged at 183'
DT-24	185-187	10	185	Brown (7.5YR4/6) poorly graded med.-texture sand, poorly graded, coarse outwash	SP									

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
DT-25	190-192	1.0	190	Brown (7.5YR4/6) fine textured silty sand w/infrequent gravel, fine outwash	SM-SP									
DT-26	195-197	1.0	195	As above, grading to finer silty sand	SM-SP									
DT-27	200-202	1.0	200	Yellowish-brown (10YR5/6) silty clay w/occasional rounded pebbles, ¼", lacustrine	CL									
DT-28	205-207	3	205	Yellowish-red (5YR4/6) clayey sand, med. coarse texture and sandy clay w/coarse texture sand w/gravel, subangular, till	SC-CL									
DT-29	210-212	3	210	As above, water becoming redder	SC-CL									Cyclone plugged at ~210'
DT-30	215-217	3	215	215-225 Yellowish red (5YR4/6) sandy clay w/fine texture sand, increased angular clasts w/depth, saprolitic till or saprolite, red water at 220	CL									
DT-31	220-222	3	220	As above	CL									
DT-32	225-227	2.3	225	Weathered metavolcanic bedrock to 235, cuttings logged by CMC	WBR									
DT-33	230-232	2.3	230	As above	WBR									
DT-34	235-237	2.3	235	As above	WBR									
DT-35	240-242	2.3	240	Weakly weathered metavolcanic bedrock, cuttings logged by CMC	BR									
DT-36	245-247	2.3	245	As above	BR									
DT-37	250-252	2.3	250	As above	BR									
DT-38	255-257	2.3	255	As above	BR									

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
DT-39	260-262	2.3	260	As above End of Boring. Abandoned w/bentonite grout Topped off w/hole plug Supplemental Bedrock, AJE Jr. 2/17/96 225-240. Tan to grey-green, weakly weathered to fresh fine grained metatuff 'Greenstone'. Trace of quartz veinlet chips. No sulfide noted. 240-260. Fresh grey-green fine grained metatuff. Rare trace pyrite and trace of quartz veinlet chips. TD 260. No significant sulfides in bedrock.										

State of Wisconsin
Department of Natural Resources

WELL/DRILLHOLE/BOREHOLE ABANDONMENT

Form 3300-5W 11-89

All abandonment work shall be performed in accordance with the provisions of Chapters NR 111, NR 112 or NR 141, Wis. Admin. Code, whichever is applicable. Also, see instructions on back.

(1) GENERAL INFORMATION

Well/Drillhole/Borehole Location | County: Forest

NW ¼ of SE ¼ of Sec. 29 ; T. 35 N R. 13 ☑ E ☐ W

(If applicable) _____ Gov't Lot _____ Grid Number

Grid Location: 18180.57 ft. ☑ N. ☐ S., 2283980.35 ft. ☑ E. ☐ W.

Civil Town Name: Lincoln

Street Address of Well: NA

City, Village: NA

(2) FACILITY NAME

Original Well Owner (If Known): Crandon Mining Company

Present Well Owner: Crandon Mining Company

Street or Route: 7 North Brown Street, 3rd Floor

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

Facility Well No. and/or Name (If applicable): CMC-TMA-102

WI Unique Well No.: _ _ _ _ _ _

Reason For Abandonment: Boring Completion

Date of Abandonment: 02/05/96

WELL/DRILLHOLE/BOREHOLE INFORMATION

(3) Original Well/Drillhole/Borehole Construction Completed On (Date) 02/05/96

☐ Monitoring Well
☐ Water Well
☐ Drillhole
☑ Borehole

Construction Report Available? ☐ Yes ☐ No

Construction Type:
☑ Drilled ☐ Driven (Sandpoint) ☐ Dug
☐ Other (Specify) _____

Formation Type:
☑ Unconsolidated Formation ☐ Bedrock

Total Well Depth (ft.) 262 (From groundsurface) Casing Diameter (ins.) ____

Casing Depth (ft.) _____

Was Well Annular Space Grouted? ☐ Yes ☐ No ☐ Unknown
If Yes, To What Depth? _____ Feet

(4) Depth to Water (Feet) _____

Pump & Piping Removed?	☐ Yes	☐ No	☑ Not Applicable
Liner(s) Removed?	☐ Yes	☐ No	☑ Not Applicable
Screen Removed?	☐ Yes	☐ No	☑ Not Applicable
Casing Left in Place?	☐ Yes	☐ No	

If No, Explain _____

Was Casing Cut Off Below Surface?	☐ Yes	☐ No
Did Sealing Material Rise to Surface?	☑ Yes	☐ No
Did Material Settle After 24 Hours?	☑ Yes	☐ No
If Yes, Was Hole Retopped?	☑ Yes	☐ No

(5) Required Method of Placing Sealing Material
☐ Conductor Pipe-Gravity ☑ Conductor Pipe-Pumped
☐ Dump Bailer ☐ Other (Explain)

(6) Sealing Materials — For monitoring wells and monitoring well boreholes only
☐ Neat Cement Grout
☐ Sand-Cement (Concrete) Grout
☐ Concrete
☐ Clay-Sand Slurry
☑ Bentonite-Sand Slurry
☑ Chipped Bentonite
☐ Bentonite Pellets
☐ Granular Bentonite
☐ Bentonite - Cement Grout

(7)

Sealing Material Used	From (Ft.)	To (Ft.)	No. Yards, Sacks Sealant or Volume	Mix Ratio or Mud Weight
Bentonite Grout/⅜" Hole Plug	Surface	262	2 bags Gel	175 gallons H_2O/100 lb Gel
			2 Granular	100 lb Grannular
			18 hole plug	

(8) Comments: Borehole tapped off with ⅜" hole plug after 24 hours.

(9) Name of Person or Firm Doing Sealing Work
Total Drilling - Luisier Drilling

Signature of Person Doing Work Date Signed

Street or Route: 7391 S Porcupine Lake Road
Telephone Number: (414) 829-5690
City, State, Zip Code: Lena, WI 54139

(10) FOR DNR OR COUNTY USE ONLY

Date Received/Inspected | District/County

Reviewer/Inspector

Follow-up Necessary

DNR/COUNTY

REASONS FOR WELL/DRILLHOLE/BOREHOLE ABANDONMENT

Wis. Adm. Code (NR 111, NR 112, & NR 141) requires well owners to permanently abandon unused wells/drillholes/boreholes on their property. The reasons for this requirement are:

- To prevent contamination from entering the well/drillhole/borehole at the surface or through corroded well casings and moving downward to an aquifer used by other wells, and
- To prevent vertical movement of water between different geologic formations of differing water quality.

Most licensed well drillers and pump installers have the equipment, knowledge and experience needed to permanently abandon wells/drillholes/boreholes. We recommend that these licensed contractors be hired to do this work.

PROCEDURE

1. Remove any pump, pump piping, debris or other obstacles that could interfere with the sealing operation. In most situations the well casing should be left in place. When the casing is removed it should be pulled during the abandonment process so the drillhole does not collapse.
2. The sealing material must be placed with a conductor (tremie) pipe either by pumping or by gravity, (except when approved chipped bentonite is used according to written department instructions and restrictions).
3. The bottom end of the conductor pipe must initially reach the bottom of the well and must be kept submerged in the sealing material as it is placed.
4. Unconsolidated formation wells should be sealed with the materials listed in item (6) on the form. When clay or sodium bentonite slurry is used to fill wells, the top 20 feet must be sealed with neat cement grout, concrete grout, concrete, or bentonite chips. Bedrock formation wells should be filled with neat cement grout, concrete grout, concrete, or bentonite chips. Monitoring wells must be filled with the materials specified by NR 141, Wis. Adm. Code.
5. Fill the entire well column from the bottom to the top with the required sealing material.
6. When using concrete or cement grout, any standing water in the hole will be forced out by the concrete or cement grout (it is more dense) resulting in an entire column of cement to seal the well. The sealing material must flow at the surface with the same consistency as it is being pumped in.
7. The casing may be cut off several feet below the ground surface.
8. To abandon flowing wells, the flow must be stopped or greatly reduced. This can be accomplished by extending the well casing to an elevation higher than the artesian head, or inserting a seal or packer in the casing. Once the flow has been stopped or reduced, the well can be abandoned the same as other wells.
9. For a municipal well, information regarding drillhole diameter and depths and geologic formations should be submitted on a separate sheet.
10. For use of alternative methods and materials, especially for deep, multi-formation wells contact DNR.

TEMPORARY ABANDONMENT

- A well may be temporarily abandoned if it is planned to place the well back in service within a time specified by administrative rule.
- Temporary abandonment is accomplished by threading or welding a watertight cover to the casing or by filling the well with a clean clay slurry and then placing a cover over the well.
- If the well is not placed back into service, it should be permanently abandoned unless a written extension is granted by DNR.

REPORT TO DNR

The Well/Drillhole/Borehole Abandonment Form 3300-5W, on the front, must be completed by the owner (or agent) and submitted to the appropriate DNR district office or delegated county office within 30 days.

This form is authorized by chapters 144, 147 and 162, Wis. Stats. Completion of this report is mandatory. Penalties: Forfeit not less than $10.00 nor more than $5,000.00 for each violation. Fined not less than $10.00 or more than $100.00 or imprisoned not less than 30 days, or both for each violation. Each day of continued violation is a separate offense, pursuant to ss. 144.99 and 162.06, Wis. Stats.

State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☑ Other: Mining

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
Crandon Project - TMA Drilling Program		CMC-TMA-103

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
TD Drilling, Inc. James Meyers	02/09/96	02/09/96	Dual Tube

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
NA	NA	NA	NA	1706.99	5¾ inches

Boring Location
State Plane 117253.21 N, 2286081.08 E S/C/N Lat
NE 1/4 of SE 1/4 of Section 29, T35N, R13E Long

Local Grid Location (if applicable)
____ N ____ E
Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Lincoln

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/Comm
DT-0	0-4			Strong brown (7.5YR4/6) silty sand w/gravel, mottled, 15% gravel subrounded to subangular till	SM									Blow counts = rate of penetration min/5' interval
DT-1	5-7	1.8	5	Dk. brown (7.5YR4/4) silty sand, med. texture, minor subrounded gravel, till	SM									Rec = sampled interval depth below ground surface (ft)
DT-2	10-12	1.8	10	As above, till	SM									
DT-3	15-17	1.8	15	Dk. brown (7.5YR4/4) silty, gravelly sand, coarse texture, 10-15% subrounded gravel, till	SM									
DT-4	20-22	1.8	20	Dk. brown (7.5YR3/4) fine, silty sand w/minor gravel, angular, till	SM									
DT-5	25-27	5.8	25	Dk. brown (7.5YR3/3) fine, silty sand, till	SM									Bit, hose plugging
DT-6	30-32	5.8	30	Boulder, rock cutting sample only	—									Bit, hose plugging
DT-7	35-37	5.8	35	As above, till	SM									Bit, hose plugging
DT-8	40-42	5.8	40	As above, till	SM									Bit, hose plugging
DT-9	45-47	2.5	45	As above w/increased gravel, 5% subrounded	SM									

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature [signature] Firm Foth & Van Dyke

This form is authorized by Chapters 114.147 and 162, Wis. Stats. Completion of this report is mandatory.
Penalties: Forfeit not less than $10 nor more then $5,000 for each violation. Fined not less than $10 or more than $100 or imprisoned not less than 30 days, or both for each violation. Each day of continued violation is a separate offense, pursuant to ss 114.06, Wis. Stats.

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
DT-10	50-52	2.5	50	As above, till	SM									
DT-11	55-57	2.5	55	As above, till	SM									
DT-12	60-62	2.5	60	As above, till	SM									
DT-13	65-67	2	65	Greyish brown (7.5YR5/2) gravelly, med.-coarse texture sand, coarse outwash	SP									
DT-14	70-72	2	70	As above, coarse outwash	SP									
DT-15	75-77	2	75	As above, grading to lt. brown (10YR5/3) med. texture sand w/less gravel, 10%, coarse outwash	SP									
DT-16	80-82	2	80	Greyish brown (10YR5/2) sandy (coarse texture), gravel	GP									
DT-17	85-87	1.5	85	As above	GP									
DT-18	90-92	1.5	90	Brown (10YR4/3) med. texture sand w/5-10% subrounded gravel, coarse outwash	SP									
DT-19	95-97	1.5	95	As above, coarse outwash	SP									
DT-20	100-102	1.5	100	As above, coarse outwash	SP									
DT-21	105-107	5	105	Very dk. brown, fine, silty sand, fine outwash	SM									Bit plugging
DT-22	110-112	5	110	Lt. olive brown (2YR5/3) fine, silty sand, fine outwash	SM									Bit plugging
DT-23	115-117	5	115	As above, grading to med. texture & dk. olive grey (5Y5/2), fine outwash	SP									Bit plugging
DT-24	120-122	5	120	As above, fine outwash	SP									Bit plugging

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
DT-25	125-127	2.3	125	Greyish brown (10YR5/2) med. texture sand w/5% rounded gravel, coarse outwash	SP									
DT-26	130-132	2.3	130	As above, grading to med.-fine sand w/5-10% subrounded gravel	SP									
DT-27	135-137	2.3	135	Lt. brown (10YR5/3) coarse outwash, as above, coarse outwash	SP									
DT-28	140-142	2.3	140	As above	SP									
DT-29	145-147	1.8	145	Dk. brown (10YR3/3) silty gravelly sand, 10-15% gravel subrounded to angular, till	SM									
DT-30	150-152	1.8	150	As above, till	SM									
DT-31	155-157	1.8	155	Yellowish brown (10YR5/4) silty, gravelly sand, till (washed)	SM									
DT-32	160-162	1.8	160	As above, till (washed)	SM									
DT-33	165-167	2.0	165	Dk. brown (7.5YR4/3) silty sand, med. texture w/gravel 5-10% subrounded to angular, till	SM									
DT-34	170-172	2.8	170	As above, grading redder brown (7.5YR3/4), till	SM									
DT-35	175-177	3.0	175	As above, till	SM									
DT-36	180-182	2.8	180	As above, till	SM									
DT-37	185-187	2	185	As above, grading to lighter brown (7.5YR4/3), till	SM									
DT-38	190-192	2	190	As above, till	SM									
DT-39	195-197	2	195	As above	SM									

State of Wisconsin | Route to: | SOIL BORING LOG INFORMATION

Department of Natural Resources | Form 4400-122 7-91

BORING NUMBER: CMC-TMA-103 |

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
DT-40	200-202	2	200	As above, grading to dk. brown (7.5YR4/2), till	SM									
DT-41	205-207	1.5	205	Brown (7.5YR4/6) fine sand, fine outwash	SM									Very soft
DT-42	210-212	1.5	210	Greyish brown (7.5YR5/3) very coarse sand w/gravel, coarse outwash	SP									Very soft
DT-43	215-217	1.5	215	As above, grading to lt. brown (7.5YR5/4) med.-fine texture sand, fine outwash	SP									Very soft
DT-44	220-222	1.5	220	Brown (7.5YR5/4) fine sand, fine outwash	SP									Very soft
DT-45	225-227	1.5	225	As above, fine outwash	SP									Bit plugged twice from 220-240 pulled out twice
DT-46	230-232	1.5	230	As above, fine outwash	SP									
DT-47	235-237	1.5	235	As above, fine outwash	SP									
DT-48	240-242	1.5	240	As above, fine outwash	SP									
DT-49	245-247	3.8	245	Dk. brown (7.5YR4/4) fine, very silty sand w/minor gravel, till	SM									
DT-50	250-252	3.8	250	As above, grading to med. texture silty sand w/10% angular gravel, till	SM									
DT-51	255-257	3.8	255	As above, till	SM									
DT-52	260-262	3.8	260	As above, till	SM									
				E.O.B. @ 260' Hole abandoned w/bentonite grout Topped off w/hole plug										

State of Wisconsin
Department of Natural Resources

WELL/DRILLHOLE/BOREHOLE ABANDONMENT

Form 3300-5W 11-89

All abandonment work shall be performed in accordance with the provisions of Chapters NR 111, NR 112 or NR 141, Wis. Admin. Code, whichever is applicable. Also, see instructions on back.

(1) GENERAL INFORMATION

Well/Drillhole/Borehole Location | County: Forest

NE ¼ of SE ¼ of Sec. 29 ; T. 35 N R. 13 ☑ E ☐ W

(If applicable) _____ Gov't Lot _____ Grid Number

Grid Location
117253.21 ft. ☑ N. ☐ S., 2286081.08 ft. ☑ E. ☐ W.

Civil Town Name
Lincoln

Street Address of Well
NA

City, Village
NA

(2) FACILITY NAME

Original Well Owner (If Known)
Crandon Mining Company

Present Well Owner
Crandon Mining Company

Street or Route
7 North Brown Street, 3rd Floor

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

Facility Well No. and/or Name (If applicable)
CMC-TMA-103

WI Unique Well No.
_ _ _ _ _ _

Reason For Abandonment
Boring Completion

Date of Abandonment
02/09/96

WELL/DRILLHOLE/BOREHOLE INFORMATION

(3) Original Well/Drillhole/Borehole Construction Completed On
(Date) 02/09/96

☐ Monitoring Well
☐ Water Well
☐ Drillhole
☑ Borehole

Construction Report Available?
☐ Yes ☐ No

Construction Type:
☑ Drilled ☐ Driven (Sandpoint) ☐ Dug
☐ Other (Specify) _____

Formation Type:
☑ Unconsolidated Formation ☑ Bedrock

Total Well Depth (ft.) 262 (From groundsurface) Casing Diameter (ins.) ____

Casing Depth (ft.) _____

Was Well Annular Space Grouted? ☐ Yes ☐ No ☐ Unknown
If Yes, To What Depth? _____ Feet

(4) Depth to Water (Feet) _____

Pump & Piping Removed?	☐ Yes	☐ No	☑ Not Applicable
Liner(s) Removed?	☐ Yes	☐ No	☑ Not Applicable
Screen Removed?	☐ Yes	☐ No	☑ Not Applicable
Casing Left in Place?	☐ Yes	☐ No	

If No, Explain _____

Was Casing Cut Off Below Surface?	☐ Yes	☐ No
Did Sealing Material Rise to Surface?	☑ Yes	☐ No
Did Material Settle After 24 Hours?	☑ Yes	☐ No
If Yes, Was Hole Retopped?	☑ Yes	☐ No

(5) Required Method of Placing Sealing Material
☐ Conductor Pipe-Gravity ☑ Conductor Pipe-Pumped
☐ Dump Bailer ☐ Other (Explain)

(6) Sealing Materials — For monitoring wells and monitoring well boreholes only
☐ Neat Cement Grout
☐ Sand-Cement (Concrete) Grout
☐ Concrete
☐ Clay-Sand Slurry
☑ Bentonite-Sand Slurry
☑ Chipped Bentonite
☐ Bentonite Pellets
☐ Granular Bentonite
☐ Bentonite - Cement Grout

(7)

Sealing Material Used	From (Ft.)	To (Ft.)	No. Yards, Sacks Sealant or Volume	Mix Ratio or Mud Weight
Bentonite Grout/⅜" Hole Plug	Surface	262	3 bags Gel	200 gallons H_2O/150 lb Gel
			4 Granular	200 lb Grannular
			10 hole plug	

(8) Comments: Borehole tapped off with ⅜" hole plug after 24 hours.

(9) Name of Person or Firm Doing Sealing Work
Total Drilling - Luisier Drilling

Signature of Person Doing Work Date Signed
Tim Maguire

Street or Route
7391 S Porcupine Lake Road

Telephone Number
(414) 829-5690

City, State, Zip Code
Lena, WI 54139

(10) FOR DNR OR COUNTY USE ONLY

Date Received/Inspected	District/County
Reviewer/Inspector	
Follow-up Necessary	

DNR/COUNTY

REASONS FOR WELL/DRILLHOLE/BOREHOLE ABANDONMENT

Wis. Adm. Code (NR 111, NR 112, & NR 141) requires well owners to permanently abandon unused wells/drillholes/boreholes on their property. The reasons for this requirement are:

- To prevent contamination from entering the well/drillhole/borehole at the surface or through corroded well casings and moving downward to an aquifer used by other wells, and
- To prevent vertical movement of water between different geologic formations of differing water quality.

Most licensed well drillers and pump installers have the equipment, knowledge and experience needed to permanently abandon wells/drillholes/boreholes. We recommend that these licensed contractors be hired to do this work.

PROCEDURE

1. Remove any pump, pump piping, debris or other obstacles that could interfere with the sealing operation. In most situations the well casing should be left in place. When the casing is removed it should be pulled during the abandonment process so the drillhole does not collapse.
2. The sealing material must be placed with a conductor (tremie) pipe either by pumping or by gravity, (except when approved chipped bentonite is used according to written department instructions and restrictions).
3. The bottom end of the conductor pipe must initially reach the bottom of the well and must be kept submerged in the sealing material as it is placed.
4. Unconsolidated formation wells should be sealed with the materials listed in item (6) on the form. When clay or sodium bentonite slurry is used to fill wells, the top 20 feet must be sealed with neat cement grout, concrete grout, concrete, or bentonite chips. Bedrock formation wells should be filled with neat cement grout, concrete grout, concrete, or bentonite chips. Monitoring wells must be filled with the materials specified by NR 141, Wis. Adm. Code.
5. Fill the entire well column from the bottom to the top with the required sealing material.
6. When using concrete or cement grout, any standing water in the hole will be forced out by the concrete or cement grout (it is more dense) resulting in an entire column of cement to seal the well. The sealing material must flow at the surface with the same consistency as it is being pumped in.
7. The casing may be cut off several feet below the ground surface.
8. To abandon flowing wells, the flow must be stopped or greatly reduced. This can be accomplished by extending the well casing to an elevation higher than the artesian head, or inserting a seal or packer in the casing. Once the flow has been stopped or reduced, the well can be abandoned the same as other wells.
9. For a municipal well, information regarding drillhole diameter and depths and geologic formations should be submitted on a separate sheet.
10. For use of alternative methods and materials, especially for deep, multi-formation wells contact DNR.

TEMPORARY ABANDONMENT

- A well may be temporarily abandoned if it is planned to place the well back in service within a time specified by administrative rule.
- Temporary abandonment is accomplished by threading or welding a watertight cover to the casing or by filling the well with a clean clay slurry and then placing a cover over the well.
- If the well is not placed back into service, it should be permanently abandoned unless a written extension is granted by DNR.

REPORT TO DNR

The Well/Drillhole/Borehole Abandonment Form 3300-5W, on the front, must be completed by the owner (or agent) and submitted to the appropriate DNR district office or delegated county office within 30 days.

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State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☑ Other: Mining

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
Crandon Project - TMA Drilling Program		CMC-TMA-104

Boring Drilled by (Firm name and name of crew chief)	Date Started	Date Completed	Drilling Method
TD Drilling, Inc. James Meyers	MM/DD/YY 02/08/96	MM/DD/YY 02/08/96	Dual Tube

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
NA	NA	NA	NA	1719.83	5¾ inches

Boring Location
State Plane 116551.79 N, 2286501.98 E S/C/N Lat
SE 1/4 of SE 1/4 of Section 29, T35N, R13E Long

Local Grid Location (if applicable)
____ N ____ E
Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Lincoln

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/Comm
DT-0	0-4			Yellowish brown (10YR5/4) sandy clay w/minor subangular gravel, till	CL									Blow counts = rate of penetration min/5' interval
DT-1	5-7	1.3	5	Brown (7.5YR4/6) silty sand, coarse textured w/abundant gravel, subangular to subrounded, till	SP-SM									Rec = sampled interval depth below ground surface (ft)
DT-2	10-12	1.3	10	As above, grading to finer texture sand w/minor gravel & increased silt, till	SM									
DT-3	15-17	1.3	15	Brown (7.5YR4/4) silty sand w/10-15% subangular gravel, till	SM									
DT-4	20-22	1.3	20	As above, grading to lighter brown (7.5YR6/4), till	SM									
DT-5	25-27	2	25	As above, till	SM									
DT-6	30-32	1	30	Lt. brown (7.5(YR6/4) fine sand w/minor silt & gravel, 10-15%, fine outwash, washed till	SP-SM									
DT-7	35-37	45	35	As above, grading to grey (7.5YR6/2) fine silt & sand boulder, till	SM									Bad bit Replaced bit and sub
DT-8	40-42	3	40	As above, till	SM									
DT-9	45-47	3.5	45	As above, till										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature [signature] Firm Foth & Van Dyke

This form is authorized by Chapters 114.147 and 162, Wis. Stats. Completion of this report is mandatory.
Penalties: Forfeit not less than $10 nor more then $5,000 for each violation. Fined not less than $10 or more than $100 or imprisoned not less than 30 days, or both for each violation. Each day of continued violation is a separate offense, pursuant to ss 114.06, Wis. Stats.

State of Wisconsin
Department of Natural Resources
BORING NUMBER: CMC-TMA-104

Route to:

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
DT-10	50-52	3.5	50	Brown (7.5YR5/4) silty sand, fine-med. textured w/minor gravel, till	SM									
DT-11	55-57	3.5	55	As above w/boulders, till	SP-SM									
DT-12	60-62	4	60	As above w/boulders, till										
DT-13	65-67	1.8	65	Brown (7.5YR4/6) silty sand w/minor gravel, subangular, till	SM									
DT-14	70-72	1.8	70	As above, grading to lt. brown (7.5YR4/2) due to boulders, till	SP-SM									
DT-15	75-77	2	75	As above (7.5YR4/2) grading to dk. brownish grey, till	SM									
DT-16	80-82	1.8	80	As above, grading to lt. greyish brown (7.5YR5/2) due to boulders, till	SP-SM									
DT-17	85-87	4.3	85	As above, boulders, till	SP-SM									
DT-18	90-92	5	90	Greyish brown (7.5YR5/3), coarse texture sand w/gravel 10-15%, coarse outwash	SP									
DT-19	95-97	3	95	As above, coarse outwash	SP									
DT-20	100-102	3	100	As above, coarse outwash	SP									
DT-21	105-107	2.3	105	As above, coarse outwash	SP									
DT-22	110-112	2.3	110	As above, fine-med. texture, coarseoutwash	SP									
DT-23	115-117	2.3	115	Brown (7.5YR5/4) silty sand w/gravel minor subangular, till	SM									
DT-24	120-122	2.3	120	As above, no sample - boulders	SM									

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
DT-25	125-127	5	125	As above, till, boulder	SM									
DT-26	130-132	2	130	Lt. brown (10YR5/3) coarse textured sand w/gravel rounded to subrounded, coarse outwash	SP									
DT-27	135-137	2	135	As above, coarse outwash w/increased fine sand	SP									
DT-28	140-142	2	140	As above, coarse outwash										
DT-29	145-147	1.5	145	Dk. brown (7.5YR4/4) silty sand w/minor gravel, subangular to angular, till	SM									
DT-30	150-152	1.5	150	As above, till	SM									
DT-31	155-157	1.5	155	Poor return appears as above, till										Plugging
DT-32	160-162	1.5	160	As above, grading to 7.5YR4/6, till	SM									
DT-33	165-167	1.8	165	As above, till	SM									
DT-34	170--177	1.8	170	As above, grading to coarse textured silty sand w/gravel, till	SM									
DT-35	175-177	1.8	175	As above, till	SM									
DT-36	180-182	1.8	180	As above, till	SM									
DT-37	185-187	5	185	As above, till	SM									
DT-38	190-192	2	190	Lt. brown (7.5YR5/4) fine sand w/minor silt, fine outwash	SP									
DT-39	195-197	2	195	As above	SP									

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
DT-40	200-202	2	200	As above, grading to lighter brown (7.5YR6/4), fine outwash	SP									
DT-41	205-207	4.8	205	As above	SP									Bit plugged
DT-42	210 212	3	210	Dk. brown (7.5YR4/3) silty sand, med. texture w/minor round to angular gravel, till	SM									
DT-43	215-217	3	215	As above, till	SM									
DT-44	220-222	3	220	As above, till	SM									
DT-45	225-227	5	225	As above, poor recovery, till	SM									Bit plugging from 220-240'
DT-46	230-232	5	230	As above, poor recovery, till	SM									
DT-47	235-237	5	235	As above, poor recovery, till	SM									
DT-48	240-242	5	240	As above, poor recovery, till	SM									
DT-49	245-247	3	245	Dk. brown (7.5YR4/4) silty sand w/gravel 5-10% angular, till	SM									
DT-50	250-252	3	250	As above, till	SM									
DT-51	255-257	3	255	As above, till	SM									
DT-52	260-262	3	260	As above, till	SM									
DT-62	265-267	5	265	As above w/increased clay, till	SM									Bit plugging to end of hole
DT-72	270-272	5	270	As above, grading to strong brown (7.5YR4/6), till	SM									

State of Wisconsin | Route to: | SOIL BORING LOG INFORMATION

Department of Natural Resources | Form 4400-122 | 7-91

BORING NUMBER: CMC-TMA-104 |

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
DT-82	275-277	5	275	Hit bedrock at 272.5, grey-green, saprolite?	BR									
				277-278 - metavolcanic unweathered bedrock Cuttings logged by CMC										
				E.O.B. @ 278'										
				Hole abandoned w/bentonite grout Due to frequent plugging, water used at 150 feet Topped off w/hole plug	BR									
				Supplemental Bedrock, AJE Jr 2/27/98										
				275-277. Grey-green fine grained probable metatuff. "Greenstone. No sulfides noted in cuttings. Cuttings soft pasty, clay weathered. Possible saprolite?										

State of Wisconsin
Department of Natural Resources

WELL/DRILLHOLE/BOREHOLE ABANDONMENT

Form 3300-5W 11-89

All abandonment work shall be performed in accordance with the provisions of Chapters NR 111, NR 112 or NR 141, Wis. Admin. Code, whichever is applicable. Also, see instructions on back.

(1) GENERAL INFORMATION

Well/Drillhole/Borehole Location | County: Forest

SE ¼ of SE ¼ of Sec. 29 ; T. 35 N R. 13 ☑ E ☐ W

(If applicable) _____ Gov't Lot _____ Grid Number

Grid Location: 116551.79 ft. ☑ N. ☐ S., 2286501.98 ft. ☑ E. ☐ W.

Civil Town Name: Lincoln

Street Address of Well: NA

City, Village: NA

(2) FACILITY NAME

Original Well Owner (If Known): Crandon Mining Company

Present Well Owner: Crandon Mining Company

Street or Route: 7 North Brown Street, 3rd Floor

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

Facility Well No. and/or Name (If applicable): CMC-TMA-104

WI Unique Well No.: _ _ _ _ _ _

Reason For Abandonment: Boring Completion

Date of Abandonment: 02/08/96

WELL/DRILLHOLE/BOREHOLE INFORMATION

(3) Original Well/Drillhole/Borehole Construction Completed On (Date) 02/08/96

☐ Monitoring Well
☐ Water Well
☐ Drillhole
☑ Borehole

Construction Report Available? ☐ Yes ☐ No

Construction Type:
☑ Drilled ☐ Driven (Sandpoint) ☐ Dug
☐ Other (Specify) _____

Formation Type:
☑ Unconsolidated Formation ☑ Bedrock

Total Well Depth (ft.) 278 (From groundsurface) Casing Diameter (ins.) ____

Casing Depth (ft.) ____

Was Well Annular Space Grouted? ☐ Yes ☐ No ☐ Unknown
If Yes, To What Depth? _____ Feet

(4) Depth to Water (Feet) _____

Pump & Piping Removed?	☐ Yes	☐ No	☑ Not Applicable
Liner(s) Removed?	☐ Yes	☐ No	☑ Not Applicable
Screen Removed?	☐ Yes	☐ No	☑ Not Applicable
Casing Left in Place?	☐ Yes	☐ No	

If No, Explain _____

Was Casing Cut Off Below Surface?	☐ Yes	☐ No
Did Sealing Material Rise to Surface?	☑ Yes	☐ No
Did Material Settle After 24 Hours?	☑ Yes	☐ No
If Yes, Was Hole Retopped?	☑ Yes	☐ No

(5) Required Method of Placing Sealing Material
☐ Conductor Pipe-Gravity ☑ Conductor Pipe-Pumped
☐ Dump Bailer ☐ Other (Explain)

(6) Sealing Materials — For monitoring wells and monitoring well boreholes only
☐ Neat Cement Grout
☐ Sand-Cement (Concrete) Grout
☐ Concrete
☐ Clay-Sand Slurry
☑ Bentonite-Sand Slurry
☑ Chipped Bentonite
☐ Bentonite Pellets
☐ Granular Bentonite
☐ Bentonite - Cement Grout

(7)

Sealing Material Used	From (Ft.)	To (Ft.)	No. Yards, Sacks Sealant or Volume	Mix Ratio or Mud Weight
Bentonite Grout/⅜" Hole Plug	Surface	278	3.5 bags Gel	175 gallons H_2O/160 lb Gel
			3 Granular	150 lb Grannular

(8) Comments: Borehole tapped off with ⅜" hole plug after 24 hours.

(9) Name of Person or Firm Doing Sealing Work
Total Drilling - Luisier Drilling

Signature of Person Doing Work Date Signed

Street or Route: 7391 S Porcupine Lake Road
Telephone Number: (414) 829-5690
City, State, Zip Code: Lena, WI 54139

(10) FOR DNR OR COUNTY USE ONLY

Date Received/Inspected | District/County

Reviewer/Inspector

Follow-up Necessary

DNR/COUNTY

REASONS FOR WELL/DRILLHOLE/BOREHOLE ABANDONMENT

Wis. Adm. Code (NR 111, NR 112, & NR 141) requires well owners to permanently abandon unused wells/drillholes/boreholes on their property. The reasons for this requirement are:

- To prevent contamination from entering the well/drillhole/borehole at the surface or through corroded well casings and moving downward to an aquifer used by other wells, and
- To prevent vertical movement of water between different geologic formations of differing water quality.

Most licensed well drillers and pump installers have the equipment, knowledge and experience needed to permanently abandon wells/drillholes/boreholes. We recommend that these licensed contractors be hired to do this work.

PROCEDURE

1. Remove any pump, pump piping, debris or other obstacles that could interfere with the sealing operation. In most situations the well casing should be left in place. When the casing is removed it should be pulled during the abandonment process so the drillhole does not collapse.
2. The sealing material must be placed with a conductor (tremie) pipe either by pumping or by gravity, (except when approved chipped bentonite is used according to written department instructions and restrictions).
3. The bottom end of the conductor pipe must initially reach the bottom of the well and must be kept submerged in the sealing material as it is placed.
4. Unconsolidated formation wells should be sealed with the materials listed in item (6) on the form. When clay or sodium bentonite slurry is used to fill wells, the top 20 feet must be sealed with neat cement grout, concrete grout, concrete, or bentonite chips. Bedrock formation wells should be filled with neat cement grout, concrete grout, concrete, or bentonite chips. Monitoring wells must be filled with the materials specified by NR 141, Wis. Adm. Code.
5. Fill the entire well column from the bottom to the top with the required sealing material.
6. When using concrete or cement grout, any standing water in the hole will be forced out by the concrete or cement grout (it is more dense) resulting in an entire column of cement to seal the well. The sealing material must flow at the surface with the same consistency as it is being pumped in.
7. The casing may be cut off several feet below the ground surface.
8. To abandon flowing wells, the flow must be stopped or greatly reduced. This can be accomplished by extending the well casing to an elevation higher than the artesian head, or inserting a seal or packer in the casing. Once the flow has been stopped or reduced, the well can be abandoned the same as other wells.
9. For a municipal well, information regarding drillhole diameter and depths and geologic formations should be submitted on a separate sheet.
10. For use of alternative methods and materials, especially for deep, multi-formation wells contact DNR.

TEMPORARY ABANDONMENT

- A well may be temporarily abandoned if it is planned to place the well back in service within a time specified by administrative rule.
- Temporary abandonment is accomplished by threading or welding a watertight cover to the casing or by filling the well with a clean clay slurry and then placing a cover over the well.
- If the well is not placed back into service, it should be permanently abandoned unless a written extension is granted by DNR.

REPORT TO DNR

The Well/Drillhole/Borehole Abandonment Form 3300-5W, on the front, must be completed by the owner (or agent) and submitted to the appropriate DNR district office or delegated county office within 30 days.

This form is authorized by chapters 144, 147 and 162, Wis. Stats. Completion of this report is mandatory. Penalties: Forfeit not less than $10.00 nor more than $5,000.00 for each violation. Fined not less than $10.00 or more than $100.00 or imprisoned not less than 30 days, or both for each violation. Each day of continued violation is a separate offense, pursuant to ss. 144.99 and 162.06, Wis. Stats.

State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☑ Other: Mining

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
Crandon Mining Company - Crandon TMA Site		CMC-TMA-105

Boring Drilled by (Firm name and name of crew chief)	Date Started	Date Completed	Drilling Method
TD Drilling, Inc. James Meyers	MM/DD/YY 01/23/96	MM/DD/YY 02/09/96	Rotary Mud/Dual Tube

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
NA	NA	NA	NA	1704.01	5¾ inches

Boring Location
State Plane 112723.05 N, 2286269.23 E S/C/N Lat
NE 1/4 of NE 1/4 of Section 35, T35N, R13E Long

Local Grid Location (if applicable)
____ N ____ E
Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Lincoln

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
SS-1 1-3'	6"	Air hammer		1-3' Med. brown (7.5YR5/3) silty sand, blocky structure, abundant round & angular pebbles Late Wis. Till	SM									
SS-2 10-12	8"	Air hammer	10	As above, grading to silty, clayey sand	SM									
SS-3 18-19.5	6"	Air hammer	20	18-19.5 as above, brown (7.5YR5/4) silty sand w/gravel, round to subangular mod. med. blocky structure, till	SM									
SS-4 28-29	1.5"	Air hammer	30	Appears as above, silty sand w/gravel	SM									
SS-5 38-39	4"	Air hammer	40	As above, cobbles preventing advancement of spoon	SM									
SS-6 50-52	6"	Air hammer	50	As above, very damp till	SM									
SS-7	2"	Air hammer	60	As above, till	SM									
SS-8 70-72	0	Air hammer	70	Pounding cobbles	—									
SS-9 72-73	3"			As above, till	SM									
SS-10 80-82	0	Air hammer	80	Pounding cobbles, spoon refusal	—									
SS-11 82-94	0													
SS-12 90-92	3"	Air hammer	90	As above, much more sand, till	SM-SP									

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm
	Foth & Van Dyke

This form is authorized by Chapters 114.147 and 162, Wis. Stats. Completion of this report is mandatory.
Penalties: Forfeit not less than $10 nor more then $5,000 for each violation. Fined not less than $10 or more than $100 or imprisoned not less than 30 days, or both for each violation. Each day of continued violation is a separate offense, pursuant to ss 114.06, Wis. Stats.

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
SS-13 100-102	3″	Air hammer	100	Lt. brown (7.5YR6/5) fine-med. sand, poorly graded, w/ minor gravel and minor silt, structureless, wet, loose (coarse outwash)	SP									
SS-14 110-112	18″	Air hammer	110	Yellowish red (5YR4/6) silty sand w/gravel, massive, dense, very damp, sl. hard (till)										
SS-15 120-122	24″	Air hammer	120	Strong brown (7.5YR4/6) fine sandy silt, minor clay laminae & some fine lenses, weak med. to fine platey structure, very damp, sl. firm to soft, locally oxidized, bottom spoon (3″) fine silt, minor sand w/fine sand lenses (lacustrine)	ML-SM									
SS-16 130-132	8″	Air hammer	130	Brown (7.5YR4/4) med. coarse, rounded gravelly sand, structureless, very damp to wet, loose, oxidized (outwash)	ML									
SS-17 140-142	10″	Air hammer	140	Strong brown (7.5YR5/6) fine-med. sand w/gravel, structureless, wet, weak stratification (outwash)	SP									
SS-18 150-152	10″	Air hammer	150	As above	SP									
SS-19 160-162	9″	Air hammer	160	Yellowish red (5YR5/8) silty sand w/gravel, massive, wet, sl. hard (till)	SM-SP									
SS-20 170-172	3″	Air hammer	170	As above	SM-SP									
SS-21 180-182	3″	Air hammer	180	Brown (7.5YR5/5) fine-med. sand w/silt & gravel, massive, wet, soft (washed till)	SM-SP									
SS-22 190-192	3″	Air hammer	190	Brown (7.5YR4/4) silty sand w/gravel, massive, dense, firm (till)	SM-SP									
SS-23	12″	Air hammer	200	Brown (7.5YR5/4) med.-coarse sand, structureless-weakly structured, subangular round gravel (coarse outwash)	SP									
SS-24	18″	Air hammer	210	As above, with fine sand lense at 211-211.5 (coarse outwash) Switch to dual tube	SP									Switched to dual tube at 210
DT-1	220-222	0.8	220	As above, grading to 7.5YR5/6, fine outwash w/mud	SP									Blow counts = rate of penetration min/5′ interval
DT-2	225-227	0.8	225	As above, grading to 7.5YR4/6, sl. darker brown, fine outwash	SP									Rec = sampled interval depth below ground surface (ft)
DT-3	230 232	0.8	230	As above, grading to sl. darker brown, fine sand (7.5YR4/4), fine outwash	SP									

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
DT-4	235-237	0.8	235	As above, fine outwash	SP									
DT-5	240-242	0.8	240	Dk. reddish brown (5YR3/4) fine silty sand and fine clayey sand w/minor subangular gravel, till	SM									
DT-6	245-247	4.8	245	As above, till	SM									Plugging to 260'
DT-7	250-252	4.8	250	As above, till	SM									
DT-8	255-257	4.8	255	As above, till	SM									
DT-9	260-262	6.0	260	As above, till	SM									
DT-10	265-267	1	265	As above, w/increased angular gravel, 10%, and grading to med. to coarse texture, silty sand, till	SM									
DT-11	270-272	1	270	Dk. reddish brown (5YR3/4), coarse texture, silty sand and gravel, 15% subangular, till	SP-SM									
DT-12	275-277	1	275	Missed sample										
DT-13	280-282	1	280	As above, till	SP-SM									
DT-14	285-287	2	285	As above, till	SP-SM									
DT-15	290-292	2	290	Dk. reddish brown (5YR3/4), silty, clayey sand w.minor gravel, med. texture, till	SM-SC									
DT-16	295-297	2	295	As above w/10% subangular to subrounded gravel, till	SM-SC									
DT-17	300-302	2	300	298 - Bedrock, metavolcanic, weathered, cuttings logged by CMC	BR									
DT-18	305-307	8	305	Greenish grey metavolcanic bedrock, weakly-moderately weathered, cuttings logged by CMC	BR									

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
DT-19	310-312		310	As above, cutting logged by CMC	BR									
				E.O.B. @ 312' Hole abandoned w/bentonite grout Topped off w/hole plug Supplemental Bedrock, AJE Jr. 2/17/98 298-302 Tan weakly weathered grey-green fine metatuff. "Greenstone". 302-312 Grey-green fine grained metatuff. "Greenstone". Trace quartz veinlet chips. No sulfides noted in bedrock.									

State of Wisconsin
Department of Natural Resources

WELL/DRILLHOLE/BOREHOLE ABANDONMENT

Form 3300-5W 11-89

All abandonment work shall be performed in accordance with the provisions of Chapters NR 111, NR 112 or NR 141, Wis. Admin. Code, whichever is applicable. Also, see instructions on back.

(1) GENERAL INFORMATION

Well/Drillhole/Borehole Location | County: Forest

NE ¼ of SE ¼ of Sec. 35 ; T. 35 N R. 13 ☑ E ☐ W

(If applicable) _____ Gov't Lot _____ Grid Number

Grid Location
112723.05 ft. ☑ N. ☐ S., 2286269.23 ft. ☑ E. ☐ W.

Civil Town Name
Lincoln

Street Address of Well
NA

City, Village
NA

(2) FACILITY NAME

Original Well Owner (If Known)
Crandon Mining Company

Present Well Owner
Crandon Mining Company

Street or Route
7 North Brown Street, 3rd Floor

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

Facility Well No. and/or Name (If applicable)
CMC-TMA-105

WI Unique Well No.
_ _ _ _ _ _

Reason For Abandonment
Boring Completion

Date of Abandonment
02/09/96

WELL/DRILLHOLE/BOREHOLE INFORMATION

(3) Original Well/Drillhole/Borehole Construction Completed On
(Date) 02/09/96

☐ Monitoring Well
☐ Water Well
☐ Drillhole
☑ Borehole

Construction Report Available? ☐ Yes ☐ No

Construction Type:
☑ Drilled ☐ Driven (Sandpoint) ☐ Dug
☐ Other (Specify) _____

Formation Type:
☑ Unconsolidated Formation ☐ Bedrock

Total Well Depth (ft.) 312 (From groundsurface) Casing Diameter (ins.) ____

Casing Depth (ft.) _____

Was Well Annular Space Grouted? ☐ Yes ☐ No ☐ Unknown
If Yes, To What Depth? _____ Feet

(4) Depth to Water (Feet) _____

Pump & Piping Removed?	☐ Yes	☐ No	☑ Not Applicable
Liner(s) Removed?	☐ Yes	☐ No	☑ Not Applicable
Screen Removed?	☐ Yes	☐ No	☑ Not Applicable
Casing Left in Place?	☐ Yes	☐ No	

If No, Explain _____

Was Casing Cut Off Below Surface?	☐ Yes	☐ No
Did Sealing Material Rise to Surface?	☑ Yes	☐ No
Did Material Settle After 24 Hours?	☑ Yes	☐ No
If Yes, Was Hole Retopped?	☑ Yes	☐ No

(5) Required Method of Placing Sealing Material
☐ Conductor Pipe-Gravity ☑ Conductor Pipe-Pumped
☐ Dump Bailer ☐ Other (Explain)

(6) Sealing Materials — For monitoring wells and monitoring well boreholes only
☐ Neat Cement Grout
☐ Sand-Cement (Concrete) Grout
☐ Concrete
☐ Clay-Sand Slurry
☑ Bentonite-Sand Slurry
☑ Chipped Bentonite
☐ Bentonite Pellets
☐ Granular Bentonite
☐ Bentonite - Cement Grout

(7) Sealing Material Used	From (Ft.)	To (Ft.)	No. Yards, Sacks Sealant or Volume	Mix Ratio or Mud Weight
Bentonite Grout/⅜" Hole Plug	Surface	312	4 bags Gel	220 gallons H_2O/200 lb Gel
			4 Granular	200 lb Grannular
			22 hole plug	

(8) Comments: Borehole tapped off with ⅜" hole plug after 24 hours.

(9) Name of Person or Firm Doing Sealing Work
Total Drilling - Luisier Drilling

Signature of Person Doing Work Date Signed

Street or Route: 7391 S Porcupine Lake Road
Telephone Number: (414) 829-5690
City, State, Zip Code: Lena, WI 54139

(10) FOR DNR OR COUNTY USE ONLY
Date Received/Inspected | District/County
Reviewer/Inspector
Follow-up Necessary

DNR/COUNTY

REASONS FOR WELL/DRILLHOLE/BOREHOLE ABANDONMENT

Wis. Adm. Code (NR 111, NR 112, & NR 141) requires well owners to permanently abandon unused wells/drillholes/boreholes on their property. The reasons for this requirement are:

- To prevent contamination from entering the well/drillhole/borehole at the surface or through corroded well casings and moving downward to an aquifer used by other wells, and
- To prevent vertical movement of water between different geologic formations of differing water quality.

Most licensed well drillers and pump installers have the equipment, knowledge and experience needed to permanently abandon wells/drillholes/boreholes. We recommend that these licensed contractors be hired to do this work.

PROCEDURE

1. Remove any pump, pump piping, debris or other obstacles that could interfere with the sealing operation. In most situations the well casing should be left in place. When the casing is removed it should be pulled during the abandonment process so the drillhole does not collapse.
2. The sealing material must be placed with a conductor (tremie) pipe either by pumping or by gravity, (except when approved chipped bentonite is used according to written department instructions and restrictions).
3. The bottom end of the conductor pipe must initially reach the bottom of the well and must be kept submerged in the sealing material as it is placed.
4. Unconsolidated formation wells should be sealed with the materials listed in item (6) on the form. When clay or sodium bentonite slurry is used to fill wells, the top 20 feet must be sealed with neat cement grout, concrete grout, concrete, or bentonite chips. Bedrock formation wells should be filled with neat cement grout, concrete grout, concrete, or bentonite chips. Monitoring wells must be filled with the materials specified by NR 141, Wis. Adm. Code.
5. Fill the entire well column from the bottom to the top with the required sealing material.
6. When using concrete or cement grout, any standing water in the hole will be forced out by the concrete or cement grout (it is more dense) resulting in an entire column of cement to seal the well. The sealing material must flow at the surface with the same consistency as it is being pumped in.
7. The casing may be cut off several feet below the ground surface.
8. To abandon flowing wells, the flow must be stopped or greatly reduced. This can be accomplished by extending the well casing to an elevation higher than the artesian head, or inserting a seal or packer in the casing. Once the flow has been stopped or reduced, the well can be abandoned the same as other wells.
9. For a municipal well, information regarding drillhole diameter and depths and geologic formations should be submitted on a separate sheet.
10. For use of alternative methods and materials, especially for deep, multi-formation wells contact DNR.

TEMPORARY ABANDONMENT

- A well may be temporarily abandoned if it is planned to place the well back in service within a time specified by administrative rule.
- Temporary abandonment is accomplished by threading or welding a watertight cover to the casing or by filling the well with a clean clay slurry and then placing a cover over the well.
- If the well is not placed back into service, it should be permanently abandoned unless a written extension is granted by DNR.

REPORT TO DNR

The Well/Drillhole/Borehole Abandonment Form 3300-5W, on the front, must be completed by the owner (or agent) and submitted to the appropriate DNR district office or delegated county office within 30 days.

This form is authorized by chapters 144, 147 and 162, Wis. Stats. Completion of this report is mandatory. Penalties: Forfeit not less than $10.00 nor more than $5,000.00 for each violation. Fined not less than $10.00 or more than $100.00 or imprisoned not less than 30 days, or both for each violation. Each day of continued violation is a separate offense, pursuant to ss. 144.99 and 162.06, Wis. Stats.

State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☑ Other: Mining

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
Crandon Project - TMA Drilling Program		CMC-TMA-106

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
TD Drilling, Inc. James Meyers	02/06/96	02/06/96	Dual Tube

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
NA	NA	NA	NA	1697.22	5¼ inches

Boring Location
State Plane 116662.99 N, 2283777.34 E S/C/N Lat
SE 1/4 of SW 1/4 of Section 29, T35N, R13E Long

Local Grid Location (if applicable)
____ N ____ E
Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Lincoln

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
														Blow counts = rate of penetration min/5′ interval
DT-1	5-7	4.3	5	Brown (7.5YR4/6) silty sand, med. textured w/subrounded to subangular gravel, till, very moist, strongly oxidized	SM									Rec = sampled interval depth below ground surface (ft)
DT-2	10-12	4.3	10	As above, grading to finer texture sand & lighter brown (7.5YR5/4), damp	SM									
DT-3	15-17	4.3	15	As above, grading to darker brown (7.5YR4/6), coarser textured silty sand w/increased subrounded to subangular grabel (till), damp	SM									
DT-4	20-22	1.3	20	As above, minor fines, damp	SM-SP									
DT-5	25-27	1.3	25	Yellowish brown (10YR4/4), fine textured silty sand w/10-15% subrounded to subangular gravel, damp, washed till	SM									
DT-6	30-32	1.3	30	Yellowish brown (10YR5/4) fine textured damp sand w/5-10% rounded to subrounded gravel, fine outwash, damp	SP									
DT-7	35-37	2	35	Brown (7.5YR4/6) silty sand, fine to med. textured till, damp	SM									
DT-8	40-42	2	40	As above w/5% subrounded to subangular gravel	SM									
DT-9	45-47	1.3	45	As above, slightly fine textured sand, 10% gravel	SM									

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature [signature] Firm Foth & Van Dyke

This form is authorized by Chapters 114.147 and 162, Wis. Stats. Completion of this report is mandatory.
Penalties: Forfeit not less than $10 nor more then $5,000 for each violation. Fined not less than $10 or more than $100 or imprisoned not less than 30 days, or both for each violation. Each day of continued violation is a separate offense, pursuant to ss 114.06, Wis. Stats.

State of Wisconsin Route to: SOIL BORING LOG INFORMATION

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
DT-10	50-52	1.3	50	As above	SM									
DT-11	55-57	1.3	55	As above, w/5% gravel	SM									
DT-12	60-62	1.5	60	Lt. brown (7.5YR6/4) fine textured silty sand, damp, occasional ¼" rounded pebbles, fine outwash	SM									
DT-13	65-67	2.3	65	As above	SM									
DT-14	70-72	2.3	70	As above	SM									
DT-15	75-77	2.3	75	As above w/5% predominantly rounded gravel	SM									
DT-16	80-82	2.3	80	As above	SM									
DT-17	85-87	1.5	85	As above, grading to darker brown (7.5YR5/4)	SM									
DT-18	90-92	1.5	90	Yellowish brown (10YR5/4) silty sand, fine texture, oxidized, damp, till	SM									
DT-19	95-97	1.5	95	Yellowish brown (10YR5/4) silty sand w/10-15% subrounded to subangular gravel, till	SM									
DT-20	100-102	2.3	100	Dark brown (7.5YR4/4), very silty sand (med. texture sand) w/5-10% gravel subrounded to subangular, damp till, oxidized	SM									
DT-21	105-107	2.5	105	As above	SM									
DT-22	110-112	2.0	110	As above, grading to finer texture silty sand, stronger brown (7.5YR4/6)	SM									
DT-23	115-117	2.3	115	As above, grading to coarser texture sand w/10-15% subrounded to angular gravel	SM									
DT-24	120-122	2.5	120	As above w/increased silt & clay	SM-SC									

State of Wisconsin
Department of Natural Resources
BORING NUMBER: CMC-TMA-106

Route to:

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
DT-25	125-127	4	125	Boulder										
DT-26	130-132	2.5	130	Brown (7.5YR5/6) med. texture poorly graded sand w/10% rounded to subrounded gravel, coarse outwash, wet	SP									
DT-27	135-137	2.5	135	As above	SP									
DT-28	140	2.5	140	As above	SP									
				E.O.B. @ 140' Hole abandoned w/hole plug										

State of Wisconsin
Department of Natural Resources

WELL/DRILLHOLE/BOREHOLE ABANDONMENT

Form 3300-5W 11-89

All abandonment work shall be performed in accordance with the provisions of Chapters NR 111, NR 112 or NR 141, Wis. Admin. Code, whichever is applicable. Also, see instructions on back.

(1) GENERAL INFORMATION

Well/Drillhole/Borehole Location | County: Forest

SE ¼ of SW ¼ of Sec. 29 ; T. 35 N R. 13 ☑ E ☐ W

(If applicable) _____ Gov't Lot _____ Grid Number

Grid Location: 116662.99 ft. ☑ N. ☐ S., 2283777.34 ft. ☑ E. ☐ W.

Civil Town Name: Lincoln

Street Address of Well: NA

City, Village: NA

(2) FACILITY NAME

Original Well Owner (If Known): Crandon Mining Company

Present Well Owner: Crandon Mining Company

Street or Route: 7 North Brown Street, 3rd Floor

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

Facility Well No. and/or Name (If applicable): CMC-TMA-106

WI Unique Well No.: _ _ _ _ _

Reason For Abandonment: Boring Completion

Date of Abandonment: 02/06/96

WELL/DRILLHOLE/BOREHOLE INFORMATION

(3) Original Well/Drillhole/Borehole Construction Completed On (Date) 02/06/96

☐ Monitoring Well
☐ Water Well
☐ Drillhole
☑ Borehole

Construction Report Available? ☐ Yes ☐ No

Construction Type:
☑ Drilled ☐ Driven (Sandpoint) ☐ Dug
☐ Other (Specify) _____

Formation Type:
☑ Unconsolidated Formation ☑ Bedrock

Total Well Depth (ft.) 140 (From groundsurface) Casing Diameter (ins.) ____

Casing Depth (ft.) _____

Was Well Annular Space Grouted? ☐ Yes ☐ No ☐ Unknown
If Yes, To What Depth? _____ Feet

(4) Depth to Water (Feet) _____

Pump & Piping Removed?	☐ Yes	☐ No	☑ Not Applicable
Liner(s) Removed?	☐ Yes	☐ No	☑ Not Applicable
Screen Removed?	☐ Yes	☐ No	☑ Not Applicable
Casing Left in Place?	☐ Yes	☐ No	

If No, Explain _____

Was Casing Cut Off Below Surface?	☐ Yes	☐ No
Did Sealing Material Rise to Surface?	☑ Yes	☐ No
Did Material Settle After 24 Hours?	☑ Yes	☐ No
If Yes, Was Hole Retopped?	☑ Yes	☐ No

(5) Required Method of Placing Sealing Material
☑ Conductor Pipe-Gravity ☐ Conductor Pipe-Pumped
☐ Dump Bailer ☐ Other (Explain)

(6) Sealing Materials — For monitoring wells and monitoring well boreholes only
☐ Neat Cement Grout
☐ Sand-Cement (Concrete) Grout
☐ Concrete
☐ Clay-Sand Slurry
☐ Bentonite-Sand Slurry
☑ Chipped Bentonite
☐ Bentonite Pellets
☐ Granular Bentonite
☐ Bentonite - Cement Grout

(7) Sealing Material Used	From (Ft.)	To (Ft.)	No. Yards, Sacks Sealant or Volume	Mix Ratio or Mud Weight
⅜" Hole Plug	Surface	140	22 bags	

(8) Comments: _____

(9) Name of Person or Firm Doing Sealing Work
Total Drilling - Luisier Drilling

Signature of Person Doing Work Date Signed

Street or Route: 7391 S Porcupine Lake Road
Telephone Number: (414) 829-5690
City, State, Zip Code: Lena, WI 54139

(10) FOR DNR OR COUNTY USE ONLY

Date Received/Inspected | District/County

Reviewer/Inspector

Follow-up Necessary

DNR/COUNTY

REASONS FOR WELL/DRILLHOLE/BOREHOLE ABANDONMENT

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PROCEDURE

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REPORT TO DNR

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State of Wisconsin | Route to: | SOIL BORING LOG INFORMATION

Department of Natural Resources | ☐ Solid Waste ☐ Haz. Waste | Form 4400-122 | 7-91

☐ Emergency Response ☐ Underground Tanks

☐ Wastewater ☐ Water Resources

☑ Other: Mining

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
Crandon Project - TMA Drilling Program		CMC-TMA-107

Boring Drilled by (Firm name and name of crew chief)	Date Started	Date Completed	Drilling Method
TD Drilling, Inc.	MM/DD/YY	MM/DD/YY	
James Meyers	02/07/96	02/07/96	Dual Tube

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
NA	NA	NA	NA	1712.04	5¾ inches

Boring Location

State Plane 114674.04 N, 2286757.54 E S/C/N Lat

SW 1/4 of SW 1/4 of Section 33, T35N, R13E Long

Local Grid Location (if applicable)

____ N ____ E

Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Lincoln

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/Comm
	2-4			Brown (7.5YR4/4) silty sand, coarse textured sand w/15% gravel, rounded, angular & subangular, till 0-42′	SM									Blow counts = rate of penetration min/5′ interval
DT-1	5-7	1	5	As above	SM									Rec = sampled interval depth below ground surface (ft)
DT-2	10-12	1	10	As above w/20-25% gravel	SM									
DT-3	15-17	1	15	As above w/increased silt	SM									
DT-4	20-22	1	20	As above w/decreased gravel content, subrounded to subangular and fine texture silty sand, till	SM									Hose plugged at ~22′
DT-5	25-27	3.5	25	Lighter brown (7.5YR5/4) silty fine sand w/10% gravel, rounded to subangular till	SM									
DT-6	30-32	3	30	As above	SM									
DT-7	35-37	4	35	As above, med. texture fine sand, lense at ~38′	SM									
DT-8	40-42	3.5	40	As above (till), sl. more med. texture sand	SM									
DT-9	45-47	1.5	45	Lt brown (10YR6/4) fine sand w/minor silt and minor subrounded to subangular cobbles and gravel fine outwash	SM-SP									

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature | Firm: Foth & Van Dyke

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SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
DT-10	50-52	1.5	50	As above, grading to sl. reddish brown (7.5YR5/6) fine sand w/silt, fine outwash	SM-SP									
DT-11	55-57	1.5	55	As above, grading to very fine, very loose sand w/silt, minor gravel, fine outwash	SM-SP									
	60-62	2.0	60	Boulder, no sample, till?										
DT-12	65-67	2.0	65	Brown (7.5YR4/6) silty sand, fine to med. texture w/minor gravel <5%, subangular, till	SM-SP									
DT-13	70-72	2.0	70	As above w/increased gravel, 10%, subangular to angular, till	SM SP									
DT-14	75-77	2	75	As above, grading to dk. brown (7.5YR3/4)	SM-SP									
DT-15	80-82	2	80	As above	SM-SP									
DT-16	85-87	1.8	85	As above	SM-SP									
DT-17	90-92	1.8	90	As above	SM-SP									
DT-18	95-97	3.0	95	As above, cobble layer drilled w/water (till?)	SP									
DT-19	100-102	1.8	100	Dk. brown (7.5YR4/4) silty sand, med. texture w/10-15% gravel, angular to subangular, till	SM									
DT-20	105-107	1.5	105	As above w/decreased gravel, 5-10%	SM									
DT-21	110-112	1.5	110	As above, till	SM									
DT-22	115-117	1.5	115	As above, grading to stronger brown (7.5YR4/6) w/increased gravel, 20-25%, till	SM-GM									
DT-23	120-122	1.5	120	As above, till	SM									

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
DT-24	125-127	1.5	125	Brown (7.5YR5/4) gravelly sand w/silt, rounded to subangular gravel (coarse outwash)	SP									
DT-25	130-132	1.5	130	Brown (7.5YR5/4) gravelly sand w/gravel rounded to subangular, coarse outwash	SP									
DT-26	135-137	1.5	135	As above, muddy due to water used in wash and remnant material in cyclone	SP									
DT-27	140-142	1.5	140	As above (coarse outwash)	SP									
DT-28	145-147	1.8	145	Dk. brown (7.5YR4/2), sl. grey silty sand, fine to med. texture w/rounded to angular gravel 5-10%, till	SM									
DT-29	150-152	1.8	150	Dk. brown, sl. grey sand w/silty gravel, till	GM									
DT-30	155-157	1.8	155	Dk. brown, sl. grey, loose gravelly sand w/minor silt, outwash or sand lense	SP									
DT-31	160-162	1.8	160	Brown (7.5YR4/4) silty, clayey sand w/10-15% gravel subrounded to angular (till)	SM									
DT-33	165-167	1	165	Lt. brown (7.5YR5/8) sandy gravel subrounded to subangular coarse outwash	GP									
DT-34	170-172	1	170	As above, predominantly med. texture sand	SP									
DT-35	175-177	1	175	As above, grading to gravelly coarse texture sand, coarse outwash	SP									
DT-36	180-182	1	180	As above, predominantly med. texture sand w/gravel, coarse outwash	SP									
DT-37	185-187	2.0	185	Sl. reddish brown (7.5YR4/4) silty sand w/gravel, rounded to subangular, till	SM									
DT-38	190-192	1.5	190	Light brown (7.5YR5/6) gravelly coarse sand, rounded to subangular (coarse outwash)	SM									Drilled very soft
DT-39	195-197	1.5	195	As above, mud from cyclone, rest is coarse outwash	SP									Drilled very soft

State of Wisconsin
Department of Natural Resources
BORING NUMBER: CMC-TMA-107

Route to:

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
DT-40	200-202	1.2	200	As above, coarse outwash	SP									Drilled very soft
DT-41	205-207	1.0	205	As above, grading to fine to med. texture sand w/minor gravel, coarse outwash	SP									Drilled very soft
DT-42	210-212	1.0	210	As above, grading to med. texture sands, lighter brown (7.5YR5/8) coarse outwash	SP									Drilled very soft
DT-43	215-217	1.0	215	Brown (7.5YR4/6) fine sand, fine outwash	SP									Drilled very soft
DT-44	220-222	2.0	220	As above, grading to lighter brown (7.5YR5/6), fine outwash	SP									Drilled very soft
DT-45	225-227	0.8	225	As above	SP									Drilled very soft
DT-46	230-232	0.8	230	Missed sample	—									Drilled very soft
DT-47	235-237	0.8	235	As above, fine outwash	SP									Drilled very soft
DT-48	240-242	0.8	240	As above	SP									Drilled very soft
DT-49	245-247	0.8	245	As above	SP									Drilled very soft
DT-50	250-252	0.8	250	As above, grading to ligher brown (7.5YR5/4)	SP									Drilled very soft
DT-51	255-257	0.8	255	As above	SP									Drilled very soft
DT-52	260-262	0.8	260	As above, fine outwash	SP									Drilled very soft
DT-53	265-267	1.3	265	Sl. reddish brown (7.5YR4/4) silty sand w/clay & gravel, subangular, till	SM-SP									
DT-54	270-272	1.3	270	As above, till										

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
DT-55	275-277	1.3	275	As above, till	SM									
DT-56	280-282	1.3	280	As above, till	SM									
DT-57	285-287	1.3	285	Brown (7.5YR4/4) med. to coarse texture sand, coarse outwash	SP									
DT-58	290-292	1.3	290	Grey weathered bedrock	BR									
DT-59	295-297	2	295	Grey weathered bedrock	BR									
DT-60	300-302	2	300	Grey weathered bedrock	BR									
				E.O.B. @ 302' Supplemental Bedrock, AJE Jr 2/17/96 290-302 Vfg Soft cuttings. Tan to pale grey-green metasediment, probably argillite. Soft, probably clay weathered. Trace quartz veinlet chips. No sulfides noted. No significant sulfides in bedrock.										

State of Wisconsin
Department of Natural Resources

WELL/DRILLHOLE/BOREHOLE ABANDONMENT

Form 3300-5W 11-89

All abandonment work shall be performed in accordance with the provisions of Chapters NR 111, NR 112 or NR 141, Wis. Admin. Code, whichever is applicable. Also, see instructions on back.

(1) GENERAL INFORMATION

Well/Drillhole/Borehole Location | County: Forest

☑ E
SW ¼ of NW ¼ of Sec. 33 ; T. 35 N R. 13 ☐ W
(If applicable)
_____ Gov't Lot _____ Grid Number

Grid Location
114674.04 ft. ☑ N. ☐ S., 2286757.54 ft. ☑ E. ☐ W.

Civil Town Name
Lincoln

Street Address of Well
NA

City, Village
NA

(2) FACILITY NAME

Original Well Owner (If Known)
Crandon Mining Company

Present Well Owner
Crandon Mining Company

Street or Route
7 North Brown Street, 3rd Floor

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

Facility Well No. and/or Name (If applicable)
CMC-TMA-107

WI Unique Well No.
_ _ _ _ _ _

Reason For Abandonment
Boring Completion

Date of Abandonment
02/07/96

WELL/DRILLHOLE/BOREHOLE INFORMATION

(3) Original Well/Drillhole/Borehole Construction Completed On
(Date) 02/07/96

☐ Monitoring Well
☐ Water Well
☐ Drillhole
☑ Borehole

Construction Report Available?
☐ Yes ☐ No

Construction Type:
☑ Drilled ☐ Driven (Sandpoint) ☐ Dug
☐ Other (Specify) _____

Formation Type:
☑ Unconsolidated Formation ☑ Bedrock

Total Well Depth (ft.) 302 (From groundsurface) Casing Diameter (ins.) ____

Casing Depth (ft.) _____

Was Well Annular Space Grouted? ☐ Yes ☐ No ☐ Unknown
If Yes, To What Depth? _____ Feet

(4) Depth to Water (Feet) _____

Pump & Piping Removed?	☐ Yes	☐ No	☑ Not Applicable
Liner(s) Removed?	☐ Yes	☐ No	☑ Not Applicable
Screen Removed?	☐ Yes	☐ No	☑ Not Applicable
Casing Left in Place?	☐ Yes	☐ No	

If No, Explain _____

Was Casing Cut Off Below Surface?	☐ Yes	☐ No
Did Sealing Material Rise to Surface?	☑ Yes	☐ No
Did Material Settle After 24 Hours?	☑ Yes	☐ No
If Yes, Was Hole Retopped?	☑ Yes	☐ No

(5) Required Method of Placing Sealing Material
☐ Conductor Pipe-Gravity ☑ Conductor Pipe-Pumped
☐ Dump Bailer ☐ Other (Explain)

(6) Sealing Materials — For monitoring wells and monitoring well boreholes only
☐ Neat Cement Grout
☐ Sand-Cement (Concrete) Grout
☐ Concrete
☐ Clay-Sand Slurry
☑ Bentonite-Sand Slurry
☑ Chipped Bentonite
☐ Bentonite Pellets
☐ Granular Bentonite
☐ Bentonite - Cement Grout

(7) Sealing Material Used	From (Ft.)	To (Ft.)	No. Yards, Sacks Sealant or Volume	Mix Ratio or Mud Weight
Bentonite Grout/⅜" Hole Plug	Surface	302	4 bags Gel	180 gallons H_2O/200 lb Gel
			3 Granular	150 lb Grannular
			7 hole plug	

(8) Comments: Borehole tapped off with ⅜" hole plug after 24 hours.

(9) Name of Person or Firm Doing Sealing Work
Total Drilling - Luisier Drilling

Signature of Person Doing Work Date Signed

Street or Route
7391 S Porcupine Lake Road

Telephone Number
(414) 829-5690

City, State, Zip Code
Lena, WI 54139

(10) FOR DNR OR COUNTY USE ONLY

Date Received/Inspected | District/County

Reviewer/Inspector

Follow-up Necessary

DNR/COUNTY

REASONS FOR WELL/DRILLHOLE/BOREHOLE ABANDONMENT

Wis. Adm. Code (NR 111, NR 112, & NR 141) requires well owners to permanently abandon unused wells/drillholes/boreholes on their property. The reasons for this requirement are:

- To prevent contamination from entering the well/drillhole/borehole at the surface or through corroded well casings and moving downward to an aquifer used by other wells, and
- To prevent vertical movement of water between different geologic formations of differing water quality.

Most licensed well drillers and pump installers have the equipment, knowledge and experience needed to permanently abandon wells/drillholes/boreholes. We recommend that these licensed contractors be hired to do this work.

PROCEDURE

1. Remove any pump, pump piping, debris or other obstacles that could interfere with the sealing operation. In most situations the well casing should be left in place. When the casing is removed it should be pulled during the abandonment process so the drillhole does not collapse.
2. The sealing material must be placed with a conductor (tremie) pipe either by pumping or by gravity, (except when approved chipped bentonite is used according to written department instructions and restrictions).
3. The bottom end of the conductor pipe must initially reach the bottom of the well and must be kept submerged in the sealing material as it is placed.
4. Unconsolidated formation wells should be sealed with the materials listed in item (6) on the form. When clay or sodium bentonite slurry is used to fill wells, the top 20 feet must be sealed with neat cement grout, concrete grout, concrete, or bentonite chips. Bedrock formation wells should be filled with neat cement grout, concrete grout, concrete, or bentonite chips. Monitoring wells must be filled with the materials specified by NR 141, Wis. Adm. Code.
5. Fill the entire well column from the bottom to the top with the required sealing material.
6. When using concrete or cement grout, any standing water in the hole will be forced out by the concrete or cement grout (it is more dense) resulting in an entire column of cement to seal the well. The sealing material must flow at the surface with the same consistency as it is being pumped in.
7. The casing may be cut off several feet below the ground surface.
8. To abandon flowing wells, the flow must be stopped or greatly reduced. This can be accomplished by extending the well casing to an elevation higher than the artesian head, or inserting a seal or packer in the casing. Once the flow has been stopped or reduced, the well can be abandoned the same as other wells.
9. For a municipal well, information regarding drillhole diameter and depths and geologic formations should be submitted on a separate sheet.
10. For use of alternative methods and materials, especially for deep, multi-formation wells contact DNR.

TEMPORARY ABANDONMENT

- A well may be temporarily abandoned if it is planned to place the well back in service within a time specified by administrative rule.
- Temporary abandonment is accomplished by threading or welding a watertight cover to the casing or by filling the well with a clean clay slurry and then placing a cover over the well.
- If the well is not placed back into service, it should be permanently abandoned unless a written extension is granted by DNR.

REPORT TO DNR

The Well/Drillhole/Borehole Abandonment Form 3300-5W, on the front, must be completed by the owner (or agent) and submitted to the appropriate DNR district office or delegated county office within 30 days.

This form is authorized by chapters 144, 147 and 162, Wis. Stats. Completion of this report is mandatory. Penalties: Forfeit not less than $10.00 nor more than $5,000.00 for each violation. Fined not less than $10.00 or more than $100.00 or imprisoned not less than 30 days, or both for each violation. Each day of continued violation is a separate offense, pursuant to ss. 144.99 and 162.06, Wis. Stats.

State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☑ Other: Mining

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
Crandon Project - TMA Site		CMC-TMA-108

Boring Drilled by (Firm name and name of crew chief)	Date Started	Date Completed	Drilling Method
TD Drilling, Inc. James Meyers	MM/DD/YY 02/05/96	MM/DD/YY 02/05/96	Reverse Dual Tube

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
NA	NA	NA	NA	1660.08 feet MSL	5⅞ inches

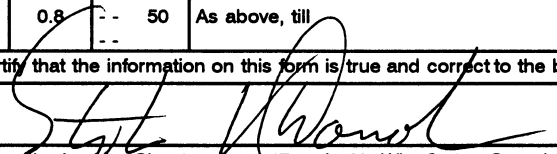
Boring Location
State Plane 114054.81 N, 2283584.73 E S/C/N Lat
NE 1/4 of SW 1/4 of Section 32, T35N, R13E Long

Local Grid Location (if applicable)
____ N ____ E
Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Lincoln

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/Comm
DT-1	5-7	0.8	5	Dk. sl. reddish brown (7.5YR4/4) damp, silty fine, med. texture sand (5%) round & angular gravel, till	SM									Blow counts = rate of penetration min/5' interval
DT-2	10-12	0.8	10	As above, till	SM									Rec = sampled interval depth below ground surface (ft)
DT-3	15-17	0.8	15	As above, till	SM									
DT-4	20-22	0.8	20	As above, grading to sl. finer texture sand & less gravel	SM									
DT-5	25-27	0.8	25	As above, till	SM									
DT-6	30-32	0.8	30	As above, grading to 5-10% subangular to angular gravel, till	SM									
DT-7	35-44	0.8	35	As above, till	SM									
DT-8	40-42	0.8	40	As above, till	SM									
DT-9	45-42	0.8	45	As above, grading to less gravel, <5%, till	SM									
DT-10	50-52	0.8	50	As above, till	SM									

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature  Firm Foth & Van Dyke

This form is authorized by Chapters 114.147 and 162, Wis. Stats. Completion of this report is mandatory.
Penalties: Forfeit not less than $10 nor more then $5,000 for each violation. Fined not less than $10 or more than $100 or imprisoned not less than 30 days, or both for each violation. Each day of continued violation is a separate offense, pursuant to ss 114.06, Wis. Stats.

State of Wisconsin
Department of Natural Resources
BORING NUMBER: CMC-TMA-108

Route to:

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
DT-11	55-57	0.8	55	As above, till	SM									
DT-12	60-62	0.8	60	As above, till	SM									
				E.O.B. @ 60' Hole remained open to bottom of borings Abandoned w/⅜" chipped bentonite										

State of Wisconsin
Department of Natural Resources

WELL/DRILLHOLE/BOREHOLE ABANDONMENT

Form 3300-5W 11-89

All abandonment work shall be performed in accordance with the provisions of Chapters NR 111, NR 112 or NR 141, Wis. Admin. Code, whichever is applicable. Also, see instructions on back.

(1) GENERAL INFORMATION

Well/Drillhole/Borehole Location | County: Forest

NE ¼ of SW ¼ of Sec. 32 ; T. 35 N R. 13 ☑ E ☐ W

(If applicable) _____ Gov't Lot _____ Grid Number

Grid Location: 114054.81 ft. ☑ N. ☐ S., 2283584.73 ft. ☑ E. ☐ W.

Civil Town Name: Lincoln

Street Address of Well: NA

City, Village: NA

(2) FACILITY NAME

Original Well Owner (If Known): Crandon Mining Company

Present Well Owner: Crandon Mining Company

Street or Route: 7 North Brown Street, 3rd Floor

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

Facility Well No. and/or Name (If applicable): CMC-TMA-108

WI Unique Well No.: _ _ _ _ _ _

Reason For Abandonment: Boring Completion

Date of Abandonment: 02/05/96

WELL/DRILLHOLE/BOREHOLE INFORMATION

(3) Original Well/Drillhole/Borehole Construction Completed On (Date) 02/05/96

☐ Monitoring Well
☐ Water Well
☐ Drillhole
☑ Borehole

Construction Report Available? ☐ Yes ☐ No

Construction Type:
☑ Drilled ☐ Driven (Sandpoint) ☐ Dug
☐ Other (Specify) _____

Formation Type:
☑ Unconsolidated Formation ☐ Bedrock

Total Well Depth (ft.) 60 (From groundsurface) Casing Diameter (ins.) ____

Casing Depth (ft.) ____

Was Well Annular Space Grouted? ☐ Yes ☐ No ☐ Unknown
If Yes, To What Depth? _____ Feet

(4) Depth to Water (Feet) _____

Pump & Piping Removed?	☐ Yes	☐ No	☑ Not Applicable
Liner(s) Removed?	☐ Yes	☐ No	☑ Not Applicable
Screen Removed?	☐ Yes	☐ No	☑ Not Applicable
Casing Left in Place?	☐ Yes	☐ No	

If No, Explain _____

Was Casing Cut Off Below Surface?	☐ Yes	☐ No
Did Sealing Material Rise to Surface?	☑ Yes	☐ No
Did Material Settle After 24 Hours?	☐ Yes	☑ No
If Yes, Was Hole Retopped?	☐ Yes	☐ No

(5) Required Method of Placing Sealing Material
☑ Conductor Pipe-Gravity ☐ Conductor Pipe-Pumped
☐ Dump Bailer ☐ Other (Explain)

(6) Sealing Materials — For monitoring wells and monitoring well boreholes only
☐ Neat Cement Grout
☐ Sand-Cement (Concrete) Grout
☐ Concrete
☐ Clay-Sand Slurry
☐ Bentonite-Sand Slurry
☑ Chipped Bentonite
☐ Bentonite Pellets
☐ Granular Bentonite
☐ Bentonite - Cement Grout

(7)

Sealing Material Used	From (Ft.)	To (Ft.)	No. Yards, Sacks Sealant or Volume	Mix Ratio or Mud Weight
⅜" Hole Plug	Surface	60	18 bags	

(8) Comments: _____

(9) Name of Person or Firm Doing Sealing Work
Total Drilling - Luisier Drilling

Signature of Person Doing Work Date Signed

Street or Route: 7391 S Porcupine Lake Road
Telephone Number: (414) 829-5690
City, State, Zip Code: Lena, WI 54139

(10) FOR DNR OR COUNTY USE ONLY

Date Received/Inspected	District/County

Reviewer/Inspector

Follow-up Necessary

DNR/COUNTY

REASONS FOR WELL/DRILLHOLE/BOREHOLE ABANDONMENT

Wis. Adm. Code (NR 111, NR 112, & NR 141) requires well owners to permanently abandon unused wells/drillholes/boreholes on their property. The reasons for this requirement are:

- To prevent contamination from entering the well/drillhole/borehole at the surface or through corroded well casings and moving downward to an aquifer used by other wells, and
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Most licensed well drillers and pump installers have the equipment, knowledge and experience needed to permanently abandon wells/drillholes/boreholes. We recommend that these licensed contractors be hired to do this work.

PROCEDURE

1. Remove any pump, pump piping, debris or other obstacles that could interfere with the sealing operation. In most situations the well casing should be left in place. When the casing is removed it should be pulled during the abandonment process so the drillhole does not collapse.
2. The sealing material must be placed with a conductor (tremie) pipe either by pumping or by gravity, (except when approved chipped bentonite is used according to written department instructions and restrictions).
3. The bottom end of the conductor pipe must initially reach the bottom of the well and must be kept submerged in the sealing material as it is placed.
4. Unconsolidated formation wells should be sealed with the materials listed in item (6) on the form. When clay or sodium bentonite slurry is used to fill wells, the top 20 feet must be sealed with neat cement grout, concrete grout, concrete, or bentonite chips. Bedrock formation wells should be filled with neat cement grout, concrete grout, concrete, or bentonite chips. Monitoring wells must be filled with the materials specified by NR 141, Wis. Adm. Code.
5. Fill the entire well column from the bottom to the top with the required sealing material.
6. When using concrete or cement grout, any standing water in the hole will be forced out by the concrete or cement grout (it is more dense) resulting in an entire column of cement to seal the well. The sealing material must flow at the surface with the same consistency as it is being pumped in.
7. The casing may be cut off several feet below the ground surface.
8. To abandon flowing wells, the flow must be stopped or greatly reduced. This can be accomplished by extending the well casing to an elevation higher than the artesian head, or inserting a seal or packer in the casing. Once the flow has been stopped or reduced, the well can be abandoned the same as other wells.
9. For a municipal well, information regarding drillhole diameter and depths and geologic formations should be submitted on a separate sheet.
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TEMPORARY ABANDONMENT

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REPORT TO DNR

The Well/Drillhole/Borehole Abandonment Form 3300-5W, on the front, must be completed by the owner (or agent) and submitted to the appropriate DNR district office or delegated county office within 30 days.

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State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☑ Other: Mining

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
Crandon Project - TMA Drilling Program		CMC-TMA-109

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
TD Drilling, Inc. James Meyers	02/10/96	02/10/96	Dual Tube

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
NA	NA	NA	NA	1676.41	5⅞ inches

Boring Location	Local Grid Location (if applicable)
State Plane 115523.32 N, 2283474.35 E S/C/N Lat NE 1/4 of NW 1/4 of Section 32, T35N, R13E Long	____ N ____ E Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Lincoln

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/Comm
DT-0	0-4			Strong brown (7.5YR4/6) silty med. to coarse sand w/10% gravel, subrounded to angular, till	SM									Blow counts = rate of penetration min/5′ interval Rec = sampled interval depth below ground surface (ft)
DT-1	5-7	1.3	5	As above, grading to lighter brown fine textured silty sand (10YR5/4), minor gravel, till (washed till)	SM									
DT-2	10-12	1.3	10	As above, lighter brown, med. sand w/gravel, washed till?	SM									
DT-3	15-17	1.4	15	Dk. brown (10YR3/4) fine textured silty sand w/minor subrounded to subangular gravel, till	SM									
DT-4	20-22	1.5	20	As above, grading to darker brown (7.5YR3/3), till	SM									
DT-5	25-27	1.8	25	As above, till	SM									
DT-6	30-32	1.8	30	As above, grading to lighter brown (7.5YR4/3) w/increased subangular to subrounded gravel, till	SM									
DT-7	35-37	1.8	35	As above, till	SM									
DT-8	40-42	1.8	40	As above, grading stronger brown (7.5YR4/4) w/minor gravel, till	SM									
DT-9	45-47	1	45	As above, grading lighter brown (7.5YR5/3) w/5% subangular gravel, till - SM	SM									

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature

Firm: Foth & Van Dyke

This form is authorized by Chapters 114.147 and 162, Wis. Stats. Completion of this report is mandatory.
Penalties: Forfeit not less than $10 nor more then $5,000 for each violation. Fined not less than $10 or more than $100 or imprisoned not less than 30 days, or both for each violation. Each day of continued violation is a separate offense, pursuant to ss 114.06, Wis. Stats.

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
DT-10	50-52	1	50	As above, grading slightly darker brown (7.5YR4/3) till	SM									
DT-11	55-57	1	55	As above, till	SM									
DT-12	60-62	8	60	As above, till strong brown (7.5YR4/4)	SM									Hose plugged
DT-13	65-67	2	65	As above, grading strong brown (7.5YR4/6), till	SM									
DT-14	70-72	1	70	As above, till	SM									
DT-15	75-77	1	75	As above, till	SM									
DT-16	80-82	1	80	As above, till	SM									
DT-17	85-87	3	85	Reddish brown (5YR4/4) med. to fine texture silty sand w/5% angular to subangular gravel, till	SM									
DT-18	90-92	4	90	As above, grading to minor gravel redder (2.5YR4/4)	SM									
DT-19	95-97	4	95	As above, till	SM									
DT-20	100-102	4	100	As above, till	SM									
DT-21	105-107	2.3	105	As above, grading browner (5YR4/4), till	SM									
DT-22	110-112	2.3	110	As above, till	SM									
DT-23	115-117	2.3	115	As above, till	SM									

State of Wisconsin
Department of Natural Resources
BORING NUMBER: CMC-TMA-109

Route to:

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
DT-24	120-122	2.3	120	As above, grading to med. texture sand w/gravel,subrounded 5-10% washed till, or outwash?	SP									
				E.O.B. @ 122' Abandoned w/hole plug										

State of Wisconsin
Department of Natural Resources

WELL/DRILLHOLE/BOREHOLE ABANDONMENT

Form 3300-5W 11-89

All abandonment work shall be performed in accordance with the provisions of Chapters NR 111, NR 112 or NR 141, Wis. Admin. Code, whichever is applicable. Also, see instructions on back.

(1) GENERAL INFORMATION

Well/Drillhole/Borehole Location | County: Forest

NE ¼ of NW ¼ of Sec. 32 ; T. 35 N R. 13 ☑ E ☐ W

(If applicable) _____ Gov't Lot _____ Grid Number

Grid Location: 115523.32 ft. ☑ N. ☐ S., 2283474.35 ft. ☑ E. ☐ W.

Civil Town Name: Lincoln

Street Address of Well: NA

City, Village: NA

(2) FACILITY NAME

Original Well Owner (If Known): Crandon Mining Company

Present Well Owner: Crandon Mining Company

Street or Route: 7 North Brown Street, 3rd Floor

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

Facility Well No. and/or Name (If applicable): CMC-TMA-109 | WI Unique Well No. _ _ _ _ _ _

Reason For Abandonment: Boring Completion

Date of Abandonment: 02/10/96

WELL/DRILLHOLE/BOREHOLE INFORMATION

(3) Original Well/Drillhole/Borehole Construction Completed On (Date) 02/10/96

☐ Monitoring Well
☐ Water Well
☐ Drillhole
☑ Borehole

Construction Report Available? ☐ Yes ☐ No

Construction Type:
☑ Drilled ☐ Driven (Sandpoint) ☐ Dug
☐ Other (Specify) _____

Formation Type:
☑ Unconsolidated Formation ☐ Bedrock

Total Well Depth (ft.) 122 (From groundsurface) Casing Diameter (ins.) ____

Casing Depth (ft.) _____

Was Well Annular Space Grouted? ☐ Yes ☐ No ☐ Unknown
If Yes, To What Depth? _____ Feet

(4) Depth to Water (Feet) _____

Pump & Piping Removed?	☐ Yes	☐ No	☑ Not Applicable
Liner(s) Removed?	☐ Yes	☐ No	☑ Not Applicable
Screen Removed?	☐ Yes	☐ No	☑ Not Applicable
Casing Left in Place?	☐ Yes	☐ No	

If No, Explain _____

Was Casing Cut Off Below Surface?	☐ Yes	☐ No
Did Sealing Material Rise to Surface?	☑ Yes	☐ No
Did Material Settle After 24 Hours?	☑ Yes	☐ No
If Yes, Was Hole Retopped?	☑ Yes	☐ No

(5) Required Method of Placing Sealing Material
☑ Conductor Pipe-Gravity ☐ Conductor Pipe-Pumped
☐ Dump Bailer ☐ Other (Explain)

(6) Sealing Materials — For monitoring wells and monitoring well boreholes only
☐ Neat Cement Grout
☐ Sand-Cement (Concrete) Grout
☐ Concrete
☐ Clay-Sand Slurry
☐ Bentonite-Sand Slurry
☑ Chipped Bentonite
☐ Bentonite Pellets
☐ Granular Bentonite
☐ Bentonite - Cement Grout

(7)

Sealing Material Used	From (Ft.)	To (Ft.)	No. Yards, Sacks Sealant or Volume	Mix Ratio or Mud Weight
⅜" Hole Plug	Surface	122	25 bags	

(8) Comments: _____

(9) Name of Person or Firm Doing Sealing Work
Total Drilling - Luisier Drilling
Signature of Person Doing Work Date Signed
Ken Mayers
Street or Route: 7391 S Porcupine Lake Road
Telephone Number: (414) 829-5690
City, State, Zip Code: Lena, WI 54139

(10) FOR DNR OR COUNTY USE ONLY
Date Received/Inspected | District/County
Reviewer/Inspector
Follow-up Necessary

DNR/COUNTY

REASONS FOR WELL/DRILLHOLE/BOREHOLE ABANDONMENT

Wis. Adm. Code (NR 111, NR 112, & NR 141) requires well owners to permanently abandon unused wells/drillholes/boreholes on their property. The reasons for this requirement are:

- To prevent contamination from entering the well/drillhole/borehole at the surface or through corroded well casings and moving downward to an aquifer used by other wells, and
- To prevent vertical movement of water between different geologic formations of differing water quality.

Most licensed well drillers and pump installers have the equipment, knowledge and experience needed to permanently abandon wells/drillholes/boreholes. We recommend that these licensed contractors be hired to do this work.

PROCEDURE

1. Remove any pump, pump piping, debris or other obstacles that could interfere with the sealing operation. In most situations the well casing should be left in place. When the casing is removed it should be pulled during the abandonment process so the drillhole does not collapse.
2. The sealing material must be placed with a conductor (tremie) pipe either by pumping or by gravity, (except when approved chipped bentonite is used according to written department instructions and restrictions).
3. The bottom end of the conductor pipe must initially reach the bottom of the well and must be kept submerged in the sealing material as it is placed.
4. Unconsolidated formation wells should be sealed with the materials listed in item (6) on the form. When clay or sodium bentonite slurry is used to fill wells, the top 20 feet must be sealed with neat cement grout, concrete grout, concrete, or bentonite chips. Bedrock formation wells should be filled with neat cement grout, concrete grout, concrete, or bentonite chips. Monitoring wells must be filled with the materials specified by NR 141, Wis. Adm. Code.
5. Fill the entire well column from the bottom to the top with the required sealing material.
6. When using concrete or cement grout, any standing water in the hole will be forced out by the concrete or cement grout (it is more dense) resulting in an entire column of cement to seal the well. The sealing material must flow at the surface with the same consistency as it is being pumped in.
7. The casing may be cut off several feet below the ground surface.
8. To abandon flowing wells, the flow must be stopped or greatly reduced. This can be accomplished by extending the well casing to an elevation higher than the artesian head, or inserting a seal or packer in the casing. Once the flow has been stopped or reduced, the well can be abandoned the same as other wells.
9. For a municipal well, information regarding drillhole diameter and depths and geologic formations should be submitted on a separate sheet.
10. For use of alternative methods and materials, especially for deep, multi-formation wells contact DNR.

TEMPORARY ABANDONMENT

- A well may be temporarily abandoned if it is planned to place the well back in service within a time specified by administrative rule.
- Temporary abandonment is accomplished by threading or welding a watertight cover to the casing or by filling the well with a clean clay slurry and then placing a cover over the well.
- If the well is not placed back into service, it should be permanently abandoned unless a written extension is granted by DNR.

REPORT TO DNR

The Well/Drillhole/Borehole Abandonment Form 3300-5W, on the front, must be completed by the owner (or agent) and submitted to the appropriate DNR district office or delegated county office within 30 days.

This form is authorized by chapters 144, 147 and 162, Wis. Stats. Completion of this report is mandatory. Penalties: Forfeit not less than $10.00 nor more than $5,000.00 for each violation. Fined not less than $10.00 or more than $100.00 or imprisoned not less than 30 days, or both for each violation. Each day of continued violation is a separate offense, pursuant to ss. 144.99 and 162.06, Wis. Stats.

State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☑ Other: Mining

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
Crandon Project - TMA Drilling Program		CMC-TMA-110

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
TD Drilling, Inc. James Meyers	02/07/96	02/07/96	Dual Tube

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
NA	NA	NA	NA	1691.23	5¾ inches

Boring Location
State Plane 114154.22 N, 2285066.57 E S/C/N Lat
NW 1/4 of SE 1/4 of Section 32, T35N, R13E Long

Local Grid Location (if applicable)
____ N ____ E
Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Lincoln

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/Comm
DT-0	0-4			Brown (7.5YR4/6) med. sand w/silt (till)	SP SM									Blow counts = rate of penetration min/5′ interval Rec = sampled interval depth below ground surface (ft)
DT-1	5-7	1.5	5	Brown (7.5YR4/4) silty sand w/subangular gravel (till)	SM									
DT-2	10-12	1.5	10	Grey brown (7.5YR4/3) silt fine-med. sand w/minor gravel angular to subangular (till)	SP-SM									
DT-3	15-17	1.5	15	As above, slightly greyer (7.5YR5/3), slight increase in gravel (5%) angular to subrounded (till)	SP-SM									
DT-4	20-22	1.5	20	As above, silt increases (till)	SM									
DT-5	25-27	1.5	25	Grading dark brown (7.5YR4/4) as above (till)	SM									
DT-6	30-32	2	30	As above, gravel increased to 10% (till)	SM									
DT-7	35-37	1.5	35	Sl. reddish dark brown (7.5YR3/4) silty sand w/very little gravel, sand is finer textured than above (till)	SM									
DT-8	40-42	3	40	Grey brown (7.5YR4/3) sandy silty gravel w/boulders (till)	GM									
DT-9	45-47	3	45	As above (7.5YR6/3) boulder (till)	GM									

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm
	Foth & Van Dyke

This form is authorized by Chapters 114.147 and 162, Wis. Stats. Completion of this report is mandatory.
Penalties: Forfeit not less than $10 nor more then $5,000 for each violation. Fined not less than $10 or more than $100 or imprisoned not less than 30 days, or both for each violation. Each day of continued violation is a separate offense, pursuant to ss 114.06, Wis. Stats.

State of Wisconsin | Route to: | SOIL BORING LOG INFORMATION

Department of Natural Resources | Form 4400-122 | 7-91

BORING NUMBER: CMC-TMA-110 |

SAMPLE No.	SAMPLE Rec (ft)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
DT-10	50-52	3	50	As above w/boulders and cobbles (till)	GM									
DT-11	55-57	2	55	As above, darker brown (7.5YR4/4) (Till)	GM									
DT-12	60-62	3	60	As above w/boulders	GM									
DT-13	65-67	4	65	As above w/boulders (till)	GM									
DT-14	70-72	4	70	As above w/boulders (till)	GM									
DT-15	75-77	2	75	Grey brown (7.5YR5/3) med. sand w/minor silt & gravel, angular to subangular (till)	SP-SM									
DT-16	80-82	1.5	80	Grey brown (7.5YR5/4) med. coarse sand w/gravel subrounded (c. outwash)	SP									
DT-17	85-87	1.5	85	As above, increase in gravel, rounded	SP									
DT-18	90-92	1.5	90	As above w/cobbles, color yellow-grey (10YR4/2) (c. outwash)	SP									
DT-19	95-97	2	95	Very lt. brown (7.5YR6/4) as above w/cobbles (c. outwash)	SP									
DT-20	100-102	1.5	100	Brown (7.5YR4/6) med.-coarse sand w/gravel & minor silt (c. outwash)	SP									
DT-21	105-107	1	105	As above (c. outwash)	SP									
DT-22	110-112	1.5	110	Dk. brown (7.5YR4/4) silty sand, fine to med. textured w/gravel (15%) subangular (till)	SM									
DT-23	115-117	2	115	Brown (7.0YR4/4) silty clayey fine sand w/gravel (till)	SM-SC									
DT-24	120-122	1.5	120	As above, sand is slightly coarser (till)	SM									
				E.O.B. 122 Abandoned w/hole plug										

State of Wisconsin
Department of Natural Resources

WELL/DRILLHOLE/BOREHOLE ABANDONMENT

Form 3300-5W 11-89

All abandonment work shall be performed in accordance with the provisions of Chapters NR 111, NR 112 or NR 141, Wis. Admin. Code, whichever is applicable. Also, see instructions on back.

(1) GENERAL INFORMATION

Well/Drillhole/Borehole Location | County: Forest

NW ¼ of SE ¼ of Sec. 32 ; T. 35 N R. 13 ☑ E ☐ W

(If applicable) _____ Gov't Lot _____ Grid Number

Grid Location
14154.22 ft. ☑ N. ☐ S., 2285066.57 ft. ☑ E. ☐ W.

Civil Town Name
Lincoln

Street Address of Well
NA

City, Village
NA

(2) FACILITY NAME

Original Well Owner (If Known)
Crandon Mining Company

Present Well Owner
Crandon Mining Company

Street or Route
7 North Brown Street, 3rd Floor

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

Facility Well No. and/or Name (If applicable)
CMC-TMA-110

WI Unique Well No.
_ _ _ _ _ _

Reason For Abandonment
Boring Completion

Date of Abandonment
02/07/96

WELL/DRILLHOLE/BOREHOLE INFORMATION

(3) Original Well/Drillhole/Borehole Construction Completed On
(Date) 02/07/96

☐ Monitoring Well
☐ Water Well
☐ Drillhole
☑ Borehole

Construction Report Available?
☐ Yes ☐ No

Construction Type:
☑ Drilled ☐ Driven (Sandpoint) ☐ Dug
☐ Other (Specify) _____

Formation Type:
☑ Unconsolidated Formation ☐ Bedrock

Total Well Depth (ft.) 122 (From groundsurface)

Casing Diameter (ins.) ____

Casing Depth (ft.) _____

Was Well Annular Space Grouted? ☐ Yes ☐ No ☐ Unknown
If Yes, To What Depth? _____ Feet

(4) Depth to Water (Feet) _____

Pump & Piping Removed?	☐ Yes	☐ No	☑ Not Applicable
Liner(s) Removed?	☐ Yes	☐ No	☑ Not Applicable
Screen Removed?	☐ Yes	☐ No	☑ Not Applicable
Casing Left in Place?	☐ Yes	☐ No	

If No, Explain _____

Was Casing Cut Off Below Surface?	☐ Yes	☐ No
Did Sealing Material Rise to Surface?	☑ Yes	☐ No
Did Material Settle After 24 Hours?	☐ Yes	☑ No
If Yes, Was Hole Retopped?	☑ Yes	☐ No

(5) Required Method of Placing Sealing Material
☑ Conductor Pipe-Gravity ☐ Conductor Pipe-Pumped
☐ Dump Bailer ☐ Other (Explain)

(6) Sealing Materials — For monitoring wells and monitoring well boreholes only
☐ Neat Cement Grout
☐ Sand-Cement (Concrete) Grout
☐ Concrete
☐ Clay-Sand Slurry
☐ Bentonite-Sand Slurry
☑ Chipped Bentonite
☐ Bentonite Pellets
☐ Granular Bentonite
☐ Bentonite - Cement Grout

(7) Sealing Material Used	From (Ft.)	To (Ft.)	No. Yards, Sacks Sealant or Volume	Mix Ratio or Mud Weight
⅜" Hole Plug	Surface	122	26 bags	

(8) Comments: _____

(9) Name of Person or Firm Doing Sealing Work
Total Drilling - Luisier Drilling

Signature of Person Doing Work Date Signed

Street or Route
7391 S Porcupine Lake Road

Telephone Number
(414) 829-5690

City, State, Zip Code
Lena, WI 54139

(10) FOR DNR OR COUNTY USE ONLY

Date Received/Inspected	District/County

Reviewer/Inspector

Follow-up Necessary

DNR/COUNTY

REASONS FOR WELL/DRILLHOLE/BOREHOLE ABANDONMENT

Wis. Adm. Code (NR 111, NR 112, & NR 141) requires well owners to permanently abandon unused wells/drillholes/boreholes on their property. The reasons for this requirement are:

- To prevent contamination from entering the well/drillhole/borehole at the surface or through corroded well casings and moving downward to an aquifer used by other wells, and
- To prevent vertical movement of water between different geologic formations of differing water quality.

Most licensed well drillers and pump installers have the equipment, knowledge and experience needed to permanently abandon wells/drillholes/boreholes. We recommend that these licensed contractors be hired to do this work.

PROCEDURE

1. Remove any pump, pump piping, debris or other obstacles that could interfere with the sealing operation. In most situations the well casing should be left in place. When the casing is removed it should be pulled during the abandonment process so the drillhole does not collapse.
2. The sealing material must be placed with a conductor (tremie) pipe either by pumping or by gravity, (except when approved chipped bentonite is used according to written department instructions and restrictions).
3. The bottom end of the conductor pipe must initially reach the bottom of the well and must be kept submerged in the sealing material as it is placed.
4. Unconsolidated formation wells should be sealed with the materials listed in item (6) on the form. When clay or sodium bentonite slurry is used to fill wells, the top 20 feet must be sealed with neat cement grout, concrete grout, concrete, or bentonite chips. Bedrock formation wells should be filled with neat cement grout, concrete grout, concrete, or bentonite chips. Monitoring wells must be filled with the materials specified by NR 141, Wis. Adm. Code.
5. Fill the entire well column from the bottom to the top with the required sealing material.
6. When using concrete or cement grout, any standing water in the hole will be forced out by the concrete or cement grout (it is more dense) resulting in an entire column of cement to seal the well. The sealing material must flow at the surface with the same consistency as it is being pumped in.
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Attachment 7

Table 3.1 Summary of Potential Dry Cover Materials from the February 1994 MEND Report Titled "Evaluation of Alternative Dry Covers for the Inhibition of Acid Mine Drainage from Tailings"

Table 3.1

SUMMARY OF POTENTIAL DRY COVER MATERIALS

GENERAL CLASSIFICATION	NATURAL SOILS	PROCESSED SOILS
Potential Dry Cover Material	Soils	Modified Soils
Form	• Natural clay, till, lake bottom sediments, and loess.	• Natural soils modified by addition of materials such as bentonite, ashes and polymers.
Source and Quantity	• May be found local to mine sites in sufficient quantities.	• May be found local to mine sites in sufficient quantities.
Perceived Benefit/Concerns	• Low permeability in the 10^{-7} to 10^{-10} ranges is useful in providing a moisture retaining cover. • Long term performance may be affected by natural forces. • Diffusion coefficient range: 10^{-6} to 5×10^{-3} cm^2 s^{-1}.	• Low permeability (high moisture retaining cover). • Low permeability in the 10^{-7} to 10^{-10} range is useful in providing a moisture retaining cover. • Stable material both physically and chemically. • Long term performance may be enhanced by additives. • Diffusion coefficient 10^{-6} to 5×10^{-3} cm^2 s^{-1}.
Experience Related to Tailings Sites	• Considerable research has been carried out on the use of natural soils as covers.	• Research has been carried out to investigate bentonite, and polymer research is underway.
Stability of Material	Stable material.	Stable material.
Estimated Cost of Dry Cover	\$10 to \$40/m^2	\$15 to \$45/m^2
Guestimate of Effective Cover Life	Indefinite with maintenance.	Indefinite with maintenance.
Guestimate Care & Maintenance Requirements	Minimal.	Minimal.

GENERAL CLASSIFICATION	OXYGEN CONSUMER		
Potential Dry Cover Material	**Crumb Rubber**	**Wood Waste**	**Peat**
Form	• Particles of rubber (+60 mesh) produced from tires.	• Sawdust, bark, logs, and other wood waste.	• Peat may be found in vicinity of mine sites in sufficient quantities.
Source and Quantity	• Tire grinding plants produce relatively small quantities. • There is at present a limited market for this material.	• Produced by the forest products industry. • Generally available in most mining districts.	• Primarily peat bog material.
Perceived Benefit/Concerns	• Large particle size prevents moisture retention. • Biotoxicity and potential for combustion are major concerns.	• Oxygen consumption. • Concerns include variable feed, high porosity, poor quality control, and potential for combustion. • Research indicates that wood waste layers can significantly reduce oxygen flux.	• May be used to form an oxygen consuming/moisture retaining dry cover. • Concerns include long term performance of the peat, maintenance of a perched water table within the peat, and high cost. • Oxygen diffusion coefficient range: 10^{-4} to 10^{-2} cm^2 s^{-1}.
Experience Related to Tailings Sites	• No experience.	• Research at East Sullivan is ongoing. • A pyrrhotite tailings pond covered by wood materials was studied from a site hydrological viewpoint.	• Research has been carried out and continues (at University of Guelph). • This work is in its early stages and suggests that peat or wood chips when mixed with tailings are a source of biomass which creates sulphate reduction and inhibits metals mobility.
Stability of Material	Unstable.	Unstable (decomposes).	Unstable (decomposes).
Estimated Cost of Dry Cover	>$30/$m^2$	<$30/$m^2$	<$30/$m^2$
Guestimate of Effective Cover Life	Unknown.	10 to 50 years.	Not established.
Guestimate Care & Maintenance Requirements	Unknown.	May require periodic reapplication.	Not established.

Table 3.1, cont'd.

GENERAL CLASSIFICATION	OXYGEN CONSUMER		
Potential Dry Cover Material	**Sewage Sludge**	**N-Viro Soil**	**Other Industrial Sludges**
Form	• Dewatered sewage sludge.	• Processed dewatered sewage sludge and alkaline materials.	• Sludges with a high biological oxygen demand.
Source and Quantity	• Large quantities available nationally but not typically local to mines.	• Small quantities may be created at a mine site, but cities are the source.	• Sludges produced by various industries often in small quantities.
Perceived Benefit/Concerns	• Expected to provide a bacterial seed and consume oxygen through biological processes. • Limited quantities are a major concern as is resultant cover effluent quality • Diffusion coefficient range 10^{-4} to 10^{-2} cm^2 s^{-1}.	• Expected to provide a source of alkalinity, and high organic oxygen demand. • Concerns include limited quantities and cost. • Diffusion coefficient range 10^{-4} to 10^{-2} cm^2 s^{-1}.	• Expected to provide high oxygen demand and be available at little or no cost. • Concerns include limited quantities available and the diverse number of sludge sources. • Diffusion coefficient range 10^{-4} to 10^{-2} cm^2 s^{-1}.
Experience Related to Tailings Sites	• Limited scientific research has been carried out.	• Limited laboratory research has been undertaken.	• No relevant experience.
Stability of Material	Unstable (decomposes).	Unstable (partly decomposes).	Unstable (decomposes).
Estimated Cost of Dry Cover	<$30/$m^2$	<$30/$m^2$	<$30/$m^2$
Guestimate of Effective Cover Life	Not established.	Not established.	Not established.
Guestimate Care & Maintenance Requirements	Frequent reapplication.	Not established.	Frequent reapplication is a possibility.

Table 3.1, cont'd.

GENERAL CLASSIFICATION	OXYGEN CONSUMER		
Potential Dry Cover Material	**Shredder Fluff**	**Compost**	**Municipal Refuse**
Form	• Mixture of non-ferrous materials primarily polymers (rubber, plastic, fibres) produced as a by-product of the shredding of automobiles and appliances.	• Immature or mature compost derived from organics such as food and yard waste. • Mature compost is a humus-like material.	• Municipal refuse excluding material sorted and diverted for recycling.
Source and Quantity	• Produced in relatively small volumes at industrial sites typically located near the US-Canada border.	• Large scale composting is just getting underway in large urban countries. • Quantities of compost available within economic transport distance of most mines are expected to be insufficient.	• Refuse produced in abundant quantities on a national basis but not regionally.
Perceived Benefit/Concerns	• May be of some use in developing a tractable surface on soft tailings. • Concerns include low level PCB contamination, and metal contaminated leachate.	• Expected to provide a high biological oxygen demand and moisture retention. • Concerns include contaminants, pathogens (and related public health issues), high cost and unknown long term performance.	• Could offer significant cost savings if refuse disposal costs were applied to cover construction. • Services concerns include leachate management, and complex permitting requirements.
Experience Related to Tailings Sites	• No relevant experience.	• Limited experience.	• No scientific research undertaken using this material at AMD sites.
Stability of Material	Unknown stability.	Unstable (decomposes).	Unstable (decomposes).
Estimated Cost of Dry Cover	<$30/m^2	<$30/m^2	<$30/m^2
Guestimate of Effective Cover Life	Not applicable.	Not established.	Indefinite if landfill constructed at site.
Guestimate Care & Maintenance Requirements	Not applicable.	Frequent reapplication is possible.	Landfill monitoring.

GENERAL CLASSIFICATION	OXYGEN CONSUMER		
Potential Dry Cover Material	**Manure**	**Hay/Straw/Silage**	**Paper Mill Sludge**
Form	• Animal and plant manure.	• Farm products.	• Paper mill sludge from both primary and secondary wastewater treatment.
Source and Quantity	• Available in small quantities in the vicinity of mine sites.	• Available in large quantities, often within 100 km radius of mining districts.	• Available in moderate quantities - 1.1 x 10^6 t/yr nationally.
Perceived Benefit/Concerns	• Perceived benefits are use as a soil conditioner, high oxygen demand and moisture retaining materials. • Concerns include long term effectiveness.	• Perceived benefits are use as a soil conditioner, high oxygen demand, and moisture retention. • Concerns include relatively high cost, porosity, and poor compressibility.	• Expected to provide high biological oxygen demand and moisture retention. • Concerns include long term effectiveness.
Experience Related to Tailings Sites	• Research has been suggested.	• Research has been suggested.	• Research has been suggested.
Stability of Material	Unstable (decomposes).	Unstable (decomposes).	Unstable (decomposes).
Estimated Cost of Dry Cover	<$30/m^2	<$30/m^2	<$30/m^2
Guestimate of Effective Cover Life	Not established (<5 years?)	Not determined (<5 years?)	Not determined.
Guestimate Care & Maintenance Requirements	Frequent reapplication may be required.	Frequent reapplication may be required.	Not determined.

GENERAL CLASSIFICATION	MOISTURE/INFILTRATION BARRIERS			
Potential Dry Cover Material	**Synthetic Liners**	**Asphaltic Liners**	**Concrete Liners**	**Waxes**
Form	• Fabricated liners.	• Typically spray-on type liners	• Shotcrete, and poured concrete.	• Liquid and solid form.
Source and Quantity	• Commercially available.	• Commercially available	• These materials could be mixed on-site using both local materials and commercial products.,	• Limited supply waste product.
Perceived Benefit/Concerns	• Provision of an impermeable layer likely to be in service for at least 50 years. • Concerns include replacement costs and cover deterioration.	• Establishment of an impermeable layer. • Concerns include ongoing maintenance, cover replacement, impact on the oxidation process, and high cost.	• Concerns include deterioration of the cover due to settlement, freeze/thaw action, etc.	• A pliable wax cover may be capable of providing a self-healing barrier. • Long term effectiveness is a concern.
Experience Related to Tailings Sites	• Significant experience regarding the properties and uses of synthetic liners has been obtained.	• Limited research has been completed	• No experience with respect to covering tailings.	• Research has been suggested.
Stability of Material	Stable (may deteriorate).	Unstable (biodegrades, deteriorates).	Unstable (deteriorates).	Relatively stable (slowly decomposes).
Estimated Cost of Dry Cover	$20 to $40/m^2	<$30/m^2	$20 to $100/m^2	<$30/m^2
Guestimate of Effective Cover Life	>50 years	Short life (<5 years?)	Short life (<5 years?)	Not determined.
Guestimate Care & Maintenance Requirements	Scheduled inspections.	Ongoing inspection and repairs as required.	Ongoing inspection and repairs as required.	Not determined.

GENERAL CLASSIFICATION	MOISTURE/INFILTRATION BARRIERS		
Potential Dry Cover Material	**Biopolymers**	**Desulphurized Tailings**	**Tailings Slimes**
Form	• Polymers	• Tailings (processed to reduce sulphur content).	• Tailings slimes (minus 200 mesh).
Source and Quantity	• Dependent upon the type of polymers used.	• Sufficient source created by processing tailings produced at a mine (or possibly at an adjacent operation).	• Sufficient source created by the particle size separation of tailings produced at a mine (or possibly at an adjacent operation).
Perceived Benefit/Concerns	• The principal concern is that the technology required for this approach is not yet available.	• This material may provide advantages associated with the use of natural soils.	• As per desulphurized tailings this material provides advantages associated with the use of natural soils.
Experience Related to Tailings Sites	• Research is underway (Alberta Research council)	• Research is underway (Ecole Polytechnique and INCO).	• Research includes field measurements at Falconbridge, lab scale at Ecole Polytechnique.
Stability of Material	Unstable (decomposes).	Stable.	Stable (sulphides, if present in slimes, will react slowly).
Estimated Cost of Dry Cover	<$30/m^2	<$30/m^2	<$30/m^2
Guestimate of Effective Cover Life	Not determined.	Indefinite with maintenance.	Indefinite with maintenance.
Guestimate Care & Maintenance Requirements	Not determined.	Scheduled inspections.	Scheduled inspections.

Table 3.1, cont'd.

GENERAL CLASSIFICATION	CHEMICAL INHIBITORS		
Potential Dry Cover Material	**Ashes**	**Limestone**	**Phosphate Rock**
Form	• Boiler ash including wood ash. • Coal bottom ash and fly ash including those from fluidized bed coal combustion operations.	• Crushed limestone.	• Crushed phosphate rock.
Source and Quantity	• Available from diverse sources in various quantities.	• Typically sourced outside mining districts and available as a commercial product.	• Typically sourced form the United States and available as a commercial product.
Perceived Benefit/Concerns	• Their alkaline content (wood ash 35% $CaCO_3$ equivalent) is expected to be useful along with moisture retention. • Concerns include cover leachate quality and long term effectiveness.	• Crushed limestone mixed in the reactive layer of tailings can buffer acid production. • Concerns include quality control during mixing and cover leachate quality.	• As per limestone, buffering capacity is provided. • Concerns include cost, lower solubility, and availability compared to limestone.
Experience Related to Tailings Sites	• Research has been suggested.	• This concept has been adequately addressed by research	• This concept has been adequately addressed by research.
Stability of Material	Unstable (reactive).	Stability dependent upon reactions.	Stability dependent upon reactions.
Estimated Cost of Dry Cover	<$30/m^2	<$30/m^2	<$30/m^2
Guestimate of Effective Cover Life	Not determined.	Variable life.	Variable life.
Guestimate Care & Maintenance Requirements	Not determined.	Possible reapplication as required.	Possible reapplication as required.

Table 3.1, cont'd.

GENERAL CLASSIFICATION	CHEMICAL INHIBITORS		SPECIAL APPLICATION
Potential Dry Cover Material	**Alkaline Sludges/Solutions**	**Inhibitors**	**PHITO Layer**
Form	• Sludges.	• Commercial preparations.	• Would be constructed at site using tailings, phosphate rock, organic material, and vegetative cover seed.
Source and Quantity	• Small quantities of diverse sludges produced by various industries.	• Available commercially.	• Components that would need to be purchased are available commercially.
Perceived Benefit/Concerns	• Buffering of acidity using low cost waste alkaline sludges. • Concerns include availability and quality control if many sludge sources are involved.	• Short term benefit.	• Inhibition of the acid generation process through oxygen demand, and moisture retention. • Concerns include long term effectiveness.
Experience Related to Tailings Sites	• Research has been suggested	• Considerable research has been undertaken in this area.	• Test plots established at Stanrock and Copper Cliff.
Stability of Material	Stability dependent upon reactions.	Unstable.	Stability conditional on conditions and reactions.
Estimated Cost of Dry Cover	<$30/m^2.	<$30/m^2	<$30/m^2
Guestimate of Effective Cover Life	Not determined.	Short Life (<1 year)	Variable life.
Guestimate Care & Maintenance Requirements	Not determined.	Frequent reapplication required.	Possible reapplication of components.

Attachment 8

March 14, 1996 Technical Memorandum
Comparison of the Foth & Van Dyke Surface Water Hydrology Model and the GeoTrans Spreadsheet Model

Foth & Van Dyke
Memorandum

March 14, 1996

TO: Jerry Sevick, Foth & Van Dyke

CC: Don Moe, Crandon Mining Company
Master File

FR: Steve Donohue, Foth & Van Dyke SVD
Mike Liebman, Foth & Van Dyke MDL
Greg Council, GeoTrans, Inc. GC

RE: Crandon Project - Comparison of the Foth & Van Dyke Surface Water Hydrology Model and the GeoTrans Spreadsheet Model

During a December 18, 1995 meeting with representatives of the Wisconsin Department of Natural Resources (WDNR) and the U.S. Army Corps of Engineers (USCOE), CMC agreed to complete a comparison of the Foth & Van Dyke surface water hydrology model developed to assess impacts to Little Sand, Duck, Deep Hole, and Skunk Lakes during TMA construction and operation to the GeoTrans spreadsheet model developed to evaluate input parameters for the regional groundwater modeling work. The purpose of the effort as defined at the meeting would be to compare individual model inputs and outputs. In completing the comparison, it is important to note that the two models were developed and used for different purposes. As such, it is logical to expect that the results from the two models will not be exactly the same. The results, though, should be reasonably comparable.

Surface Water Hydrology Model

Documentation of the Foth & Van Dyke surface water hydrology model is found in Appendix 4.2-4 of the project's Environmental Impact Report (EIR) (Foth & Van Dyke, 1995). The main purpose of the model was to quantify hydrologic flows for the watersheds of Little Sand Lake, Duck Lake, Deep Hole Lake, and Skunk Lake under current and projected operational conditions. The most easily comparative input parameters from this model and the GeoTrans spreadsheet model are runoff coefficients and drainage basin areas of the watersheds. These parameters are used to calculate overland flow into the lake systems.

The runoff volumes for the surface water hydrology model are calculated as precipitation multiplied by area multiplied by a runoff coefficient that varies monthly and with land cover and slopes. The results of the model show that for all four lake basins, roughly 10 percent of precipitation volume is transported to the individual lake systems as overland runoff (approximately 3.2 inches of the 30.36 inches of annual precipitation) under current conditions. The remaining water dissipates through either evapotranspiration or percolation through the soil into the groundwater system.

Lake Water Balance ("Spreadsheet") Models

A separate spreadsheet model was developed by GeoTrans, Inc. as part of the project's regional groundwater modeling work for each of Little Sand, Duck, Deep Hole, and Skunk Lakes. A brief documentation of the models is provided in Section 3.6 of Appendix 4.2-3 of the project's EIR (Foth & Van Dyke, 1995). A technical memorandum containing a more detailed description of these models (GeoTrans, 1996) was distributed to the WDNR and USCOE at the March 4 through 8, 1996 WDNR groundwater modeling meeting. The main purpose of the spreadsheet models was to identify sensitive parameters related to the computation of stage for each of the four lakes. The spreadsheet models also provided a way of estimating lake bed conductivity prior to running the project's more complicated and time-consuming regional groundwater model. The spreadsheet model shows that Little Sand, Duck, and Deep Hole Lakes are sensitive to outfall conditions that may vary over a period of years. Skunk Lake, which has no outfall, is most sensitive to lake bed conductivity.

The GeoTrans models were used, along with the regional groundwater model, to estimate a "practical worst case" lake bed hydraulic conductivity for each of the four lakes. The spreadsheet models treat each lake system, including any connected wetlands, as an individual entity. Runoff inflow to the system is conceptually similar to the upland runoff computed by the Foth & Van Dyke surface water hydrology model. For the Little Sand Lake system, however, additional surface inflow comes from Duck and Deep Hole Lakes via their stream outlets. As considered in the Little Sand Lake spreadsheet model, these stream outlets are in reality diffuse wetland-like connections to the lake basin. For simplicity, and to make the lake stage calculations independent, the Little Sand Lake watershed area in the Little Sand Lake spreadsheet model includes the Duck and Deep Hole Lake watersheds. As with the surface water hydrology model, runoff volume is calculated as the product of precipitation, drainage area, and a runoff coefficient.

Derivation of Runoff Coefficients

The principal parameter in the estimation of monthly runoff in the Foth & Van Dyke surface water hydrology model is the runoff coefficient. As referenced in Appendix 4.2-4 of the EIR (Foth & Van Dyke, 1995), a rigorous approach was used to establish the runoff coefficients for upland wetland and lake areas. The approach involved the selection of runoff coefficients based on slope, land cover, and seasonal conditions (e.g., frozen ground). The range of runoff coefficients used in the modeling was 0.05 to 0.20 for non-frozen conditions. For the period when the ground is frozen, a range of 0.35 to 0.55 was used.

The runoff coefficient used in the GeoTrans models is based on data from Dames & Moore (1985). Dames & Moore calculated monthly runoff coefficients based on streamflow measurements for area streams and contemporaneous precipitation records. These computed runoff coefficients ranged from 0.09 to 0.16 for non-frozen conditions. The November to April period, during which frozen conditions occur, was not part of the spreadsheet model analyses since significant inputs to the lakes do not occur during that timeframe.

Comparison of the Models

The upland runoff parameters and volumes computed by the surface water hydrology model are compared to the spreadsheet model in Table 1 for the month of October. This time period was used because, as outlined in Appendix 4.2-3 of the project's EIR (Foth & Van Dyke, 1995),

October 1984 was selected for steady state calibration of the GeoTrans regional groundwater model and the spreadsheet models. Since the spreadsheet model does not compute runoff for the wetland and lake areas as is computed by the surface water hydrology model, the only directly comparable portion of the two models is the upland runoff volume.

Table 1

Comparison of Upland Surface Water Runoff Calculations for the Month of October

	Surface Water Hydrology Model	Spreadsheet Model
Watershed/Upland Area (acres)[1]		
Little Sand Lake	556.27	448.28[2]
Duck Lake	282.70	202.73
Deep Hole Lake	749.42	769.67
Skunk Lake	292.38	102.92
Runoff Coefficient	0.10	0.15
Precipitation (inches)	2.46	2.46
Runoff Volume (acre-ft)		
Little Sand Lake	11.40	13.78[2]
Duck Lake	5.80	6.23
Deep Hole Lake	15.36	23.67
Skunk Lake	5.99	3.16

[1]Not including the lakes and their adjoining wetlands.
[2]For purposes of evaluating the Little Sand Lake water budget, the spreadsheet model actually includes the Duck and Deep Hole Lake watersheds within the Little Sand Lake drainage basin. For purposes of the comparison made in this table, the Duck and Deep Hole Lake watershed areas are not included in the Little Sand Lake drainage area.

Prepared by: GC/MDL
Checked by: JWS

As is evident in Table 1, differences between the models exists in the watershed areas and runoff coefficients. The biggest difference in area is related to Skunk Lake which has a larger watershed area in the Foth & Van Dyke surface water model. The reason for the difference rests with the methods used to estimate the watershed area. The Dames & Moore Skunk Lake watershed area used by GeoTrans is an effective watershed area that discounts for closed depressions in the Skunk Lake watershed. The Foth & Van Dyke estimate is a total watershed area based solely on topography which includes the Burr Oak watershed in the estimated Skunk Lake watershed area. The runoff coefficient used in the lake stage spreadsheet models was taken from a field study performed in the mid 1980s (Dames & Moore, 1985). The runoff coefficient used for the surface water model is based on published values for various soil types

and slopes. Overall, the two approaches provide a reasonable range of estimated upland runoff to the lakes.

Table 1 shows that the Foth & Van Dyke surface water hydrology model uses an October upland runoff coefficient of 0.10 to calculate the impact of TMA construction and operation on the runoff to each lake. A consistent change in the runoff coefficient used in the model would change the total runoff value, but would not result in a different percent change in runoff when comparing TMA construction and operation conditions to baseline conditions.

As also shown in Table 1, the amount of runoff computed by the lake spreadsheet models is larger than that computed with the surface water hydrology model for Little Sand, Duck, and Deep Hole Lakes. For Skunk Lake, the amount of runoff calculated by the lake spreadsheet model is less than the runoff computed with the surface water hydrology model. The use of a lower value of runoff in the spreadsheet model would lead to a lower prediction of lake bed conductivity by the lake spreadsheet models since these models are governed by the following mass-balance equations:

$$\frac{\Delta S}{\Delta T} = \frac{RO + P - E - OF - SEEP}{A}$$

and

$$SEEP = K_L \left[\frac{S - H}{b} \right] A$$

where S is the lake stage, T is time, RO is the runoff rate, P is the direct precipitation inflow, E is the evaporation rate, OF is the stream outflow, $SEEP$ is the seepage from the lake to the groundwater, A is the lake area, K_L is the lake bed conductivity, H is the average head in the groundwater, and b is the lake bed sediment thickness. Rearranging the terms yields:

$$K_L = \left[\frac{b}{S - H} \right] \left[\frac{RO + P - E - OF}{A} - \frac{\Delta S}{\Delta T} \right].$$

The above relationship shows that, for the spreadsheet models to produce an equally good match to observed stage changes with less runoff, the conductivity would have to be changed (with all other variables held constant). This agrees with physical intuition because a change in inflow must be matched by a change in outflow (i.e., increased or decreased conductivity) to maintain mass balance. Using the runoff amounts from the Foth & Van Dyke surface water model in the lake spreadsheet models would lower the estimate of lake bed conductivities for Little Sand Lake, Duck Lake, and Deep Hole Lake, while raising the conductivity estimate for Skunk Lake. The result would be to lessen the predicted drawdown impacts on Little Sand Lake, Duck Lake, and Deep Hole Lake, while increasing the predicted drawdown impacts on Skunk Lake.

Summary

As described above, the differences in the surface water hydrology and spreadsheet models are related to differences in values used for watershed areas and runoff coefficients. With the exception of Skunk Lake which is described above, the spreadsheet model watershed areas are similar to those in the Foth & Van Dyke surface water hydrology model.

With respect to runoff coefficients, the value used in the spreadsheet models, which was derived from site specific data and was also used previously by the USGS, is an appropriate value to use in the groundwater modeling effort. With regards to the Foth & Van Dyke surface water hydrology model, a consistent change in the runoff coefficient will not change the predicted percent change in runoff during TMA construction and operation.

References

Foth & Van Dyke, 1995. *Environmental Impact Report for the Crandon Project.*

Dames & Moore, 1985. *Hydraulic Relations Between Little Sand Lake, Oak, Duck, Skunk, and Deep Hole Lakes and the Main Groundwater Aquifer.* Crandon Project.

GeoTrans, 1996. Spreadsheet Model Documentation. Technical Memorandum, March 5, 1996.

Attachment 9

February 26, 1996 Technical Memorandum
Fragipan Investigation Evaluation near the Burr Oak Swamp

MEMORANDUM

To: **Jerry W. Sevick, Foth & Van Dyke**
Don Moe, Crandon Mining Company

From: **John E. Thresher, Jr., Thresher & Son, Inc.**

Date: **February 26, 1996**

re: Fragipan Investigation Evaluation near the Burr Oak Swamp

On February 7, 1996, Crandon Mining Company (CMC) has conducted an investigation of the soils developed in a drumlin to the east and southeast of the Burr Oak Swamp at the proposed project site to determine if fragipans are present in the soil, and to evaluate their potential influence, if present, on recharge to the swamp (wetland). The area investigated is along the northwestern margin of the proposed tailings management area (TMA). Mr. Chris Carlson with WDNR was present to view the soil profiles for six of the seven test pits.

Seven test pits were dug using a backhoe in the soils across and down the west-facing slope of the drumlin at the locations shown on Drawing No. 1. Detailed descriptions of the test pit soils are contained in the attached appendix.

Fragipans were found in the two pits (CMC-TMA-TP4 and 5) dug at the slope break. Fragipans were not found in the test pits dug upslope and downslope from CMC-TMA-TP4 and 5. Three of the non fragipan-bearing pits (CMC-TMA-TP1, 2 and 6) contained thin layers of soil having a firm soil consistence which differentiated them from the surrounding friable materials. The firm layers do not meet the requirements for a fragipan classification (Witty and Knox, 1989) but appear to be morphologically and spatially related to the fragipan layers. The firm layers lack the high degree of soil consistence required to be classed fragipans.

The fragipan layers were developed in glacial till material. The firm layers in some of the non fragipan-bearing pits were developed in till (CMC-TMA-TP1 and 2) or in both loess and till (CMC-TMC-TP6). The material in which the fragipan and/or firm layers were formed, and the slope position of the fragipans locations are common to other localities (Bridges, 1978 and Franzmeier, et. al., 1989).

A soil survey of Forrest County has recently been completed by others. A preliminary evaluation and correlation of the soils in the county suggests that scattered fragiorthods (spodisols that contain a fragipan) might be found near the eastern end of the proposed Crandon Project site (SCS, personal communication). The soils found at CMC-TMA-TP4

and 5 would be classified as a fragiorthods. The soils found at the other test pits would likely be classified as quartzipsamments (entisols in which >95% of the sand-sized fraction consists of quartz and other resistant minerals) (Buol, et. al., 1989).

No evidence of textural mottling, and no evidence of features related to horizontal flow of water, above either the fragipans or the firm layers was found within the soil record. Whereas fragipans are considered to have lead to the development of such drainage features at other sites, the presence of moderately to strongly developed structures within the fragipan and firm layers at the site enhances internal vertical soil drainage, thereby maintaining well drained conditions within these soils. An empirical relationship between soil texture, structure and consistence, and internal soil drainage, can be found in Wis. Admin. Code ILHR 83, Table 0. Based upon the information contained within this table it would be predicted that the soils evaluated at the site would be well drained, a conclusion which verifies the evaluation performed in the field.

Respectfully submitted,

John E. Thresher, Jr.

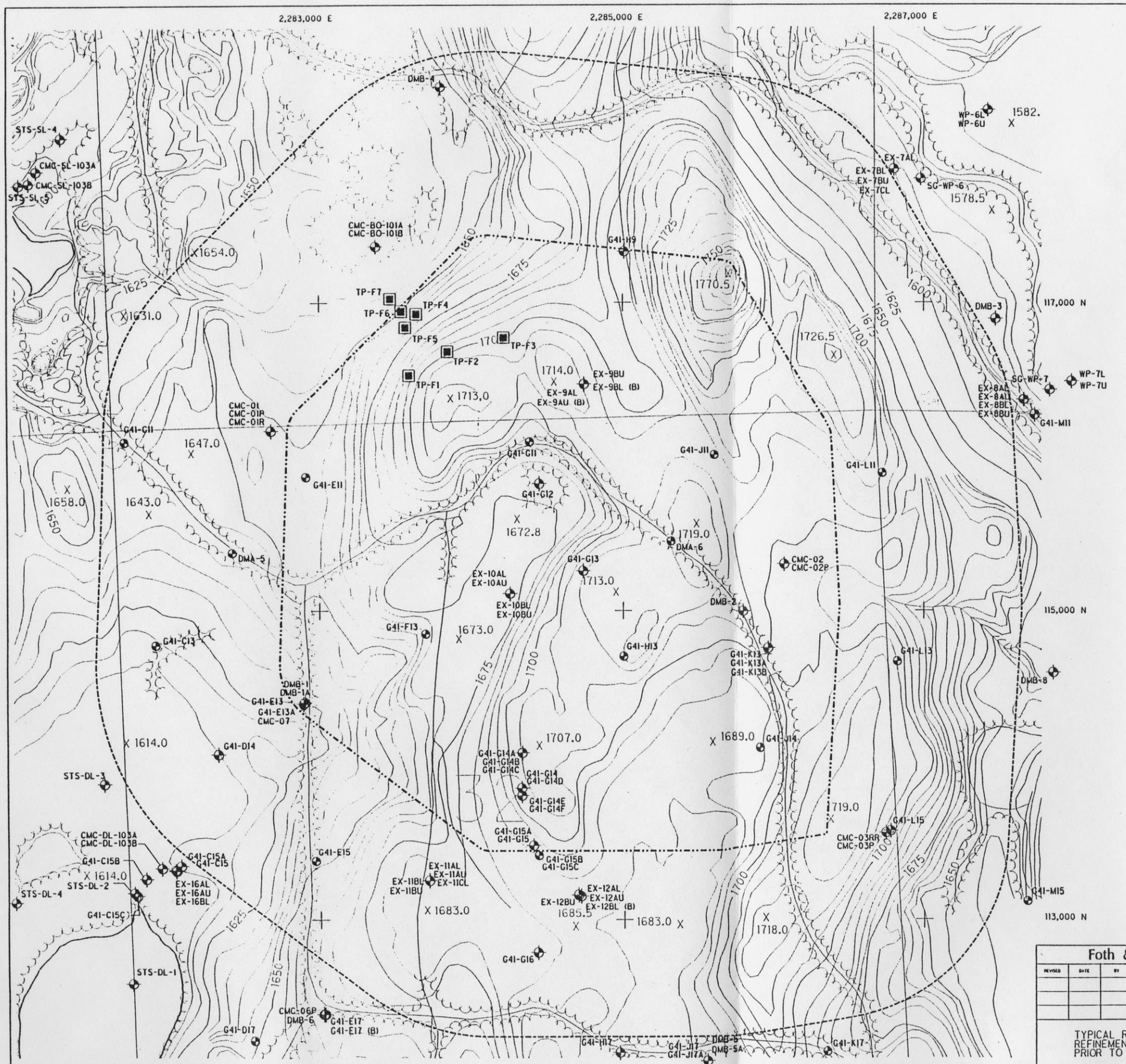
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Bridges, E.M. 1978. *World Soils*. Cambridge University Press. New York, New York.

Buol, S.W., F.D. Hole and R.J. McCraken. 1989. *Soil Genesis and Classification*. Iowa State University Press. Ames, Iowa.

Franzmeier, D.P., L.D. Norton and G.C. Steinhardt. 1989. Fragipan Formation in Loess of the Midwestern United States. in N.E. Smeck and E.J. Ciolkosz, eds. *Fragipans: Their Occurrence, Classification, and Genesis*. SSSA Special Publication No. 24. Soil Science Society of America. Madison, Wisconsin. pp. 69-98.

Witty, J.E. and E.G. Knox. 1989. Identification, Role in Soil Taxonomy, and Worldwide Distribution of Fragipans. in N.E. Smeck and E.J. Ciolkosz, eds. *Fragipans: Their Occurrence, Classification, and Genesis*. SSSA Special Publication No. 24. Soil Science Society of America. Madison, Wisconsin. pp. 1-10.



LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- —1675— EXISTING CONTOUR
- 1692.0 X SPOT ELEVATION
- SECTION LINE
- PERIMETER OF MINE WASTE SITE (AS PER NR182)
- COMPLIANCE BOUNDARY
- SOIL BORING LOCATION (SEE NOTE 5)
- MONITORING WELL LOCATION (SEE NOTE 5)
- TEST PIT LOCATION (SEE NOTE 5)

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. SOIL BORING, TEST PIT OR MONITORING WELL NUMBERS ADJACENT TO SYMBOL.

SCALE
0 300' 600'

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

Crandon Mining Company

TITLE
LOCATION OF FRAGIPAN TEST PITS

SCALE AS SHOWN	STATE WISCONSIN		COUNTY FOREST		
DRAWN BY GAM	DATE 3/96	CHECKED BY A	DATE 3/96		
APPROVED BY	DATE 3/96	APPROVED BY A	DATE 3/96		
APPROVED BY	DATE 3/96	CRANDON MINING COMPANY DEM	DATE 3/96		
DRAWING NO. A	SHEET OF	REVISION NO. 0			

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Appendix 1

Soil Test Pit Logs

LOG OF TEST PIT: CMC-TMA-TP1

CLIENT: Crandon Mining Company
PROJECT: Fragipan Evaluation
PROJECT NUMBER: 93C049
LOCATION: Tailings Management Area (TMA)

SURFACE ELEVATION: 1688.2 feet msl
PIT DEPTH: 96 inches
DATE: 02/07/96

MSL ELEV	DEPTH FR LND SURF	SAMP DEPTH INTERVAL	TYPE	#	MUNSELL COLOR	DESCRIPTION OF MATERIAL	CLASS	LABORATORY TESTS	SAMPLING NOTES
	0-23"					Variegated, black-dark reddish brown, silt loam (SCS). Some gravel. Moist, friable soil. Weak, medium coarse granular structure.	SM		
	23-35"					Variegated, dark reddish brown, silty clay loam (SCS). Trace gravel. Moist soil. Soil consistence mainly friable, but layer contains a few thin, firm layers. Material has moderate, coarse subangular blocky structure. No evidence of textural mottling associated with the firm layers.	CL		
	35-96+"					Reddish brown, fine sandy loam (SCS). Trace gravel. Moist, friable soil. Weak, coarse granular structure developed in moderate, coarse geologic layering.	SM		

TEST PIT DATA

START DATE: 02/07/96
COMPLETION DATE: 02/07/96
LOGGED BY: JET
METHOD: Backhoe
CONTRACTOR: —

WATER LEVEL INFORMATION (Datum = SURF)

DEPTH AT COMPLETION: —
LATER TIME/DEPTH: —
LATER TIME/DEPTH: —
CAVE IN DEPTH: —

LOG OF TEST PIT: CMC-TMA-TP2

CLIENT: Crandon Mining Company
PROJECT: Fragipan Evaluation
PROJECT NUMBER: 93C049
LOCATION: Tailings Management Area

SURFACE ELEVATION: 1697.5 feet msl
PIT DEPTH: 58 inches
DATE: 02/07/96

MSL ELEV	DEPTH FR LND SURF	SAMP DEPTH INTERVAL	TYPE	#	MUNSELL COLOR	DESCRIPTION OF MATERIAL	CLASS	LABORATORY TESTS	SAMPLING NOTES
	0-58+"					Variegated, black to dark reddish brown, silt loam grading to silty clay loam grading to sandy loam (SCS). Trace gravel. Moist soil. Soil consistence mainly friable, but soil contains two 4" thick layers of firm material (at 22 and 40" depth). Firm layers have strong, coarse angular blocky structure. No evidence of textural mottling associated with these firm layers. No evidence of horizontal water movement over the top of the firm layers.	SM		

TEST PIT DATA

START DATE: 02/07/96
COMPLETION DATE: 02/07/96
LOGGED BY: JET
METHOD: Backhoe
CONTRACTOR: —

WATER LEVEL INFORMATION (Datum = SURF)

DEPTH AT COMPLETION: —
LATER TIME/DEPTH: —
LATER TIME/DEPTH: —
CAVE IN DEPTH: —

LOG OF TEST PIT: CMC-TMA-TP3

CLIENT: Crandon Mining Company
PROJECT: Fragipan Evaluation
PROJECT NUMBER: 93C049
LOCATION: Tailings Management Area

SURFACE ELEVATION: 1696.3 feet msl
PIT DEPTH: approx. 60 inches
DATE: 02/07/96

MSL ELEV	DEPTH FR LND SURF	SAMP DEPTH INTERVAL	TYPE	#	MUNSELL COLOR	DESCRIPTION OF MATERIAL	CLASS	LABORATORY TESTS	SAMPLING NOTES
	0-60+"					Variegated, black to dark reddish brown, silt loam grading to silty clay loam grading to sandy loam (SCS). Water seeping into pit from several locations and depths below about 24". Moist to wet, friable soil. Did not enter pit, but soil appears to have some minor soil consistence discontinuities similar to those noted in CMC-TMA-TP2.	SM		

TEST PIT DATA

START DATE: 02/07/96
COMPLETION DATE: 02/07/96
LOGGED BY: JET
METHOD: Backhoe
CONTRACTOR: —

WATER LEVEL INFORMATION (Datum = SURF)

DEPTH AT COMPLETION: —
LATER TIME/DEPTH: —
LATER TIME/DEPTH: —
CAVE IN DEPTH: —

LOG OF TEST PIT: CMC-TMA-TP4

CLIENT: Crandon Mining Company
PROJECT: Fragipan Evaluation
PROJECT NUMBER: 93C049
LOCATION: Tailings Management Area

SURFACE ELEVATION: 1665.0 feet msl
PIT DEPTH: 53 inches
DATE: 02/07/96

MSL ELEV	DEPTH FR LND SURF	SAMP DEPTH INTERVAL	TYPE	#	MUNSELL COLOR	DESCRIPTION OF MATERIAL	CLASS	LABORATORY TESTS	SAMPLING NOTES
	0-2"					Black, silt loam (SCS). Moist, friable topsoil.	SM		
	variable 2 to 4-6"					Light gray, silt loam (SCS). Moist-dry, friable. Developing elluvial (E) horizon.	SM		
	variable 5 to 13-15"					Dark reddish brown, sandy clay loam (SCS). Moist, very firm to indurated. Hydrous iron oxide cement appears to be dominant cementing agent. Strong, coarse subangular blocky structure. Some of the overlying E horizon Fingers down the margins of the subangular blocks. Classified as a fragipan. No evidence of textural mottling above layer, and no evidence of horizontal movement of water over top of layer.	SM-SC		
	14-53+"					Reddish brown, sandy loam (SCS). Moist, friable soil. Weak, coarse granular structure developed in strong, coarse geologic layering.	SM		

TEST PIT DATA

START DATE: 02/07/96
COMPLETION DATE: 02/07/96
LOGGED BY: JET
METHOD: Backhoe
CONTRACTOR: —

WATER LEVEL INFORMATION (Datum = SURF)

DEPTH AT COMPLETION: —
LATER TIME/DEPTH: —
LATER TIME/DEPTH: —
CAVE IN DEPTH: —

89056466998



b89056466998a

Foth & Van Dyke & Associates, Inc.

LOG OF TEST PIT: CMC-TMA-TP5

CLIENT: Crandon Mining Company
PROJECT: Fragipan Evaluation
PROJECT NUMBER: 93C049
LOCATION: Tailings Management Area

SURFACE ELEVATION: 1665.8 feet msl
PIT DEPTH: 65 inches
DATE: 02/07/96

MSL ELEV	DEPTH FR LND SURF	SAMP DEPTH INTERVAL	TYPE	#	MUNSELL COLOR	DESCRIPTION OF MATERIAL	CLASS	LABORATORY TESTS	SAMPLING NOTES
	0-15"					Variegated, black to dark reddish brown, silt loam to silty clay loam (SCS). Moist, friable soil.	SM-CL		
	15-65+"					Dark reddish brown, sandy clay loam (SCS). Moist, very firm to indurated. Hydrous iron oxide appears to be the dominant cementing agent. Strong, coarse subangular blocky structure. Classified as a fragipan. No evidence of textural mottling, and no evidence of horizontal movement of water above the layer.	SC		

TEST PIT DATA

START DATE: 02/07/96
COMPLETION DATE: 02/07/96
LOGGED BY: JET
METHOD: Backhoe
CONTRACTOR: —

WATER LEVEL INFORMATION (Datum = SURF)

DEPTH AT COMPLETION: —
LATER TIME/DEPTH: —
LATER TIME/DEPTH: —
CAVE IN DEPTH: —

LOG OF TEST PIT: CMC-TMA-TP6

CLIENT: Crandon Mining Company
PROJECT: Fragipan Evaluation
PROJECT NUMBER: 93C049
LOCATION: Tailings Management Area

SURFACE ELEVATION: 1650.0 feet msl
PIT DEPTH: 51 inches
DATE: 02/07/96

MSL ELEV	DEPTH FR LND SURF	SAMP DEPTH INTERVAL	TYPE	#	MUNSELL COLOR	DESCRIPTION OF MATERIAL	CLASS	LABORATORY TESTS	SAMPLING NOTES
	0-51+"					Variegated, black to dark reddish brown, thick silt loam grading to sandy loam (SCS). The silt loam (loess) varies in thickness from 25-33". Soil contains a curviplanar paleoweathering surface approximately 25" below surface. Paleoweathering surface is delineated by occurrence of a few, scattered gravel fragments. Soil is moist and friable above the paleoweathering surface. Below the paleoweathering surface the soil is mainly moist and friable, but a few thin layers of firm material exist immediately below the weathering surface. Firm material has moderate, coarse subangular blocky structure. No evidence of textural mottling and no evidence of horizontal movement of water above the firm layers.	SM-SC		

TEST PIT DATA

START DATE: 02/07/96
COMPLETION DATE: 02/07/96
LOGGED BY: JET
METHOD: Backhoe
CONTRACTOR: —

WATER LEVEL INFORMATION (Datum = SURF)

DEPTH AT COMPLETION: —
LATER TIME/DEPTH: —
LATER TIME/DEPTH: —
CAVE IN DEPTH: —

LOG OF TEST PIT: CMC-TMA-TP7

CLIENT: Crandon Mining Company
PROJECT: Fragipan Evaluation
PROJECT NUMBER: 93C049
LOCATION: Tailings Management Area

SURFACE ELEVATION: 1647.0 feet msl
PIT DEPTH: 46 inches
DATE: 02/07/96

MSL ELEV	DEPTH FR LND SURF	SAMP DEPTH INTERVAL	TYPE	#	MUNSELL COLOR	DESCRIPTION OF MATERIAL	CLASS	LABORATORY TESTS	SAMPLING NOTES
	0-46+"					Variegated, black to dark reddish brown to gray, silt loam, silty clay loam and sandy loam (SCS). Moist, friable soil. Highly variable soil texture and structure in pit suggests that some material may be colluvial in origin and that pit may contain soil which has filled in base of a fallen tree.	SM		

TEST PIT DATA

START DATE: 02/07/96
COMPLETION DATE: 02/07/96
LOGGED BY: JET
METHOD: Backhoe
CONTRACTOR: —

WATER LEVEL INFORMATION (Datum = SURF)

DEPTH AT COMPLETION: —
LATER TIME/DEPTH: —
LATER TIME/DEPTH: —
CAVE IN DEPTH: —