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# Addendum no. 5. 1998

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Nicolet Minerals
a Rio Algom company

Rhinelander Office:
7 N. Brown St., Third Floor
Rhinelander, WI 54501-3161
715.365.1450 tel
715.365.1457 fax

Crandon Office:
104 W. Madison St., P.O. Box 336
Crandon, WI 54520-0336
715.478.3393 tel
715.478.3641 fax
www.crandonmine.com

April 20, 2000

Mr. Bill Tans
Wisconsin Department of Natural Resources
Bureau of Integrated Science Services
101 South Webster Street
P.O. Box 7921
Madison, WI 53707-7921

Ms. Char Hauger
U.S. Army Corps of Engineers
St. Paul District
190 Fifth Street East
St. Paul, MN 55101

Dear Mr. Tans and Ms. Hauger:

Re: Crandon Project - *Addendum No. 5 to the May 1995 Crandon Project Tailings Management Area Feasibility Report/Plan of Operation*

Nicolet Minerals Company (NMC) is pleased to submit the enclosed update to Addendum No. 5 to the *May 1995 Crandon Project Tailings Management Area Feasibility Report/Plan of Operation* (Addendum No. 5). The update has been prepared on behalf of NMC by Foth & Van Dyke and Associates, Inc.

NMC has distributed the information to appropriate state and federal agencies, to local officials, and to various interested parties. It is our understanding that the Wisconsin Department of Natural Resources (WDNR) and the U.S. Army Corps of Engineers (USCOE) will be responsible for distribution of the updates to their appropriate staff members.

The enclosed pages are considered to be an update to Addendum No. 5 according to Items 5 through 10 on the attached reference list. The reference list serves as a log and reference identifying changes made to Addendum No. 5 by NMC throughout the permitting process. If additional revisions are made, they will be added to the attached list in sequential order, and the list will be forwarded with the changes.

This update has been prepared in response to a request contained in a December 13, 1999 letter sent to NMC by the WDNR for additional information required for a TMA feasibility determination. WDNR's comment and NMC's response are provided below.

Comment 1: Based on our review of the waste characterization and TMA documentation to date, we believe that some additional work is needed to provide assurance that the TMA drain layer will not experience significant geochemical clogging due to precipitation of secondary minerals such as oxides, sulfates, and carbonates. For the purpose of assessing project feasibility, please provide the results of geochemical model simulations of drain layer conditions under differing $P_{O2}$ and $PC_{O2}$ conditions using approximately mixed process water and oxidized zone water as the starting conditions. This information should be provided as an update to Appendix B of the GWQPE and the TMA Feasibility Report. The update to the Feasibility Report should indicate that the Plan of Operation will include a proposal to design and implement a laboratory experimentation program to

test the potential for clogging of the drain layer using an acceptable recipe for expected leachate under atmospheres with differing concentrations of oxygen and carbon dioxide.

Response 1: *Section 5.4.5 and Appendix J have been added to Addendum No. 5 to provide the requested assessment. The work is consistent with that presented by NMC at the technical working session held with the WDNR during the week of February 21, 2000, with the addition of the requested sensitivity analyses. Electronic versions of the MINTEQA2 model simulations performed as a part of the assessment will be forwarded to selected reviewers under separate cover. Given the fact that the requested analysis applies to the TMA drain and not to the derivation of TMA pore water quality, and to avoid unnecessary duplication of the presentation of the same information, it is NMC's opinion that the proper location for this analysis is in Addendum No. 5. Also note that NMC has committed to preparing a consolidated feasibility report to be submitted at the time the project's Draft Environmental Impact Statement is released. The TMA drain analysis will be included in the consolidated report.*

*Finally, Section 5.4.5 includes a commitment on NMC's part to include the requested study proposal in the TMA Plan of Operation.*

If you or your staff have any questions regarding this update, please contact either Ken Black or myself at (715) 478-3393.

Sincerely,

Gordon Reid, P.E.
Manager of Engineering

GR:cer1
Enclosures

**Nicolet Minerals COMPANY**

*Rhinelander Office:* 7 N. Brown Street, 3rd Floor • Rhinelander, WI 54501-3161 • Ph: 715.365.1450 • Fax: 715.365.1457
*Crandon Office:* 104 W. Madison Street, P.O. Box 336 • Crandon, WI 54520-0336 • Ph: 715.478.3393 • Fax: 715.478.3641
*Web Site:* www.crandonmine.com

July 19, 1999

Mr. Bill Tans
Wisconsin Department of Natural Resources
Bureau of Integrated Science Services
101 South Webster Street
P.O. Box 7921
Madison, WI 53707-7921

Ms. Char Hauger
U.S. Army Corps of Engineers
St. Paul District
190 Fifth Street East
St. Paul, MN 55101

Dear Mr. Tans and Ms. Hauger:

Re: Crandon Project - *Addendum No. 5 to the May 1995 Crandon Project Tailings Management Area Feasibility Report/Plan of Operation*

Nicolet Minerals Company (NMC) is pleased to submit the enclosed updated pages to *Addendum No. 5 to the May 1995 Crandon Project Tailings Management Area Feasibility Report/Plan of Operation* (Addendum No. 5). The update has been prepared on behalf of NMC by Foth & Van Dyke and Associates, Inc.

This document has been prepared to update the HELP model results presented in Addendum No. 5 to reflect modified initial soil moisture content values for the simulation of the post-closure care period of the TMA. For Addendum No. 5, porosity values were used as inputs to the HELP model. For the 2-year consolidation period, the use of field capacities for the drainage layers and the till protective layers is more appropriate. Addendum No. 5 Tables 8.2-6, 8.2-7, and 8.2-8 for layers 15 and 16, layer 11, and layers 16 and 17, respectively, have been modified to reflect this change. In addition, a typographical error for the initial soil water content of layer 1, Table 8.2-6, has been corrected.

New HELP model sums were generated with the modified values, and the results are included in the enclosed updated Table 8.3-5. As shown by the updated table, the

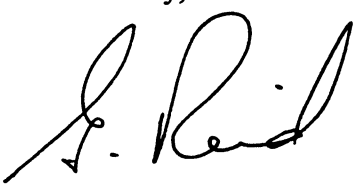
modified initial soil moisture content affects the percolation values through the lower sideslope liner for the first two years after closure, and the base for the first year. In addition, a typographical error for percolation through the base for layer 6 has been corrected on Table 8.3-5.

NMC has distributed the information to appropriate state and federal agencies, to local officials, and to various interested parties. It is our understanding that the Wisconsin Department of Natural Resources (WDNR) and the U.S. Army Corps of Engineers (USCOE) will be responsible for distribution of the updates to their appropriate staff members.

The enclosed pages are considered to be an update to Addendum No. 5 according to Items 1 through 4 on the attached reference list. The reference list serves as a log and reference identifying changes made to Addendum No. 5 by NMC throughout the permitting process. If additional revisions are made, they will be added to the attached list in sequential order, and the list will be forwarded with the changes.

If you or your staff have any questions regarding this update, please contact either Ken Black or myself at (715) 478-3393.

Sincerely,



Gordon Reid
*Manager of Engineering*
Nicolet Minerals Company

GR:cer1
Enclosures

**Nicolet Minerals COMPANY**

*Rhinelander Office:* 7 N. Brown Street, 3rd Floor • Rhinelander, WI 54501-3161 • Ph: 715.365.1450 • Fax: 715.365.1457
*Crandon Office:* 104 W. Madison Street, P.O. Box 336 • Crandon, WI 54520-0336 • Ph: 715.478.3393 • Fax: 715.478.3641
*Web Site:* www.crandonmine.com

December 24, 1998

Mr. Bill Tans
Wisconsin Department of Natural Resources
Bureau of Integrated Science Services
101 South Webster Street
P.O. Box 7921
Madison, WI 53707-7921

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Ms. Char Hauger
U.S. Army Corps of Engineers
St. Paul District
190 Fifth Street East
St. Paul, MN 55101

Dear Mr. Tans and Ms. Hauger:

Re: Crandon Project - Addendum No. 5 to the Tailings Management Area Feasibility Report/Plan of Operation

Nicolet Minerals Company (NMC) is pleased to submit the report titled *Addendum No. 5 to the May 1995 Crandon Project Tailings Management Area Feasibility Report/Plan of Operation* (Addendum No. 5).

Addendum No. 5 has been prepared on behalf of NMC by Foth & Van Dyke and Associates, Inc. As noted on the attached distribution list, NMC has distributed the information to appropriate state and federal agencies, to local officials, and to various interested parties. It is our understanding that the Wisconsin Department of Natural Resources (WDNR) and the U.S. Army Corps of Engineers (USCOE) will be responsible for distribution of the document to their appropriate staff members.

The primary purpose of Addendum No. 5 is to present TMA design changes made as a result of NMC's decision to add pyrite removal to its planned mill circuit. The depyritized tailings will be placed in the TMA, with the pyritic tailings placed back underground as mine backfill using paste technology. As a result of this design change,

the potential to generate acidic conditions in the TMA will be greatly reduced, and the volume of tailings to be placed in the TMA will also be significantly reduced.

This Addendum incorporates relevant information contained in NMC's response to the WDNR's September 26, 1997, Feasibility Completeness Determination Letter and relevant information from Addenda No. 3 and 4 to the May 1995 *Crandon Project Tailings Management Area Feasibility Report/Plan of Operation.* Additionally, the project's *Geosynthetic Material Decision Matrices* (GMDM) has been updated and is included as an appendix to Addendum No. 5 in response to WDNR comments included in the September 26, 1997 Feasibility Completeness Determination Letter, and a February 27, 1998, letter from the USCOE.

WDNR comments to Addendum No. 4 were received by NMC in a letter dated November 17, 1998. NMC has addressed these comments either in this letter or as part of Addendum No. 5, as indicated below:

| WDNR Comment Number | Where Addressed |
|---|---|
| 1 | See response below |
| 2 | Section 5.4 |
| 3 | See response below |
| 4 | See response below |
| 5 | Section 10.2.1/See response below |
| 6 | Section 9 |
| 7 | See response below |
| 8 | See response below |
| 9 | See response below |
| 10 | Section 5.2/5.4 |
| 11 | See response below |
| 12 | See response below |
| 13 | Section 9 |
| 14 | See response below |

| WDNR Comment Number | Where Addressed |
|---|---|
| 15 | See response below |
| 16 | Section 3.4 |
| 17 | Section 11.2 |
| 18 | Section 4.3 |
| 19 | Section 6.5 |

For ease in review, the WDNR November 17, 1998, comment is provided, followed by NMC's response.

**Comment 1 (RCD Response 1):** Since working off of the tailings beach seems to be an important concept for TMA operation, maintenance, and construction, the FR should identify alternative means for preparing the beach for traffic and stockpiling. This would mainly concern the techniques and materials to be used to improve strength. Possibilities include the following: geotextile or geogrid and aggregate pads or roadbeds; use of limited applications of paste fill; mixing pozzolanic agents such as lime, cement or pozzolanic fly ash to the beach surface; or simply shutting down the mill temporarily until the beach firms up appropriately.

**Response 1:** *The use of geotextile or geogrid along with waste rock or till soil to provide support above the tailings beaches for traffic and material staging was discussed in RCD Response 1. Alternative means for preparing the beaches for traffic and stockpiling will be addressed in the consolidated 1999 FR.*

**Comment 2 (RCD Response 2b):** Due to the revision in the proposed TMA's waste mass due to depyritization and the associated changes to the expected process water chemistry, please reanalyze the potential for geochemical clogging in the filter and drain layers. As part of the new work, add some flow or block diagrams explaining the expected processes and their locations within the TMA, and include an assessment of how conditions are expected to change once the draining of a given TMA cell begins. Develop an estimate of clogging potential and effective life of the drain during consolidation and closure. Include a review of any expected changes to clogging potential due to the potential addition of limestone to the waste mass. Please provide a digital copy of the MINTEQ input files for the updated model runs prepared for the response to these comments.

The current analysis regarding potential for geochemical clogging in the filter and drain layers makes several assumptions which may or may not be appropriate. In the updated analysis, please provide a discussion of all the assumptions made and their rationale, including (but not limited to):

- Tailings $P_{CO2}$ = Atmospheric $P_{CO2}$ throughout the tailings.
- No significant preferential flow through the tailings.
- All significant precipitation reactions will take place within the tailings mass.

Please also include a sensitivity analysis of the of the significant parameters, including $P_{CO2}$ and Eh.

**Response 2:** *An update of the potential for geochemical clogging at the drainage and filter layers is provided in Section 5.4 of Addendum No. 5.*

**Comment 3 (RCD Response 4):** The approach to periods of non-pumping outlined in the response is reasonable if the FR details clear limits on potential pond size in TMA cells to avoid erosion.

**Response 3:** *The consolidated 1999 FR will provide greater detail on the potential pond size in the TMA cells to minimize erosion.*

**Comment 4 (RCD Response 6 and 24):** The Final Cover Replacement Criteria and TMA Monitoring Plan have not yet been submitted. Please submit the necessary information as soon as it is available.

**Response 4:** *The TMA Monitoring Plan has been prepared as an Appendix to the update to the project's Mine Permit Application (MPA). The plan includes monitoring of groundwater, tailings, and leachate, as well as reclaim pond liner performance and final cover performance monitoring, including replacement criteria.*

**Comment 5 (RCD Response 7):** Since the December 1997 date of this response, changes have been made to the project proposal resulting in the placement of depyritized tailings into the TMA. NMC has indicated that limestone would be mixed with the tails on an as needed basis to achieve a net neutral chemistry within each cell of the TMA. Please respond more completely to Completeness Comment 7, providing details on the amendment program. Include information detailing the necessary chemical character of any added limestone and the necessary grain size distribution to ensure the limestone and the remaining tailings sulfides are not segregated within the TMA.

**Response 5:** *A detailed neutralization potential (NP) control program is outlined in Appendix B of the updated MPA. Typical limestone chemical characteristics are included as Appendix I of Addendum No. 5. The proposed method of limestone addition to the tailings is in the pump box as a fine grained slurry which would allow sufficient blending with the tailings prior to deposition. The grind of the limestone will match that of the tailings (i.e., ≥89%, passing the U.S. Sieve No. 200). Therefore, segregation of the limestone and tailings is not expected to occur. Refer to Section 10.2.1 for additional details.*

**Comment 6 (RCD Response 9):** Based upon the information included in the recently revised regional groundwater flow model, the portion of the proposed TMA disturbance area within the Bur Oak Swamp watershed will be significantly reduced in the revised FR. The concerns about appropriate water supply to Bur Oak Swamp (temporal and spatial distribution, quantity, and quality) remain. When we have had a chance to review the revised facility footprint and design, we will be better able to assess the potential impacts to the wetland.

**Response 6:** *The TMA disturbance area within the Bur Oak Swamp watershed has been significantly reduced. The disturbance area of, and water supply to, the Bur Oak watershed are addressed in Section 9 of Addendum No. 5.*

**Comment 7 (RCD Response 12):** The test work done at Colorado State University on the chemical response of bentonite responds directly to the comment. Changes in the proposed project made since the testing was completed indicate that the process water chemistry may be different, that limestone may be added to portions or all of the facility, and that brine from the tertiary water treatment may be pumped to the TMA. Please provide an analysis of the changes in the leachate water quality expected from these changes in the project and an assessment of the applicability of these test results given those changes.

**Response 7:** *Brine from tertiary water treatment will be mixed with pyritic tailings as paste backfill for the mine and will not be placed in the TMA.*

*Changes in the TMA leachate quality as a result of pyrite removal will not adversely impact the GCL as indicated in the letter report from Dr. Charles Shackelford of Colorado State University contained in Appendix F of Addendum No. 5.*

**Comment 8 (RCD Response 14):** The response on criteria for timing of cover placement is reasonable, though limited in details. NMC basically states that judgement will be made based on the condition of the tailings surface and shear strength

monitoring of the tailings surface. It might be useful to extend monitoring deeper than the surface. The plan should also be revised to indicate that the data collected on surface conditions and shear strength will be reported to the Department.

**Response 8:** *A procedure for estimating the stability of the tailings for placement of the grading layer, preparing specifications for grading layer placement, and providing quality control during its placement is provided in NMC's May 12, 1998, Response 19 to Comment 19 of the December 22, 1997, USCOE letter to NMC regarding their review of the Feasibility Report. Both the USCOE Comment 19 and NMC response 19 are repeated below. As stated in the response, on site shear strength measurements are one potential method of developing a lower bound value for developing a stable slope for grading layer placement. As field data on surface conditions and shear strength become available, they will be provided to WDNR.*

**Comment 19:** We anticipate that the use of geosynthetic materials may be required to prevent displacement of the tailings mass during placement of the cap grading materials. Displacement of the tailings mass would result in an increased thickness of grading fill and potential ponding of runoff water, which in turn would affect the performance of the cover system, especially with respect to water balance. However, we realize that a preliminary design may be difficult to develop because assumptions regarding construction operations, undrained shear strength of the upper tailings, and information regarding the formation and strength of a crust would be required.

To satisfy our concerns regarding this issue, please provide a list of design steps that will be utilized prior to capping, when the current unknowns are quantifiable. This list should anticipate extremes in potential strength of the surface of the tailings. This procedure may become a condition of the permit, if granted.

**Response 19:** *NMC concurs with USCOE that geosynthetic materials may have to be used to separate the tailings and the cap grading materials. However, it should also be noted that unlike undrained tailings management facilities where the consolidated water travels only upwards (in the absence of a design drainage system at the base), the primary migration of moisture for the Crandon Project TMA will be towards the base leachate collection system due to forces of gravity. Such a scenario will induce negative pore pressures compared with positive pore pressures under upward drainage. When upward drainage and positive pore pressure develop, the tailings strength will be low. Downward drainage and negative pore pressures will result in increased tailings strength. Based on the above scenario, the design steps proposed for the placement of final cover,*

*including the grading layer, consist of calculation of the stability of the grading layer, development of construction specifications, and QA/QC during construction of the grading layer to verify conformance with the specifications*

*Estimation of the Stability of the Grading Layer:*

*Sinking of the grading materials into the tailing mass is the manifestation of insufficient bearing capacity. In other words, displacement of the tailings during placement of the grading materials indicates that the tailings do not have the required bearing capacity to support the loads imposed by the grading materials placed and the equipment placing them. The bearing capacity can be increased either by using reinforcing (and separation) geotextiles or by providing a surcharge beyond the points of heavy loads. The latter can be achieved by providing a gradual and relatively flat slope for the grading materials being placed over the till. NMC proposes to approach the analysis from the perspective of stable angles rather than immediate use of geotextiles. The analysis will consist of developing a plot between the tailing strength and stable slopes of the grading materials. The analyses will be conducted using PCSTABLE6. A range of potential tailing strengths, grading material densities, strengths and thicknesses (ranging from a minimum of 3.0 feet to a maximum of 25 feet) will be used. The equipment to be considered will be wide-tracked dozers and excavators. A factor of safety of 1:2 to 1:3 will be used.*

*Preparation of Construction Specifications:*

*Based on the plot developed and inferred tailings strength (a lower bound value based on past experience, literature values, or in situ shear strength measurements), a stable slope for the construction activities will be determined. The outer slope of the grading layer being placed (i.e., from the tailings surface to the top of the grading layer) will be the stable slope thus determined. By specifying the minimum soil thickness under the equipment and minimum required distance from the tailings surface, and observing for evidence for tailings displacement, a stable slope for the grading layer can be achieved in the field. It is anticipated that a 3-foot cover will be placed first. The final grades will be achieved by placing additional grading layer and cover soils as required to reach final elevation afterwards.*

*Quality Control During Construction:*

*Based on the specifications for stable slopes, QA monitors will verify that the required thickness of "surcharge" is available beyond the grading material placed and the equipment placing it. At the same time the monitors will also look for development of "waves" in the tailings thus indicating shear displacements. Such waves will indicate areas of smaller strengths than those used for preparing the specifications. If practical, a flatter slope will then be specified. If not practical, a geosynthetic reinforcement will be used. A geotextile design assuming extremely low tailings strength will be prepared and implemented in such areas.*

*In summary, the grading layer placement will consist of the following three steps:*

1. *Design of stable outer slopes for different tailings strengths.*
2. *Preparation of construction specifications and construction per these specifications.*
3. *QA/QC during construction and modifications to the specifications as needed.*

*It is to be noted that the tailings will undergo 6 to 12 months of consolidation prior to placement of grading layer soils, and that the tailings and grading layer soils will undergo an additional period of consolidation prior to placement of final cover soils. Prior to the construction of the final cover, regrading of the grading layer soils will be effected to repair any areas of ponding.*

**Comment 9 (RCD Response 16):** The response on the potential for volumetric expansion of the tailings is reasonable for the scenario envisioned. Please provide an additional assessment of the potential that a positive feedback system could be established whereby a small failure in the final cover could lead to a small increase in waste volume which could enlarge the original failure. The analysis should consider that this positive feedback cycle may operate for considerable time prior to any response.

**Response 9:** *An assessment of the potential that a positive feedback system could develop will be addressed in the consolidated 1999 FR.*

**Comment 10 (RCD Response 20):** The response on drainage layer conductivity is reasonable for production of the material. However, it is not clear that the design conductivity can be maintained over the desired active life of the drain. The conductivity can be affected by both physical and chemical factors. As indicated above,

more work on the potential for geochemical clogging is needed. We believe that the drainage filter test work was reasonable. If, however, the specifications for the drain layer need to be adjusted at the plan of operation stage, a geotextile filter may be necessary to separate the filter layer from the sand drain on the base of each cell. We suggest that the FR be revised to indicate that a geotextile filter may be used if necessary at the filter/drain interface.

**Response 10:** *The potential for physical and geochemical clogging is addressed in Sections 5.2 and 5.4 of Addendum No. 5.*

**Comment 11 (RCD Response 23):** The response to the additional information requests concerning the Reclaim Pond are reasonable. As you are aware, due to the changes in the groundwater rules in ch. NR 182, Wis. Adm. Code, the Reclaim Pond will be considered an "other" facility with an expected DMZ of 150 feet. Given the constant head on the liner and the average chemical characteristics of process water for the water in the facility, the Reclaim Pond is a potentially significant source of groundwater contamination. NMC should take that into account and consider revising the proposed design of the Reclaim Pond.

**Response 11:** *As the WDNR is aware, NMC is currently updating the TMA solute transport model to reflect recent changes to the project's flow model as documented by HSI GeoTrans in a report to be prepared during January 1999. As part of this update, NMC will assess the compliance of the reclaim pond with NR 140, Wis. Admin. Code, Groundwater Quality Standards, at the expected DMZ of 150 feet. If the analysis shows that the reclaim pond design will not result in compliance with groundwater quality standards, NMC will propose design changes so that compliance can be demonstrated.*

**Comment 12 (RCD Response 47b,c,d):** The Department continues to evaluate issues surrounding pipe strength and pipe placement designs.

**Response 12:** *Comment noted.*

**Comment 13 (RCD Response 53):** In general, the response to the comment on surface water management is reasonable. We may have some comments on the design and location of specific basin outfalls. Due to the downsizing of the TMA, the location and sizing of the TMA runoff basins are likely to be adjusted. Therefore, we will reserve additional comments until after the submittal of the revised FR.

**Response 13:** *Comment noted. The surface water control system design has been updated in Section 9 of Addendum No. 5 to accommodate changes in the TMA configuration.*

**Comment 14 (TMA Dust Management Plan):** The approach detailed in the TMA DMP appears to be reasonable with a few modifications. Visual inspections are a major part of the program. The inspections are called "routine". We suggest that the plan detail that inspections be made on a regular schedule, with additional inspections made when weather conditions significantly change. The plan indicates a similar weather-condition based approach with 20 mph wind speeds resulting in more frequent inspections. Please provide more information on the 20 mph inspection threshold using literature-reported threshold entrainment velocities for dry materials with similar grain size distributions as that expected for the Crandon project tailings.

Since the submittal of the DMP, the design of the upper stage of each cell has been modified to incorporate a leachate drain and a P40 filter layer. Note that the use of sprayers will have to be compatible with the thin lift thickness and the properties of the P40 material.

During cold weather conditions, the potential use of a perimeter sprinkler system to control dust is indicated. In such cold weather, the use of a perimeter sprinkler system seems not likely to be successful without a lot of work to keep the lines and sprinklers from freezing.

For long-term control of dusting, we would advocate caution in the use of ponding as a dust control measure due to erosion potential. Binders and/or sprinklers could be used if the shut down is not expected to be prolonged. Under an extended shut down, the plan should detail riprap placement prior to any flooding of a cell.

**Response 14:** *An updated dust management plan will be included as part of the 1999 consolidated FR.*

**Comment 15 (TMA Disposal of Treatment Plant Brine):** As indicated above, the Department has some concerns about the placement of the treatment plant brine into the TMA. The brine will be a very concentrated solution consisting largely of common ions captured from the treated process water - primarily sulfate and calcium. Though the Department does not yet have information on the treatment plant brine quality or quantity, it appears that the brine would add to the loading caused by the process water. NMC should investigate the possibility of beneficially using all or a portion of the brine as a solidified salt cake or a process chemical.

**Response 15:** *The treatment plant brine will be combined with the pyritic tailings which will be used as underground mine backfill, incorporating paste technology. Treatment plant brine will not be placed in the TMA.*

**Comment 16 (Revised Marketability Analysis):** Due to changes in the proposed project, NMC should revise the required waste marketability analysis to bring it up to date. Please address any improvement for pyrite reuse due to captive costs from the proposed pyrite separation and to demonstrate the effects on the mine and TMA operations if pyrite reuse is practical. In addition, please address the marketability of the wastewater treatment plant brine and potential products from the brine, such as salt cake.

**Response 16:** *An updated pyrite marketability analysis is discussed in Section 3.4 of Addendum No. 5.*

*In contrast to the Crandon Project as proposed in the 1980s, the current project would produce a wastewater treatment plant brine from the evaporation/condensation of the reverse osmosis reject consisting mostly of calcium sulfate with a substantial amount of magnesium and a lesser amount of sodium. Chloride content would be more than minimal. There would also be several metals such as selenium, iron, zinc, and manganese in trace amounts. Production could be 4.8 to 8 tons per day. Capital costs for a crystalizer are currently estimated at $1.5 to $2.05 million.*

*Based on this material being mostly impure calcium sulfate which is readily available from other sources, and that costs for additional treatment which would be required to attempt to market it are substantial, the economics of such an undertaking are not positive. Therefore, further studies to determine marketability are not proposed by NMC.*

**Comment 17 (A Table of Standard Density Values for Project Tailings and Waste Rock):** Please include in the revised FR a single table showing the updated expected density (or expected range in density) for the major project materials, including ore (separated into massive and stringer, if appropriate), waste rock (separated into formations, if appropriate), pyrite concentrate, and depyritized tails. For reference, please also include values for the previously proposed pyritic tails.

**Response 17:** *Table 11.2-1 of Addendum No. 5 presents the expected densities for the major project materials, including zinc phase tailings, copper phase tailings, waste rock, and wastewater treatment plant solids. The dry density of the zinc and copper phase depyritized tailings have decreased from 97 pcf (pyritic) to 93 pcf (depyritized).*

**Comment 18 (Update TMA Materials Balance):** Please include in the revised FR an updated materials balance, including the additional soils to be used for liner and riprap of the Reclaim Pond and other lined facilities.

**Response 18:** *Drawing 13 and Figure 12.2-2 of Addendum No. 5 have been updated to reflect the soil balance for the site with the revised TMA configuration. Liner and riprap volumes for the reclaim pond are included in the soil balance.*

**Comment 19 (TMA Drain Layer Head Monitoring System Design):** Please include in the revised FR, a proposed design for the drain layer head level monitoring system. Though much of the TMA monitoring program will not require major facility design changes, the Department is concerned that whatever approach is proposed for drain layer head monitoring will require some potential design changes to the TMA.

**Response 19:** *A detail depicting construction of a leachate head monitoring device is included as Figure 6.5-2 of Addendum No. 5. Locations proposed for head monitoring devices are shown on Drawing 16 of Addendum No. 5.*

If you or your staff have any questions regarding Addendum No. 5, please contact me at (715) 478-3393.

Sincerely,

Gordon Reid
*Manager of Engineering*
Nicolet Minerals Company

GR:cer1

## Distribution

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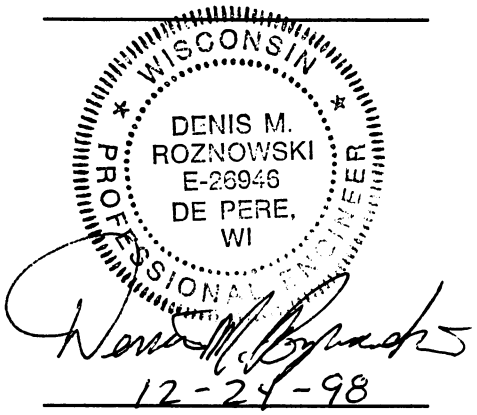
# Addendum No. 5 to the May 1995 Crandon Project Tailings Management Area Feasibility Report/Plan of Operation

## Log of Updates and Additional Information

| Entry Number | Date Revision Issued | Page(s) | Document/ Section Number | Description |
|---|---|---|---|---|
| 1 | 7/19/99 | 1-7 | Distribution List | Updated |
| 2 | 7/19/99 | 1 | Log of Updates | Addition - place behind Distribution List |
| 3 | 7/19/99 | 56-61 | Tables 8.2-6, 8.2-7, and 8.2-8 | Updated to reflect corrected initial soil moisture content values |
| 4 | 7/19/99 | 82-83 | Table 8.3-5 | Updated to reflect correct HELP model sums |
| 5 | 4/20/00 | 1-7 | Distribution List | Updated |
| 6 | 4/20/00 | 1 | Log of Updates | Updated - place behind Distribution List |
| 7 | 4/20/00 | iii, viii | Table of Contents | Updated |
| 8 | 4/20/00 | 35 | Section 5.4 | Updated to add Section 5.4.5 |
| 9 | 4/20/00 | 133 | Section 16 | Updated to add WDNR reference |
| 10 | 4/20/00 | — | Appendix J | New - Add behind Appendix I |

# Addendum No. 5 to the May 1995 Crandon Project Tailings Management Area Feasibility Report/Plan of Operation

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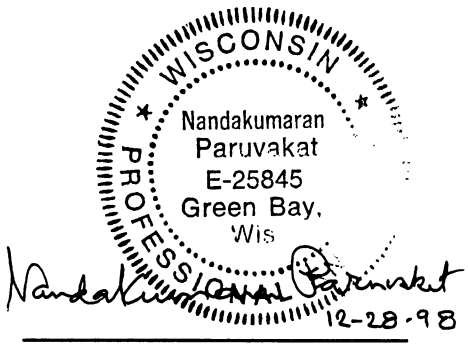


Prepared for

**Nicolet Minerals Company**
7 North Brown Street, 3rd Floor
Rhinelander, Wisconsin 54501-3161

Prepared by

**Foth & Van Dyke and Associates Inc.**

December 1998

**Foth & Van Dyke 1998**
2737 S. Ridge Road, P.O. Box 19012, Green Bay, Wisconsin 54304, 414/497-2500, FAX: 414/497-8516

# Addendum No. 5 to the May 1995 Crandon Project Tailings Management Area Feasibility Report/Plan of Operation

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# 1 Introduction

Through its predecessor company, Nicolet Minerals Company (NMC) submitted its *Crandon Project Tailings Management Area Feasibility Report/Plan of Operation* (Foth & Van Dyke, 1995) to the Wisconsin Department of Natural Resources (WDNR) and the U.S. Army Corps of Engineers (USCOE) in May 1995. On February 21, 1996, the document titled *Addendum No. 1 to the May 1995 Crandon Project Tailings Management Area Feasibility Report/Plan of Operation* (Addendum No. 1) (Foth & Van Dyke, 1996a), was submitted to the WDNR and USCOE. Addendum No. 1 presented responses to a portion of the comments raised in the WDNR's January 4, 1996, TMA Completeness Determination Letter (WDNR, 1996). The addendum was provided to the WDNR at a February 22, 1996, TMA meeting with the WDNR, the USCOE, and others. At this meeting, WDNR requested clarification of and additional information for some of the responses contained in Addendum No. 1.

The document titled *Addendum No. 2 to the May 1995 Crandon Project Tailings Management Area Feasibility Report/Plan of Operation* (Addendum No. 2) (Foth & Van Dyke, 1996b), was submitted to the WDNR and USCOE on April 4, 1996. Addendum No. 2 was prepared both to clarify responses to the 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 (WDNR, 1996).

*Addendum No. 3 to the May 1995 Crandon Project Tailings Management Area Feasibility Report/Plan of Operation* (Addendum No. 3) (Foth & Van Dyke, 1997a), was submitted to the WDNR on January 30, 1997. Addendum No. 3 was prepared to document modifications to the facilities footprint in the vicinity of the Bur Oak Swamp, to consolidate modifications made to the facilities proposed liner, final cover, and leachate management system design, and to address the remaining issues raised at a May 28, 1996, TMA meeting.

Finally, the document titled *Addendum No. 4 to the May 1995 Crandon Project Tailings Management Area Feasibility Report/Plan of Operation* (Addendum No. 4) (Foth & Van Dyke, 1998a), submitted to the WDNR and USCOE on June 17, 1998, presented design changes to the TMA liner system made as a result of GCL compatibility tests. Addendum No. 4 also updated estimates of percolation through the liner and cover system during TMA operation, closure, and post-closure periods due to the proposed design changes, namely, the addition of a drainage sidewall layer on the upper stages of the TMA cells.

This document, titled *Addendum No. 5 to the May 1995 Crandon Project Tailings Management Area Feasibility Report/Plan of Operation* (Addendum No. 5), has been prepared to document a reduction in the footprint of the TMA resulting from a tailings volume reduction as a result of NMC's plan to remove pyrite from the tailings prior to deposition in the TMA, with the placement of pyritic tailings underground as paste backfill. The P40 filter layer between the tailings and the till protective layer above the drainage layer has also been replaced by six inches of till to enhance liner performance in association with changed characteristics of the depyritized

tailings. The project's Geosynthetic Materials Decision Matrix (GMDM) has also been updated to respond to regulatory agencies' comments and is included as an appendix to Addendum No. 5.

NMC intends to consolidate relevant portions of the original *Feasibility Report/Plan of Operation,* addenda and responses to regulatory agency comments into a consolidated Feasibility Report to be issued in early 1999 to assist the regulatory community in review of the Crandon Project proposal.

## 2 Purpose and Scope

The purpose of this document is to provide information required by NR 182, Wis. Admin. Code, and to satisfy requirements of the WDNR September 26, 1997, Completeness Determination Letter for the *May 1995 Crandon Project Tailings Management Area Feasibility Report/Plan of Operation* (Feasibility Report) (WDNR, 1997). Where applicable, this document also incorporates responses to requests from the WDNR and other agencies for specific additional information required for the WDNR to make a completeness and feasibility determination.

Specifically, Addendum No. 5 contains the following:

- A reduction of the TMA footprint to store a reduced volume of tailings resulting from the incorporation of the depyritization and paste backfill process into the project plan. The number of TMA cells has been reduced from four to three.
- Redesign of the TMA footprint to provide additional setback from Bur Oak Swamp.
- Redesign of TMA 1 into two sub-cells (1A and 1B) for the first stage level.
- Update of the TMA liner design, including changes to the till soil component above the drainage layer.
- Update of the HELP model to reflect changes in the tailings properties, modification of the till soil component above the drainage layer, and modifications made to the footprint.
- Redesign of the surface water management facilities.
- Modifications to site development and site phasing.
- Reassessment of the potential impacts to local drainage basins given the design modifications referenced above.
- Recalculation of the earthwork balance for the facility.
- Incorporation of relevant responses raised by the WDNR in the September 26, 1997, TMA Completeness Determination Letter (WDNR, 1997).
- Update of the GMDM to address WDNR issues in the September 26, 1997 TMA Completeness Determination Letter (WDNR, 1997), as well as issues raised by the USCOE in the February 27, 1998, letter (USCOE, 1998).

# 3 Background/General Project Information

## 3.1 Project Description

Since the original May 1995 *Tailings Management Area Feasibility Report/Plan of Operation for the Crandon Project* (Feasibility Report) (Foth & Van Dyke, 1995) submittal, several modifications to the project have been made. A complete summary of the proposed project is contained in the updated *Mine Permit Application* (MPA) (Foth & Van Dyke, 1995/1998a). The major modifications to the project since submittal of the original MPA which are part of the current project include:

- Removal of pyrite from the whole tailings prior to deposition in the TMA, thereby significantly reducing long term environmental risk.

- Placement of pyritic whole tailings underground as mine backfill, using paste technology.

- Reduction of the volume of tailings to be deposited and a subsequent reduction in the footprint of the TMA as a result of the pyrite removal and paste backfill processes.

- Construction of a 25-foot thick grout blanket within the crown pillar region of the mine to control water inflow.

- Modification to the water management facilities to allow the discharge of treated wastewater to an adjacent soil absorption system. The proposed advanced treatment technology involving reverse osmosis and evaporation is described in the updated *Preliminary Engineering Report for Wastewater Treatment Facilities* (Foth & Van Dyke, 1995/1998b).

The above project modifications significantly reduce project impacts, as detailed in the updated *Environmental Impact Report* (EIR) (Foth & Van Dyke, 1995/1998c). Specific impact reductions relative to the TMA are described in detail in Section 4 of that report.

## 3.2 Applicability to County Solid Waste Management Plan, s. 289.24(1)(c)

Wisconsin State Statute 289.24(1)(c) requires that feasibility reports include a description of how the proposed facility relates to any applicable county solid waste management plan (SWMP) approved under s. 289.10.

Contacts with the Forest County zoning administrator and clerk, as well as WDNR northern and northeast region waste program team leaders, indicate that Forest County does not presently have a SWMP approved under s. 289.10. Since Forest County does not have a SWMP, and since the TMA will not accept waste generated outside the project area, the proposed project will not impact any SWMP approved under s. 289.10.

## 3.3 Advisory Process Undertaken by Applicant, s. 289.24(1)(d)

Wisconsin State Statute 289.24(1)(d) requires that feasibility reports include a description of the advisory process undertaken by the applicant. Information regarding this project has been provided to the public and affected municipalities, and public opinion on the proposed facility has been solicited through, but not limited to, the following means:

- Public consultation through hearings required for the Notice of Intent process;
- NMC informational meetings at the time the NOI/SOS was submitted;
- USCOE scoping hearings for a federal EIS process;
- Numerous technical meetings pertaining to the siting and design of the TMA facilities were conducted. These meetings were posted and open to the public; and
- Public outreach sessions conducted by the WDNR in seven communities (Green Bay, New London, Town of Ainsworth, City of Crandon, City of Rhinelander, City of Tomahawk, and City of Wausau). Responses to all comments were provided by the WDNR.

Additionally, NMC staff have attended numerous county board, township, and lake association meetings to inform and involve the public. Under the Local Agreements negotiated with the affected municipalities, a Citizen Advisory Committee was established to improve the consultative process. More recently, NMC conducted a series of listening sessions in the City of Antigo, City of Rhinelander, and the City of Crandon to receive input on the proposed changes to the project.

As a consequence of this consultative process, NMC has modified its mining plans to address public concerns raised about water and waste management issues.

## 3.4 Pyrite Marketability Analysis

The marketability of pyrite concentrate from the Crandon Project has been re-evaluated to determine if conditions have improved since the April 1995 analysis was completed. Appendix A contains the updated market analysis. The conclusions of the analysis are that there is no market for pyrite concentrate due to the low cost of elemental sulfur and the ability to purchase acid from other sources at lower costs compared to the cost of manufacturing acid from the pyrite concentrate.

# 4 TMA Design Modifications Overview

## 4.1 Design Objectives

The performance objectives as stated in Section 6.1.1 of the Feasibility Report (Foth & Van Dyke, 1995) have not changed appreciably with the design modifications described in this report. The primary objective of the design changes proposed herein for the TMA is to further reduce long-term environmental risk by removing pyrite from the tailings to be placed in the TMA, which reduces the potential to produce acidic conditions. As a consequence of the pyrite removal process, the overall size of the TMA can be reduced. In evaluating the design, careful consideration was given to minimizing impacts to Bur Oak Swamp (wetland F15), minimizing direct wetland taking, and maintaining surface water drainage patterns. The overall long-term performance of the TMA in terms of potential environmental impacts has been enhanced by the design modifications proposed. The sections which follow provide an overview of the design modifications related to changes in waste characterization and volume.

## 4.2 Waste Characterization

### 4.2.1 Physical Properties

The results of physical property testing on depyritized tailings conducted by Steffen Robertson and Kirsten (SRK) are contained in two memoranda; one pertaining to density projections and one pertaining to moisture regime testing. In addition, STS Consultants, Ltd. (STS) conducted permeability tests on the tailings. The results of the three test programs are included in Appendix B.

Table 4.2-1 contains a summary of the index, and engineering properties of the depyritized tailings from the tests conducted by SRK and STS. The properties include particle size distribution characteristics, specific gravity, hydraulic conductivity, consolidation properties, and density information.

The grain size analysis shows that 89.2 percent of the tailings particles are finer than 75 microns (U.S. Sieve No. 200). The tailings are non-plastic and classified as ML under the Unified Soil Classification System. The hydraulic conductivity of dense tailings will be in the range of $6.5 \times 10^{-6}$ cm/sec. SRK has estimated that the tailings will consolidate as rapidly as they are placed in the cells, with an average dry density of 93 pcf.

### 4.2.2 Chemical Properties

During the operation of the mill, tailings will be mixed with process water and pumped to the TMA cells. Initially, tailings will be added to the each of the cells subaqueously. Once a sufficient bed of tailings has been deposited, excess water will be drained from the surface using a decant system, and from beneath the tailings by activating the leachate collection system located in the base of each of the cells. Thereafter, tailings will be added to the cells subaerially.

## Table 4.2-1

## Summary of Tailings Properties

| Property | Description | Value/Units |
|---|---|---|
| Grain Size | -75$\mu$ | 89.2% |
| | -5$\mu$ | 8.8% |
| | $D_{85}$ | 0.068 mm |
| | $D_{60}$ | 0.035 mm |
| | $D_{50}$ | 0.0269 mm |
| | $D_{30}$ | 0.0149 mm |
| | $D_{15}$ | 0.0074 mm |
| | $D_{10}$ | 0.0055 mm |
| | $C_c$ | 1.16 |
| | $C_u$ | 6.2 |
| | USCS Classification | ML |
| Specific Gravity | $G_s$ | 2.81 |
| Hydraulic Conductivity | at $\gamma_d$ = 89.6 pcf | 6.5 E-06 cm/sec |
| | at $\gamma_d$ = 95.6 pcf | 7.27 E-06 cm/sec |
| Coefficient of Consolidation | At normal load 541 psf | 1.28 E-04 $ft^2$/sec |
| | At normal load 1084 psf | 1.06 E-04 $ft^2$/sec |
| | At normal load 2164 psf | 1.15 E-04 $ft^2$/sec |
| | At normal load 4320 psf | 1.01 E-04 $ft^2$/sec |
| | At normal load 8637 psf | 8.97 E-05 $ft^2$/sec |
| Dry Density | At consolidation pressure of 1084 psf | 92.2 pcf |
| | At consolidation pressure of 4320 psf | 94.3 pcf |

Note: Hydraulic conductivity results from STS, October 1998. All other results from SRK. See Appendix B for detailed reports.

Prepared by: NXP
Checked by: DMR

Since the Crandon Project was reinitiated in 1993, a series of three investigations has been performed to characterize the tailings expected to be produced by the project. Between the second and third investigation, the mineral processing option was also reassessed, and depyritization of the tailings was incorporated into the project plan.

The first investigation comprised static testing, and kinetic testing using large scale humidity cells. The test methods and results are described in Section 3.5.5 of the project's EIR (Foth & Van Dyke, 1995/1998c). The second investigation, in addition to static testing, also included kinetic tests using small scale humidity cells and anoxic neutralization columns. The methods and results of these tests are presented in the document *Crandon TMA - Supplementary Waste Characterization Program Final Report* (SRK, 1998a). This investigation was completed on the coarse and fine fractions of the pyritic tailings, originally planned for use in backfilling mined out stopes and for placement in the TMA, respectively.

The third investigation was completed on pyrite concentrate planned for use as paste backfill, and on the depyritized tailings now planned for placement in the TMA. Static testing of these materials has been completed. Kinetic testing of these products has also been initiated. The static test methods and results, and kinetic test methods and initial results, are described in the report *Geochemical Characterization of Depyritized Tailings, Pyrite Concentrate and Pyritic Paste Backfill* (SRK, 1998b).

The waste rock generated underground that will be hoisted to the surface during the preproduction phase of the project has been classified into two types based on geochemical properties. Type I waste rock will consist of material that will not produce acid rock drainage if left exposed on the surface for any length of time, and may leach only minute quantities of solutes. Type II waste rock will be material that has the potential to produce acid rock drainage if left exposed on the surface under oxidizing conditions. The characteristics which distinguish Type I and Type II waste rock are described in Section 3.5.5 of the project's EIR (Foth & Van Dyke, 1995/1998c). A detailed waste rock management plan is presented in Section 4.8.9.3 of the project's MPA (Foth & Van Dyke, 1995/1998a). All Type II waste rock will be placed in the TMA and will be fully immersed in tailings. Type I waste rock will, following testing, be used in the TMA cell grading layer.

In addition to tailings and waste rock, wastewater treatment plant solids and a small amount of laboratory waste will also be placed in the TMA. The impact of the addition of these latter two materials types on the TMA pore water characteristics is described in the report *TMA Source Concentrations for Depyritized Tailings* (SRK, 1998c).

## 4.3 Volumes

The material to be placed in the TMA includes depyritized tailings, hoisted waste rock, wastewater treatment plant solids, and small amounts of demolition and laboratory wastes. The tailings volume to be deposited in the TMA has been significantly reduced due to the planned removal of pyrite and the introduction of paste backfill technology.

Table 4.3-1 is an update of Table 13 of the December 1997 Completeness Determination Response (NMC, 1997). When Table 4.3-1 is compared with Table 13, the following general conclusions can be drawn:

- The total volume of the TMA has decreased from 20.56 million cy to 14.10 million cy (including contingency). This is an approximate 31 percent reduction in volume.

- The estimated quantity of tailings to be placed in the TMA has decreased from 17.08 million cy to 11.77 million cy (without contingency).

- The amount of waste rock to be placed of in the TMA is reduced from 1.26 million cubic yards to approximately 487,000 cy (730,000 tons).

Section 11 provides greater detail on the breakdown of waste types and quantities to be placed in the TMA.

## 4.4 TMA Facility Description

Due to process changes, the TMA volume requirement has been reduced from 20.56 million cubic yards (cy) to 14.10 million cy, or by 31.4 percent. As a consequence of these changes, the TMA has been downsized from the original four cell design to a design consisting of three cells: TMA 1, TMA 2, and TMA 3. TMA 1 is designed to contain the depyritized tailings during zinc ore production, and TMA 2 and 3 are designed to contain the depyritized tailings during copper ore production.

This section provides information concerning the design modifications which were made as a result of the introduction of pyrite removal and paste backfill. Following is a general listing of the major design components of the TMA, along with a brief explanation of the design modifications made, if any, as a result of the changes mentioned above.

- TMA operating system has not been modified.

- TMA composite liner system design has been changed as follows:

  - The 6 inch layer of till fines at the cell base has been eliminated and replaced with 6 inches of till soils. Refer to Section 5 of this report for additional explanation.

  - The geocomposite drainage layer has been extended to the second stage of the TMA cells (note that this design change was described in Addendum No. 4 (Foth & Van Dyke, 1998a).

## Table 4.3-1

### Estimated Volumes and Site Life for TMA Cells and Stages

(Updated Table 13 from December 1997 Completeness Determination Response)

| Tailings Cell | Stage | Tailings[1] (cy) | Approximate Phase Life (yrs.) | Other Wastes[2] (cy) | Contingency[3] (cy) | Calculated Need (cy) | Cell Design Total[4] (cy) | Capacity as Percent of Total |
|---|---|---|---|---|---|---|---|---|
| **Zinc Ore Production** | | | | | | | | |
| TMA 1A | I | 648,000 | 2.1 | 361,000 | — | 1,009,000 | 1,000,000 | |
| TMA 1B | II | 1,173,000 | 3.8 | 61,000 | — | 1,234,000 | 1,220,000 | |
| TMA 1 | III | 3,117,000 | 10.1 | 59,000 | 641,000 | 3,817,000 | 3,840,000 | |
| **Zinc Total Tailings** | | 4,938,000 | 16.0 | 481,000 | 641,000 | 6,060,000 | 6,060,000 | 100.0 |
| **Copper Ore Production** | | | | | | | | |
| TMA 2 | IV | 1,367,000 | 2.4 | 41,000 | — | 1,408,000 | 1,390,000 | |
| TMA 2 | V | 2,050,000 | 3.6 | 31,000 | 531,000 | 2,612,000 | 2,630,000 | |
| **Subtotal** | | 3,417,000 | 6.0 | 72,000 | 531,000 | 4,020,000 | 4,020,000 | 50.0 |
| TMA 3 | VI | 1,367,000 | 2.4 | 41,000 | — | 1,408,000 | 1,400,000 | |
| TMA 3 | VII | 2,050,000 | 3.6 | 183,000 | 379,000 | 2,612,000 | 2,620,000 | |
| **Subtotal** | | 3,417,000 | 6.0 | 224,000 | 379,000 | 4,020,000 | 4,020,000 | 50.0 |
| **Copper Total Tailings** | | 6,834,000 | 12.0 | 296,000 | 910,000 | 8,040,000 | 8,040,000 | 100.0 |
| **Total Zinc & Copper** | | 11,772,000 | 28 | 777,000 | 1,551,000 | 14,100,000 | 14,100,000 | |

[1] Zinc ore production tailings generation rate is 308,600 cy/yr; copper ore production tailings generation rate is 569,400 cy/yr.

[2] Other wastes include waste rock, wastewater treatment solids, laboratory wastes, and demolition wastes. Demolition wastes estimated at 150,000 cy will be placed in TMA 3 Stage VII.

[3] The zinc and copper cells include an approximate 12% and 13% contingency respectively, based on the total expected production of tailings and other wastes.

[4] Cell design total is the actual design volume based on model calculation performed by Computer Aided Drafting and Design (CADD). The design total is within 0.5% of the required total.

cy = Cubic yards
yrs = Years

Prepared by: SAD2
Checked by: DMR

- The TMA leachate collection system remains unchanged from the modification proposed in Addendum No. 3 (Foth & Van Dyke, 1997a) and Addendum No. 4 (Foth & Van Dyke, 1998a), except as follows:

  - The sideslope riser design has been modified to accommodate the interior separation berm between TMA 1A and 1B (i.e., Stages I and II). Refer to Section 6.6 of this report for a detailed description.

- The TMA embankment configuration and design remains unchanged, except for the following:

  - The design of TMA 1 includes an interior berm which separates TMA 1A and TMA 1B. The proposed TMA liner system will be extended over this berm. The berm will not be extended to the second stage of TMA 1A and 1B (i.e., Stage III). Refer to Section 4.4.2 of this report for a detailed description;

  - The sequencing of the berm earth work has been modified to minimize double handling of soil during construction. The modified phasing development of the TMA cells is described in Section 12 of this report.

- TMA composite final cover design elements were modified to include the following:

  - A cushioning 12 oz/square yard nonwoven geotextile has been added between the drainage layer and the geomembrane (NMC, 1997);

  - A 12 inch thick layer of 3 inch to 8 inch cobbles has been added as a biotic layer above the drainage layer. The purpose of this layer is to mitigate potential damage to the geomembrane from burrowing animals (NMC, 1997).

- TMA water budget calculations have been modified to reflect the changes in the material properties, the facility configuration, and other design components.

- TMA surface water management design has been modified by relocating the runoff basins and redirecting surface water flow during certain periods of time to minimize the impacts of the TMA on local drainage basins. Diversion berms were also added to the outboard embankment sideslopes to minimize uninterrupted flow distance (thereby reducing sediment loss), and more efficiently route surface water to the sedimentation basins. In addition, the runoff basin discharge design has been modified to better mimic natural conditions. Refer to Section 9 of this report for details.

- The setback to wetland F15 (Bur Oak Swamp) and the distance between runoff basin discharge points and the wetland have been increased

- TMA traffic routing, security and screening remain largely unchanged except as related to aesthetics as discussed in Section 10.3.

- TMA site phasing and development, including the material balances, have been modified as follows:

  - The change in the site phasing resulting from the change from four cells to three cells is described in Section 12 of this report.

  - The material balance has been recalculated and is described in Section 12 of this report.

  - The design and configuration of the reclaim pond has been modified as described in Section 10 of this report.

- The foundation and stability analysis previously performed for the TMA remain valid.

- Revised TMA reclamation and environmental monitoring plans are as described in the update to the MPA (Foth & Van Dyke, 1995/1998a).

### 4.4.1 TMA Footprint

The revised footprint for the TMA and its surrounding facilities are shown on Figure 4.4-1. This footprint includes the TMA, TMA borrow area, reclaim pond, perimeter road, embankment slopes, exterior drainage system, and runoff basins. The revised footprint avoids or minimizes direct and indirect disturbance to wetland F15 and other wetlands due to the construction of the TMA. The Setback Alternative No. 2 footprint (Foth & Van Dyke, 1997a) resulted in a total area of disturbance of 345 acres, including approximately 22.8 acres of direct wetland disturbance. The revised Addendum No. 5 footprint results in a total of 282 acres of disturbance, including 19.9 acres of direct wetland disturbance, or a total decrease in disturbance area of 63 acres (18.2 percent) (see Table 4.4-1). The reduction in total wetland disturbance results primarily from moving the north limit of the TMA further south, completely avoiding wetlands F33, 13, 14, and 15, and reducing disturbance to wetland M4. A comparison of watershed disturbance acres follows. The disturbance areas of the Setback Alternative No. 2 footprint are shown in parentheses following the revised footprint value.

The disturbance for the wetland F15 watershed will be approximately 25.9 acres (63.1), which is approximately 59 percent less than in the Setback Alternative No. 2 proposal. The disturbance within the lake watersheds will be approximately 56.5 acres (86.3) for Deep Hole Lake, 117.1 acres (130.0) for Duck Lake, and 43.7 acres (89.9) for Skunk Lake. Approximately 65.0 acres (68.5) of the Hemlock Creek watershed will also be disturbed. When compared to the Setback Alternative No. 2 footprint contained in Addendum No. 3 (Foth & Van Dyke, 1997a) (see Figure 4.4-1), the disturbance within lake and stream watersheds for the revised footprint are similar for Duck Lake and Hemlock Creek, and significantly decreased for Deep Hole Lake and Skunk Lake, in addition to the significant reduction to the wetland F15 watershed.

## Table 4.4-1

## Acreages of Wetland Types Removed During TMA Construction

| Wetland No. | Revised Footprint[1] Wetland Types: Emergent Marsh | Shrub Swamp | Deciduous Swamp | Coniferous Swamp | Bog | Total Area Impacted |
|---|---|---|---|---|---|---|
| F30[2] | | | 0.02 | | | 0.02 |
| F31 | | | 2.16 | 4.29 | | 6.45 |
| F32 | | | 0.68 | | | 0.68 |
| F66 | | 2.54 | | 4.64 | | 7.18 |
| F81 | 0.33 | | | | | 0.33 |
| 16 | | | 0.10 | | | 0.10 |
| 17 | | | 0.54 | | | 0.54 |
| M4 | | | 0.27 | | | 0.27 |
| M3 | | | 1.82 | 1.60 | | 3.42 |
| Unnamed (3) | | | 0.89 | | | 0.89 |
| Total | 0.33 | 2.54 | 6.48 | 10.53 | | 19.88 |

[1] Includes TMA, TMA borrow area, reclaim pond, perimeter road, exterior drainage system, and runoff basins.

[2] Wetland F30 is classified as a "streamside wetland" (SW) in Table 5-4 of the project's updated *Section 404 Permit Application Addendum 1* (Foth & Van Dyke, 1995/1998d). The impacted portion of this wetland is dominated by deciduous swamp.

Prepared by: BDH
Checked by: JWS

The revised design involves a slight reduction in the elevation of the highest point on the final cover of the TMA. The TMA final grade is approximately 5.5 feet lower than the Alternative No. 2 design, with a maximum final elevation of approximately 1,754.5 feet. The perimeter berm heights are essentially unchanged from the Setback Alternative No. 2 design. However, due to the smaller footprint, the highest berm elevation in the center of the facility is approximately 4 feet lower than the previous proposal.

The reduction in the overall height and lateral extent of the TMA was accomplished while minimizing or avoiding direct impact to wetlands. As shown on Figure 4.4-1, the proposed borrow area configuration has been modified to address the maximum stockpiling and borrow needs of TMA cells 2 and 3. The borrow area may be reduced in size if waste rock, after testing, can be used in the grading layer below the final cover. The adjustment of the borrow site final grades, as shown on Drawing 18, minimizes the hydraulic impact to wetland F15 by matching the original F15 drainage divide and discharging a portion of the borrow area's surface water through runoff basin 12 toward Hemlock Creek.

### 4.4.2 Embankment Configuration

Two modifications have been made to the TMA embankment configuration. The first involves the design of TMA 1, which includes a separation berm between the first two horizontal stages (TMA 1A and TMA 1B) of development. This modification is explained below. Note that TMA 2 and 3 embankment configuration is the same as the previous design; that is, each has two vertical stages as described in Sections 6.5.2 and 6.5.3 of the *Feasibility Report/Plan of Operation* (Foth & Van Dyke, 1995). The second modification is related to the sequence for construction of the embankments. This is described in Section 12 of this report.

TMA 1 is proposed for development as two adjacent horizontal stages (TMA 1A Stage I and TMA 1B Stage II), and a vertical stage above TMA 1A and 1B, denoted as TMA 1 Stage III. TMA 1A and 1B are separated by an interior berm which extends to the height of the first stage of cell development (refer to Drawing 15). The facility liner will extend over the top of the interior separation berm. Liner placement for TMA 1 Stage III will take place before TMA 1B is full and after the exterior berms have been constructed to the required elevations. The filling sequence of TMA 1 Stage III consists of filling over TMA 1A and TMA 1B.

Figure 4.4-2 is a detail of the separation berm between TMA 1A and 1B. The figure shows TMA 1A (Stage I) berm and liner constructed, with the future liner construction for TMA 1B (Stage II) shown screened. The liner system extends north over the interior separation berm to the TMA 1B (Stage II) cell. The liner on top of the berm will be protected with an 18 inch till layer covered by a gravel layer for vehicle travel. The future area for liner splice to the TMA 1B liner will be temporarily covered with geotextile and plywood sheeting to protect the liner materials from damage.

#### 4.4.2.1 Revised Estimates of Erosion Potential of the Embankment Slopes

The outer slopes of the TMA will be vegetated after construction and in the course of time will be invaded by trees, shrubs, and mature grasses. The Revised Universal Soil Loss Equation (RUSLE) analysis for the final cover and exterior berm slopes, as presented in Appendix L of the Feasibility Report (Foth & Van Dyke, 1995), has been used to establish the estimated erosion rate for the thawed condition for the revised TMA design. The calculations show that once vegetation is established, soil loss is estimated at 2.24 tons per acre per year. This value is very conservative, since soil loss will be limited to less than the calculated estimate by the engineering controls added, including diversion berms, runoff detention basins, geotextile filter fabrics, wrapping outlet discharge pipes and flow distribution systems. The soil lost from the embankments will be directed through the surface water management features listed above and further described in Section 9 of this report. Methods used to stabilize the slopes include seeding, fertilizing, and mulching the embankments as soon as practicable after construction is completed. The reclamation of these slopes is detailed in Section 5 of the updated MPA (Foth & Van Dyke, 1995/1998a).

## 4.5 Comparison of Revised Footprint Impacts

Table 4.5-1 presents a summary of the impacts of the revised footprint as compared to the Setback Alternative No. 2 footprint (Foth & Van Dyke, 1997a). The summary demonstrates that the revised footprint results in significant decreases in overall impact.

## Table 4.5-1

## Summary of Revised Footprint Impacts as Compared to Setback Alternative No. 2

| Parameter | Change |
|---|---|
| Historical, Archaeological, Cultural Resources | • Increased buffer to Bur Oak Swamp by 400 feet. |
| Transportation and Utilities | • No significant difference. |
| Climatology - Air Quality | • No significant difference. |
| Geology - Soils | • No significant difference. |
| Groundwater | • No significant difference. |
| Surface Water | • 63 acres less total disturbance.<br>• 59 percent less watershed disturbance in F15 wetland watershed.<br>• Surface water discharge through F33 to F15 is maintained.<br>• Achievement of a comparable match of pre-development to post-reclamation runoff into wetland F15. |
| Biology | • No significant difference. |
| Wetlands | • Avoidance of disturbance to wetlands F33, 13, 14 and 15.<br>• 0.8-acre reduction of disturbance to wetland M4<br>• Total reduction in wetland disturbance of 2.9 acres. |
| Noise | • No significant difference. |
| Land Use - Zoning | • No significant difference. |
| Aesthetics | • No significant difference. |
| Socioeconomics | • No significant difference. |
| Native American Communities | • No significant difference. |

Prepared by: DMR
Checked by: SVD1

# 5 TMA Liner System Update

## 5.1 Background

Addendum No. 4 (Foth & Van Dyke, 1998a) presented the following TMA liner configurations (listed from the top to the bottom).

Base Liner

- 18-inch riprap;
- 6-inch till fines (P40);
- 12-inch glacial till;
- 24-inch granular soil drainage layer;
- geotextile;
- 60 mil high density polyethylene (HDPE) geomembrane;
- GCL; and
- 12-inch low permeability soil (P40).

First and Second Stage Sideslope

- 6-inch till fines (P40)
- 12-inch glacial till;
- geocomposite drainage layer;
- HDPE textured (both sides) 60 mil geomembrane;
- GCL; and
- 12-inch low permeability soil (P40).

In addition, an 18-inch riprap layer was included over the 6-inch till fines layer on the interior slopes during final tailings deposition. Based on compatibility testing of both prehydrated and non-prehydrated GCL's with synthetic leachates (Shackelford, 1998a), NMC opted in Addendum No. 4 to conservatively assume the GCL used in the TMA liner system will function with a hydraulic conductivity of $8.8 \times 10^{-6}$ cm/sec. Since the GCL in the final cover system will not be exposed to leachates, its hydraulic conductivity was established at the manufacturer's reported value of $3 \times 10^{-9}$ cm/sec for the HELP model analysis. The value was also supported by the GCL testwork. Section 8.0 includes a discussion of the hydraulic conductivity of the GCL with the new process water as a permeant. The value of $8.8 \times 10^{-6}$ cm/sec has been found to be appropriate for the proposed design.

Previous Feasibility Report submittals (Foth & Van Dyke, 1995, 1996a, 1996b, 1997a, and 1998a) were based on the TMA receiving fine tailings containing pyrite. NMC is currently proposing that depyritized whole tailings be placed in the TMA. From the perspective of the design of the liner system, the significance of this change is in the gradation of the tailings. The transition between the tailings and the coarse drainage layer was, therefore, re-evaluated considering filtration criteria.

## 5.2 Filter Layer Modifications

In the previous submittals of the Feasibility Report and Addenda, the transition zone between the tailings and the drainage layer consisted of a 6-inch layer of till fines passing the U.S. Sieve No. 40, overlying a 12-inch layer of unprocessed till with boulders removed, overlying the drainage layer. This filter system was shown to be appropriate by the application of Terzaghi's Filter Criteria (NAVFAC DM7.1) and a large scale laboratory test using actual materials (J&L Testing, 1998).

The revised filter calculations in Appendix C show that for the coarser depyritized whole tailings a filter layer consisting of unprocessed till will prevent migration of fines. An analysis was also completed to address the potential for segregation of the tailings. Based on industry experience (personal communication with Les MacPhie, SNC Lavelin - Montreal), it was assumed that the tailings further away from the discharge points in the TMA will be finer, and that the maximum size of these segregated tailings were 50 percent the size of the non-segregated tailings. Using these assumptions, a gradation for the segregated tailings was developed and filter criteria was checked between this material and the unprocessed tills. As shown in Appendix C, it was concluded that even for the segregated tailings unprocessed till would prevent migration of tailings fines into the drainage layer.

NMC is cognizant of the importance of the drainage layers and the importance of preventing clogging of these layers during the period of active leachate extraction. Therefore, prior to the preparation of the TMA Plan of Operation, NMC proposes to conduct additional laboratory filter tests. The tests will be similar to those conducted earlier at J&L Testing in Canonsburg, Pennsylvania (J&L Testing, 1998), the results of which were submitted to WDNR and the USCOE by NMC on June 30, 1998. In the proposed tests, NMC will use tailings with a maximum size equal to 50 percent of the size of the depyritized tailings. The proposed test program will be used to verify the theoretical segregation analysis.

## 5.3 Liner Design Modifications

Based on the discussion presented in Section 5.2, the TMA liner system design has been modified as follows (from the top to the bottom). Refer to Figure 5.3-1.

Base Liner

- 18-inch riprap;
- 18-inch filter layer (glacial till);
- 24-inch drainage layer;
- cushioning geotextile;
- 60 mil HDPE geomembrane;
- GCL; and
- 12-inch permeability soil (P40).

First and Second Stage Sideslope

- 18-inch filter layer (glacial till);
- geocomposite drainage layer;
- textured (both sides) 60 mil HDPE geomembrane;
- GCL; and
- 12-inch low permeability soil (P40).

In addition, a minimum 18-inch riprap layer will be placed over the 18-inch till layer on the interior slopes as required during final tailings deposition.

## 5.4 Analysis of Potential for Geochemical Clogging in the Filter and Drainage Layers

Due to the adoption of depyritization and a tailings neutralization potential (NP) control program (as discussed in Section 10.2.1), the conditions in the TMA have changed from the previous analysis relating to geochemical clogging. Due to these changes, the process water characteristics will differ from the original estimate, and the tailings mass will no longer be net acid generating.

The process water that will be discharged to the TMA will comprise flows from various unit operations in the mill. As discussed below, these flows will be alkaline and concentrations of most solutes will be low. The significance of this is that, unlike for acidic flows, contact of the alkaline process water with the alkaline carbonate minerals that may be present in the filter layer will not lead to scaling secondary mineral precipitation. The tailings similarly will contain a significant proportion of carbonate minerals, which again will not lead to excessive precipitation reactions on equilibration with the process water. The process water equilibrated with the tailings, or tailings pore water, when entering the drainage layer will already have partly or fully equilibrated with the carbonates in the tailings so that the filter layer will in effect be inert to the tailings process water.

The geochemical conditions that will control the interaction between the aqueous and solid phases will change as the process streams mix to generate the process water discharge, and then as the process water passes through the tailings and filter layer to finally enter the drainage layer. The conditions during each of these steps are discussed in detail below. The discussion has been divided into three parts. The first addresses changes in the process water chemistry. The next describes geochemical controls that will influence both process and pore water before and after they enter the filter and drainage layers. The third part presents and discusses results from selected geochemical modeling runs.

### 5.4.1 Process Water Chemistry

Changes in the expected process water chemistry will result from the addition of the depyritization flotation process to the mill circuit. Previously the zinc tailings pore water

characterized the process water chemistry. With the addition of the depyritization flotation step, the tailings process water that will enter the TMA will comprise a mixture of several flows that affect the composition to varying degrees. Table 5.4-1 presents the process streams and flow rates that will contribute to process water flows to the TMA. The total flow will still be dominated by the flow from the zinc tailings thickener, but the effects of other streams have to be taken into consideration. The process water associated with the depyritization flotation process represents about 20 percent of the total flow that will be discharged to the TMA.

## Table 5.4-1

## Summary of Process Streams Discharging to TMA

| Stream | Stream ID | Flow (gpm) | pH (s.u.) |
|---|---|---|---|
| Depyritized Tailings Process Water | DTPW | 475 | 6 |
| Zinc Tails Thickener Overflow | ZTTO | 1328 | 11.2 |
| Pyrite Backfill PPSM Overflow | PBPO | 197 | 6 |
| Zinc Concentrate Thickener Overflow | ZCTO | 240 | 11.8 |
| Lead Hydroseparator Overflow | LHSO | 55 | 8.5 |
| Lead Concentrate Thickener Overflow | LCTO | 30 | 8.5 |
| Copper Concentrate Thickener Overflow | CCTO | 42 | 7.2 |

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Checked by: TAD

Solute concentrations in each flow component of the process water entering the TMA were estimated based on the following assumptions:

- Solute concentrations in the zinc tailings thickener overflow were assumed to be the same as in the zinc tailings process water used in the Ground Water Quality Performance Evaluation (GWQPE) (Foth and Van Dyke, 1998b).

- Solute concentrations in the depyritized tailings process water will be as measured by Lakefield (SRK, 1998b) during locked cycle testing.

- Solute concentrations in the pyrite backfill PPSM overflow were obtained by conservatively selecting the higher solute concentrations from the process water quality measured for Pyrite Concentrate 1 and 2, respectively (SRK, 1998b).

- Zinc concentrate process water was assumed to be similar to the zinc tailings process water from the GWQPE (Foth & Van Dyke, 1998b) on the basis of the high pH.

- The pH values of the remainder of the flows ranged from 7.2 to 8.5; therefore the depyritized tailings pore water was assumed to be representative of these flows. The relatively low flows make the calculation of the composite water less sensitive to the assumed solute concentrations for these flow components.

The estimated solute concentrations for the various process streams are summarized in Table 5.4-2. The "Process Water Discharge to TMA" column shows the weighted average of the input flows. The estimate of the pH was calculated from a free $OH^-$ balance.

As shown in Table 5.4-2, solute concentrations in the process water are expected to be relatively low, with the exception of calcium and sulfate. Saturation indices were calculated to assess the potential for secondary minerals to form directly from the process water. At the elevated pH conditions, potentially a number of metal hydroxide phases may be precipitated (MINTEQA2 files NMC1.in and NMC1.out). Generally, the precipitation of hydroxide phases occurs rapidly, and the process water is expected to reach equilibrium conditions before it enters the TMA.

Since lime is used during mineral processing to adjust the process water pH, equilibrium conditions for the process water were calculated by first estimating the lime equivalent alkalinity from the $OH^-$ balance. This was then used as an input to MINTEQA2, and equilibrium pH and solute concentrations were calculated. The results are summarized in Table 5.4-3 (only solutes that change are shown). The results show that the equilibrium pH will remain near 11 s.u. and concentrations of some minor solutes decrease (i.e., Fe, Al, Ba, Ni, Mn, Pb, Cr). In contrast, gypsum is not expected to precipitate from solution since the calculated saturation index (SI= -0.14) suggests that the process is near equilibrium conditions (slightly under-saturated) with respect to this secondary mineral phase.

Initially, the Eh was calculated, but this yielded a negative value well below that expected for the tailings. The Eh was, therefore, fixed at a more realistic value of 250 mV. This affected primarily the iron and manganese speciation, and thus their dissolved concentrations; however, the differences were not significant. The estimated equilibrium concentrations shown in Table 5.4-3 reflect only those precipitation reactions that are expected to occur rapidly, and reach near equilibrium conditions within the tailings. The modeling results further suggest that lead (SI for $Pb(OH)_2 = 2.47$) and zinc (SI for $Zn(OH)_2$=0.351) may be precipitated from solution.

The effect of atmospheric $CO_2$ partial pressure was not considered for this initial calculation, as it represents the transfer of tailings by pipeline from the tailings pump box to the TMA. Equilibration with atmospheric carbon dioxide is therefore unlikely to occur. It should be noted that the assessment for the depyritized tailings and pyrite concentrate process water (SRK, 1998b) indicated near equilibrium conditions with respect to calcite. Insufficient data were available for the calculation of the composition of the mixed process water to calculate a saturation index for calcite, but it is expected that similarly, the mixed process water will likely also be at or near equilibrium with calcite. This is discussed below in Section 5.4.3.

## Table 5.4-2

## Summary of Solute Concentration Estimates and Calculated Mixed Concentrations

| Parameter | Units | STREAM ID (See Table 5.4-1 for Descriptions) | | | | | | | Process Water Discharge To TMA |
|---|---|---|---|---|---|---|---|---|---|
| | | ZTTO | DTPW | PBPO | ZCTO | LHSO | LCTO | CCTO | |
| Operating Flow | gpm | 1328 | 475 | 197 | 240 | 55 | 30 | 42 | 2367 |
| Operating pH | s.u. | 11.2 | 6 | 6 | 11.8 | 8.5 | 8.5 | 7.2 | 11.1 |
| Acidity | eq. | | 34 | 60 | | | < 0.0002 | | 12 |
| Aluminum | mg/L | 1.4 | < 0.018 | 0.043 | 1.4 | | < 0.022 | | 0.94 |
| Antimony | mg/L | 0.1 | 0.017 | 0.014 | 0.1 | | 0.0061 | | 0.071 |
| Arsenic | mg/L | 0.1 | 0.0048 | 0.022 | 0.1 | | 0.0025 | | 0.069 |
| Barium | mg/L | 0.0196 | 0.063 | 0.091 | 0.0196 | | 0.028 | | 0.035 |
| Beryllium | mg/L | 0.0006 | < 0.00012 | < 0.00012 | 0.0006 | | < 0.00033 | | 0.0004 |
| Boron | mg/L | | 0.021 | 0.021 | | | 0.022 | | 0.0071 |
| Cadmium | mg/L | 0.0002 | 0.018 | 0.027 | 0.0002 | | 0.0018 | | 0.0061 |
| Calcium | mg/L | 299 | 210 | 270 | 299 | | 300 | | 279 |
| Chloride | mg/L | | 36 | 36 | | | 33 | | 12 |
| Chromium | mg/L | 0.056 | 0.0022 | 0.0042 | 0.056 | | < 0.00053 | | 0.038 |
| Cobalt | mg/L | 0.041 | 0.037 | 0.038 | 0.041 | | 0.03 | | 0.039 |
| Copper | mg/L | 0.063 | 0.0081 | 0.039 | 0.063 | | 0.0017 | | 0.047 |

**Table 5.4-2** *(Continued)*

| Parameter | Units | STREAM ID (See Table 5.4-1 for Descriptions) | | | | | | | Process Water Discharge To TMA |
|---|---|---|---|---|---|---|---|---|---|
| | | ZTTO | DTPW | PBPO | ZCTO | LHSO | LCTO | CCTO | |
| Cyanide, total | mg/L | | < 0.0034 | < 0.0034 | | | < 0.0034 | | 0.0011 |
| Cyanide, WAD | mg/L | | < 0.0029 | < 0.0029 | | | < 0.0029 | | 0.0010 |
| Fluoride | mg/L | | 0.28 | 0.22 | | | 1 | | 0.13 |
| Iron | mg/L | 0.41 | 0.049 | 0.6 | 0.41 | | < 0.0023 | | 0.33 |
| Lead | mg/L | 0.27 | 0.017 | 0.091 | 0.27 | | 0.0044 | | 0.19 |
| Magnesium | mg/L | 0.15 | 12 | 14 | 0.15 | | 27 | | 5.1 |
| Manganese | mg/L | 0.0046 | 2 | 2.5 | 0.0046 | | 1.2 | | 0.68 |
| Mercury | mg/L | 0.0002 | 0.00018 | < 0.00008 | 0.0002 | | < 0.00008 | | 0.0002 |
| Nickel | mg/L | 0.006 | 0.12 | 0.2 | 0.006 | | 0.016 | | 0.045 |
| Potassium | mg/L | 10.3 | 24 | 21 | 10.3 | | 27 | | 14.8 |
| Selenium | mg/L | 0.29 | 0.032 | 0.041 | 0.29 | | 0.024 | | 0.20 |
| Silver | mg/L | 0.1 | < 0.0003 | 0.00067 | 0.1 | | 0.00028 | | 0.066 |
| Sodium | mg/L | 30 | 20 | 20 | 30 | | 26 | | 27 |
| Sulfate | mg/L | 868 | 490 | 620 | 868 | | 901 | | 773 |
| Zinc | mg/L | 0.455 | 19 | 33 | 0.455 | | 1.3 | | 6.9 |

Note: eq = $mgCaCO_3$ eq/L

Prepared by: JTC
Checked by: TAD

## Table 5.4-3

## Summary of Solute Concentration Estimates and Calculated Mixed Concentrations

| Parameter | Units | Process Water Discharge toTMA | Equilibrated Process Water to TMA |
|---|---|---|---|
| MINTEQA2 file | | — | NMC3 |
| pH | s.u. | 11.1 | 10.9 |
| Eh (est.) | mV | — | 250 |
| Aluminum | mg/L | 0.94 | |
| Antimony | mg/L | 0.071 | 0.02 |
| Arsenic | mg/L | 0.069 | |
| Barium | mg/L | 0.035 | 0.003 |
| Beryllium | mg/L | 0.0004 | |
| Boron | mg/L | 0.0071 | |
| Cadmium | mg/L | 0.0061 | |
| Calcium | mg/L | 279 | |
| Chloride | mg/L | 12 | |
| Chromium | mg/L | 0.038 | 0.005 |
| Cobalt | mg/L | 0.039 | |
| Copper | mg/L | 0.047 | |
| Cyanide, total | mg/L | 0.0011 | |
| Cyanide, WAD | mg/L | 0.0010 | |
| Fluoride | mg/L | 0.13 | |
| Iron | mg/L | 0.33 | < 0.01 |
| Lead | mg/L | 0.19 | |
| Magnesium | mg/L | 5.1 | 1.0 |
| Manganese | mg/L | 0.68 | 0.07 |

**Table 5.4-3** *(Continued)*

| Parameter | Units | Process Water Discharge toTMA | Equilibrated Process Water to TMA |
|---|---|---|---|
| MINTEQA2 file | | — | NMC3 |
| Mercury | mg/L | 0.0002 | |
| Nickel | mg/L | 0.045 | < 0.001 |
| Potassium | mg/L | 14.8 | |
| Selenium | mg/L | 0.20 | |
| Silver | mg/L | 0.066 | |
| Sodium | mg/L | 27 | |
| Sulfate | mg/L | 773 | |
| Zinc | mg/L | 6.9 | |

Prepared by: JTC
Checked by : TAD

### 5.4.2 Anticipated Geochemical Conditions

#### 5.4.2.1 Operational Conditions

The "mixed" equilibrated process water, together with the tailings solids, will be discharged in the TMA. The TMA operational strategy is to spigot tailings from the embankment of each cell. The spigoting location will rotate around the cell, with a full rotation approximately once every three months. This will result in a tailings beach that will be formed close to the embankment, and process water will tend to pond towards the center of the TMA cell. As the TMA reaches capacity, the pond will be shifted to one side of the cell.

The potential geochemical controls that may affect the process water before it enters the filter and drainage layers, and as it flows through these layers, are illustrated diagrammatically in Figure 5.4-1. As shown on the figure, the ponded water will be oxygenated, and, depending on the retention time in the pond, atmospheric $CO_2$ at a partial pressure of about 0.00035 atm. may influence the water chemistry. It is, however, unlikely that this water will fully equilibrate with atmospheric $CO_2$. While the water is ponded, the precipitates formed during the mixing of the different flows are expected to settle together with the tailings, resulting in a low suspended matter content of the water.

The configuration of the filter and drainage layers are shown in Figure 5.3-1. There are two mechanisms by which process water may then enter the filter and drainage layers, as shown in Figure 5.4-2. First, water may flow directly into the drainage layer, or through a very thin layer of tailings, at the spigot location. Second, the process water will pass through the tailings.

The relative length of the flow paths along which the process water will pass through the tailings will vary with time (i.e., depth of tailings placed) and the physical properties of the tailings. First, towards the end of active operation of each cell, in order to develop the final topography of the tailings surface, the pond will be forced to the low side of the cell. Second, the deposition method may result in zones where the horizontal permeability exceeds the vertical permeability. This may lead to some degree of selective flow paths forming, leading to a flow pattern as suggested in Figure 5.4-2.

Under saturated conditions, i.e. below the phreatic surface in both the filter layer and the tailings, atmospheric oxygen will be excluded and anoxic conditions will develop. Similarly, atmospheric $CO_2$ will also be excluded. Therefore, the only source for $CO_2$ will be that generated from carbonate neutralization of acidity. As shown in Table 5.4-2, the process water is alkaline. Since the process water is not acidic, its contact with the carbonates in the tailings or the filter layer will not result in acid neutralization reactions, and no excess carbon dioxide will be generated.

During operations, as discussed in the oxygen transport modeling presented in the GWQPE (Foth & Van Dyke, 1998b), the tailings will remain saturated, with tailings beaches exposed for less than three months before the next layer of tailings is deposited. The potential for oxidation during this period is minimal, and is not expected to significantly influence the process water.

Furthermore, the tailings will not be net acid generating, therefore, as indicated by the humidity cell test results, solute release from the oxidation zone will be limited by equilibrium reactions (SRK, 1998b). As the humidity cell results show, these secondary mineral phases form rapidly, and the oxidation zone is not expected to significantly contribute to the water chemistry. Any $CO_2$ that may be generated from oxidation will occur in the near surface, and thus will be vented to the atmosphere. The $CO_2$ concentration within the oxidation zone may increase slightly above atmospheric, but is not expected to influence any of the zones below it.

#### 5.4.2.2 Consolidation Period

The consolidation period is expected to take up to 2 years. Soon after tailings deposition to the TMA cell ceases, the pond will be decanted. As the phreatic surface in the tailings is lowered, sulfides in the near surface tailings will be oxidized. Acidity generated by these reactions will be neutralized within the oxidation zone. As before, the $CO_2$ from carbonate neutralization of free acidity will be generated in the near surface oxidation zone, and as such is expected to be vented to the atmosphere. The $CO_2$ partial pressure may slightly exceed atmospheric conditions in the oxidation zone, but is not expected to affect the water chemistry significantly.

As shown by the humidity cell test results, solute release from the oxidation zone will be limited by the precipitation of secondary minerals. However, unlike during operations, the rate of water flux will be reduced to that brought about by rainfall and snowmelt. Under the reduced flow rates, there will be no significant change in the solubility controls limiting the release of solutes from the oxidation zone. However, sulfate from oxidation may result in concentrations exceeding the solubility of gypsum. Again, test results presented in the Supplemental Waste Characterization Program (SRK, 1998a) show that gypsum precipitates from solution rapidly, and equilibrium conditions are generally reached within the relative confines of the humidity cell and column tests. Therefore, solute concentrations in water from the oxidation generally are not expected to exceed saturation limits. Furthermore, the relative flux of water from the oxidation zone will be small in comparison to pore water that is released due to consolidation. Therefore, the chemistry of water entering the filter and drainage layers during the consolidation period will be characterized by process water that had equilibrated with the tailings.

During the consolidation period, the primary source of water entering the filter and drainage layers will be tailings pore water. The water will be alkaline, and no excess $CO_2$ is expected to be generated. There will also be no significant changes in physico chemical conditions as the water flows from the tailings into the filter and drainage layers.

#### 5.4.2.3 Post Capping

After capping of the TMA cell, the following significant changes will occur:

- Water influx to the tailings will be reduced to very low levels so that only draindown of pore water will enter the filter and drainage layers.

- Oxygen entry to the tailings will be limited so that conditions will become anoxic to reducing at depth.

- The system will approximate a closed system so that a build-up of carbon dioxide may be expected within the confines of the TMA cell.

Post closure, the primary mechanism for water entering the filter and drainage layers will be draindown of the pore water. This water will originate from below the phreatic surface within the tailings and will represent pore water that has equilibrated with the tailings.

Oxygen entry to the TMA will be most significant through the cover, and oxidation is likely to occur only above the phreatic surface in the tailings. Acidity from oxidation will be neutralized by Ca+Mg carbonates, which will result in the release of $CO_2$, which will be accumulated within the TMA cell. The effects of the excess $CO_2$ will be most significant at the phreatic surface, but is not expected to significantly impact pore water below the phreatic surface. Hence, during the draindown the process water that has equilibrated with the tailings under anoxic conditions will characterize the water entering the filter and drainage layers.

### 5.4.3 Geochemical Modeling

#### 5.4.3.1 Operational Conditions

The first step in the assessment is the equilibration of the process water under high pH conditions. This is addressed in Section 5.4.1. This water is then expected to equilibrate with the tailings solids, i.e. calcium and magnesium carbonates present in the tailings, or with the carbonates present in the filter layer where the process water decants directly into this layer. To assess the potential effect of this step, saturation indices were calculated for the process water as this occurs. The ponded water is in time also expected to equilibrate with atmospheric carbon dioxide. Therefore, a series of MINTEQA2 runs were completed to calculate saturation indices for each of these occurrences. As discussed in Section 5.4.1 above, the initial Eh for the process water was fixed at 250 mV, and calculated thereafter. The results from these initial runs are summarized in Table 5.4-4. Digital versions of the MINTEQA2 files are available on disk.

The results indicate that the pH of the water will decrease as it first equilibrates with the calcite, and then with atmospheric carbon dioxide. The saturation indices clearly indicate that most phases that may be precipitated from the alkaline process water (i.e., primarily hydroxide phases) would become more soluble with these changes. Some solutes, mainly aluminium, will become less soluble as these changes occur, as indicated by the increase in saturation indices for phases such as $Al(OH)_3$ and alunite, and would tend to precipitate. In some cases, such as for zinc and possibly lead, the solubility controlling phase would change from a hydroxide to a carbonate phase. Notably, however, the calculated saturation index for gypsum remains below zero, and therefore gypsum is not expected to precipitate from solution.

## Table 5.4-4

## Summary of Calculated Saturation Indices

| | File | | |
|---|---|---|---|
| Parameter | NMC-Bla | NMC-B2 | NMC-B3 |
| Eh (mV) | 250 | -93 | -9 |
| pH (s.u.) | 11.1 | 8.3 | 7.8 |
| $CO_2$ (atm.) | — | — | 0.00035 |
| Calcite | — | Yes | Yes |
| Mineral Phase | Sat. Index | Sat. Index | Sat. Index |
| Pyrolusite | 5.335 | -17.285 | -16.223 |
| Goethite | 4.526 | 3.891 | 3.97 |
| Lepidocrocite | 3.837 | 3.201 | 3.28 |
| Ni(OH)2 | 3.074 | 0.022 | -0.888 |
| Pb(OH)2(C) | 2.219 | 0.779 | -0.084 |
| Brucite | 0.996 | -4.55 | -5.466 |
| Cr(OH)3(A) | 0.753 | 1.492 | 1.439 |
| Diaspore | 0.748 | 3.476 | 3.838 |
| Ferrihydrite | 0.316 | -0.319 | -0.24 |
| Zn(OH)2(A) | 0.305 | -0.359 | -1.202 |
| Gypsum | -0.145 | -0.165 | -0.16 |
| Al(OH)3(A) | -2.789 | -0.062 | 0.30 |
| Anglesite | -6.321 | -2.18 | -2.13 |
| Fe3(OH)8 | -6.839 | -0.067 | -0.817 |
| Al4(OH)10SO4 | -15.667 | 0.826 | 3.186 |
| Alunite | -16.581 | -0.02 | 2.432 |
| Calcite | | 0 | 0 |

**Table 5.4-4** *(Continued)*

| Parameter | File | | |
|---|---|---|---|
| | NMC-Bla | NMC-B2 | NMC-B3 |
| Cerrusite | | -0.236 | -0.19 |
| Otavite | | 0.057 | 0.047 |
| Rhodochrosite | | -0.811 | -0.819 |
| Smithsonite | | -0.493 | -0.429 |
| $ZnCO3, 1H_2O$ | | -0.179 | -0.114 |

Prepared by: JTC
Checked by: TAD

As discussed in Section 5.4.1, the hydroxide phases are expected to precipitate rapidly, while the kinetics for the formation of the carbonates are much slower. Therefore, (a) any precipitates from the process water are likely to occur before the tailings are deposited in the TMA; (b) any of the process water decant that may directly enter the filtration layer will have a lower potential for precipitating solids; and (c) the decrease in calculated saturation indices as equilibration with carbonates occurs further detracts from the potential for precipitates to form. While aluminium may be precipitated in the filter layer, the concentration of this solute is low, and the overall potential for accumulation is not considered significant. It is therefore concluded that process water decant to the filtration layer will not significantly impact its permeability, and consequently will not impact the drainage layer.

Process water passing through the tailings is expected to equilibrate with the carbonates contained in the tailings, prior to entering the filtration layer. This is expected to occur even for selective or preferential flow paths that may develop in the tailings due to the relative abundance of the carbonates present in the depyritized tailings, and because of the experimental results observed for the small scale humidity cell tests. In these tests in excess of 500 ml of water is forced through a shallow bed of tailings (0.75 inches; approximately 200 g) over a short time span, and yet sufficient carbonate dissolution occurs to buffer the leachate pH. Therefore, the kinetics of carbonate dissolution appear to be sufficiently rapid to suggest that the majority of the water that passes through the tailings before entering the filter layer will have equilibrated with the carbonates present. The transition of flow from the tailings to the filter layer will occur under saturated anoxic conditions, with calcium and magnesium carbonates the primary "reactive" mineral in both media. Therefore, this transition does not represent a significant change in geochemical conditions and consequently will not result in the precipitation of secondary mineral phases within the filter layer.

#### 5.4.3.2 Consolidation Period

Conditions during the consolidation period will not differ significantly from those during operations. The same conclusions therefore are valid.

#### 5.4.3.3 Post Capping

As discussed in Section 5.4.2 above, after the cap is in place, the potential exists for a buildup of carbon dioxide within the TMA. Due to the reduction in the effect of atmospheric conditions, the system may also become more reducing. Therefore two sets of MINTEQA2 runs were completed to estimate the possible effects of these changes on the water entering the filter and drainage layers.

To assess the potential impact from $CO_2$, the MINTEQA2 run with process water as input was repeated with $CO_2$ at partial pressures of 0.0035 atm. (0.35 percent), 0.035 atm. (3.5 percent) and at 0.35 atm. (35 percent) (see MINTEQA2 file NMC-B4). The results are summarized in Table 5.4-5.

## Table 5.4-5

## Summary of Saturation Indices Calculated for Increasing $CO_2$ Partial Pressure

| | File: NMC-B4 | | |
|---|---|---|---|
| Parameter | Input 1 | Input 2 | Input 3 |
| Eh (mV) | 66 | 133 | 200 |
| pH (s.u.) | 7.3 | 6.8 | 6.3 |
| $CO_2$ (atm.) | 0.0035 | 0.035 | 0.35 |
| Mineral Phase | Sat. Index | Sat. Index | Sat. Index |
| Al4(OH)10SO4 | 5.32 | 6.8 | 7.381 |
| Alunite | 4.789 | 6.662 | 7.863 |
| Goethite | 3.715 | 3.255 | 2.702 |
| Lepidocrocite | 3.025 | 2.565 | 2.012 |
| Gibbsite (C) | 2.243 | 2.353 | 2.23 |
| Cr(OH)3(A) | 1.282 | 0.933 | 0.311 |
| Sb(OH)3 (s) | 0.672 | 0.673 | 0.674 |
| Al(OH)3(A) | 0.58 | 0.69 | 0.567 |
| Otavite | 0.01 | -0.089 | -0.306 |
| ZnCO3, $1H_2O$ | -0.139 | -0.241 | -0.467 |
| Gypsum | -0.144 | -0.105 | -0.034 |
| Aragonite | -0.154 | -0.154 | -0.154 |
| Cerrusite | -0.187 | -0.229 | -0.367 |
| Smithsonite | -0.453 | -0.555 | -0.781 |
| Ferrihydrite | -0.495 | -0.955 | -1.509 |
| Rhodochrosite | -0.849 | -0.929 | -1.096 |
| Siderite | -1.062 | -1.133 | -1.28 |
| Pb(OH)2(C) | -1.08 | -2.122 | -3.261 |
| Malachite | -1.114 | -1.711 | -3.056 |

Prepared by: JTC
Checked by: TAD

The net effect is a further decrease in pH to 6.8 s.u at partial pressure of 0.03 atm, and reaching a pH of about 6.3 s.u. at a $CO_2$ partial pressure of 0.35 atm. This causes an increase in the solubility of most solutes, which has a net "cleansing" effect. Again, the results suggest that aluminum may be precipitated, but due to the relatively low concentrations the overall potential is small. While the decrease in pH also causes an increase in the Ca concentration (from calcite dissolution), gypsum saturation is not reached, and gypsum is therefore not expected to precipitate in the filter or drainage layers.

The results for a sweep of Eh ranging from 250 mV down to about –215 mV are provided in Table 5.4-6. As shown by the calculated saturation indices, increasingly reducing conditions affect only mineral phases for solutes which have redox couples. As shown, reducing conditions invariably favor the lower valance ionic form. Therefore, controlling phases that would form under oxidizing conditions would be dissolved at the onset of reducing conditions. This implies that, after capping, the reducing conditions would lead to the "cleansing" of the filter and drainage layers.

### 5.4.4 Summary of Conclusions

The conclusions from this assessment can be summarized as follows:

- The process water that will be discharged to the TMA will be alkaline with most solutes present at low concentrations. The process water is expected to be in near equilibrium conditions with respect to gypsum.

- Since the tailings that will be placed in the TMA will not be net acid generating, the oxidation zone will remain neutral. As shown by the humidity cell test results, solute release will be limited by the in-situ precipitation of secondary mineral phases, and therefore solute release from the oxidation zone will not impact the pore water quality.

- Contact of the process water with the filter and drainage layer materials is not expected to result in the formation of significant quantities of secondary mineral precipitates. Similarly tailings pore water, i.e. process water equilibrated with the tailings, is not expected to generate significant quantities of secondary mineral precipitates when entering the filter layer.

- Since neither the process nor the pore water is expected to generate significant quantities of secondary mineral precipitates within the filter or drainage layers, the effect of selective flowpaths within the tailings is not significant.

## Table 5.4-6

## Summary of Saturation Indices Calculated for a Progressive Decrease in Redox Potential

| | File: NMC-B5 | | | | |
|---|---|---|---|---|---|
| Parameter | Sweep 1 | Sweep 2 | Sweep 3 | Sweep 4 | Sweep 5 |
| pH (s.u.) | 7.8 | 7.8 | 7.8 | 7.8 | 7.8 |
| $CO_2$ (atm.) | 0.00035 | 0.00035 | 0.00035 | 0.00035 | 0.00035 |
| Eh (mV) | 250 | 134 | 17 | -99 | -215 |
| Mineral Phase | Sat. Index | Sat. Index | Sat. Index | Sat. Index | Sat. Index |
| Goethite | 7.16 | 6.348 | 4.415 | 2.416 | 0.416 |
| Lepidocrocite | 6.47 | 5.658 | 3.725 | 1.726 | -0.274 |
| Jarosite K | 5.913 | 3.477 | -2.32 | -8.318 | -14.318 |
| Fe3(OH)8 | 4.305 | 3.869 | 0.072 | -3.926 | -7.926 |
| Ferrihydrite | 2.95 | 2.138 | 0.205 | -1.794 | -3.794 |
| Jarosite NA | 2.746 | 0.309 | -5.488 | -11.486 | -17.485 |
| Jarosite H | -1.443 | -3.879 | -9.676 | -15.674 | -21.674 |
| Siderite | -2.293 | -1.105 | -1.037 | -1.037 | -1.037 |
| Manganite | -3.02 | -5.02 | -7.02 | -9.02 | -11.02 |
| Pyrolusite | -7.333 | -11.332 | -15.332 | -19.332 | -23.332 |

Prepared by: JTC
Checked by: TAD

- Calcium (and magnesium) carbonates will be present in both the tailings and the drainage layers. The addition of limestone (i.e., more calcium carbonate) to the tailings will not alter the geochemical conditions in the tailings. Therefore, since the geochemical modeling (completed for conditions where the process water equilibrates with calcium carbonate in the tailings and in the filter layer) shows no impact on the permeability of the filter and drainage layers, it is concluded that the addition of limestone will have no impact.

- Following capping, the potential build-up of carbon dioxide and the potential development of reducing conditions will tend to increase the solubility of secondary mineral phases, and would result in a net 'cleansing' effect.

### 5.4.5 Additional Analyses

In a letter dated December 13, 1999 (WDNR, 1999), the WDNR requested that additional work be completed to provide assurance that the TMA drain layer will not experience significant geochemical clogging due to precipitation of secondary minerals such as oxides, sulfates, and carbonates. The requested assessment has been completed on behalf of NMC by SRK Consulting. A technical memorandum describing the analysis and the results is included in Appendix J.

In addition to the above analysis, NMC will include a proposal in the TMA Plan of Operation to design and implement a laboratory experimentation program to test the potential for clogging of the drain layer using an acceptable recipe for expected leachate under atmospheres with differing concentrations of oxygen and carbon dioxide.

The results from the geochemical modeling and the additional analyses requested by the WDNR show that the permeability of the filter and drainage layers will not be impacted by the precipitation of secondary mineral phases in the short and long term.

## 5.5 Geosynthetic Material Decision Matrices

The proposed design for the Crandon Project TMA and other project facilities include several geosynthetic components. The specific TMA and reclaim pond geosynthetics, including geomembranes, geotextiles, geocomposites, and geosynthetic clay liners (GCLs), are discussed in Sections 5.3, 7.1, and 10.1.

NMC proposes that decision matrices be used for future evaluation of alternative geosynthetics after the Crandon Project permitting process specifying certain geosynthetics has been completed. The *Geosynthetic Material Decision Matrices for Crandon Project Containment Facilities* (GMDM) (Foth & Van Dyke, 1997b) provided such a method for evaluation of alternative geosynthetics. Alternative geosynthetics would only be allowed if they are shown to be equivalent or superior to the originally specified products.

In response to comments by the regulatory agencies (WDNR, 1997) (USCOE, 1998) regarding the GMDM, the GMDM has been updated and is included as Appendix D to this report.

# 6 Leachate Management System Update NR 182.11(1)(o)

## 6.1 Background Information

The waste characterization studies performed on the tailings and waste rock proposed for placement in the TMA are discussed in Section 4. Section 4 includes a discussion of the leaching potential, including acid generation potential of the tailings. Additionally, the chemical and physical properties and testing of the tailings material is discussed.

## 6.2 Design Rationale for Leachate Collection System (LCS)

The primary design function of the LCS is accomplished by four main system components, which are the:

- leachate drainage layer;
- leachate collection system piping
- leachate removal system; and
- leachate transfer system.

The design of LCS components will be discussed in the context of the following performance goals:

- to provide transmissivity so as to limit the head on the liner during the operation and post-closure periods;

- to provide collection and removal such that the overall allowable percolation rates during the design and post-closure periods can be met; and

- to provide a plumbing system which can be cleaned during the operating and post-closure periods.

The primary design functions of the LCS are to convey water that drains through the tailings (leachate) to collection points in an efficient manner and to remove it as needed.

## 6.3 Cell Base Configuration

The base of each TMA cell is designed with grades which result in a ridge which in general runs diagonally across each cell, as shown on Drawing 15. From the ridge, the cell base slopes at a two percent grade in opposite directions toward sumps located in cell corners. For example, TMA 1 has four sumps: two in cell 1A (south), and two in cell 1B (north). The sumps in TMA 1A are located on the southeast and northwest corners, while the sumps in TMA 1B are located on the southwest and northeast corners. The maximum leachate flow distance (i.e., perpendicular distance from the sump to the central ridge) varies from approximately 600 feet in TMA 1 to approximately 500 feet in TMA 2 and 3. The drainage on the sideslopes of the cells is

achieved by geocomposites placed over the geomembrane liner and covered with an unprocessed till protective layer. As shown on Figure 5.3-1, the geocomposite will extend a minimum distance of 5 feet beyond the toe of the slope below the drainage layer at the base of the each cell.

## 6.4 Leachate Drainage System

The purpose of the leachate drainage system is to minimize the head on the base liner and convey the leachate to the LCS piping. Certain properties of the drainage layer, the filter layer, and the composite liner which govern flow through those layers, have been input to the HELP model. A 24-inch drainage layer has been incorporated into the design to account for any potential clogging due to unforeseen circumstances during construction. The drainage layer has been designed to maintain its hydraulic conductivity and have sufficient hydraulic capacity for the design flow. To maintain the hydraulic conductivity, migration of tailings into the drainage layer and the potential for clogging should be prevented. A filter has therefore been designed between the tailings and the drainage layer.

Since the tailings are very fine and consist mostly of particles passing the number 200 sieve (P200>89 percent) and the drainage layer is coarse and consists mainly of particles passing the two-inch sieve and retained on the U.S. Sieve No. 40, a filter layer is necessary to prevent the physical migration of tailings to the drainage layer. Appendix C contains filter calculations which show that with an unprocessed till layer between the tailings and the drainage layer, all filter criteria are met. The design for the filter layers and drainage layer for the leachate collection system thus consists of an 18-inch filter layer of unprocessed till soil over a 24-inch drainage layer. The drainage layer is a processed till which passes through a U.S. Sieve 2 inch and is retained on a U.S. Sieve No. 40.

## 6.5 Leachate Collection System Piping

The LCS piping is located along the toe of the interior 3:1 (H:V) slopes in each cell. In addition, as described in Addendum No. 3 (Foth & Van Dyke, 1997a), 4-inch diameter perforated polyethylene pipes will be placed at a spacing of approximately 260 feet on the base of the cells. Drawing 16 shows the location on LCS piping on the base grades. The pipe system along the toe of the interior slope consists of a perforated 6-inch diameter polyethylene (PE) pipe with a standard dimension ratio (SDR) of 17. The pipe is designed with an open channel flow capacity which exceeds the predicted peak flows and with a strength which exceeds the stresses under anticipated loads. The pipes are designed against large deflections (>5 percent of pipe diameter) under the maximum load expected after closure. The pipe bedding and the placement of bedding material around the pipe will cause a uniform loading on the pipe, as well as reduction of load on the pipe due to soil-structure interaction of the bedding material completely surrounding the pipe and the strength of the tailings material itself. Pipe flow calculations and pipe strength analysis had been provided in Appendix G of the Feasibility Report (Foth & Van Dyke, 1995). Since the proposed modifications do not adversely impact the bedding conditions or the load on the leachate collection pipes, the calculations do not require updating. Each 6 inch LCS pipeline drains to a leachate collection system sump. The 6-inch diameter pipes are provided with

cleanouts at each end to allow for cleaning, as shown on Figure 6.5-1. The locations of the sumps and cleanout pipes are shown on Drawing 16. The design of the leachate collection sumps is discussed in Section 6.6.

The leachate head level within the TMA cells will be monitored through a series of leachate head monitoring risers (LHR), as shown on Drawing 16. A detail of the LHRs is shown on Figure 6.5-2.

## 6.6 Leachate Removal System

The base of the facility is designed with a minimum two percent slope toward the leachate collection sumps. The TMA liner system extends below the sumps so there is no need for liner penetrations. Details of the sump design were provided on Figure 2-3 of Addendum No. 4 (Foth & Van Dyke, 1998a) and Drawing 30 of Addendum No. 3 (Foth & Van Dyke, 1997a). The sumps, pumps, and sideslope risers (SSRs) provide a mechanical means of evacuating leachate from the base collection point of each tailings cell. The SSRs as presented in Addenda No. 3 and 4 come up the sideslope in the corner of the TMA cells (two per cell). With TMA 1 now being proposed for development in three stages, the SSR design has been modified for SSR-1 and SSR-4. Since the corner of the cell does not extend all the way up to the top of the second stage for the northwest corner of TMA 1A and the southwest corner of TMA 1B (see Drawing 16), the SSRs at these two locations (SSR-1 and SSR-4) will be placed in a shallow trench and run up the west side wall of TMA 1 as shown on Drawing 16 and Figure 6.6-1.

Sumps and pumps have been sized (see calculations in Appendix E) such that under maximum leachate flow, the leachate can be removed to an acceptable level. The pumps will be installed against a stop in the SSR and operated in such a way that a water trap exists at all times after pumping.

The SSR riser pipe will be an 18-inch PE pipe with perforations in the sump section. Inside the 18-inch pipe is a submersible pump designed for operation in adverse environments. The pump curve determination based on total dynamic head loss for each TMA sump pump is provided in Table 6.6-1. The pumps proposed for the TMA sumps are rated at 150-175 gpm, with a maximum total head of 105-130 feet (see Appendix E). Each pump will be actuated by a submersible liquid level transducer mounted over the submersible pump. The transducer will be programmed to provide an automatic pump response and alarm system, as follows (refer to Figure 6.6-1):

- Pump on - water level at 6.25 feet above SSR invert at upslope edge of SSR sump;
- Pump off - water level 3.25 feet above SSR invert at upslope edge of SSR sump; and
- Pump alarm - water level greater than 2.25 feet above SSR invert at upslope edge of SSR sump.

The design and operation of the system have the goal that a water trap remains in the sump even if the pump off switch malfunctions. Thus, the opportunity for oxygen intrusion is minimized.

## Table 6.6-1

## Leachate Sump Evacuation Pumps

| Sump No. | Location | Design Flow (gal/min) | Static Head (ft) | Total Dynamic Head (ft) |
|---|---|---|---|---|
| SSR-1 | TMA 1A, NW Corner | 170 | 98 | 107 |
| SSR-2 | TMA 1A, SE Corner | 170 | 98 | 110 |
| SSR-3 | TMA 1B, NE Corner | 155 | 108 | 130 |
| SSR-4 | TMA 1B, SW Corner | 160 | 108 | 121 |
| SSR-5 | TMA 2, SW Corner | 172 | 93 | 105 |
| SSR-6 | TMA 2, NE Corner | 150 | 93 | 130 |
| SSR-7 | TMA 3, NW Corner | 165 | 93 | 117 |
| SSR-8 | TMA 3, SE Corner | 150 | 93 | 130 |

Note: Indicated flows based on headless curves and pump curve for EPG, model WSD27 pump. Pump calculations assume only one leachate pump runs at a time and that leachate pumps and decant pump (reclaim water line) do not operate at the same time.

Prepared by: HJA
Checked by: NXP

All SSR pump alarms will report to the mill control room and signal the operator of a malfunction or other problem in the LCS pump(s).

Leachate will be pumped to the surface through a flexible 4-inch polyethylene (PE) pipe SDR 17. The pump and transducer attached to the PE pipe will be mounted on a transporter. The transporter will be attached to two stainless steel cables (including one standby/backup) extending to the surface, which will enable the operator to easily remove the pump and transducer for maintenance, repair, or replacement.

The 18-inch PE SSR pipe, along with the 6-inch PE LCS cleanout pipe, will extend up the cell interior slope. A cushioning geotextile has been provided between the pipe bedding and the liner to prevent puncture of the geomembrane liner by the pipe bedding material.

Appendix I of the Feasibility Report (Foth & Van Dyke, 1995) contains pipe crushing calculations for the SSR which indicate than an 18-inch PE SDR11 pipe has sufficient strength to

meet the anticipated loadings. The calculations have not been updated because the proposed changes do not adversely impact the bedding conditions or the load on the pipe.

The LCS cleanouts are designed so there are no liner penetrations. LCS cleanouts are located at each end of each LCS pipe to allow the LCS piping to be cleaned from two directions. The SSR pipe can be cleaned by removing the flexible leachate transfer pipe, and pump with transducer.

## 6.7 Leachate Transfer System

Leachate will be pumped from the cell bottoms to the surface using a submersible pump connected to a 4-inch diameter flexible PE pipe. The flexible PE pipe will connect to a 4-inch PE forcemain located next to the tailings pipeline and reclaim water return line in a notch in the berm. In the unlikely vent that a breach would occur, spillage will be contained, since the leachate transfer pipe is located within the TMA cell lined area. The 4-inch leachate forcemain will join the 12-inch PE reclaim water pipeline, as shown on Drawing 16, with the leachate transferred to the reclaim pond.

The reclaim piping will penetrate the liner system at six locations prior to entering the reclaim pond. These penetrations are approximately one foot below the maximum free board elevation, so the likelihood of tailings or leachate attaining this height is remote. Drawing 29, Detail 5-29 of Addendum No. 3 (Foth & Van Dyke, 1997a), provides a detail of the seal design for the liner penetration. Wherever the reclaim water pipe exists outside a lined area, it will be encased in an 18-inch diameter PE pipe. The reclaim water pipe, once outside the lined area of the TMA, flows by gravity to discharge in the reclaim pond. In the reclaim pond the leachate and reclaim water will have a minimum retention time of approximately three days, after which it will be recycled with the water decanted back to the concentrator as process water.

## 6.8 Leachate Management System During Post-Closure

During progressive stages of mining, and finally at the cessation of mining operations, the TMA cells will be closed with a low permeability final cover system resulting in a significant reduction in the volume of leachate generated. The estimated daily and annual leachate generation rates after closure of all three TMA cells are presented in Section 10.1. Following mine and TMA closure, leachate pumped from the TMA will be stored in the reclaim pond and treated periodically at the treatment plant prior to discharge. The reclaim pond, which has a 15 million gallon capacity, will remain operational until approximately year 16 after TMA closure, at which time it will likely be replaced by storage tanks due to a reduction in leachate volume (see Section 10.1).

The wastewater treatment system for the project has been designed with two treatment trains having a nominal capacity of approximately 370 gallons per minute. Each train can operate successfully at rates much lower than the rated capacity. Initially, during the first couple of years after closure, the treatment plant would be operated intermittently to treat stored leachate. In subsequent years, as the leachate generation rate continues to reduce, the frequency of operation

of the full scale treatment system will be proportionately reduced. At some point, it will not be practical to operate the full scale system for the reduced leachate flow. Alternate methods of leachate treatment will need to be implemented at that time. NMC will explore the options available at that time and implement the most suitable one. Options that could be pursued consist of:

1. Contracting with a third party to treat the leachate. Under this scenario, the leachate would be collected and hauled to an industrial treatment system or publicly owned treatment works (POTW) designed to handle leachate of the type generated within the TMA. Examples of industrial treatment systems are those used by another mine or a metal plating operation.

2. The installation of a reduced size treatment system maintaining a discharge to the soil absorption system. The discharge to the soil absorption system may or may not use the pumping system and pipeline as proposed for the full scale treatment plant. The reduced volume may allow for hauling of the treated water to the soil absorption system for discharge. Solids generated from the treatment process will be disposed of at a disposal facility licensed to accept solids from this type of process. Concentrated liquid from this process will also need to be reclaimed or disposed of in a facility licensed to accept materials from this type of process.

The final selection of the option to implement will be based upon the conditions in effect at the time leachate generation rates decrease to such a level that continued operation of the project's wastewater treatment system is not practical.

If leachate is to be treated at an alternative industrial wastewater treatment facility, such as one used by another mine or a metal plating operation, or if the leachate would be discharged to a publicly owned treatment works (POTW), the owner/operator of the treatment system will need to establish limitations on the quality and quantity of the leachate from NMC's project.

If an industrial treatment facility is used, it will, at a minimum, need to employ similar or equivalent treatment technologies to the base (lime/sulfide) treatment system used by NMC. Permit conditions in place for the facility will need to be reviewed and addressed. The owner of this facility will be required to notify the appropriate regulatory agencies of the change in raw wastewater sources and other permit conditions that are affected will need to be met.

If a POTW is used, NMC will need to meet pretreatment standards for the POTW. This could be accomplished in two ways. One option would require NMC to install and operate the pretreatment system. A second option would involve contracting with the POTW to operate the pretreatment system.

The method of treatment needed to meet the POTW pretreatment standards will be similar to the (lime/sulfide) base treatment system proposed for the full scale treatment facility. Other pretreatment options may include reverse osmosis or ion exchange. The solids generated from a treatment or pretreatment process will need to be disposed of in a licensed disposal facility.

The POTW pretreatment system may be located at the mine site. If the current site was used, the treatment system would occupy a much smaller area. Utilities and roadways would need to be maintained for this system.

The pretreatment system could also be located closer to the POTW. In this case, the leachate would be hauled to the treatment site. Minimal facilities would be maintained at the mine site. A haul road and collection system would remain at the site to facilitate the collection of leachate.

The site operator will be responsible for arranging the timely removal and hauling of the leachate. NMC will maintain the leachate collection system and leachate storage system during the forty-year post-closure care period and, if necessary, a longer period as needed. If the leachate collection rate drops to a sufficiently low level, the operation of the LCS and wastewater treatment may be discontinued early.

# 7 Final Cover System Update

## 7.1 General

The general performance objectives for the design, construction, and long-term care of the final cover system remain unchanged. However, the modification of the TMA design from four cells to three cells, and changes made in response to WDNR comments, have resulted in the following modifications as documented in this Addendum:

- The December 12, 1997, response to the WDNR Completeness Determination Letter (NMC, 1997) added a 12-inch thick biotic barrier consisting of cobbles located directly above the sand drainage layer in the final cover. Figure 7.1-1 is a typical section of the proposed final cover which shows that the overall thickness remains unchanged since the combined cobble layer and rooting layer thickness is 36 inches.

- The December 12, 1997, response to the WDNR Completeness Determination Letter also added a 12 ounce per yard non-woven geotextile as a cushioning layer located directly over the 60 mil HDPE geomembrane. The cushioning geotextile layer is also shown on Figure 7.1-1.

- The general elevation of the final grades has been decreased from a maximum elevation of approximately 1760 to one of 1754.5.

- The final cover as proposed will consist of three final cover construction events, with TMA 1 being the largest at approximately 66 acres, and TMA 2 and TMA 3 each being approximately 47.5 acres.

## 7.2 Final Grades

Final grades will be achieved by completion of two processes: the final placement of tailings, as described in Section 6.6.2.1 of the Feasibility Report (Foth & Van Dyke, 1995); and the placement of the grading layer as described in Section 6.6.2.2 of the Feasibility Report and Response 50 to the WDNR Completeness Determination Letter (NMC, 1997). These processes remain unchanged, although waste rock after testing may be used as part of the grading layer for TMA closure. The physical and chemical characteristics of the waste rock are provided in Section 3.5.5 and Appendix 4.2-12 of the project's updated *Environmental Impact Report* (Foth & Van Dyke, 1995/1998c). Waste rock would be hauled by truck from a stockpile at the plant site and placed in a minimum 3 foot thick working mat. As indicated in earlier submittals [e.g., Feasibility Report (Foth & Van Dyke, 1995), and Response 51 to the WDNR Completeness Determination Letter (NMC, 1997)], a high modulus woven geotextile may be required to bridge over soft areas or to provide support for high traffic areas.

Section 7.3.9 of the Feasibility Report (Foth & Van Dyke, 1995) describes the tailings discharge procedures that will be implemented during the final filling of a TMA cell. Figure 6.6-2 of the

referenced document illustrates in plan and section the tailings surface configuration as this final discharge process is in progress. The figure shows the configuration of the tailings pond surface before and after shifting the water pond from the center to near the outer berm. As illustrated, the pond will be shifted to allow the center depression to be filled with tailings and to create a high point opposite of the outer berm. The resulting surface will more closely approximate final cell slopes, which will result in less soil material being required for the grading layer. This final filling process will remain unchanged with the reconfiguration of the TMA cells.

Appendix E of the Feasibility Report (Foth & Van Dyke, 1995) contains a series of detailed design calculations pertaining to the selection of riprap for erosion control for the pond area when it is shifted during final cell filling. The design calculations address wave erosion possibilities, wave runup, and riprap design. In review of the modification of the configuration of the TMA cells, it is apparent that TMA 1 Stage III represents the largest cell and the worst case fetch for wave run up. The Appendix E calculations assumed a worst case maximum fetch of 2,600 feet, which is greater than the maximum fetch for the prevailing southwesterly winds direction for the proposed TMA 1 Stage III. Therefore, the calculations presented in the Feasibility Report are conservative and valid for the reconfigured TMA cells.

## 7.3 Closure Schedule

The schedule for closure for each of the three TMA cells is based on a 28-year operating life and production assumptions which result in producing tailings at the average rate of 308,600 cy/year for the zinc phase and 569,400 cy/year for the copper phase, not including contingencies. The anticipated closure schedule for each of the three cells is provided in Section 12 of this report.

## 7.4 Premature Closure

Discussion of premature closure is presented in Section 6.6.10.2, Premature Closure, of the Feasibility Report (Foth & Van Dyke, 1995). The premature closure scenario will not change with the reconfiguration of the TMA cells.

# 8 HELP Model Update

## 8.1 Background

Section 6.7 of the Feasibility Report (Foth & Van Dyke, 1995) explains how the HELP model analyses were used to estimate the quantity of percolation through the liner and cover systems during the operation, closure, and post-closure periods. Section 6.7.2 provided a HELP model program overview discussing the rationale for selecting model input data for evapotranspiration, precipitation, temperature, and solar radiation. Section 6.7.3 provided the rationale for selection of the various soil and geosynthetic material properties and the tailings properties which were estimated taking into account the depth at which each tailings layer was located.

The HELP models presented in the Feasibility Report (Foth & Van Dyke, 1995) were updated in *Addendum No. 3 to the TMA Feasibility Report* (Foth & Van Dyke, 1997a) to reflect the modifications made to the TMA's composite liner, LCS, and final cover. *Addendum No. 4 to the TMA Feasibility Report* (Foth & Van Dyke, 1998a) presented further updates to the HELP model to account for inclusion of a geocomposite on the sideslopes and a revised hydraulic conductivity of the GCL in the base liner. This addendum (Addendum No. 5) provides updates to the HELP model due to the change in tailings properties as a result of proposed placement of depyritized tailings in the TMA.

## 8.2 Design Data

### 8.2.1 Soil Data Requirements

The *Feasibility Report* (Foth & Van Dyke, 1995) described the engineering principles used in selecting appropriate soil and tailings properties for use in the HELP model. Section 6.7.3.2.1 of that document described porosity, field capacity, and wilting point of tailings obtained from laboratory tests. Section 6.7.3.2.2 of that document described the saturated hydraulic conductivity of tailings from laboratory tests. Because of the change in the tailings properties as a result of the depyritization process, the laboratory tests were rerun. The relevant properties are described below. Soil properties used have not changed, and, therefore, the descriptions that follow pertain to depyritized tailings characteristics only.

#### 8.2.1.1 Porosity, Field Capacity, and Wilting Point

Laboratory tests conducted on the depyritized tailings (SRK, 1998d) show the specific gravity of the depyritized tailings to be 2.81 (see Appendix B). Based on the value of specific gravity, a relationship between tailings dry density and porosity was established as shown on Figure 8.2-1. Results of pressure membrane testing on the depyritized tailings (SRK, 1998e) are also contained in Appendix B. From these results, both field capacity (volumetric moisture content at a suction pressure of 5 psi) and wilting point (volumetric moisture content at a suction pressure of 15 bar), as shown on Figure 8.2-1, were obtained as a function of sample density. Consolidation test data provided in Appendix B was used to develop a relationship between the depth of tailings and

resultant dry density (see Figure 1 of SRK, 1998d). Thus, once the depth of tailings is known (to the midpoint of any tailings layer used in the HELP model), the dry density can be estimated from the referenced Figure 1 and the corresponding porosity, field capacity, and wilting point values can be obtained from Figure 8.2-1, or from the equation of the fitted curve.

#### 8.2.1.2 Saturated Hydraulic Conductivity

For HELP model simulation of the water balance of the TMA, the values of saturated hydraulic conductivity of the tailings and the geosynthetic clay liner are important. Information regarding the methods used to develop appropriate saturated hydraulic conductivity values for the two materials for use in the HELP models is discussed below.

##### 8.2.1.2.1 Hydraulic Conductivity of Tailings

Appendix B contains the results of tests performed by STS on the depyritzed tailings to determine their hydraulic conductivity. Other tests on the depyritized tailings (Appendix B) had also provided estimates of hydraulic conductivity for the depyritized tailings (SRK, 1998d). Based on the data available, a hydraulic conductivity value of $6.5 \times 10^{-6}$ cm/sec was assigned to the densest tailings layer (at the base of 90 feet of tailings after consolidation). A higher value of $1 \times 10^{-5}$ cm/sec was used for the uppermost layer of tailings based on best engineering judgement. A linear interpolation between these values was used for tailings layers in between the top and bottom layers.

##### 8.2.1.2.2 Hydraulic Conductivity of GCL

Addendum No. 4 to the Feasibility Report (Foth & Van Dyke, 1998a) used a hydraulic conductivity of $8.8 \times 10^{-6}$ cm/sec for the GCL in the liner based on permeability tests conducted on a sodium bentonite GCL using both a synthetic leachate representing potential conditions for the Crandon Project and process water as permeants.

With the addition of the depyritization process to the mill circuit, some change in the pore water within the TMA will occur when compared to pore water within the originally proposed pyritic fine tailings. To determine if the different process water characteristics would affect the conclusions reached by Dr. Charles Shackelford, Ph.D., in his April 22, 1998, report (Shackelford, 1998a), NMC asked Dr. Shackelford to review the revised process water data. In a letter dated September 3, 1998 (Shackelford, 1998b) contained in Appendix F, Dr. Shackelford concluded that he did not expect the different process water characteristics to result in "any significant differences in the analyses and conclusions" contained in his April 22, 1998, report. Based on the above evaluation, no change was made to the saturated hydraulic conductivity of GCL in the base liner from the $8.8 \times 10^{-6}$ cm/sec value used in HELP models discussed in Addendum No. 4 (Foth & Van Dyke, 1998a).

### 8.2.2 Primary Models

Three primary HELP models were used for water balance determination of the selected TMA design. The model designs are referred to as lower slideslope, upper slideslope, and Base HELP models. Sideslope models refer to the cases where a geocomposite drainage layer is placed over the liner on the sideslope. Sideslope and Base HELP Models have the same final cover configuration. The Sideslope HELP Model bottom liner layer is sloped at 33 percent. The Base HELP Model has a different bottom liner configuration which is sloped at two percent from a high point in the center of each cell.

### 8.2.3 Submodels

The Sideslope and Base HELP models have been further defined to better represent the primary configurations over time. The Sideslope HELP models have been subdivided into several models to represent filling, closure, and post-closure scenarios. The Base HELP model has also been divided into submodels representing the same time periods to more accurately represent the water balance at different time periods. The primary Sideslope and Base HELP models have been divided into the following submodels:

- Stages I, II, IV, and VI (first stage of TMA cell filling), referred to as initial stages;
- Stages III, V, and VII (second stage of TMA cell filling) referred to as second stages;
- Post-Closure Period With Lateral Drainage on the Sideslopes and Base (represents the case with active leachate removal);
- Post-Closure Period With Lateral Drainage on the Sideslopes and No Lateral Drainage on the Base (represents the case when leachate removal is discontinued); and
- Post-Closure Period With Lateral Drainage on the Sideslope and No Lateral Drainage on Base, and the hydraulic barrier in the liner consists of only GCL and P40 till layer (represents an assumed case in which the geomembrane may no longer be functional after a very long period).

The first four scenarios listed above represent the TMA defined by construction, operation, and post-closure conditions. The fifth scenario represents a postulated condition where the geomembrane in the composite liner is assumed to degrade after 150 years. The postulated degradation scenario is very conservative and is included in the analysis to assess the performance of the TMA if such an unlikely condition were to occur. In fact, the report, titled *Assessment of Long-Term Performance of the Proposed HDPE Geomembrane Liner and Cap at the Crandon Project TMA Facility* (GeoSyntec, 1996), indicates that "the HDPE geomembrane liner and cap at the TMA facility should function as designed for a very long time (e.g., hundreds of years) without deterioration in performance."

The lower Sideslope and Base HELP models for the initial stages have been conducted based on the following generalized design specifications and soil characteristic input parameters:

Lower Sideslope HELP Model: Initial Stages

- no cover;
- no surface water runoff;
- vertical profile of 20 feet of tailings (half of maximum tailings depth);
- 120-foot length of base drainage at 3H:1V slope;
- lateral drainage through till layer;
- lateral drainage through geocomposite above the liner;
- geomembrane;
- GCL;
- P40 till layer; and
- soil and tailings layer data as provided in Table 8.2-1.

Base HELP Model: Initial Stages

- no cover;
- no surface water runoff;
- vertical profile of 40 feet of tailings;
- 600-foot length of base drainage at two percent slope;
- lateral drainage above the liner;
- geomembrane;
- GCL;
- P40 till layer; and
- soil and tailings layer data as provided in Table 8.2-2.

The 4-inch diameter leachate collection system laterals with a typical 260-foot spacing at the cell base were not considered in the analyses. The more conservative 600-foot leachate collection system spacing was used in the Base HELP models.

## Table 8.2-1

## Soil, Waste and Geosynthetic Characteristics Used for Water Balance Model
## Lower Sideslope - Initial Stages (I, II, IV, VI)

| Layer # | General Description | Thickness (Inches) | Classification | | | Total Porosity (vol/vol) | Field Capacity (vol/vol) | Wilting Point (vol/vol) | Saturated Hydraulic Conductivity (cm/sec) | Initial Soil Water Content (vol/vol) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | HELP | USDA | USCS | | | | | |
| 1 | Tailings | 120 | 0 | — | — | 0.4816 | 0.3262 | 0.0400 | $1.0x10^{-5}$ | 0.4816 |
| 2 | Tailings | 120 | 0 | — | — | 0.4753 | 0.3287 | 0.0400 | $9.5x10^{-6}$ | 0.4753 |
| 3 | Till/Lateral Drainage | 18 | 10 | SCL | SC | 0.3980 | 0.2440 | 0.1360 | $1.2x10^{-4}$ | 0.2440 |
| 4 | Geocomposite/ Lateral Drainage | 0.24 | 34 | — | — | 0.8500 | 0.0100 | 0.0050 | 33.0 | 0.0100 |
| 5 | Geomembrane | 0.06 | 35 | — | — | — | — | — | $2.0x10^{-13}$ | — |
| 6 | GCL[1] | 0.24 | 0 | — | — | 0.7500 | 0.7470 | 0.4000 | $8.8x10^{-6}$ | 0.7500 |
| 7 | P40 Till | 12 | 0 | SiL | ML | 0.5010 | 0.2840 | 0.1350 | $2.0x10^{-5}$ | 0.5010 |

[1]Geosynthetic Clay Liner

Prepared by: NXP
Checked by: MRS

## Table 8.2-2

## Soil, Waste and Geosynthetic Characteristics Used for Water Balance Model Base - Initial Stages (I, II, IV, VI)

| Layer # | General Description | Thickness (Inches) | Classification | | | Total Porosity (vol/vol) | Field Capacity (vol/vol) | Wilting Point (vol/vol) | Saturated Hydraulic Conductivity (cm/sec) | Initial Soil Water Content (vol/vol) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | HELP | USDA | USCS | | | | | |
| 1 | Tailings | 120 | 0 | — | — | 0.4816 | 0.3262 | 0.0400 | $1.0x10^{-5}$ | 0.4816 |
| 2 | Tailings | 120 | 0 | — | — | 0.4753 | 0.3287 | 0.0400 | $9.5x10^{-6}$ | 0.4753 |
| 3 | Tailings | 120 | 0 | — | — | 0.4719 | 0.3301 | 0.0400 | $9.0x10^{-6}$ | 0.4719 |
| 4 | Tailings | 120 | 0 | — | — | 0.4698 | 0.3312 | 0.0400 | $8.5x10^{-6}$ | 0.4693 |
| 5 | Till/Lateral Drainage | 18 | 10 | SCL | SC | 0.3980 | 0.2440 | 0.1360 | $1.2x10^{-4}$ | 0.2440 |
| 6 | Granular Soil/ Lateral Drainage | 24 | 21 | Gravel | | 0.3970 | 0.0320 | 0.0130 | $3.0x10^{-1}$ | 0.0320 |
| 7 | Geomembrane | 0.06 | 35 | — | — | — | — | — | $2.0x10^{-13}$ | — |
| 8 | GCL[1] | 0.24 | 0 | — | — | 0.7500 | 0.7470 | 0.4000 | $8.8x10^{-6}$ | 0.7500 |
| 9 | P40 Till | 12 | 0 | SiL | ML | 0.5010 | 0.2840 | 0.1350 | $2.0x10^{-5}$ | 0.5010 |

[1]Geosynthetic Clay Liner

Prepared by: NXP
Checked by: MRS

The Sideslope and Base HELP models for second stages have been conducted based on the following generalized design specifications and soil characteristic input parameters:

Lower Sideslope HELP Model: Second Stages

- no cover;
- no surface water runoff;
- vertical profile of 70 feet of tailings (average of tailings depth at ends);
- 120-foot length of drainage at 3H:1V slope;
- lateral drainage through till layer;
- lateral drainage through geocomposite;
- geomembrane;
- GCL;
- P40 till layer; and
- soil and tailings layer data as provided in Table 8.2-3.

Upper Sideslope HELP Model: Second Stages

- no cover;
- no surface water runoff;
- vertical profile of 25 feet of tailings (average of tailings depth at ends);
- 270-foot length of base drainage at 3H:1V slope;
- lateral drainage through till layer;
- lateral drainage through geocomposite;
- geomembrane;
- GCL;
- P40 till layer; and
- soil and tailings layer data as provided in Table 8.2-4.

Base HELP Model: Second Stages

- no cover;
- no surface water runoff;
- vertical profile of 90 feet of tailings;
- 600-foot length of base drainage at two percent slope;
- lateral drainage above the liner;
- geomembrane;
- GCL;
- P40 till layer; and
- soil and tailings layer data as provided in Table 8.2-5.

## Table 8.2-3

## Soil, Waste and Geosynthetic Characteristics Used for Water Balance Model
## Lower Sideslope - Second Stages (III, V, VII)

| Layer # | General Description | Thickness (Inches) | Classification | | | Total Porosity (vol/vol) | Field Capacity (vol/vol) | Wilting Point (vol/vol) | Saturated Hydraulic Conductivity (cm/sec) | Initial Soil Water Content (vol/vol) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | HELP | USDA | USCS | | | | | |
| 1 | Tailings | 120 | 0 | — | — | 0.4816 | 0.3262 | 0.0400 | $1.0x10^{-5}$ | 0.4816 |
| 2 | Tailings | 120 | 0 | — | — | 0.4753 | 0.3287 | 0.0400 | $9.5x10^{-6}$ | 0.4753 |
| 3 | Tailings | 120 | 0 | — | — | 0.4719 | 0.3301 | 0.0400 | $9.0x10^{-6}$ | 0.4719 |
| 4 | Tailings | 120 | 0 | — | — | 0.4693 | 0.3312 | 0.0400 | $8.5x10^{-6}$ | 0.4693 |
| 5 | Tailings | 120 | 0 | — | — | 0.4668 | 0.3322 | 0.0400 | $8.0x10^{-6}$ | 0.4668 |
| 6 | Tailings | 120 | 0 | — | — | 0.4651 | 0.3329 | 0.0400 | $7.5x10^{-6}$ | 0.4651 |
| 7 | Tailings | 120 | 0 | — | — | 0.4633 | 0.3336 | 0.0400 | $7.0x10^{-6}$ | 0.4633 |
| 8 | Till/Lateral Drainage | 18 | 10 | SCL | SC | 0.3980 | 0.2440 | 0.1360 | $1.2x10^{-4}$ | 0.2440 |
| 9 | Geocomposite/ Lateral Drainage | 0.24 | 34 | — | — | 0.8500 | 0.0100 | 0.0050 | 33.0 | 0.0100 |
| 10 | Geomembrane | 0.06 | 35 | — | — | — | — | — | $2.0x10^{-13}$ | — |
| 11 | GCL[1] | 0.24 | 0 | — | — | 0.7500 | 0.7470 | 0.4000 | $8.8x10^{-6}$ | 0.7500 |
| 12 | P40 Till | 12 | 0 | SiL | ML | 0.5010 | 0.2840 | 0.1350 | $2.0x10^{-5}$ | 0.5010 |

[1]Geosynthetic Clay Liner

Prepared by: NXP
Checked by: MRS

## Table 8.2-4

## Soil, Waste and Geosynthetic Characteristics Used for Water Balance Model Upper Sideslope - Second Stages (III, V, VII)

| Layer # | General Description | Thickness (Inches) | Classification | | | Total Porosity (vol/vol) | Field Capacity (vol/vol) | Wilting Point (vol/vol) | Saturated Hydraulic Conductivity (cm/sec) | Initial Soil Water Content (vol/vol) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | HELP | USDA | USCS | | | | | |
| 1 | Tailings | 60 | 0 | — | — | 0.4844 | 0.3250 | 0.0400 | $1.0 \times 10^{-5}$ | 0.4844 |
| 2 | Tailings | 120 | 0 | — | — | 0.4776 | 0.3278 | 0.0400 | $9.5 \times 10^{-6}$ | 0.4776 |
| 3 | Tailings | 120 | 0 | — | — | 0.4736 | 0.3294 | 0.0400 | $9.0 \times 10^{-6}$ | 0.4736 |
| 4 | Till/Lateral Drainage | 18 | 10 | SCL | SC | 0.3980 | 0.2440 | 0.1360 | $1.2 \times 10^{-4}$ | 0.2440 |
| 5 | Geocomposite/ Lateral Drainage | 0.24 | 34 | — | — | 0.8500 | 0.0100 | 0.0050 | 33.0 | 0.0100 |
| 6 | Geomembrane | 0.06 | 35 | — | — | — | — | — | $2.0 \times 10^{-13}$ | — |
| 7 | GCL[1] | 0.24 | 0 | — | — | 0.7500 | 0.7470 | 0.4000 | $8.8 \times 10^{-6}$ | 0.7500 |
| 8 | P40 Till | 12 | 0 | SiL | ML | 0.5010 | 0.2840 | 0.1350 | $2.0 \times 10^{-5}$ | 0.5010 |

[1]Geosynthetic Clay Liner

Prepared by: NXP
Checked by: MRS

## Table 8.2-5

## Soil, Waste and Geosynthetic Characteristics Used for Water Balance Model Base - Second Stages (III, V, VII)

| Layer # | General Description | Thickness (Inches) | Classification | | | Total Porosity (vol/vol) | Field Capacity (vol/vol) | Wilting Point (vol/vol) | Saturated Hydraulic Conductivity (cm/sec) | Initial Soil Water Content (vol/vol) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | HELP | USDA | USCS | | | | | |
| 1 | Tailings | 240 | 0 | — | — | 0.4776 | 0.3278 | 0.0400 | $1x10^{-5}$ | 0.4776 |
| 2 | Tailings | 120 | 0 | — | — | 0.4719 | 0.3301 | 0.0400 | $9.5x10^{-6}$ | 0.4719 |
| 3 | Tailings | 120 | 0 | — | — | 0.4693 | 0.3312 | 0.0400 | $9.0x10^{-6}$ | 0.4693 |
| 4 | Tailings | 120 | 0 | — | — | 0.4668 | 0.3322 | 0.0400 | $8.5x10^{-6}$ | 0.4668 |
| 5 | Tailings | 120 | 0 | — | — | 0.4651 | 0.3329 | 0.0400 | $8.0x10^{-6}$ | 0.4651 |
| 6 | Tailings | 120 | 0 | — | — | 0.4633 | 0.3336 | 0.0400 | $7.5x10^{-6}$ | 0.4633 |
| 7 | Tailings | 120 | 0 | — | — | 0.4616 | 0.3343 | 0.0400 | $7.0x10^{-6}$ | 0.4616 |
| 8 | Tailings | 120 | 0 | — | — | 0.4599 | 0.3350 | 0.0400 | $6.5x10^{-6}$ | 0.4599 |
| 9 | Till/Lateral Drainage | 18 | 10 | SCL | SC | 0.3980 | 0.2440 | 0.1360 | $1.2x10^{-4}$ | 0.2440 |
| 10 | Granular Soil/ Lateral Drainage | 24 | 21 | Gravel | | 0.3970 | 0.0320 | 0.0130 | $3.0x10^{-1}$ | 0.0320 |
| 11 | Geomembrane | 0.06 | 35 | — | — | — | — | — | $2.0x10^{-13}$ | — |
| 12 | GCL[1] | 0.24 | 0 | — | — | 0.7500 | 0.7470 | 0.4000 | $8.8x10^{-6}$ | 0.7500 |
| 13 | P40 Till | 12 | 0 | SiL | ML | 0.5010 | 0.2840 | 0.1350 | $2.0x10^{-5}$ | 0.5010 |

[1]Geosynthetic Clay Liner

Prepared by: NXP
Checked by: MRS

The Sideslope and Base HELP models for Post-Closure Period with lateral drainage on the base have been conducted based on the following generalized design specifications and soil characteristic input parameters:

Lower Sideslope HELP Model: Post-Closure Period With Lateral Drainage on the Base

- final cover soils;
- 770-foot length of cover drainage at 2 percent slope;
- geomembrane;
- GCL;
- P40 till layer;
- vertical profile of 70 feet of tailings (average of tailings depths at the end);
- 120-foot length of base drainage at 3H:1V slope;
- lateral drainage through till layer;
- lateral drainage through geocomposite;
- geomembrane;
- GCL;
- P40 till layer; and
- soil and tailings layer data as provided in Table 8.2-6

Upper Sideslope HELP Model: Post-Closure Period With Lateral Drainage on the Base

- final cover soils;
- 700-foot length of cover drainage at 2 percent slope;
- geomembrane;
- GCL;
- P40 till layer;
- vertical profile of 25 feet of tailings (average of tailings depths at ends);
- 270-foot length of base drainage at 3H:1V slope;
- lateral drainage through till layer;
- lateral drainage through geomembrane
- geomembrane;
- GCL;
- P40 till layer; and
- soil and tailings layer data as provided in Table 8.2-7.

Base HELP Model: Post-Closure Period With Lateral Drainage on the Base

- final cover soils;
- 770-foot length of cover drainage at 2 percent slope;
- geomembrane;
- GCL;
- P40 till layer;
- vertical profile of 90 feet of tailings;
- 600-foot length of base drainage at 2 percent slope ;
- lateral drainage above the liner;
- geomembrane;
- GCL;
- P40 till layer; and
- soil and tailings layer data as provided in Table 8.2-8.

## Table 8.2-6

## Soil, Waste and Geosynthetic Characteristics Used for Water Balance Model Lower Sideslope - Post-Closure Period With Lateral Drainage on the Base

| Layer # | General Description | Thickness (Inches) | Classification | | | Total Porosity (vol/vol) | Field Capacity (vol/vol) | Wilting Point (vol/vol) | Saturated Hydraulic Conductivity (cm/sec) | Initial Soil Water Content (vol/vol) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | HELP | USDA | USCS | | | | | |
| 1 | Topsoil | 6 | 8 | L | ML | 0.4630. | 0.2320 | 0.1160 | $3.7x10^{-4}$ | 0.4630 |
| 2 | Till/Rooting Zone | 36 | 10 | SCL | SC | 0.3980 | 0.2440 | 0.1360 | $1.2x10^{-1}$ | 0.3980 |
| 3 | Granular Soil/ Lateral Drainage | 12 | 21 | Gravel | | 0.3970 | 0.0320 | 0.0130 | $3.0x10^{-4}$ | 0.3970 |
| 4 | Geomembrane | 0.06 | 35 | — | — | — | — | — | $2.0x10^{-13}$ | — |
| 5 | GCL[1] | 0.24 | 17 | — | — | 0.7500 | 0.7470 | 0.4000 | $3x10^{-9}$ | 0.7500 |
| 6 | P40 Till | 12 | 0 | SiL | ML | 0.5010 | 0.2840 | 0.1350 | $2x10^{-5}$ | 0.5010 |
| 7 | Till/Grading Layer | 36 | 10 | SCL | SC | 0.3980 | 0.2440 | 0.1360 | $1.2x10^{-4}$ | 0.2440 |
| 8 | Tailings | 120 | 0 | — | — | 0.4816 | 0.3262 | 0.0400 | $1x10^{-5}$ | 0.4816 |
| 9 | Tailings | 120 | 0 | — | — | 0.4753 | 0.3287 | 0.0400 | $9.5x10^{-6}$ | 0.4753 |
| 10 | Tailings | 120 | 0 | — | — | 0.4719 | 0.3301 | 0.0400 | $9.0x10^{-6}$ | 0.4719 |
| 11 | Tailings | 120 | 0 | — | — | 0.4693 | 0.3312 | 0.0400 | $8.5x10^{-6}$ | 0.4693 |

**Table 8.2-6** *(Continued)*

| Layer # | General Description | Thickness (Inches) | Classification | | | Total Porosity (vol/vol) | Field Capacity (vol/vol) | Wilting Point (vol/vol) | Saturated Hydraulic Conductivity (cm/sec) | Initial Soil Water Content (vol/vol) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | HELP | USDA | USCS | | | | | |
| 12 | Tailings | 120 | 0 | — | — | 0.4668 | 0.3322 | 0.0400 | $8.0x10^{-6}$ | 0.4668 |
| 13 | Tailings | 120 | 0 | — | — | 0.4651 | 0.3329 | 0.0400 | $7.5x10^{-6}$ | 0.4651 |
| 14 | Tailings | 120 | 0 | — | — | 0.4633 | 0.3336 | 0.0400 | $7.0x10^{-6}$ | 0.4633 |
| 15 | Till/Lateral Drainage | 18 | 10 | SCL | SC | 0.3980 | 0.2440 | 0.1360 | $1.2x10^{-4}$ | 0.2440 |
| 16 | Geocomposite/ Lateral Layer | 0.24 | 34 | — | — | 0.8500 | 0.0100 | 0.0050 | 33.0 | 0.0100 |
| 17 | Geomembrane | 0.06 | 35 | — | — | — | — | — | $2x10^{-13}$ | — |
| 18 | GCL[1] | 0.24 | 0 | — | — | 0.7500 | 0.7470 | 0.4000 | $8.8x10^{-6}$ | 0.7500 |
| 19 | P40 Till | 12 | 0 | SiL | ML | 0.5010 | 0.2840 | 0.1350 | $2x10^{-5}$ | 0.5010 |

[1]Geosynthetic Clay Liner

Prepared by: NXP
Checked by: MRS
Revised by: NXP
Checked by: JWS

## Table 8.2-7

## Soil, Waste and Geosynthetic Characteristics Used for Water Balance Model Upper Sideslope - Post-Closure Period With Lateral Drainage on the Base

| Layer # | General Description | Thickness (Inches) | Classification | | | Total Porosity (vol/vol) | Field Capacity (vol/vol) | Wilting Point (vol/vol) | Saturated Hydraulic Conductivity (cm/sec) | Initial Soil Water Content (vol/vol) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | HELP | USDA | USCS | | | | | |
| 1 | Topsoil | 6 | 8 | L | ML | 0.4630 | 0.2320 | 0.1160 | $3.7x10^{-4}$ | 0.4630 |
| 2 | Till/Rooting Zone | 36 | 10 | SCL | SC | 0.3980 | 0.2440 | 0.1360 | $1.2x10^{-4}$ | 0.3980 |
| 3 | Granular Soil/ Lateral Drainage | 12 | 21 | Gravel | | 0.3970 | 0.0320 | 0.0130 | $3.0x10^{-1}$ | 0.3970 |
| 4 | Geomembrane | 0.06 | 35 | — | — | — | — | — | $2.0x10^{-13}$ | — |
| 5 | GCL[1] | 0.24 | 17 | — | — | 0.7500 | 0.7470 | 0.4000 | $3.0x10^{-9}$ | 0.7500 |
| 6 | P40 Till | 12 | 0 | SiL | ML | 0.5010 | 0.2840 | 0.1350 | $2.0x10^{-5}$ | 0.5010 |
| 7 | Till/Grading Layer | 36 | 10 | SCL | SC | 0.3980 | 0.2440 | 0.1360 | $1.2x10^{-4}$ | 0.2440 |
| 8 | Tailings | 60 | 0 | — | — | 0.4844 | 0.3250 | 0.0400 | $1.0x10^{-5}$ | 0.4844 |
| 9 | Tailings | 120 | 0 | — | — | 0.4776 | 0.3278 | 0.0400 | $9.5x10^{-6}$ | 0.4776 |
| 10 | Tailings | 120 | 0 | — | — | 0.4736 | 0.3294 | 0.0400 | $9.0x10^{-6}$ | 0.4736 |
| 11 | Till/Lateral Drainage | 18 | 10 | SCL | SC | 0.3980 | 0.2440 | 0.1360 | $1.2x10^{-4}$ | 0.2440 |

**Table 8.2-7** *(Continued)*

| Layer # | General Description | Thickness (Inches) | Classification | | | Total Porosity (vol/vol) | Field Capacity (vol/vol) | Wilting Point (vol/vol) | Saturated Hydraulic Conductivity (cm/sec) | Initial Soil Water Content (vol/vol) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | HELP | USDA | USCS | | | | | |
| 12 | Geocomposite/ Lateral Drainage | 0.24 | 34 | — | — | 0.8500 | 0.0100 | 0.0050 | 33.0 | 0.0100 |
| 13 | Geomembrane | 0.06 | 35 | — | — | — | — | — | $2.0 \times 10^{-13}$ | — |
| 14 | GCL[1] | 0.24 | 0 | — | — | 0.7500 | 0.7470 | 0.4000 | $8.8 \times 10^{-6}$ | 0.7500 |
| 15 | P40 Till | 12 | 0 | SiL | ML | 0.5010 | 0.2840 | 0.1350 | $2.0 \times 10^{-5}$ | 0.5010 |

[1]Geosynthetic Clay Liner

Prepared by: NXP
Checked by: MRS
Revised by: NXP
Checked by: JWS

## Table 8.2-8

## Soil, Waste and Geosynthetic Characteristics Used for Water Balance Model Base - Post-Closure Period With Lateral Drainage on the Base

| Layer # | General Description | Thickness (Inches) | Classification | | | Total Porosity (vol/vol) | Field Capacity (vol/vol) | Wilting Point (vol/vol) | Saturated Hydraulic Conductivity (cm/sec) | Initial Soil Water Content (vol/vol) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | HELP | USDA | USCS | | | | | |
| 1 | Topsoil | 6 | 8 | L | ML | 0.4630. | 0.2320 | 0.1160 | $3.7x10^{-4}$ | 0.4630 |
| 2 | Till/Rooting Zone | 36 | 10 | SCL | SC | 0.3980 | 0.2440 | 0.1360 | $1.2x10^{-1}$ | 0.3980 |
| 3 | Granular Soil/ Lateral Drainage | 12 | 21 | Gravel | | 0.3970 | 0.0320 | 0.0130 | $3.0x10^{-1}$ | 0.3970 |
| 4 | Geomembrane | 0.06 | 35 | — | — | — | — | — | $2.0x10^{-13}$ | — |
| 5 | GCL[1] | 0.24 | 17 | — | — | 0.7500 | 0.7470 | 0.4000 | $3.0x10^{-9}$ | 0.7500 |
| 6 | P40 Till | 12 | 0 | SiL | ML | 0.5010 | 0.2840 | 0.1350 | $2.0x10^{-5}$ | 0.5010 |
| 7 | Till/Grading Layer | 36 | 10 | SCL | SC | 0.3980 | 0.2440 | 0.1360 | $1.2x10^{-4}$ | 0.2440 |
| 8 | Tailings | 240 | 0 | — | — | 0.4776 | 0.3278 | 0.0400 | $1.0x10^{-5}$ | 0.4776 |
| 9 | Tailings | 120 | 0 | — | — | 0.4719 | 0.3301 | 0.0400 | $9.5x10^{-6}$ | 0.4719 |
| 10 | Tailings | 120 | 0 | — | — | 0.4693 | 0.3312 | 0.0400 | $9.0x10^{-6}$ | 0.4693 |
| 11 | Tailings | 120 | 0 | — | — | 0.4668 | 0.3322 | 0.0400 | $8.5x10^{-6}$ | 0.4668 |

**Table 8.2-8** *(Continued)*

| Layer # | General Description | Thickness (Inches) | Classification | | | Total Porosity (vol/vol) | Field Capacity (vol/vol) | Wilting Point (vol/vol) | Saturated Hydraulic Conductivity (cm/sec) | Initial Soil Water Content (vol/vol) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | HELP | USDA | USCS | | | | | |
| 12 | Tailings | 120 | 0 | — | — | 0.4651 | 0.3329 | 0.0400 | $8.0x10^{-6}$ | 0.4651 |
| 13 | Tailings | 120 | 0 | — | — | 0.4633 | 0.3336 | 0.0400 | $7.5x10^{-6}$ | 0.4633 |
| 14 | Tailings | 120 | 0 | — | — | 0.4616 | 0.3343 | 0.0400 | $7.0x10^{-6}$ | 0.4616 |
| 15 | Tailings | 120 | 0 | — | — | 0.4599 | 0.3350 | 0.0400 | $6.5x10^{-6}$ | 0.4599 |
| 16 | Till/Lateral Drainage | 18 | 10 | SCL | SC | 0.3980 | 0.2440 | 0.1360 | $1.2x10^{-4}$ | 0.2440 |
| 17 | Granular Soil/ Lateral Drainage | 24 | 21 | Gravel | | 0.3970 | 0.0320 | 0.0130 | $3.0x10^{-1}$ | 0.0320 |
| 18 | Geomembrane | 0.06 | 35 | — | — | — | — | — | $2.0x10^{-13}$ | — |
| 19 | GCL[1] | 0.24 | 0 | — | — | 0.7500 | 0.7470 | 0.4000 | $8.8x10^{-6}$ | 0.7500 |
| 20 | P40 Till | 12 | 0 | SiL | ML | 0.5010 | 0.2840 | 0.1350 | $2.0x10^{-5}$ | 0.5010 |

[1]Geosynthetic Clay Liner

Prepared by: NXP
Checked by: MRS
Revised by: NXP
Checked by: JWS

The Sideslope and Base HELP models for the Post-Closure Period with lateral drainage on the sideslope and no lateral drainage on the base have been conducted based on the following generalized design specifications and soil characteristic input parameters:

Lower Sideslope HELP Model: Post-Closure Period With No Lateral Drainage on the Base

- final cover soils;
- 770-foot length of cover drainage at 2 percent slope;
- geomembrane;
- GCL;
- P40 till layer;
- vertical profile of 70 feet of tailings (average of tailings depths at the ends);
- 120-foot length of base drainage at 3H:1V slope;
- lateral drainage through till layer;
- lateral drainage through geocomposite;
- geomembrane;
- GCL;
- P40 till layer; and
- soil and tailings layer data as provided in Table 8.2-9.

Upper Sideslope HELP Model: Post-Closure Period With No Lateral Drainage on the Base

- final cover soils;
- 770-foot length of cover drainage at 2 percent slope;
- geomembrane;
- GCL;
- P40 till layer;
- vertical profile of 25 feet of tailings (average of the depths at the ends);
- 270-foot length of base drainage at 3H:1V slope;
- lateral drainage through the till layer;
- lateral drainage through geocomposite;
- geomembrane;
- GCL;
- P40 till layer; and
- soil and tailings layer data as provided in Table 8.2-10.

Base HELP Model: Post-Closure Period With No Lateral Drainage

- final cover soils;
- 770-foot length of cover drainage at 2 percent slope;
- geomembrane;
- GCL;
- P40 till layer;
- vertical profile of 90 feet of tailings;
- till and granular soil layer as vertical percolation layers;
- geomembrane;
- GCL;
- P40 till layer; and
- soil and tailings layer data as provided in Table 8.2-11.

## Table 8.2-9

## Soil, Waste and Geosynthetic Characteristics Used for Water Balance Model Lower Sideslope - Post-Closure Period With No Lateral Drainage on the Base

| Layer # | General Description | Thickness (Inches) | Classification | | | Total Porosity (vol/vol) | Field Capacity (vol/vol) | Wilting Point (vol/vol) | Saturated Hydraulic Conductivity (cm/sec) | Initial Soil Water Content (vol/vol) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | HELP | USDA | USCS | | | | | |
| 1 | Topsoil | 6 | 8 | L | ML | 0.4630 | 0.2320 | 0.1160 | $3.7x10^{-4}$ | 0.2610 |
| 2 | Till/Rooting Zone | 36 | 10 | SCL | SC | 0.3980 | 0.2440 | 0.1360 | $1.2x10^{-4}$ | 0.2363 |
| 3 | Granular Soil/ Lateral Drainage | 12 | 21 | Gravel | | 0.3970 | 0.0320 | 0.0130 | $3.0x10^{-1}$ | 0.0320 |
| 4 | Geomembrane | 0.06 | 35 | — | — | — | — | — | $2.0x10^{-13}$ | — |
| 5 | GCL[1] | 0.24 | 17 | — | — | 0.7500 | 0.7470 | 0.4000 | $3.0x10^{-9}$ | 0.7500 |
| 6 | P40 Till | 12 | 0 | SiL | ML | 0.5010 | 0.2840 | 0.1350 | $2.0x10^{-5}$ | 0.2840 |
| 7 | Till/Grading Layer | 36 | 10 | SCL | SC | 0.3980 | 0.2440 | 0.1360 | $1.2x10^{-4}$ | 0.2440 |
| 8 | Tailings | 120 | 0 | — | — | 0.4816 | 0.3262 | 0.0400 | $1.0x10^{-5}$ | 0.2043 |
| 9 | Tailings | 120 | 0 | — | — | 0.4753 | 0.3287 | 0.0400 | $9.5x10^{-6}$ | 0.2014 |
| 10 | Tailings | 120 | 0 | — | — | 0.4719 | 0.3301 | 0.0400 | $9.0x10^{-6}$ | 0.1998 |
| 11 | Tailings | 120 | 0 | — | — | 0.4693 | 0.3312 | 0.0400 | $8.5x10^{-6}$ | 0.1986 |

**Table 8.2-9** *(Continued)*

| Layer # | General Description | Thickness (Inches) | Classification | | | Total Porosity (vol/vol) | Field Capacity (vol/vol) | Wilting Point (vol/vol) | Saturated Hydraulic Conductivity (cm/sec) | Initial Soil Water Content (vol/vol) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | HELP | USDA | USCS | | | | | |
| 12 | Tailings | 120 | 0 | — | — | 0.4668 | 0.3322 | 0.0400 | $8.0 \times 10^{-6}$ | 0.1974 |
| 13 | Tailings | 120 | 0 | — | — | 0.4651 | 0.3329 | 0.0400 | $7.5 \times 10^{-6}$ | 0.1966 |
| 14 | Tailings | 120 | 0 | — | — | 0.4633 | 0.3336 | 0.0400 | $7.0 \times 10^{-6}$ | 0.1958 |
| 15 | Till/Lateral Drainage | 18 | 10 | SCL | SC | 0.3980 | 0.2440 | 0.1360 | $1.2 \times 10^{-4}$ | 0.2440 |
| 16 | Geocomposite/ Lateral Layer | 0.24 | 34 | — | — | 0.8500 | 0.0100 | 0.0050 | 33.0 | 0.0100 |
| 17 | Geomembrane | 0.06 | 35 | — | — | — | — | — | $2.0 \times 10^{-13}$ | — |
| 18 | GCL[1] | 0.24 | 0 | — | — | 0.7500 | 0.7470 | 0.4000 | $8.8 \times 10^{-6}$ | 0.7500 |
| 19 | P40 Till | 12 | 0 | SiL | ML | 0.5010 | 0.2840 | 0.1350 | $2.0 \times 10^{-5}$ | 0.1886 |

[1]Geosynthetic Clay Liner

Prepared by: NXP
Checked by: MRS

## Table 8.2-10

## Soil, Waste and Geosynthetic Characteristics Used for Water Balance Model Upper Sideslope - Post-Closure Period With No Lateral Drainage on the Base

| Layer # | General Description | Thickness (Inches) | Classification | | | Total Porosity (vol/vol) | Field Capacity (vol/vol) | Wilting Point (vol/vol) | Saturated Hydraulic Conductivity (cm/sec) | Initial Soil Water Content (vol/vol) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | HELP | USDA | USCS | | | | | |
| 1 | Topsoil | 6 | 8 | L | ML | 0.4630. | 0.2320 | 0.1160 | $3.7x10^{-4}$ | 0.2610 |
| 2 | Till/Rooting Zone | 36 | 10 | SCL | SC | 0.3980 | 0.2440 | 0.1360 | $1.2x10^{-4}$ | 0.2363 |
| 3 | Granular Soil/ Lateral Drainage | 12 | 21 | Gravel | | 0.3970 | 0.0320 | 0.0130 | $3.0x10^{-1}$ | 0.0320 |
| 4 | Geomembrane | 0.06 | 35 | — | — | — | — | — | $2.0x10^{-13}$ | — |
| 5 | GCL[1] | 0.24 | 17 | — | — | 0.7500 | 0.7470 | 0.4000 | $3.0x10^{-9}$ | 0.7500 |
| 6 | P40 Till | 12 | 0 | SiL | ML | 0.5010 | 0.2840 | 0.1350 | $2.0x10^{-5}$ | 0.2840 |
| 7 | Till/Grading Layer | 36 | 10 | SCL | SC | 0.3980 | 0.2440 | 0.1360 | $1.2x10^{-4}$ | 0.2440 |
| 8 | Tailings | 60 | 0 | — | — | 0.4844 | 0.3250 | 0.0400 | $1.0x10^{-5}$ | 0.2056 |
| 9 | Tailings | 120 | 0 | — | — | 0.4776 | 0.3278 | 0.0400 | $9.5x10^{-6}$ | 0.2024 |
| 10 | Tailings | 120 | 0 | — | — | 0.4736 | 0.3294 | 0.0400 | $9.0x10^{-6}$ | 0.2006 |
| 11 | Till/Lateral Drainage | 18 | 10 | SCL | SC | 0.3980 | 0.2440 | 0.1360 | $1.2x10^{-4}$ | 0.2440 |

**Table 8.2-10** *(Continued)*

| Layer # | General Description | Thickness (Inches) | Classification | | | Total Porosity (vol/vol) | Field Capacity (vol/vol) | Wilting Point (vol/vol) | Saturated Hydraulic Conductivity (cm/sec) | Initial Soil Water Content (vol/vol) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | HELP | USDA | USCS | | | | | |
| 12 | Geocomposite/ Lateral Drainage | 0.24 | 34 | — | — | 0.8500 | 0.0100 | 0.0050 | 33.0 | 0.0100 |
| 13 | Geomembrane | 0.06 | 35 | — | — | — | — | — | $2.0 \times 10^{-13}$ | — |
| 14 | GCL[1] | 0.24 | 0 | — | — | 0.7500 | 0.7470 | 0.4000 | $8.8 \times 10^{-6}$ | 0.7500 |
| 15 | P40 Till | 12 | 0 | SiL | ML | 0.5010 | 0.2840 | 0.1350 | $2.0 \times 10^{-5}$ | 0.2015 |

[1]Geosynthetic Clay Liner

Prepared by: NXP
Checked by: MRS

## Table 8.2-11

## Soil, Waste and Geosynthetic Characteristics Used for Water Balance Model Base - Post-Closure Period With No Lateral Drainage

| Layer # | General Description | Thickness (Inches) | Classification | | | Total Porosity (vol/vol) | Field Capacity (vol/vol) | Wilting Point (vol/vol) | Saturated Hydraulic Conductivity (cm/sec) | Initial Soil Water Content (vol/vol) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | HELP | USDA | USCS | | | | | |
| 1 | Topsoil | 6 | 8 | L | ML | 0.4630. | 0.2320 | 0.1160 | $3.7x10^{-4}$ | 0.2610 |
| 2 | Till/Rooting Zone | 36 | 10 | SCL | SC | 0.3980 | 0.2440 | 0.1360 | $1.2x10^{-4}$ | 0.2363 |
| 3 | Granular Soil/ Lateral Drainage | 12 | 21 | Gravel | | 0.3970 | 0.0320 | 0.0130 | $3.0x10^{-1}$ | 0.0320 |
| 4 | Geomembrane | 0.06 | 35 | — | — | — | — | — | $2.0x10^{-13}$ | — |
| 5 | GCL[1] | 0.24 | 17 | — | — | 0.7500 | 0.7470 | 0.4000 | $3.0x10^{-9}$ | 0.7500 |
| 6 | P40 Till | 12 | 0 | SiL | ML | 0.5010 | 0.2840 | 0.1350 | $2.0x10^{-5}$ | 0.2840 |
| 7 | Till/Grading Layer | 36 | 10 | SCL | SC | 0.3980 | 0.2440 | 0.1360 | $1.2x10^{-4}$ | 0.2440 |
| 8 | Tailings | 240 | 0 | — | — | 0.4776 | 0.3278 | 0.0400 | $1.0x10^{-5}$ | 0.2024 |
| 9 | Tailings | 120 | 0 | — | — | 0.4719 | 0.3301 | 0.0400 | $9.5x10^{-6}$ | 0.1998 |
| 10 | Tailings | 120 | 0 | — | — | 0.4693 | 0.3312 | 0.0400 | $9.0x10^{-6}$ | 0.1986 |
| 11 | Tailings | 120 | 0 | — | — | 0.4668 | 0.3322 | 0.0400 | $8.5x10^{-6}$ | 0.1974 |

**Table 8.2-11** *(Continued)*

| Layer # | General Description | Thickness (Inches) | Classification | | | Total Porosity (vol/vol) | Field Capacity (vol/vol) | Wilting Point (vol/vol) | Saturated Hydraulic Conductivity (cm/sec) | Initial Soil Water Content (vol/vol) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | HELP | USDA | USCS | | | | | |
| 12 | Tailings | 120 | 0 | — | — | 0.4651 | 0.3329 | 0.0400 | $8.0x10^{-6}$ | 0.1966 |
| 13 | Tailings | 120 | 0 | — | — | 0.4633 | 0.3336 | 0.0400 | $7.5x10^{-6}$ | 0.1958 |
| 14 | Tailings | 120 | 0 | — | — | 0.4616 | 0.3343 | 0.0400 | $7.0x10^{-6}$ | 0.1950 |
| 15 | Tailings | 120 | 0 | — | — | 0.4599 | 0.3350 | 0.0400 | $6.5x10^{-6}$ | 0.1942 |
| 16 | Till | 18 | 10 | SCL | SC | 0.3980 | 0.2440 | 0.1360 | $1.2x10^{-4}$ | 0.2440 |
| 17 | Granular Soil/ Vertical Percolation | 24 | 21 | Gravel | | 0.3970 | 0.0320 | 0.0130 | $3.0x10^{-1}$ | 0.0320 |
| 18 | Geomembrane | 0.06 | 35 | — | — | — | — | — | $2.0x10^{-13}$ | — |
| 19 | GCL[1] | 0.24 | 0 | — | — | 0.7500 | 0.7470 | 0.4000 | $8.8x10^{-6}$ | 0.7500 |
| 20 | P40 Till | 12 | 0 | SiL | ML | 0.5010 | 0.2840 | 0.1350 | $2.0x10^{-5}$ | 0.1856 |

[1]Geosynthetic Clay Liner

Prepared by: NXP
Checked by: MRS

The Sideslope and Base HELP models for the Post-Closure Period with lateral drainage on the sideslope and no lateral drainage on base and a hypothesized lack of a geomembrane layer in the base after 150 years. The following generalized design specifications and soil characteristic input parameters represent this case:

Lower Sideslope HELP Model: Post-Closure Period With No Lateral Drainage on the Base and No Base Geomembrane

- final cover soils;
- 770-foot length of cover drainage at 2 percent slope;
- geomembrane;
- GCL;
- P40 till layer;
- vertical profile of 70 feet of tailings;
- 120-foot length of base drainage at 3H:1V slope;
- lateral drainage through till layer;
- lateral drainage through geocomposite;
- GCL;
- P40 till layer; and
- soil and tailings layer data as provided in Table 8.2-12.

Upper Sideslope HELP Model: Post-Closure Period With No Lateral Drainage on the Base and No Base Geomembrane

- final cover soils;
- 770-foot length of cover drainage at 2 percent slope;
- geomembrane;
- GCL;
- P40 till layer;
- vertical profile of 25 feet of tailings;
- 270-foot length of base drainage at 3H:1V slope;
- lateral drainage through the till layer;
- lateral drainage through geocomposite;
- GCL;
- P40 till layer; and
- soil and tailings layer data as provided in Table 8.2-13.

Base HELP Model: Post-Closure Period With No Lateral Drainage and No Base Geomembrane

- final cover soils;
- 770-foot length of cover drainage at 2 percent slope;
- geomembrane;
- GCL;
- P40 till layer;
- vertical profile of 90 feet of tailings;
- GCL;
- P40 till layer; and
- soil and tailings layer data as provided in Table 8.2-14.

## Table 8.2-12

## Soil, Waste and Geosynthetic Characteristics Used for Water Balance Model
## Lower Sideslope - Post-Closure Period
## With No Lateral Drainage on the Base and No Base Geomembrane

| Layer # | General Description | Thickness (Inches) | Classification | | | Total Porosity (vol/vol) | Field Capacity (vol/vol) | Wilting Point (vol/vol) | Saturated Hydraulic Conductivity (cm/sec) | Initial Soil Water Content (vol/vol) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | HELP | USDA | USCS | | | | | |
| 1 | Topsoil | 6 | 8 | L | ML | 0.4630. | 0.2320 | 0.1160 | $3.7x10^{-4}$ | 0.2610 |
| 2 | Till/Rooting Zone | 36 | 10 | SCL | SC | 0.3980 | 0.2440 | 0.1360 | $1.2x10^{-4}$ | 0.2363 |
| 3 | Granular Soil/ Lateral Drainage | 12 | 21 | Gravel | | 0.3970 | 0.0320 | 0.0130 | $3.0x10^{-1}$ | 0.0320 |
| 4 | Geomembrane | 0.06 | 35 | — | — | — | — | — | $2.0x10^{-13}$ | — |
| 5 | GCL[1] | 0.24 | 17 | — | — | 0.7500 | 0.7470 | 0.4000 | $3.0x10^{-9}$ | 0.7500 |
| 6 | P40 Till | 12 | 0 | SiL | ML | 0.5010 | 0.2840 | 0.1350 | $2.0x10^{-5}$ | 0.2840 |
| 7 | Till/Grading Layer | 36 | 10 | SCL | SC | 0.3980 | 0.2440 | 0.1360 | $1.2x10^{-4}$ | 0.2440 |
| 8 | Tailings | 120 | 0 | — | — | 0.4816 | 0.3262 | 0.0400 | $1.0x10^{-5}$ | 0.2043 |
| 9 | Tailings | 120 | 0 | — | — | 0.4753 | 0.3287 | 0.0400 | $9.5x10^{-6}$ | 0.2014 |
| 10 | Tailings | 120 | 0 | — | — | 0.4719 | 0.3301 | 0.0400 | $9.0x10^{-6}$ | 0.1998 |

**Table 8.2-12** *(Continued)*

| Layer # | General Description | Thickness (Inches) | Classification | | | Total Porosity (vol/vol) | Field Capacity (vol/vol) | Wilting Point (vol/vol) | Saturated Hydraulic Conductivity (cm/sec) | Initial Soil Water Content (vol/vol) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | HELP | USDA | USCS | | | | | |
| 11 | Tailings | 120 | 0 | — | — | 0.4693 | 0.3312 | 0.0400 | $8.5x10^{-6}$ | 0.1986 |
| 12 | Tailings | 120 | 0 | — | — | 0.4668 | 0.3322 | 0.0400 | $8.0x10^{-6}$ | 0.1974 |
| 13 | Tailings | 120 | 0 | — | — | 0.4651 | 0.3329 | 0.0400 | $7.5x10^{-6}$ | 0.1966 |
| 14 | Tailings | 120 | 0 | — | — | 0.4633 | 0.3336 | 0.0400 | $7.0x10^{-6}$ | 0.1958 |
| 15 | Till/Lateral Drainage | 18 | 10 | SCL | SC | 0.3980 | 0.2440 | 0.1360 | $1.2x10^{-4}$ | 0.2440 |
| 16 | Geocomposite/ Lateral Drainage | 0.24 | 34 | — | — | 0.8500 | 0.0100 | 0.0050 | 33.0 | 0.0100 |
| 17 | GCL[1] | 0.24 | 0 | — | — | 0.7500 | 0.7470 | 0.4000 | $8.8x10^{-6}$ | 0.7500 |
| 18 | P40 Till | 12 | 0 | SiL | ML | 0.5010 | 0.2840 | 0.1350 | $2.0x10^{-5}$ | 0.1886 |

[1]Geosynthetic Clay Liner

Prepared by: NXP
Checked by: MRS

## Table 8.2-13

## Soil, Waste and Geosynthetic Characteristics Used for Water Balance Model
## Upper Sideslope - Post-Closure Period
## With No Lateral Drainage on the Base and No Base Geomembrane

| Layer # | General Description | Thickness (Inches) | Classification | | | Total Porosity (vol/vol) | Field Capacity (vol/vol) | Wilting Point (vol/vol) | Saturated Hydraulic Conductivity (cm/sec) | Initial Soil Water Content (vol/vol) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | HELP | USDA | USCS | | | | | |
| 1 | Topsoil | 6 | 8 | L | ML | 0.4630. | 0.2320 | 0.1160 | $3.7x10^{-4}$ | 0.2610 |
| 2 | Till/Rooting Zone | 36 | 10 | SCL | SC | 0.3980 | 0.2440 | 0.1360 | $1.2x10^{-4}$ | 0.2363 |
| 3 | Granular Soil/ Lateral Drainage | 12 | 21 | Gravel | | 0.3970 | 0.0320 | 0.0130 | $3.0x10^{-1}$ | 0.0320 |
| 4 | Geomembrane | 0.06 | 35 | — | — | — | — | — | $2.0x10^{-13}$ | — |
| 5 | GCL[1] | 0.24 | 17 | — | — | 0.7500 | 0.7470 | 0.4000 | $3.0x10^{-9}$ | 0.7500 |
| 6 | P40 Till | 12 | 0 | SiL | ML | 0.5010 | 0.2840 | 0.1350 | $2.0x10^{-5}$ | 0.2840 |
| 7 | Till/Grading Layer | 36 | 10 | SCL | SC | 0.3980 | 0.2440 | 0.1360 | $1.2x10^{-4}$ | 0.2440 |
| 8 | Tailings | 60 | 0 | — | — | 0.4844 | 0.3250 | 0.0400 | $1.0x10^{-5}$ | 0.2056 |
| 9 | Tailings | 120 | 0 | — | — | 0.4776 | 0.3278 | 0.0400 | $9.5x10^{-6}$ | 0.2024 |
| 10 | Tailings | 120 | 0 | — | — | 0.4736 | 0.3294 | 0.0400 | $9.0x10^{-6}$ | 0.2006 |

**Table 8.2-13** *(Continued)*

| Layer # | General Description | Thickness (Inches) | Classification | | | Total Porosity (vol/vol) | Field Capacity (vol/vol) | Wilting Point (vol/vol) | Saturated Hydraulic Conductivity (cm/sec) | Initial Soil Water Content (vol/vol) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | HELP | USDA | USCS | | | | | |
| 11 | Till/Lateral Drainage | 18 | 10 | SCL | SC | 0.3980 | 0.2440 | 0.1360 | $1.2x10^{-4}$ | 0.2440 |
| 12 | Geocomposite/ Lateral Drainage | 0.24 | 34 | — | — | 0.8500 | 0.0100 | 0.0050 | 33 | 0.0100 |
| 13 | GCL[1] | 0.24 | 0 | — | — | 0.7500 | 0.7470 | 0.4000 | $8.8x10^{-6}$ | 0.7500 |
| 14 | P40 Till | 12 | 0 | SiL | ML | 0.5010 | 0.2840 | 0.1350 | $2.0x10^{-5}$ | 0.2015 |

[1]Geosynthetic Clay Liner

Prepared by: NXP
Checked by: MRS

## Table 8.2-14

## Soil, Waste and Geosynthetic Characteristics Used for Water Balance Model
## Base - Post-Closure Period With No Lateral Drainage on the Base and No Base Geomembrane

| Layer # | General Description | Thickness (Inches) | Classification | | | Total Porosity (vol/vol) | Field Capacity (vol/vol) | Wilting Point (vol/vol) | Saturated Hydraulic Conductivity (cm/sec) | Initial Soil Water Content (vol/vol) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | HELP | USDA | USCS | | | | | |
| 1 | Topsoil | 6 | 8 | L | ML | 0.4630 | 0.2320 | 0.1160 | $3.7x10^{-4}$ | 0.2610 |
| 2 | Till/Rooting Zone | 36 | 10 | SCL | SC | 0.3980 | 0.2440 | 0.1360 | $1.2x10^{-4}$ | 0.2363 |
| 3 | Granular Soil/ Lateral Drainage | 12 | 21 | Gravel | | 0.3970 | 0.0320 | 0.0130 | $3.0x10^{-1}$ | 0.0320 |
| 4 | Geomembrane | 0.06 | 35 | — | — | — | — | — | $2.0x10^{-13}$ | — |
| 5 | GCL[1] | 0.24 | 17 | — | — | 0.7500 | 0.7470 | 0.4000 | $3.0x10^{-9}$ | 0.7500 |
| 6 | P40 Till | 12 | 0 | SiL | ML | 0.5010 | 0.2840 | 0.1350 | $2.0x10^{-5}$ | 0.2840 |
| 7 | Till/Grading Layer | 36 | 10 | SCL | SC | 0.3980 | 0.2440 | 0.1360 | $1.2x10^{-4}$ | 0.2440 |
| 8 | Tailings | 240 | 0 | — | — | 0.4776 | 0.3278 | 0.0400 | $1.0x10^{-5}$ | 0.2024 |
| 9 | Tailings | 120 | 0 | — | — | 0.4719 | 0.3301 | 0.0400 | $9.5x10^{-6}$ | 0.1998 |
| 10 | Tailings | 120 | 0 | — | — | 0.4693 | 0.3312 | 0.0400 | $9.0x10^{-6}$ | 0.1986 |
| 11 | Tailings | 120 | 0 | — | — | 0.4668 | 0.3322 | 0.0400 | $8.5x10^{-6}$ | 0.1974 |

**Table 8.2-14** *(Continued)*

| Layer # | General Description | Thickness (Inches) | Classification | | | Total Porosity (vol/vol) | Field Capacity (vol/vol) | Wilting Point (vol/vol) | Saturated Hydraulic Conductivity (cm/sec) | Initial Soil Water Content (vol/vol) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | HELP | USDA | USCS | | | | | |
| 12 | Tailings | 120 | 0 | — | — | 0.4651 | 0.3329 | 0.0400 | $8.0 \times 10^{-6}$ | 0.1966 |
| 13 | Tailings | 120 | 0 | — | — | 0.4633 | 0.3336 | 0.0400 | $7.5 \times 10^{-6}$ | 0.1958 |
| 14 | Tailings | 120 | 0 | — | — | 0.4616 | 0.3343 | 0.0400 | $7.0 \times 10^{-6}$ | 0.1950 |
| 15 | Tailings | 120 | 0 | — | — | 0.4599 | 0.3350 | 0.0400 | $6.5 \times 10^{-6}$ | 0.1942 |
| 16 | Till | 18 | 10 | SCL | SC | 0.3980 | 0.2440 | 0.1360 | $1.2 \times 10^{-4}$ | 0.2440 |
| 17 | Granular Soil/ Vertical Percolation | 24 | 21 | Gravel | | 0.3970 | 0.0320 | 0.0130 | $3.0 \times 10^{-1}$ | 0.0320 |
| 18 | GCL[1] | 0.24 | 0 | — | — | 0.7500 | 0.7470 | 0.4000 | $8.8 \times 10^{-6}$ | 0.7500 |
| 20 | P40 Till | 12 | 0 | SiL | ML | 0.5010 | 0.2840 | 0.1350 | $2.0 \times 10^{-5}$ | 0.1856 |

[1]Geosynthetic Clay Liner

Prepared by: NXP
Checked by: MRS

Tables 8.2-1 through 8.2-5 show that the models do not include the ponding of the slurry water. Dr. Paul Schroeder of the USCOE Waterways Experiment Station, who is the primary author of HELP, suggested that the model may be operated to mimic the presence of ponding on the surface if the precipitation values were increased and surface runoff prevented. Accordingly, the submodels during the initial simulations for the open conditions were run with the precipitation values increased by a factor of two. For all analyses, the geomembrane included in the final cover and the base liner was considered to have one pinhole per acre due to manufacturing defects and one hole per acre due to installation defects. The contact between the membrane and the GCL component of the composite liner was assigned as "excellent". The above parameters are direct functions of the construction quality assurance (CQA) program, and are readily achievable. For example, a leak location survey and repair of the located leaks is part of the CQA program. With the GCL as the soil component of the composite liner, excellent contact can be achieved in the field between the geomembrane and the soil component. Thus, by considering different geometries, appropriate material properties, and techniques for simulating operation scenarios, the HELP model should provide conservative values of leachate quantities and percolation from the site. These results are discussed in Section 8.3.

## 8.3 Summary of Results

### 8.3.1 Percolation Through the Liner and Leachate Generation

A summary of the results from the water balance study using the HELP models is shown in Table 8.3-1. The results shown pertain to the different submodels of both the Sideslope HELP models and Base HELP model. Thus different operation scenarios are covered; such as open case with doubled precipitation, closed case during initial post-closure period, closed case after the discontinuation of leachate removal and closed case after a very long time period when the geomembrane in the base liner is hypothetically assumed to be no longer effective. The percolation and leachate generation are given in terms of annual averages for the duration of the simulation period.

Yearly values of percolation through the liner during the operation period based on doubled precipitation for the initial stages and second stages are shown on Tables 8.3-2 and 8.3-3, respectively. The validity of this approach (increased precipitation) to simulate the effects of ponding has already been demonstrated in earlier submittals (Foth & Van Dyke, 1995, 1997a, 1998a).

After closure of each TMA cell when there will be no ponding and draining of the tailings is occurring, the results from the analyses with normal rainfall are appropriate.

## Table 8.3-1

## Results of HELP Model Water Balance Analyses

| HELP Model ID | Average Annual Totals for the Simulation Period | | | | | Peak Daily Values for Simulation Period | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Water Balance Simulation Period Years | Percolation Through Cover[1] in/yr; (Percent) | Lateral Drainage/Leachate Collected[1] in/yr; (Percent) | Percolation Through Liner[1] in/yr; (Percent) | Average Head Across Liner (in) | Percolation Through Cover (in/day) | Lateral Drainage/Leachate Collected (in/day) | Percolation through Liner (in/day) | Average Head Across Liner (in) |
| Lower Sideslope - Initial Stage (Table 8.2-1) | 10 | NA | 22.76239 (36.16522) | 0 (0) | 0.005 | NA | 0.32413 | 0 | 0.024 |
| Base - Initial Stage (Table 8.2-2) | 10 | NA | 25.41980 (40.38736) | 0.00644 (0.01024) | 1.229 | NA | 0.28916 | 0.000115 | 5.103 |
| Lower Sideslope - Second Stage (Table 8.2-3) | 10 | NA | 29.04885 (46.15324) | 0 (0) | 0.008 | NA | 0.30214 | 0 | 0.030 |
| Upper Sideslope - Second Stage (Table 8.2-4) | 10 | NA | 23.30196 (37.02249) | 0 (0) | 0.005 | NA | 0.30724 | 0 | 0.023 |
| Base - Second Stage (Table 8.2-5) | 10 | NA | 31.40371 (49.89467) | 0.00847 (0.01345) | 1.517 | NA | 0.28 | 0.000109 | 4.941 |
| Lower Sideslope - Final Cover (Table 8.2-6) | 115 | 0.00002 (0.00005) | 2.03032 (6.60115) | 0.0001217 (0.000393) | 0.006 | 0.000008 | 2.63254 | 0.013884 | 214.566 |
| Upper Sideslope - Final Cover (Table 8.2-7) | 115 | 0.00002 (0.00005) | 0.764174 (2.4845) | 0.000066 (0.000212) | 0.002 | 0.000008 | 2.16798 | 0.007538 | 76.546 |
| Base - Final Cover (Table 8.2-8) | 115 | 0.00002 (0.00005) | 2.653605 (8.6277) | 0.0059674 (0.019400) | 0.134 | 0.000008 | 3.22475 | 0.606080 | 296.451 |
| Lower Sideslope - Final Cover (Table 8.2-9) | 25 | 0.00002 (0.00005) | 0.00014 (0.00046) | 0 (0) | 0 | 0.000001 | 0.00073 | 0 | 0 |
| Upper Sideslope - Final Cover (Table 8.2-10) | 25 | 0.00002 (0.00005) | 0.00008 (0.00026) | 0 (0) | 0 | 0.000001 | 0.00141 | 0 | 0 |

**Table 8.3-1** *(Continued)*

| HELP Model ID | Average Annual Totals for the Simulation Period | | | | | Peak Daily Values for Simulation Period | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Water Balance Simulation Period Years | Percolation Through Cover[1] in/yr; (Percent) | Lateral Drainage/Leachate Collected[1] in/yr; (Percent) | Percolation Through Liner[1] in/yr; (Percent) | Average Head Across Liner (in) | Percolation Through Cover (in/day) | Lateral Drainage/Leachate Collected (in/day) | Percolation through Liner (in/day) | Average Head Across Liner (in) |
| Base - No Drainage (Table 8.2-11) | 25 | 0.00002 (0.00005) | NA | 0.0 (0.00001) | 0 | 0.000001 | NA | 0 | 0.001 |
| Lower Sideslope - No Geomembrane in the Liner (Table 8.2-12) | 200 | 0.00002 (0.00005) | 0.00001 (0.00003) | 0.00003 (0.00009) | 0 | 0.000001 | 0.00021 | 0.000566 | 0 |
| Upper Sideslope - No Geomembrane in the Liner (Table 8.2-13) | 200 | 0.00002 (0.00005) | 0.00001 (0.00002) | 0.00001 (0.00005) | 0 | 0.000001 | 0.00044 | 0.000969 | 0 |
| Base - No Geomembrane in the Liner (Table 8.2-14) | 200 | 0.00002 (0.00005) | NA | 0 (0.00001) | 0 | 0.000001 | NA | 0.00048 | 0 |

[1]These values are given in inches/year as well as a percentage of precipitation, the latter within parentheses.

Notes:
- HELP Model ID - Soil properties are provided in respective table listed under the HELP Model ID.
- NA - Not applicable.
- Zero (0) represents values less than 0.0000005.

Prepared by: NXP
Checked by: MRS

## Table 8.3-2

## Percolation from TMA Based on Doubled Precipitation Values During Operation of Initial Stages

| Year | Sideslope (in/yr) | Base (in/yr) |
|---|---|---|
| 1 | 0.000001 | 0.024968 |
| 2 | <0.0000005 | 0.003517 |
| 3 | <0.0000005 | 0.004562 |
| 4 | <0.0000005 | 0.008642 |
| 5 | <0.0000005 | 0.003126 |
| 6 | <0.0000005 | 0.004671 |
| 7 | <0.0000005 | 0.005429 |
| 8 | <0.0000005 | 0.001883 |
| 9 | <0.0000005 | 0.001380 |
| 10 | <0.0000005 | 0.006263 |
| Average | <0.0000005 | 0.006440 |

Note: HELP model output rounds off to six digits.

Prepared by: MRS
Checked by: NXP

## Table 8.3-3

## Percolation from TMA Based on Doubled Percolation Values During Operation of Second Stages

| Year | Lower Sideslope (in/yr) | Upper Sideslope (in/yr) | Base (in/yr) |
|---|---|---|---|
| 1 | 0.000001 | 0.000002 | 0.034353 |
| 2 | 0.000001 | 0.000001 | 0.016261 |
| 3 | <0.0000005 | 0.000001 | 0.005851 |
| 4 | <0.0000005 | 0.000001 | 0.004205 |
| 5 | <0.0000005 | 0.000001 | 0.007981 |
| 6 | <0.0000005 | 0.000001 | 0.003110 |
| 7 | <0.0000005 | 0.000001 | 0.004669 |
| 8 | <0.0000005 | <0.0000005 | 0.004549 |
| 9 | <0.0000005 | 0.000001 | 0.001967 |
| 10 | <0.0000005 | 0.000001 | 0.001725 |
| Average | <0.0000005 | 0.000001 | 0.008470 |

Note: HELP model output rounds off to six digits.

Prepared by: MRS
Checked by: NXP

### 8.3.2 Total Percolation from the TMA

The results of HELP model studies show that the rate of percolation varies with time due to varying operation conditions (i.e., open, closed, geomembrane assumptions, etc.). Also, the rate of percolation varies due to changes in geometry (i.e., sideslope profile, base profile, tailing thickness, etc.). Therefore, in order to estimate the percolation rate through the liner with time, these conditions need to be considered.

Table 8.3-4 shows the estimated rates of percolation for the initial and second stages of a TMA cell. The second stage includes the consolidation period. The values in the table represent the average values from Tables 8.3-2 and 8.3-3.

For the remaining periods, the estimated percolation rates following placement of the cell final cover are shown in Table 8.3-5.

### 8.3.3 Leachate Generated

Tables 8.3-6 and 8.3-7 show leachate quantities for initial and second stage filling of a TMA cell, respectively. The results are shown for the case where ponding is simulated (i.e., two times precipitation). After closure of the unit, the estimated leachate quantities can be obtained from Table 8.3-1.

## Table 8.3-4

## Percolation During Cell Filling

| | Rates of Percolation (in/yr) | |
|---|---|---|
| | Initial Stages | Second Stages and Consolidation Period |
| Lower Sideslope | <0.0000005 | <0.0000005 |
| Upper Sideslope | NA | 0.000001 |
| Base Area | 0.006440 | 0.008470 |

NA - Not Applicable
Note: Since HELP model output gives only six digits, values less than 0.0000005 are shown as 0.

Prepared by: NXP
Checked by: MRS

# Table 8.3-5

## Post-Closure Percolation

| Year from Placement of Cover | Lower Sideslope (in/yr) | Upper Sideslope (in/yr) | Base (in/yr) |
|---|---|---|---|
| 1 | 0.000001 | 0.000002 | 0.038786 |
| 2 | 0.000001 | <0.0000005 | 0.014870 |
| 3 | <0.0000005 | <0.0000005 | 0.001169 |
| 4 | <0.0000005 | <0.0000005 | 0.001021 |
| 5 | <0.0000005 | <0.0000005 | 0.000916 |
| 6 | <0.0000005 | <0.0000005 | 0.000835 |
| 7 | <0.0000005 | <0.0000005 | 0.000763 |
| 8-15 | <0.0000005 | <0.0000005 | 0.000552 |
| 16-25 | <0.0000005 | <0.0000005 | 0.000308 |
| 26-35 | <0.0000005 | <0.0000005 | 0.000195 |
| 36-40 | <0.0000005 | <0.0000005 | 0.000151 |
| 41-50 | <0.0000005 | 0 | 0.000123 |
| 51-60 | <0.0000005 | 0 | 0.000097 |
| 61-70 | <0.0000005 | 0 | 0.000081 |
| 71-80 | <0.0000005 | 0 | 0.000069 |
| 81-90 | <0.0000005 | 0 | 0.000059 |
| 91-115 | 0 | 0 | 0.000004 |
| 116-140 | 0 | 0 | 0.000004 |
| 141-165 | 0 | 0 | 0 |
| 166-175 | 0 | 0 | 0 |
| 176-185 | 0 | 0 | 0 |
| 186-195 | 0 | 0 | 0 |
| 196-205 | 0 | 0 | 0 |

**Table 8.3-5** *(Continued)*

| Year from Placement of Cover | Lower Sideslope (in/yr) | Upper Sideslope (in/yr) | Base (in/yr) |
|---|---|---|---|
| 206-215 | 0 | 0 | 0 |
| 216-220 | 0 | 0 | 0 |
| 221-230 | 0 | 0 | 0 |
| 231-240 | 0 | 0 | 0 |
| 241 plus[1] | 0.00002 | 0.00002 | 0.00002 |

Note: HELP model output rounds off to six digits.

[1] Percolation is conservatively assumed at this time period to be equal to infiltration through cover, even though the HELP model indicates it will take longer to achieve this equilibrium.

Prepared by: MRS
Checked by: NXP
Revised by: NXP
Checked by: JWS

# Table 8.3-6

## Lateral Drainage/Leachate Collected[1]
## Initial Stages

| Year | Lower Sideslope (in/yr) | Upper Sideslope (in/yr) | Base (in/yr) |
|---|---|---|---|
| 1 | 43.0405 | NA | 71.9075 |
| 2 | 23.9066 | NA | 18.0333 |
| 3 | 27.8540 | NA | 21.3250 |
| 4 | 19.9097 | NA | 34.7522 |
| 5 | 18.2194 | NA | 16.0117 |
| 6 | 26.6501 | NA | 21.0785 |
| 7 | 15.7886 | NA | 23.8886 |
| 8 | 11.1964 | NA | 10.9709 |
| 9 | 22.8162 | NA | 31.8800 |
| 10 | 18.2424 | NA | 27.3965 |

NA - Not Applicable.

[1] Table based on results from HELP model runs with twice the normal mean monthly precipitation values.

Prepared by: NXP
Checked by: MRS

## Table 8.3-7

## Lateral Drainage/Leachate Collected[1]
## Second Stages

| Year | Lower Sideslope (in/yr) | Upper Sideslope (in/yr) | Base (in/yr) |
|---|---|---|---|
| 1 | 91.6334 | 49.3791 | 92.3306 |
| 2 | 38.2208 | 22.5715 | 56.5571 |
| 3 | 19.9497 | 25.8238 | 27.4459 |
| 4 | 27.7578 | 24.1563 | 20.6678 |
| 5 | 24.4566 | 15.9578 | 33.8886 |
| 6 | 16.0657 | 25.1980 | 16.6885 |
| 7 | 24.1878 | 20.3310 | 22.5145 |
| 8 | 22.0697 | 11.2900 | 21.6275 |
| 9 | 10.2703 | 19.8413 | 11.6032 |
| 10 | 15.8768 | 18.4708 | 10.7135 |

[1] Tabled based on results from HELP model runs with twice the normal mean monthly precipitation values.

Prepared by: NXP
Checked by: MRS

## 8.4 Input Parameters

Per Section 6.7.2 of the Feasibility Report (Foth & Van Dyke 1995) HELP model inputs can be grouped into the following three categories:

- Weather data;
- Soil data; and
- Design data.

Sections 6.7.2.1 through 6.7.2.5 of the Feasibility Report (Foth & Van Dyke, 1995) describe how weather data inputs were arrived at. Such information should be considered to be of the highest caliber since it represents actual recorded data.

Section 6.7.3 and subsections 6.7.3.1 through 6.7.3.2.3 of the Feasibility Report (Foth & Van Dyke, 1995) and Section 8.2.1 of this addendum describe how the soil data inputs were obtained. The properties of the tailings, which may impact the rate at which leachate is collected and may also impact the estimated site percolation rates, have been obtained from laboratory tests.

The sensitivity analyses completed by Peyton and Schroeder (1990) and Helmy Emam (1995) suggest that the quantity of percolation from a site will be impacted most by the hydraulic conductivities of the barrier layer (composite liner) and the drainage layer above it. For the Crandon Project, both of these items are "specified parameters". In other words, the values used in the HELP model runs are those which are specified in the design process and which will be verified in the field during construction. It should also be noted that NMC is proposing to perform post-installation leak testing of the geomembrane. This step, not a customary part of solid waste landfill construction, has been proposed as a result of NMC's recognition of the importance of achieving the effective hydraulic conductivity of the composite liner as part of the construction process. Post-installation leak testing will also help to verify the validity of the geomembrane manufacturing and installation defects quality control data used in the HELP model runs.

In view of the above discussion, NMC believes that the HELP model analyses completed for the TMA have been performed using scientifically supportable input data resulting in defensible output.

# 9 Surface Water Control System Update

## 9.1 Background

This section presents a discussion of the updated surface water management system at the TMA during operations and after closure of the site. The modifications to the TMA facilities footprint discussed in Section 4 resulted in the need to make several changes in the planned surface water management facilities and their discharge locations. Surface water erosion control practices during construction will be consistent with the procedures outlined in Section 4 of the MPA.

Figures 6.12-1 through 6.12-5 originally presented in the May 1995 Feasibility Report (Foth & Van Dyke, 1995), Figures 6.12-2a, 6.12-3a, and 6.12-4a presented in Addendum No. 3 (Foth & Van Dyke, 1997a), and Figures 9.1-1 through 9.1-7 and Drawing 22 for this addendum have been updated to show the sequence of TMA stage development, including excavation, construction, and closure of the three TMA cells and their respective staging/borrow areas. Additionally, these plans reflect the TMA location watersheds. These figures also show the locations of construction staging areas, including soil stockpiles, the planned surface water management system developed to minimize surface water erosion, and surface water discharge points.

## 9.2 Stockpile Management and Erosion Control

### 9.2.1 General

Stockpiling of soils for future use and/or processing will occur during each stage of TMA construction. Removal of soil from stockpiles and/or processing will occur during the closure of each TMA cell. Addendum No. 2 to the Feasibility Report (Foth & Van Dyke, 1996b) established the general principles NMC will follow in the stockpiling of soils. These principles are repeated in Section 9.2.2 below, along with additional details concerning stockpile management. Till processing activities for the first 16 years of TMA construction and operation will be confined to the construction staging areas shown on Figures 9.1-1 through 9.1-5. For the remaining 14 years of TMA operation and the 3 years of final reclamation, till processing activities will be located in the construction staging, stockpile, and borrow area to the north of TMA 3, as shown on Figures 9.1-5 through 9.1-7, and Drawing 22. As a result, surface water management and erosion control features will be designed and constructed as permanent features. The final design of these features will be completed as part of the development of the project's Plan of Operation.

### 9.2.2 Principles of Surface Water Management and Erosion Control

The general principles for soil stockpiling as outlined in Addendum No. 2 (Foth & Van Dyke, 1996b) are:

- 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 of soil for processing will be located in the construction staging area within the TMA, or adjacent to it, after the first 16 years of TMA construction and operation until site construction requires them to be relocated to the borrow area.

- 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.

The construction of surface water management features and installation of erosion control devices as the first step in construction or stockpiling activities will result in the minimization of soil erosion and the control of sedimentation in the disturbed area. Following is a list of the principles of erosion and sediment control from the *Wisconsin Construction Site Best Management Practices Handbook* (WDNR, 1989), and a description of what steps NMC will take to comply with these principles.

Diversion of Surface Water Flow from Disturbed Areas

The construction staging area and the soil and aggregate stockpile sites will be surrounded by a diversion berm and ditch system, which will typically be installed as shown on Figures 9.2-1, 9.2-2, and 9.2-3. Installation of the diversion berm and ditch will prevent stormwater run-on from entering disturbed areas and stormwater from leaving disturbed areas prior to being routed through a runoff basin. The diversion berm and ditch will be fertilized, seeded, and mulched following construction. Where stormwater flow velocity is high, erosion control devices such as riprap or erosion matting will be provided in the ditch or on the berm.

Managing Overland Run-on

The diversion berms/ditches mentioned above will prevent overland flow from undisturbed areas from entering areas disturbed by soil stockpiling processing or borrow activities. Overland flow will also be managed by locating the site, if possible, in higher areas of topography so that overland flow is easier to manage.

Trapping Sediment in Channelized Flow

Figures 9.2-1 and 9.2-2 are a plan view and cross section of a typical stockpile area showing soil processing activities in progress. This typical stockpiling plan shows the following features designed to trap sediment originating from disturbed areas:

- rock berm (Figure 9.2-2), silt fence (Figure 9.2-4) or similar erosion control devices installed around all stockpiled soils or aggregates;

- internal drainage ditch to direct contact water to temporary runoff basins which will discharge surface water to the site's permanent surface water management system;

- exterior berm and ditch which directs contact water to temporary runoff basins; and

- temporary runoff basins to which all contact water drains and which are designed to remove silt size particles for the 25-year, 24-hour rainfall event.

Establishing Permanent Drainageways

The drainageways around the construction staging area will be constructed as permanent drainageways since these drainageways will exist over approximately 16 years of the TMA cells' life for the construction staging area. The drainageways around stockpile areas will be designed and constructed in the same manner.

Trapping Sediment During Temporary Site Dewatering

Temporary dewatering activities required for the construction of TMA facilities will likely be limited to dewatering of areas of perched water associated with wetlands located within the TMA cell footprint. All water from wetland dewatering activities will be directed to a ditch which drains to a temporary runoff basin.

Preventing Tracking of Soil

Tracking of soil in and out of the stockpile and soil processing areas is minimized by providing a minimum 100-foot length of 2- to 3-inch clear stone at the entrance and exit (Figure 9.2-1). The clear stone will help reduce the quantity of soil tracked into and from the disturbed area.

Stabilizing Stockpile or Cut Areas

Stockpiles, cut areas, or other disturbed areas on which future activities will occur will be seeded with a temporary seed mixture immediately after borrow or stockpiling activities are completed for that year. Prior to seeding, the stockpile or cut slope surface will be "track walked" (i.e., driving a bulldozer up and down the slope to leave a pattern of imprints parallel to slope contours) to create a rough surface. Seed mixtures which conform to the State of Wisconsin Department of Transportation Standard Specification (WisDOT Specification) for road and bridge construction Section 630.3.3.42 (Borrow Pits and Waste Areas) will be applied as follows.

- 60 percent temporary species seeds consisting of oats and perennial rye grass.

- 40 percent permanent species seeds consisting of WisDOT Specification Seed Mixture No. 10.

- The borrow pit mixture listed above will be seeded at a rate of 1.5 pounds per 1,000 square feet (or approximately 65.3 pounds per acre).

Protecting Against Runoff Velocities

The design goal of both temporary and permanent erosion control facilities is keeping velocities of flowing water low and protecting soils where velocities are high. The measures proposed to accomplish this are as follows:

- provide riprap at inlets and outlets of temporary runoff basins and culverts, and in areas of the ditch where water velocities and/or volumes are high;
- provide energy dissipation (e.g., rock check dams) where velocities are high; and
- provide erosion control matting or other material to increase erosion resistance in ditches, when required.

Implementing a Sedimentation and Erosion Control Inspection and Maintenance Program

NMC has committed to a TMA operation inspection plan which includes routine inspection of the operating systems of the TMA and its appurtenant structures. The sedimentation and erosion control devices constructed for the TMA, construction staging area, and soil stockpiles are included in this program. Appendix P of the Feasibility Report (Foth & Van Dyke, 1995) contains a typical assignment operation log for these inspections. This log includes inspection of surface water management and erosion control structures after each significant storm event. The Plan of Operation will include a more detailed inspection log for the facilities proposed for the initial phases.

## 9.3 Reevaluation of Surface Water Management Structures

Several runoff basins were relocated after the TMA was modified to increase the setback from wetland F15. The relocated basins are shown on Drawing 22. Likewise, other components of the surface water management system were also modified including drainage diversion berms, downslope swales, perimeter drainage ditches, culverts, and runoff basins. The surface water management components are illustrated on Drawing 31, Details 1/31 through 4/31.

To control surface water runoff over the final cover of the reclaimed site, surface water diversion berms will be provided as needed to direct flows to provide the best possible match to the pre-mining existing condition hydrology of the various wetlands. A perimeter drainage ditch will convey the surface water runoff to runoff basins provided at various points around the facility. The revised runoff basins will be constructed prior to TMA construction and maintained until after reclamation. Design calculations for all components of the surface water management system are provided in Appendix H of this report. The erosion control plan presented in Section 4

of the MPA (Foth & Van Dyke, 1995/1998a) describes the erosion control features of the plan during various operational phases.

All drainageways and swales are designed to safely accommodate the runoff from the 100-year, 24-hour precipitation event without scouring or eroding the bottom and sides of the receiving channels. Mannings's equation and Natural Resources Conservation Service (NRCS) grassed swale design procedures were used to develop ditch dimensions adequate for the design discharge. Factors included in this analysis include channel configuration, type of soil, channel vegetation, peak flow, longitudinal slope, and channel runoff velocity. Velocities are checked for erosion and for sediment deposition. Various erosion control measures are specified for the swales, berms, and channels to help stabilize the bare ground surface until vegetation is established. Culverts are designed to pass the peak runoff with no road overtop or erosion at the inlet or outlet points.

To minimize the risk of sediment transport from the site, treatment facilities (runoff basins) will receive all runoff from the site. These facilities are designed with adequate capacity to settle out at least silt-sized (10 micron) particles during storm events up to a 100-year, 24-hour frequency for the TMA. Typical sections of runoff basins located around the site are shown on Drawing 31. The runoff basins discharge into uplands that border the TMA site, ultimately flowing to various wetland areas. In addition to sediment control, the runoff basins provide runoff detention which will reduce peak discharges from the site, thereby minimizing any impact to the surrounding areas. The storage and outlet capabilities of the runoff basins are such that peak runoff from the 100-year, 24-hour precipitation event is stored without reaching the emergency spillway elevation of each runoff basin, thus meeting the requirements of NR 182.11. Appendix H contains the TR-55 hydrology and POND2 (Haestad Methods routing program) documentation showing the adequacy of the design. Table 9.3-1 provides a comparison of actual storage area with required storage area for the runoff basins at the site, along with other more specific routing information.

Based on this comparison, the actual storage areas for the runoff basins exceed the required storage areas, and adequate sedimentation will be provided. Also, these storage volumes are conservative in that additional storage volume is available for sediment storage, which is considered dead storage for these routing calculations.

The runoff basins are equipped with a bypass outlet (emergency spillway). As documented in Appendix G, storage is available to handle the peak flow of runoff from the 100-year, 24-hour precipitation event without damage to the runoff basin or surrounding structures. Riprap or equivalent erosion protection is provided on the discharge side of the spillway to minimize damage to the receiving areas.

All discharge structures are designed to dissipate the flow discharge with a perforated header pipe distribution system. This will spread the outflow over a wide area to better match existing conditions.

# Table 9.3-1

## Runoff Basin Design Details for 100-Year, 24-Hour Event

| Basin No. | Peak Inflow (cfs) | Peak Discharge[1] (cfs) | Maximum Water Elevation (ft) | Storage Volume (ac-ft) | Required[2] Surface Area (sf) | Actual Water[3] Surface Area (sf) | Actual Sediment Particle Removal Size[4] (microns) |
|---|---|---|---|---|---|---|---|
| Runoff Basin 9 | 55 | 9.5 | 1635.3 | 5.83 | 19,285 | 82,938 | 7 |
| Runoff Basin 10 | 39 | 8.1 | 1694.6 | 2.73 | 16,443 | 75,794 | 6 |
| Runoff Basin 11 | 13 | 3.5 | 1703.1 | 0.71 | 7,105 | 16,117 | 9 |
| Runoff Basin 12 | 19 | 1.5 | 1624.5 | 2.27 | 3,045 | 34,412 | 4 |
| Runoff Basin 13 | 10 | 2.2 | 1694.6 | 0.54 | 4,466 | 14,810 | 8 |
| Runoff Basin 14 | 20 | 7.3 | 1713.7 | 0.76 | 14,819 | 41,382 | 8 |

[1] Discharge values rounded to 1/10th of a cfs.
[2] Based on silt-sized (10 micron) particle settling (2,030 sq ft per cfs out).
[3] Water surface area at maximum water level in the pond for the 100-year, 24-hour precipitation event.
[4] Particle size removed during 100-year, 24-hour precipitation event is equal to or greater than the size indicated for each basin.

Notes:

cfs - cubic feet per second
ac-ft - acre feet
sf - square feet
ft - feet

Prepared by: SRB
Checked by: PAE

## 9.4 Runoff Basins 12 and 13

To better match the pre-mining overland flow to wetland F15 and Hemlock Creek, a drainage divide was established in the borrow to direct runoff into runoff basins 12 and 13. The addition of these runoff basins will result in those portions of the construction stockpile, borrow and staging areas, which are within the Hemlock Creek watershed, to drain into the Hemlock Creek watershed; and those portions of the construction stockpile/borrow area which are within the wetland F15/Skunk Lake watershed to drain into F15/Skunk Lake watershed. Design calculations for runoff basins 12 and 13 are included in Appendix G. Runoff basin 12 is proposed to be located at the northeast toe of slope of the construction stockpile, borrow, and staging areas and to settle out 10 micron sized particles before runoff discharges to the Hemlock Creek watershed.

Runoff basin 13 will be located in the northwest corner of the borrow/stockpile area and discharge its entire water to the wetland F15/Skunk Lake watershed. In contrast to the other runoff basins, runoff basin 13 will include a wide weir outlet to allow the dispersion of runoff over a broader area to minimize erosion.

The drainage area associated with runoff basin 12 consists of 26.2 acres of reclaimed upland. This basin will be long and narrow, and have a 30-foot wide emergency spillway as the outlet. The spillway will be overtopped by 0.1 foot under the 100-year storm event so discharge routes downslope will have insignificant velocity and will not impact the downstream area. Details pertaining to the runoff basin design are shown on Drawing 31. An updated summary of TMA runoff basin hydraulics is provided in Table 9.3-1, including the updated runoff basin 12.

The drainage area associated with runoff basin 13 consists of 11.6 acres of reclaimed upland. This basin will be long and narrow and have a 30-foot wide emergency spillway acting as the outlet. The spillway will be overtopped by 0.1 foot under a 100-year storm event so discharge rates down slope will have insignificant velocities and will not impact the downstream area. Details pertaining to runoff basin design are shown on Drawing 31. An updated summary of TMA runoff basin hydraulics is provided in Table 9.3-1.

## 9.5 Sediment Removal Efficiency

### 9.5.1 Soil Loss Analysis

The Revised Universal Soil Loss Equation (RUSLE) (Appendix L, Foth & Van Dyke, 1995) and sediment removal efficiency calculations of the TMA runoff basins (Appendix G) were used to determine estimated sediment loadings to be discharged from runoff basins in the vicinity of the TMA. The sediment loading evaluation discussed below was performed by establishing the minimum particle size each of the TMA runoff basins can remove for the design storm and then using the RUSLE and the soil types on site to estimate sediment loading for existing conditions and proposed conditions. The evaluation shows that the actual as designed particle size removal for the proposed runoff basins is smaller than the 10 micron size standard normally used for the 100-year 24-hour design storm. As presented in Table 9.3-1, the removal size ranges from

4 microns to 9 microns for the basins in the vicinity of the TMA. This particle size removal performance information was used in conjunction with the RUSLE results to estimate the total sediment discharges that will result from the TMA runoff basin flow.

The sediment loading calculations that have been performed are contained in Appendix H. Two sediment loading conditions were analyzed: 1) the mulched condition which represents the year in which a reclaimed area is seeded and mulched; and 2) the grassed condition which represents the following year after vegetation is established.

Two material gradations were considered for use in the analysis. The first was a sandy material which coincides with the majority of the soil materials at the TMA site. The second soil type was represented by finer material containing some clay sized particles. For the purposes of the calculations, the more conservative finer material gradation was used to estimate sediment loading. The sediment density is assumed to be 2,530 lbs per cubic yard.

Calculations were performed for each respective runoff basin drainage area to estimate the sediment loading for both the mulched soil condition and a grassed condition. Table 9.5-1 presents the results of the calculations for each TMA runoff basin for the two scenarios. Based on the results for basins 9 through 14, the sediment load for the mulched condition ranges from approximately 1.9 cubic yards per year for basin 12 to 18.8 cubic yards per year for basin 9. For the grassed condition, the range is 1.1 to 11.3 cubic yards per year for basins 12 and 9, respectively. Table 9.5-1 also presents the removal efficiency of each respective basin based on the estimated sediment loading to the basin. The removal efficiencies for either the mulched or grassed conditions ranges from 91 percent to 97 percent. The percent of sediment removed by the basins is based on a 100-year, 24 hour design storm. This percent is then used for estimating the sediment leaving the basin. Storms smaller than the 100-year, 24 hour design storm will result in a higher percentage of sediment remaining in the basins. The sediment loading numbers are therefore maximum values and average year sediment loadings will be significantly less. Also, as presented below in Section 9.6, since the outfall pipe for the runoff basins header will discharge into a distribution system, actual sediment discharge into downstream surface water bodies and wetlands will be minimized. With this, and the fact that the TMA basin sediment discharge is calculated based on the 100-year, 24-hour storm event (a very rare and severe condition), the results are conservative when compared to annual totals based on average annual storm events.

Based on the Erosion and Sediment Control Handbook (Goldman, 1986), a retention structure is typically designed with a removal efficiency of 50 percent to 75 percent. The basin efficiency is a function of the particle distribution of the inflowing sediment. When evaluating the runoff basins for the TMA, it is notable that the efficiency for runoff basins 9 through 14 ranges from 91 percent to 97 percent, which exceeds typical detention structure performance.

## Table 9.5-1

## Discharge Sediment Loading and Runoff Basin Efficiencies

| | Mulched | | Grassed | |
|---|---|---|---|---|
| Basin Number | Sediment Discharge[1] (cu yd/yr) | Basin Efficiency[2] (%) | Sediment to Discharge[1] (cu yd/yr) | Basin Efficiency[2] (%) |
| 9 | 18.8 | 93 | 11.3 | 93 |
| 10 | 8.9 | 94 | 5.4 | 94 |
| 11 | 3.2 | 91 | 1.9 | 91 |
| 12 | 1.9 | 97 | 1.1 | 97 |
| 13 | 2.2 | 92 | 1.4 | 92 |
| 14 | 5.6 | 92 | 3.4 | 92 |

1 The sediment discharge is calculated using the basin efficiency, which is based on a 100-year, 24-hour design storm settling rate.

2 Efficiencies based on an assumed grain size distribution curve for finer material and the designed minimum micron size removal for each basin. See Appendix H for supporting basin efficiency and sediment discharge calculations.

Prepared by: JJF1
Checked by: PAE

### 9.5.2 Wetland F15 (Bur Oak Swamp) Analysis

To assess the effectiveness of the surface water management system design in removing sediment prior to discharge of water from the runoff basins, an evaluation of the existing conditions was performed as an example for the wetland F15 (Bur Oak Swamp) watershed using the RUSLE. The results of this analysis show (see Table 2 of Appendix H) that the existing wetland F15 drainage basin, estimated at approximately 118.7 acres, yields a calculated sediment load of approximately 3.1 tons per year or 2.5 cubic yards per year.

To compare the post development conditions to existing conditions, the erosion rate for basin 13 should be combined with the erosion rate for the undisturbed portion of wetland F15 upland. As shown on Table 9.5-1, the sediment loading for the disturbed portion of the F15 wetland watershed would be 1.4 cubic yards per year. The sediment load from basin 13 should be combined with the sediment load from the portion of upland area (92.8 acres) which will not be disturbed by TMA development. Therefore, the post-development sediment loading to wetland F15 will be approximately 4.2 tons per year, or 3.3 cubic yards per year. In comparison to pre-development conditions, this represents a 36 percent increase above current conditions. As

presented below in Sections 9.6 and 9.7, this analysis assumes flow comparable to the 100-year, 24-hour storm event, and does not consider the additional sediment removal resulting from the geocomposite wrap on the runoff basin standpipes described in Section 9.6 or the runoff basins outfall distribution systems described in Section 9.7. Use of 100-year, 24-hour storms for the analysis results in very high sediment discharge estimates rather than the probable sediment loads generated by typical annual rainfall amounts. Even with these very conservative estimates, increase in sediment loading is projected to be only 36 percent, and, therefore, the disturbed areas in the watershed should only have minimal impact.

Since basin 14 discharges into wetland F33, which in turn discharges into wetland F15, the sediment discharged from basin 14 will be removed as it flows through wetland F33, and therefore has not been incorporated into the analysis for wetland F15.

### 9.5.3 Sediment Storage and Removal Practices

The TMA runoff basins have been designed as extended detention facilities. Extended detention, or wet/dry basins are normally dry, since they have outlets that allow a slow release of impounded water. The TMA runoff basins have been designed with sediment storage capacity (dead storage). Dead storage capacity is not considered in the performance modeling of the runoff basins, i.e., if the dead storage area, (bottom 3 feet of the basin), were filled with sediment, the basin would still function as designed, as related to particle removal efficiency.

When considering the volume of the basin for design purposes, the 3-foot dead storage area is ignored. Its sole purpose is to act as a sediment storage area, and to potentially offer additional detention time in the event that the design 100-year storm is exceeded. Table 9.5-2 presents the "as designed" dead storage capacity for each of the runoff basins. During TMA operations, inspections to determine accumulation of sediment in the TMA runoff basins will be performed, with sediment removal performed as necessary to maintain adequate dead storage capacity within the runoff basins.

## 9.6 Runoff Basin Standpipe Design

As shown on Drawing 31, a geocomposite wrapping (Enkadrain) is proposed to be installed around the perforated standpipe. This will provide an additional opportunity for filtration through the geotextile component of the geocomposite as stormwater empties out of the runoff basins. As the function of the standpipe perforations and geocomposite wrap is only to slowly drain the basin after the peak flows have passed, this drainage is not included in the hydrologic/hydraulic calculations for the basin outlets (i.e., flow of water into the top of the standpipe will provide "as designed" hydraulic performance). Therefore, any blinding of the geotextile is not a critical issue. If pond drainage below the standpipe crest becomes too sluggish (not probable from field experience), then dredging of sediments and replacement of the wrapping will be done. This is considered a standard maintenance task for runoff basins and will not diminish the effectiveness of the runoff basins performance.

## Table 9.5-2

## Soil Sediment Storage Volumes

| Basin Number | Depth of Dead Storage (feet) | Sediment Storage Capacity (cubic yards) |
|---|---|---|
| 9 | 3 | 7,389 |
| 10 | 3 | 7,163 |
| 11 | 3 | 968 |
| 12 | 3 | 1,823 |
| 13 | 3 | 839 |
| 14 | 3 | 4,017 |

Prepared by: SRB
Checked by: PAE

### 9.7 Distribution System

The runoff basin discharge will be accomplished using distribution piping. Drawing 31, Detail 4/31 shows a typical distribution piping arrangement which will be used to assist in enhancing sediment removal prior to discharge into wetlands adjacent to runoff basins. Vegetation filter strips will be constructed at the discharge pipe outlet. The vegetation filter strips are areas of land with natural or planted vegetation designed to receive sheet runoff from the runoff basins. Their primary function is to remove additional soil particles and nutrients from overland sheet flow before it moves past the system. The distribution piping system will be constructed with a flat sloped vegetation strip immediately downstream of the outfall. Water discharged into this area will pass through the vegetation strip prior to exiting the distribution system, resulting in additional sediment removal above and beyond the 91 percent to 97 percent removal provided by the runoff basins themselves. Through the use of the distributed flow outfall from the runoff basins, it is anticipated that there will be minimal sediment loading impacts directly to wetlands adjacent and downstream of runoff basins.

A critical component to the ongoing sediment removal effectiveness will be maintaining the runoff basins and the filter strips, allowing them to function in an effective manner. With proper maintenance and removal of accumulated sediment on a regular interval, the runoff basins will continue to perform with efficiencies greater than 90 percent and satisfy water quality standards. Based on the Minnesota Construction Site Erosion Control and Sediment Control Planning Handbook (USDA, 1988), where damage from sediment loading would occur to high value property, surface waters or environmentally sensitive areas, a trap efficiency of 80 percent or more may be required. As presented within this analysis, the 80 percent trap efficiency has been exceeded for the TMA runoff basins and supports that best management practices for surface water management have been used for the proposed design.

Through the use of the distribution header system from the runoff basins, as well as the additional removal accomplished in the undisturbed area downstream of the runoff basins, there will be minimal sediment loading impacts directly to wetlands and surface waters adjacent and downstream of the runoff basins. As presented within the sediment loading analysis, the TMA runoff basins and distribution header system design, along with ongoing system maintenance, will provide the means to maintain the best management practices for surface water management for the TMA.

## 9.8 Overview of Level of Design

A 90 percent design level has been achieved for the surface erosion control system. A surface water management plan for the TMA including phase drawings and surface water runoff evaluations has been completed for each stage of site development. The analysis of impacts to wetlands and waterways is addressed in Section 4 of the updated *Environmental Impact Report for the Crandon Project* (EIR) (Foth & Van Dyke, 1995/1998c).

While developing the revised footprint presented in this document, stage construction plans were prepared to evaluate surface water drainage patterns throughout the operational period of the TMA. These plans were, in turn, used to evaluate resulting hydrology through the operational period on a monthly basis using a water balance approach. Figures 9.1-1 through 9.1-7 and Drawing 22 present the construction sequence for the TMA Stages I through VII and the final reclamation conditions, respectively.

Detail 4 on Drawing 31 presents 90 percent design level information for the distribution piping system for TMA runoff basins. The figure shows a typical section through a runoff basin and references key design elevations for individual basins in an index. It presents the refinement of the distribution header which will be used to dissipate surface water from runoff basins. The distribution header system shown will enhance infiltration and shallow interflow conditions, as well as act as a biofilter upstream of wetlands and surface waters adjacent to the TMA. The distribution header system will be constructed within the limits of disturbance for the TMA.

Using the updated stage construction plan views shown in Figures 9.1-1 through 9.1-7 and Drawing 18, the drainage areas for each stage of construction were determined and used to evaluate surface water runoff impacts, on an annual basis, on the surface water watersheds and wetlands in the vicinity of the TMA. Information regarding this analysis is discussed in the upland EIR Section 4 (Foth & Van Dyke, 1995/1998c). Table 4.2.7-5 of that update presents the TMA wetland surface water runoff volume comparison for existing conditions to TMA operating conditions. The information contained in the table is a summary of a detailed analysis presented in Appendix 4.2-5 of the updated EIR, and shows that surface water runoff for each of the wetlands in the vicinity of the TMA will be maintained throughout the TMA operational period at a level comparable to existing conditions.

In summary, runoff basin modifications presented here provide the means to protect surface water and wetlands in the vicinity of the TMA.

# 10 Other System Updates

## 10.1 Reclaim Pond

Details of the reclaim pond and reclaim water pumping system are shown on Figures 10.1-1 and 10.1-2, including a plan view of the pond area, a cross-section of the pond liner system, a discharge pipe detail, an influent pipe detail and a pumping schematic. The reclaim pond volume remains unchanged at 15 million gallons; however, its shape has been modified to accommodate the new TMA footprint.

Table 10.1-1 presents a summary of daily and annual leachate volumes estimated to be removed from the TMA leachate collection system during the post-closure period, which is defined as commencing at the closure of TMA 3 (i.e., year 35 of site operation). The volumes were derived from the post-closure HELP model runs completed for the project by multiplying the leachate collection rate (inches/year) for each TMA cell by the area of each slope type within each TMA cell (see Section 8).

Since the time of closure for each TMA cell varies over the total site operating life (e.g., 35 years), the volume of post-closure leachate collection for each TMA cell during post-closure was estimated based on the length of time a cell was closed prior to the commencement of the post-closure period for the entire TMA. This method of analysis takes into consideration the period of time for which cells closed during the operating period (35 years) will drain.

It is estimated that the reclaim pond will be closed and reclaimed after year 16 of post-closure, at which time leachate generation is projected to be approximately 16,000 gallons per day (gpd). To manage leachate, at that time NMC proposes to install leachate storage tanks that will provide 60,000 gallons storage, or approximately 4 days storage capacity at year 16 leachate generation rates. Records of post-closure leachate generation will be available to more precisely size the tanks at that time. A 4-day storage capacity was selected to provide weekend coverage with a 2-day contingency. As depicted in Table 10.1-1, the leachate generation rates will drop off steadily in subsequent post-closure years (e.g., at year 20 of post-closure a generation rate of approximately 12,600 gpd is projected), resulting in the storage tank capacity providing more than a 4-day storage capacity at that time.

The tank is proposed to be located adjacent to the TMA access road. The leachate will be transported either by truck or sewer line to a treatment facility, as discussed in Section 6.8. Details of the leachate tank, piping, and potential loadout structure are not provided at this time since the tank is not expected to be constructed until 16 years into the post-closure period.

## Table 10.1-1

## TMA Post-Closure Leachate Volumes

| Year After Total TMA Closure | Estimate Total Gallons Per Year | Estimated Total Gallons Per Day |
|---|---|---|
| 1 | 115,938,000 | 317,600 |
| 2 | 45,533,000 | 124,700 |
| 3 | 16,067,000 | 44,000 |
| 4 | 14,494,000 | 39,700 |
| 5 | 13,207,000 | 36,200 |
| 6 | 12,131,000 | 33,200 |
| 7 | 11,065,000 | 30,300 |
| 8 | 10,046,000 | 27,500 |
| 9 | 9,323,000 | 25,500 |
| 10 | 8,731,000 | 23,900 |
| 11 | 8,177,000 | 22,400 |
| 12 | 7,680,000 | 21,000 |
| 13 | 7,106,000 | 19,500 |
| 14 | 6,537,000 | 17,900 |
| 15 | 6,166,000 | 16,900 |
| 16 | 5,856,000 | 16,000 |
| 17 | 5,547,000 | 15,200 |
| 18 | 5,284,000 | 14,500 |
| 19 | 4,960,000 | 13,600 |
| 20 | 4,592,000 | 12,600 |
| 21 | 4,385,000 | 12,000 |
| 22 | 4,210,000 | 11,500 |
| 23 | 4,043,000 | 11,100 |

**Table 10.1-1** *(Continued)*

| Year After Total TMA Closure | Estimate Total Gallons Per Year | Estimated Total Gallons Per Day |
|---|---|---|
| 24 | 3,896,000 | 10,700 |
| 25 | 3,745,000 | 10,300 |
| 26 | 3,616,000 | 9,900 |
| 27 | 3,486,000 | 9,600 |
| 28 | 3,375,000 | 9,200 |
| 29 | 3,261,000 | 8,900 |
| 30 | 3,155,000 | 8,600 |
| 31 | 3,054,000 | 8,400 |
| 32 | 2,969,000 | 8,100 |
| 33 | 2,873,000 | 7,900 |
| 34 | 2,792,000 | 7,600 |
| 35 | 2,714,000 | 7,400 |
| 36 | 2,640,000 | 7,200 |
| 37 | 2,564,000 | 7,000 |
| 38 | 2,500,000 | 6,800 |
| 39 | 2,434,000 | 6,700 |
| 40 | 2,377,000 | 6,500 |

Prepared by: MRS
Checked by: NXP/KWC

## 10.2 Tailings Delivery

Subaerial deposition of tailings using spigots around the perimeter of the active TMA cell continues to be the preferred method of delivering tailings to the TMA cells. The tailings delivery system will generally be as described in Section 6.2.4 (Tailings Distribution System) of the *Feasibility Report/Plan of Operation* (Foth & Van Dyke, 1995). Modifications to the description provided in the referenced document occur only for TMA 1. In TMA 1 the tailings delivery system will be relocated as follows:

- After TMA 1A Stage I filling is completed, the tailings delivery system will be relocated to TMA 1B Stage II (i.e., the adjacent horizontal stage). This will be accomplished by simply relocating the tailings delivery and decant return pipelines from the TMA 1A bench berm to the opposite side of the separation berm, onto the TMA 1B bench berm.

- After TMA 1B Stage II berm filling is completed, the tailings delivery and decant return piping will be relocated to the top of the Stage III berm which is above and surrounds TMA 1A Stage I and TMA 1B Stage II. Tailings delivery can then continue as in the second stage of any of the TMA cells.

## 10.3 NP Control Plan

NMC is committed to placing net neutral tailings in the TMA, and to accomplish this has proposed pyrite removal prior to the tailings being pumped to the TMA. A detailed plan for monitoring and adjusting, if necessary, the neutralization potential (NP) of the tailings has been prepared and is included in Section 4 of the TMA Monitoring Plan, which is included in Appendix F to the updated MPA (Foth & Van Dyke, 1995/1998a).

Limestone addition to the tailings, blended with the tailings at the pump box, is proposed as the method to control the NP of the tailings, if necessary. The limestone will be ground to match the tailings' grain size (approximately 89 percent, passing the U.S. Sieve No. 200) to eliminate segregation between the blended limestone and tailings slurry. Typical chemical characteristics of limestone readily available in the Crandon Project area are provided in Appendix I.

## 10.4 TMA Screening NR 132.17(1)(a) through (d)

NR 132.17(1)(a) through (d) contain criteria related to the visual and aesthetic qualities of the proposed TMA and appurtenant features. The aesthetics are described in Section 4.2.12 of the update to the EIR (Foth & Van Dyke, 1995/1998c). Impacts of the revised footprint for the TMA and appurtenant features are discussed in other various subsections of Section 4 of the update to the EIR. Since the total limit of disturbance for the TMA has decreased from approximately 345 acres to approximately 282 acres and the overall height of the finished TMA has been reduced by approximately 5.5 feet, the overall aesthetic impacts should be less than for the previous Setback Alternative No. 2 design.

# 11 Waste Quantity Estimate and Waste Rock Placement in TMA

## 11.1 General

This section provides an update of the anticipated types and quantities of materials to be placed in the TMA which are a result of the recent improvements made to the project. The major components to be placed in the TMA include depyritized tailings and waste rock. Much smaller amounts of wastewater treatment solids, lab wastes and other inert demolition materials will also be placed in the TMA.

The primary change to the project which affects the TMA is that NMC plans to implement separation of pyrite from the tailings. The pyritic whole tailings will be placed underground as a cemented paste backfill. The depyritized whole tailings will then be placed hydraulically in the TMA. Placement of depyritized whole tailings in the TMA results in an approximate 31 percent reduction in the volume of the tailings which will be placed in that facility.

NMC has also changed the plan for management of waste rock generated during the preproduction and mining periods. The volume of wastewater treatment plant solids has been reduced due to changes in the project's water balance. Estimates of the quantity of lab and demolition wastes have not changed.

## 11.2 Waste Quantity Estimate

This section provides an update of the estimate of materials projected to be placed in the TMA and an update of the estimated capacity of the TMA cells resulting from the changes described above. Table 4.1-1 of the Feasibility Report has been updated and included in this report as Table 11.2-1. Table 11.2-1 contains an updated estimate of the materials expected to be placed in the TMA cells. The design capacity of the revised TMA is 14.1 million cubic yards, which allows for a contingency of approximately 12 to 13 percent.

## 11.3 Tailings Quantity

Mining will occur for both the zinc and copper phases at a rate of 2,000,000 tons per year (all tons are dry units). Depyritized tailings produced from the zinc and copper ore pyrite flotation that will report to the TMA will contain less than 1 percent sulfur. Based on test work performed by SRK (1998d), the final dry density of the depyritized tailings in the TMA will be approximately 93 pcf.

Depyritized zinc tailings would be generated at a rate of approximately 388,000 tons/year during the first 16 years of the project. This results in a total of 6.20 million tons of depyritized zinc tailings for placement in TMA Cell 1. Using a density of 93 pcf results in a volume of approximately 4.94 million cy of depyritized zinc tailings.

## Table 11.2-1

## Updated TMA Estimated Waste Quantities

| Waste Type | Density (PCF) | Annual Generation | | Total Placed in TMA | |
|---|---|---|---|---|---|
| | | Tons | Cubic Yards | Tons | Cubic Yards |
| Zinc Tailings | 93[1] | 387,500 | 308,600 | 6,199,000 | 4,938,000 |
| Copper Tailings | 93[1] | 714,900 | 569,400 | 8,579,000 | 6,834,000 |
| Waste Rock (Blasted)[2,3] | 111.1 | Varies | Varies | 730,000 | 487,000 |
| Wastewater Treatment Plant Solids[4] | 77.2[5] | 5,200 | 5,000 | 146,000 | 140,000 |
| Laboratory Waste[6] | NA | — | — | — | — |
| Demolition Waste | NA[7] | — | — | 230,000 | 150,000 |
| Total[8] | | | | 15,884,000 | 12,549,000 |
| Reclaim Pond Solids[9] | 77.2[5] | — | — | 0.27 | 0.26 |

1 93 pcf (pounds per cubic foot) from SRK (1998d) assumes subaerial deposition.
2 Density from EMC (1985), quantity from the MPA (Foth & Van Dyke, 1995/1998a)
3 Assumes 730,000 tons of Type II waste rock is placed directly in the TMA from the MPA (Foth & Van Dyke, 1995/1998a)
4 Wastewater treatment plant solids are estimated at 5,000 cy/year for the 28-year site life (140,000 cy total)
5 Based on solids density for a similar treatment system.
6 Laboratory waste will be approximately 10 tons/year or approximately 280 tons for the total site life.
7 Density of demolition waste varies depending on the material.
8 Total does not include the contingency.
9 Reclaim pond solids are not included in the waste quantities total as this is fine tailings carryover that has already been accounted for in the tailings quantities.

NA = not applicable
— = not calculated since volume is very small or waste stream does not occur on an annual basis.

Prepared by: SAD2
Checked by: DMR

Depyritized copper tailings would be generated at a rate of approximately 715,000 tons/year for 12 years (year 17 through 28 of mining). This results in a total of approximately 8.58 million tons of depyritized copper tailings for placement in TMA Cells 2 and 3. Using a density of 93 pcf results in a volume of approximately 6.83 million cy of depyritized copper tailings.

## 11.4 Waste Rock Quantity

A detailed description of the waste rock management plan is provided in Section 4 of the updated MPA (Foth & Van Dyke, 1995/1998a). Waste rock which is hoisted to the surface during the preproduction period will be temporarily stored on the lined preproduction ore storage and waste rock pad located on the north end of the plant site. After the TMA is available for receiving tailings, waste rock will be transported directly to the TMA for beneficial construction uses inside of contained areas, or as general fill. The beneficial uses will be as riprap on top of the liner/leachate collection system, or as grading layer beneath the final cover. Prior to using waste rock for the grading layer, testing will be performed to verify that this material will not produce acidic leachate in the TMA. NMC will develop a WDNR approved waste rock testing program prior to construction of mining facilities.

The quantity of waste rock which is anticipated to be hoisted to the surface over the life of the mine is approximately 1,588,000 tons. Of this, it is expected that approximately 858,000 tons (572,000 cy) will be beneficially used in the TMA as riprap or grading layer. The balance of the waste rock, 730,000 tons (487,000 cy) will be placed in the TMA along with the tailings. Type II waste rock will be used as riprap, and Type I waste rock, after testing, may be used as grading layer for the TMA cells.

## 11.5 Other Wastes Quantity

Other wastes include wastewater treatment plant solids, laboratory wastes, inert demolition debris, and solids from the reclaim pond. The solids from the lime/sulfide wastewater treatment process are estimated at 5,000 cy/year or 140,000 cy over the life of the mine.

Laboratory wastes, inert demolition waste and reclaim pond solids are the same as the previous design. As before, the reclaim pond solids are not included in the waste quantity totals in Table 11.2-1 because they represent fine tailings carryover that has already been accounted for in the tailings quantities.

# 12 Site Development and Phasing

## 12.1 Description of Site Development

The revised TMA consists of three cells designated TMA 1, TMA 2, and TMA 3 with two subcells in TMA 1 extending only up to the first stage level designated as TMA 1A and TMA 1B. TMA 1 is designed to contain mine wastes resulting from the zinc ore production. Table 4.3-1 shows that TMA 1A and 1B have a combined capacity of 6.06 million cy. This volume includes tailings, waste rock, wastewater treatment solids, small amounts of demolition and laboratory wastes, and an approximate 12 percent contingency. TMA 2 and 3 are designed to contain mine wastes resulting from copper ore production which is estimated in Table 4.3-1 at 8.04 million cy. This volume includes the tailings and other mine wastes as listed above plus an approximate 13 percent contingency.

TMA 1 will be constructed and operated initially in two adjacent cells, TMA 1A (Stage I) and TMA 1B (Stage II) separated by an internal berm which extends only to the height of the first stage. TMA 1A will be constructed first, then filled, followed by construction and filling of TMA 1B. The final stage of TMA 1, Stage III, includes construction and operation over the entire TMA 1 footprint.

TMA cells 2 and 3 will each be constructed and operated in two vertical stages. TMA 2 consists of Stage IV and Stage V, while TMA 3 has Stage VI and Stage VII.

The following site development scenario portrays, to the extent possible, the development of the TMA. This site development scenario is based on an average annual tailings/waste filling rate during operation of each cell. Tailings/waste filling rates vary as shown on Table 4.3-1. Table 12.1-1 provides a summary of the expected construction schedule and duration of filling for the three TMA cells assuming these average annual filling rates. Table 12.1-1 also provides an indication as to whether a particular cell or stage is under construction (CUC), operating, full (F), final cover under construction (FCC), or closed (C), along with the cumulative mine waste volume based on the filling rate given. This operating scenario was developed with the following assumptions:

- Construction of each stage will occur over approximately two construction seasons (i.e., two years). During the first year the major earthwork is completed, and the liner and leachate collection system are constructed during the second year.

- Each cell will operate until it reaches capacity. The final year of each cell operation (except TMA 3) will have two cells open to allow for transition of filling from one cell to the next.

## Table 12.1-1

## TMA Staging Volumes[1] and Stage Life

| | TMA 1A[2] | TMA 1B[2] | TMA 1 | TMA 2 | | TMA3 | |
|---|---|---|---|---|---|---|---|
| Operating Year | Stage I (cy x $10^6$) | Stage II (cy x $10^6$) | Stage III (cy x $10^6$) | Stage IV (cy x $10^6$) | Stage V (cy x $10^6$) | Stage VI (cy x $10^6$) | Stage VII (cy x $10^6$) |
| Filling Rate | 0.480 | 0.325 | 0.378 | 0.587 | 0.726 | 0.587 | 0.726 |
| 2 | CUC | — | — | — | — | — | — |
| 3 | CUC | — | — | — | — | — | — |
| 4 | 0.480 | CUC | — | — | — | — | — |
| 5 | 0.960 | CUC | — | — | — | — | — |
| 6 | 1.000 | 0.440 | — | — | — | — | — |
| 7 | F | 0.765 | CUC | — | — | — | — |
| 8 | N | 1.09 | CUC | — | — | — | — |
| 9 | N | 1.220 | 0.195 | — | — | — | — |
| 10 | N | F | 0.573 | — | — | — | — |
| 11 | N | N | 0.951 | — | — | — | — |
| 12 | N | N | 1.329 | — | — | — | — |
| 13 | N | N | 1.707 | — | — | — | — |
| 14 | N | N | 2.085 | — | — | — | — |
| 15 | N | N | 2.463 | — | — | — | — |
| 16 | N | N | 2,841 | — | — | — | — |
| 17 | N | N | 3.219 | CUC | — | — | — |
| 18 | N | N | 3.597 | CUC | — | — | — |
| 19 | N | N | 3,840 | 0.135 | — | — | — |
| 20 | N | N | F | 0.722 | CUC | — | — |
| 21 | NC | NC | FCC | 1.309 | CUC | — | — |

**Table 12.1-1** *(Continued)*

| Operating Year | TMA 1A[2] Stage I (cy x $10^6$) | TMA 1B[2] Stage II (cy x $10^6$) | TMA 1 Stage III (cy x $10^6$) | TMA 2 Stage IV (cy x $10^6$) | TMA 2 Stage V (cy x $10^6$) | TMA3 Stage VI (cy x $10^6$) | TMA3 Stage VII (cy x $10^6$) |
|---|---|---|---|---|---|---|---|
| 22 | NC | NC | FCC | 1.390 | 0.506 | — | — |
| 23 | NC | NC | C | F | 1.232 | CUC | — |
| 24 | NC | NC | C | N | 1.958 | CUC | — |
| 25 | NC | NC | C | N | 2.630 | 0.054 | — |
| 26 | NC | NC | C | N | F | 0.641 | CUC |
| 27 | NC | NC | C | NC | FCC | 1.228 | CUC |
| 28 | NC | NC | C | NC | FCC | 1.400 | 0.415 |
| 29 | NC | NC | C | NC | C | F | 1.141 |
| 30 | NC | NC | C | NC | C | N | 1.867 |
| 31 | NC | NC | C | NC | C | N | 2.620 |
| 32 | NC | NC | C | NC | C | N | F |
| 33 | NC | NC | C | NC | C | NC | FCC |
| 34 | NC | NC | C | NC | C | NC | FCC |
| 35 | NC | NC | C | NC | C | NC | C |

[1] Staging volume refers to total tailings volume placed by at the end of the year.

[2] Stage filling rates were calculated by dividing the cell "calculated need" by the "approximate phase life" from Table 4.3-1.

Conditions are:

| | |
|---|---|
| C | Closed. |
| F | Full - cell has been filled to its maximum capacity but final cover is not in place. Assumes cell will remain open for one year or less prior to final covering. |
| FCC | Final Cover Construction - cell is graded to the required grades, the final cover is constructed, and the other reclamation activities for that cell are completed. |
| CUC | Cell Under Construction. |
| cy x $10^6$ | In-place cubic yards x $10^6$ (millions) for each stage based on the annual filling rate for each stage. Assumes no interruptions of ore production and/or milling. |
| — | Indicates cell or stage is not constructed at that time. |
| N | Next stage above being filled. |
| NC | Next stage above closed. |

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Checked by: REM

- Each cell will remain open for one year or less prior to placing the grading layer. During this time period the tailings are expected to settle. At the end of this time period mine waste rock, beach tailings, coarse tailings, or till can be placed and graded to shape the cell to the minimum 2 percent grades required prior to the placement of the final cover components.

- The placement and construction of the final cover is expected to be completed during one construction period in the construction season following placement of the grading layer.

### 12.1.1 Site Sequencing

Detailed phasing plans for TMA 1, TMA 2, and TMA 3 are shown on Figures 9.1-1 through 9.1-7. Construction material requirements for each stage of development of the TMA and the overall site sequencing plan are shown on Drawing No. 13.

Figures 9.1-1 through 9.1-7 and Drawing 18 show the phasing of the construction and closure of TMA 1 through TMA 3, along with phasing of the construction staging areas and surface water drainage. The construction staging areas generally accommodate topsoil, till soil and mulch stockpiles, soil stockpiles for the soils used for processing, the soil processing plant and related facilities, and an area for storing construction materials (including processed soils) and construction equipment. A general description of the construction or closure shown, along with a general description of construction staging areas and surface water management, is as follows:

- Figure 9.1-1, TMA 1A Stage I Construction shows the condition after completion of TMA 1A Stage I construction, including the following:

  - TMA 1A Stage I base grades are depicted.

  - The reclaim pond, access road, and runoff basin 9 are constructed.

  - Surface water drainage swales and diversion berms are established to route water to runoff basin 9.

  - The construction staging area east of TMA 1B is prepared.

  - TMA 1A Stage I is operational.

- Figure 9.1-2, TMA 1B Stage II Construction shows the conditions after completion of TMA 1B Stage II construction, including the following:

  - TMA 1B Stage II base grades are depicted.

- TMA 1 Stage III west berm is approximately 70 percent complete, constructed with excess soil from TMA 1B subbase preparation.

- Surface water drainage swales are constructed to route surface water to runoff basin 9.

- The construction staging area east of TMA 1B continues to be used.

- TMA 1A Stage I and TMA 1B Stage II are operational.

• Figure 9.1-3 TMA 1 Stage III Construction shows the conditions after completion of TMA 1 Stage III construction, including the following:

- TMA 1 Stage III base grades are depicted, which is the vertical stage over Stage I and II.

- The remaining ±30 percent of the TMA 1 Stage III berm is constructed with cut from TMA 2 Stage IV.

- Surface water drainage swales are constructed to route water to runoff basin 9.

- TMA 1 Stage III is operational.

• Figure 9.1-4, TMA 2 Stage IV Construction shows the condition after completion of TMA 2 Stage IV construction, including the following:

- TMA 2 Stage IV base grades are depicted and approximately 70 percent of the TMA 2 Stage V berms are completed.

- Runoff basins 10, 11, and 12 are constructed and surface water drainage ditches established to route surface water to these runoff basins. Runoff basin 9 continues to operate.

- The stockpiling area transitions from north of TMA 2 to north of TMA 3.

- TMA 2 Stage IV is operational.

• Figure 9.1-5, TMA 2 Stage V Construction, TMA 1 Final Grades shows the condition after completion of TMA 2 Stage V construction and final grades for TMA1, including the following:

- TMA 2 Stage V base grades are depicted showing all berm construction is completed.

- TMA 2 Stage V is operational.

- Runoff basin 14 is constructed.

- Runoff basins 9, 10, 11, and 12 continue to receive surface water runoff from the facilities.

- The construction staging area transitions from north of TMA 2 to north of TMA 3.

- TMA1 final grades are depicted.

- Figure 9.1-6, TMA 3 Stage VI Construction shows the conditions after completion of TMA 3 Stage VI construction, including the following:

  - TMA 3 Stage VI base grades are depicted.

  - TMA 2 Stage V base grades are depicted since this cell is operational.

  - TMA 3 Stage VII berms are 70 percent completed with excess cut soils.

  - TMA 1 final grades are depicted and the final cover system is completed at this time.

  - The construction staging area and soil stockpiles are north of TMA 3.

  - Runoff basins 9, 10, 11, 12, and 14 continue to serve the constructed and closed TMA cells and the stockpile area north of TMA 3.

  - TMA 3 Stage VI is operational.

- Figure 9.1-7, TMA 3 Stage VII Construction, TMA 2 Final Grades shows the conditions after completion of TMA 3 Stage VII construction and final grades for TMA 2, including the following:

  - TMA 3 Stage VII base grades are depicted showing all berm construction is completed.

  - TMA 1 and TMA 2 final grades are depicted.

  - Runoff basins 9, 10, 11, 12, and 14 continue to serve the constructed and closed TMA cells and the soil borrow and construction staging area north of TMA 3.

  - TMA 3 Stage VII is operational.

- Drawing 18 Final Grades shows the conditions after completion of the final cover construction for all three cells, including the following:

  - Final grades are depicted for TMA 1, 2 and 3.

  - The soil borrow area is regraded and reclamation activities completed.

  - Runoff basin 13 is constructed, as are drainage ditches to channel runoff from the soil borrow area.

  - Runoff basins 9, 10, 11, 12, and 14 remain in service.

## 12.2 TMA Earthwork Balance and Stockpile Sizing

The current design requires that only geosynthetic material (e.g., geomembrane, GCL, and geotextiles) are brought in from off-site. All other soil materials required for the earthwork construction of the TMA cells are excavated from the cells themselves, from the borrow area north of TMA 3, or from waste rock hoisted from underground operations. Materials excavated from the TMA cells will either be used as unprocessed tills (i.e., as they come out of the excavation with minor modifications, or as processed tills, i.e., screened, washed, and/or crushed to meet specific gradation requirements). The earthwork balance and the processing of the required soil materials are described in the sections which follow. These sections show that:

- the TMA earthwork balances, and all materials can be excavated on-site;

- borrow outside of the proposed TMA containment berms is kept to a minimum, thus limiting overall environmental impacts; and

- the progression of construction during the site life results in a need for an on-site borrow area outside the TMA containment berms only for the final cover construction for TMA 3. The quantity required from the borrow area, approximately 1.3 million cubic yards, may be reduced depending on the amount of available Type I waste rock for use in the TMA grading layer during the operating life of the mine. Up to 461,000 cubic yards (692,000 tons) of verified Type I waste rock may be used as grading layer material. Should this occur, the soil borrow volume of 1.3 million cubic yards would be reduced by a similar amount, reducing it to approximately 840,000 cubic yards (a 35 percent reduction).

### 12.2.1 Unprocessed Till Soil

Glacial till excavated from within the TMA footprint is the primary source of soil for the TMA embankments and other features. The proposed uses for unprocessed till remain as described in the *Feasibility Report* (Foth & Van Dyke, 1995) and Addenda No. 1 through 4 (Foth & Van Dyke, 1996a, 1996b, 1997a, and 1998a).

### 12.2.2 Mine Waste Rock

Waste rock will be generated during the three preproduction years and during mine operation. Prior to construction of TMA 1A, waste rock generated during preproduction will be temporarily stockpiled at the plant site. After the first year of mine operation, when the TMA is operational, waste rock will generally be transported directly to the TMA.

Stockpiled waste rock will then be transported to the TMA for beneficial use such as riprap or the grading layer inside of the TMA containment area. Prior to use as the grading layer, the waste rock will be tested to verify that it is Type I material.

Over the life of the mine, it is estimated that approximately 1,588,000 tons of waste rock will be hoisted to the surface. Of this tonnage, it is anticipated that approximately 858,000 tons will be beneficially used within TMA containment areas (166,000 tons as riprap and up to 692,000 tons as grading layer for TMA final cover). Type II waste rock will be used as riprap, and only verified Type I waste rock may be used in the final cover grading layer. Additionally, approximately 730,000 tons of Type II waste rock will be transported directly to the TMA as fill mixed with tailings.

### 12.2.3 Processed Glacial Till

The TMA facility is designed such that all earthwork is constructed with glacial till from excavation of the cells, from a borrow area or from waste rock from the mine. Figure 12.2-1 illustrates how the glacial till is processed to generate the required volumes of various soil types for TMA construction.

### 12.2.4 Earthwork Balance

#### 12.2.4.1 General

Section 4 of this Addendum No. 5 discusses the reconfiguration of the TMA footprint resulting from the decrease in the size of the TMA and decrease in the number of cells from four to three. This section discusses the updated earthwork balance for the revised footprint, and provides a general discussion of the stockpile sizing throughout the phased construction process. Figure 12.2-2 presents the overall earthwork balance for the TMA project.

#### 12.2.4.2 Phased TMA Construction

Following is a detailed description of the phased construction of the TMA. Drawing 13, Site Sequencing Plan, and Figure 12.2-2 can be referred to for details regarding cut/fill and other material quantities. Stockpile volumes are approximate and can vary depending on the amount of contingency used as the project progresses.

- TMA 1A Stage I will be constructed from soil excavated in the Stage I area. TMA 1A Stage I excavation has a cut which exceeds the fill needs; therefore, approximately 600,000 cy will be stockpiled in the construction staging area east of TMA 1B for TMA 1B Stage II and TMA 1 Stage III construction (refer to Figure 9.1-1). In addition, approximately 15,000 cy of excess P40 resulting from the manufacturing of drainage layer material will be stockpiled in the construction staging area for use in TMA 1B Stage II.

- TMA 1B Stage II will be constructed with soil excavated from the Stage II footprint and the excess, along with previously stockpiled soils will be used to continue construction of the Stage III berm along the west side of TMA 1A and TMA 1B (refer to Figure 9.1-2). The Stage III berm is about 70 percent complete at this time. Excess P40, approximately 10,000 cy, will again be produced and will be added to the stockpile from Stage I construction, bringing the total in the stockpile to approximately 25,000 cy to be used for TMA 1 Stage III liner.

- TMA 1 Stage III (the vertical stage over Stages I and II) berms will be constructed with soils excavated from TMA 2 Stage IV (see Figure 9.1-3). Approximately 700,000 cy will be excavated from Stage IV to complete the Stage III berms. This excavation will result in the subbase for Stage IV also being about 35 percent complete. An excess of approximately 5,000 cy of P40 soil will be stockpiled for use for TMA 2 Stage IV liner.

- TMA 2 Stage IV will be constructed with approximately 1.4 million cy of cut from the Stage IV area. Figure 9.1-4 shows that a portion of the excess cut will be used to construct approximately 70 percent of the Stage V berm on the west, south, and east sides of the cell. Approximately 720,000 cy of general fill will also be stockpiled in the borrow area north of TMA 3 for later use as grading layer for TMA 1. As a result of manufacturing of drainage layer soil, approximately 40,000 cy of excess P40 soil will be stockpiled for future use for TMA 2 Stage V liner.

- TMA 1 final cover grading layer placement takes place during the TMA 2 Stage IV operation. The approximate 1.05 million cy of general fill required for the TMA 1 grading layer will be obtained from the 720,000 cy of stockpiled material and the remainder from the TMA 3 Stage VI subbase excavation.

- TMA 1 final cover will be placed during the operation of TMA 2 Stage IV. The final cover components will be obtained and processed from the approximately 635,000 cy excavated from the TMA 3 Stage VI subbase, which results in the Stage VI subbase being approximately 40 percent complete. Excess P40 soil, approximately 95,000 cy, will be stockpiled for use in the TMA 3 Stage VI liner or TMA 2 final cover, which brings the total P40 stockpile to approximately 135,000 cy.

- The remainder of the TMA 2 Stage V berm and the Stage V liner will be constructed with approximately 194,000 cy of material excavated from the TMA 3 subbase (see Figure 9.1-5). The P40 soil for the liner will be obtained from P40 soil stockpiled in the borrow area. The quantity of P40 soil remaining in the stockpile will now be reduced to approximately 110,000 cy for use in TMA 3 Stage VI liner or TMA 2 final cover.

- TMA 3 Stage VI construction completion requires approximately 1,000 cy of additional fill and approximately 180,000 cy from the TMA 3 cell excavations. Excess excavated soil will be used to construct the Stage VII berm on the west side, east side, and northeast corner of TMA 3, resulting in the Stage VII berm being approximately 75 percent complete (see Figure 9.1-6). Approximately 45,000 cy of excess P40 soils will be stockpiled in the borrow area, bringing the P40 stockpile to approximately 155,000 cy. Approximately 1.2 million cy of excess cut soil will also be stockpiled at this time in the borrow area for use as grading layer on TMA 2.

- The remainder of the TMA 3 Stage VII berm will be constructed during TMA 3 Stage VI operation (refer to Figure 9.1-7). This material will be removed from the stockpile in the borrow area, resulting in approximately 1.1 million cy remaining in the stockpile. Following TMA 3 Stage VII liner placement, approximately 130,000 cy of P40 will also remain stockpiled for use in TMA 2 final cover construction.

- TMA 2 grading layer consisting of approximately 725,000 cy from the stockpile will be placed during TMA 3 Stage VII operation. At this time, approximately 350,000 cy will remain in the stockpile and approximately 70,000 cy of excess P40 material will be added to the P40 stockpile, bringing its total to approximately 200,000 cy.

- TMA 2 final cover requires approximately 500,000 cy of cut from soils stockpiled in the borrow area. After completion of the TMA 2 final cover, approximately 50,000 cy of excess P40 soils will remain in the borrow area and the general fill stockpile will be exhausted (refer to Figure 9.1-7).

- TMA 3 grading layer will be placed in year 30 of TMA operation after TMA 3 Stage VII operations are completed. Approximately 50,000 cy of excess stockpiled P40 material will be used for the TMA 3 grading layer, exhausting this supply. In addition, approximately 680,000 cy will be excavated from the borrow area.

- TMA 3 final cover placement requires the excavation of approximately 620,000 cy in the borrow area. Excess processed P40 soil and general fill will be used as the rooting layer in the final cover. Drawing 18 shows the final grades for TMA 1, 2, and 3, along with the final reclamation grades for the stockpile/soil borrow area. Drawing 18 also shows the runoff basins which will be in service after reclamation of the TMA cells and borrow area.

### 12.2.4.3 Calculation Method

Drawing 13, Site Sequencing Plan, contains cut/fill volumes (in-place quantities) for site construction and closure for each of the three TMA cells. These volumes were determined using the Site Works™ program of an Intergraph™ CADD system. Drawing 13 also contains the in-place quantities of the major geosynthetic materials required. The materials added or modified in conjunction with the redesign of the liner and final cover are also included on Drawing 13. In general, the modifications made in conjunction with the redesign include the following:

Liner/Leachate Collection System

- The 6 inch thick P40 (fines) filter layer has been removed from the base of the TMA cell over the drainage layer. The 6 inches of fines is replaced with an additional 6 inches of till, making the till layer a total thickness of 18 inches (refer to Figure 5.3-1).

- The 6 inch P40 (fines) filter layer was also eliminated from the liner section on the sideslopes and the till thickened to 18 inches, as described above (refer to Figure 5.3-1).

- As discussed in Addendum No. 3 (Foth & Van Dyke, 1997a), a geocomposite drain has been added to the sideslope for both the first and second stage of each cell.

Final Cover

- A 12 inch biotic layer consisting of 3 inch to 8 inch cobble size material has been added to the final cover above the drainage layer (refer to Figure 7.1-1). The total thickness of the final cover remains the same since the biotic layer replaces the lower 12 inches of the rooting zone.

- A cushioning geotextile has been added above the final cover geomembrane, as shown on Figure 7.1-1.

Figure 12.2-2 has been prepared to provide a preliminary earthwork balance for the construction, operation, and closure of TMA 1 through TMA 3. Figure 12.2-2 shows the total cut in comparison with the total fill needs for TMA construction and closure. The processing of drainage layer, P40 till, and biotic (cobble) layer material is taken into consideration and the quantity of each major soil layer on a per cell basis is presented. Figure 12.2-2 also shows the estimated quantity of the unused grain sizes of the till referred to in the Feasibility Report (Foth & Van Dyke, 1995) as "by-products". These by-products from the manufacture of drainage layer and P40 till can be blended with excavated till and used as earth fill in applications where no till processing is required. In Figure 12.2-2 these by-products are added back into the unprocessed till, reducing the quantity of unprocessed till required. In addition, the cobble by-products are used in the biotic layer in the final cover. The quantities estimated in Figure 12.2-2 were an input

used to estimate the size required for the stockpile, soil processing, and construction staging areas shown on Figures 9.1-1 through 9.1-7. The quantities in Figure 12.2-2 do not include riprap for the TMA base, since it will be obtained from mine waste rock.

### 12.2.4.4 Earthwork Contingency

An earthwork contingency is necessary to account for uncertainties which are difficult to quantify for two components of the earthwork balance. The uncertainties are accounted for as follows:

- A 15 percent contingency has been added to the quantity of soil required to manufacture the drainage layer material for the leachate collection system, and the final cover drainage layer. The contingency is needed primarily to account for the variability in the till properties. A contingency is not required for the manufacture of the P40 till soils, since Figure 12.2-2 shows that approximately 144,600 cubic yards of excess P40 are available assuming conservative average properties of the Late Wisconsinan Till (refer to Addendum No. 2, Attachment 11 (Foth & Van Dyke, 1996b)).

- A 15 percent contingency has been added to the quantity of unprocessed till required for the final cover grading layer. This contingency is needed to account for settlement during the consolidation period which may take place over the approximate 153 acres of tailings surface which will be covered.

The contingencies mentioned above are calculated in the footnote on Figure 12.2-2 as equaling approximately 525,700 cubic yards. So, if till properties were not as anticipated and/or if excessive settlement occurred in the tailings, an additional 525,700 cubic yards is available as borrow from the stockpile/borrow area north of TMA 3.

The total Type I mine waste rock that could be available for the TMA grading layer material is approximately 692,000 tons (461,000 cubic yards). If the waste rock is used, the borrow area requirement (north of TMA 3) could be reduced by an amount equal to the amount of waste rock.

In addition, demolition waste (i.e., railroad ballast and sub-ballast, road gravel, broken concrete from on-site structures, etc.) could be used as part of the grading layer for the final cover for TMA 3. Using these materials in the final cover of TMA 3 would further reduce the need for borrow from the borrow area north of TMA 3.

### 12.2.4.5 Typical Annual Waste Material Balances, NR 182.08(2)(e) 6., a. through d.)

NR 182.08(2)(e)6. requires the preparation from the best available information of a material balance for the time periods listed in NR 182.08(2)(e) 6. a. through d. The information which follows is taken from Table 4.3-1 and supplies the required material balances. The narratives designated a. through d. which follows provides the requested information.

NR 182.08(2)(e)6. a. A typical production year will result in the placement in the TMA of approximately 379,000 cy of depyritized whole tailings and other mine waste during the zinc phase, and approximately 670,000 cy during the copper phase. Other mine wastes may include wastewater treatment plant solids, waste rock, demolition wastes, and laboratory wastes.

NR 182.08(2)(e)6. b. The possible changes in operation due to long or short term shutdown are as in Section 6.6.10 of the *Feasibility Report* (Foth & Van Dyke, 1995) and Response 4 to the WDNR Completeness Determination Letter (NMC, 1997).

NR 182.08(2)(e)6. c. The projected conditions existing at the end of operations as proposed herein is that TMA cells TMA 1, TMA 2, and TMA 3 would be filled. All mine wastes including tailings, mine waste rock, wastewater treatment plant solids, demolition waste, and laboratory wastes would be placed in the TMA cells. It is estimated that this would amount to approximately 14.1 million cubic yards, which includes an approximate 12-13 percent contingency factor.

NR 182.08(2)(e)6. d. At the end of reclamation, a final cover would have been placed on the TMA cells and no additions to the waste balance are anticipated after that time.

## 13 Environmental Monitoring (NR 182.13)

A construction and operation phase monitoring program will be conducted for the TMA facility commencing prior to tailings placement, and will run until closure of the site. This occurs when final site grading and initial revegetation is complete. A long-term care and maintenance monitoring program will begin after final grading and revegetation of the TMA. A specific TMA monitoring plan, including proposals for monitoring of groundwater, tailings, leachate, final cover, and reclaim pond liner, is included as Appendix F to the MPA (Foth & Van Dyke, 1995/1998a).

# 14 Operations Manual

## 14.1 General

This section contains the modifications to the TMA operational plan resulting from the changes made to the TMA cell design configuration and location. As in past submittals, construction specifications are provided to the level of detail necessary to analyze the environmental performance of the TMA facility components. Changes to components included in past submittals (e.g., change from native clay liner to geosynthetic clay liner (GCL) are not incorporated into this addendum.

## 14.2 Specifications for Site Construction NR 182.09(2)(b)2

Following is a listing of the general sequencing of construction which includes a description of the construction activity. The construction sequence described is for the initial site preparation and construction for TMA 1 Stage I. Following access road and reclaim pond construction (construction year 1), each major cell construction event, such as TMA 1 Stage I, will occur over two construction seasons generally as follows:

Construction Year 1

- Clear and grub TMA access road;
- Construct access road tailings delivery and reclaim water return pipelines;
- Clear and grub for reclaim pond; and
- Excavate and construct reclaim pond base grade and liner system.

Construction Year 2

- Clearing and grubbing of:
  - TMA 1 Stage I footprint;
  - construction storage area;
  - TMA access road;
  - runoff basin 9; and
  - soil and mulch stockpiling area.

- Site preparation, such as:
  - salvage marketable timber;
  - cut and pile unmarketable timber, stumps, and brush;
  - cut and chip unmarketable timber and brush and stockpile in a mulch storage area within the construction staging area; and
  - excavate and stockpile topsoil in the construction staging area.

- Install temporary and permanent erosion control and surface water diversion structures as detailed in Section 4 of the MPA (Foth & Van Dyke, 1995/1998a) in the general areas of:
  - downslope from TMA 1 Stage I construction area; and
  - downslope from construction staging area and stockpiles.

- Excavate and grade access road between plant and TMA and install culvert pipes and erosion control measures.

- Excavate and stockpile upper till soil in the construction staging area in the area designated for processing on-site soils.

- Excavate, place and compact till soils from TMA 1 Stage I in embankments (berms).

- Grade and shape to required sub-base grades.

- Process and stockpile soils and aggregates for:
  - till fines (P40) layer;
  - drainage layer;
  - till protective layer;
  - riprap; and
  - crushed road base.

- Prepare location in the construction staging area for geosynthetic storage.

- Topsoil outside slopes of TMA 1 Stage I berms.

- Seed, fertilize, and mulch outside slopes of TMA 1 Stage I berms.

- Install fencing, gates, and other access limiting measures.

Construction Year 3

- Continually inspect, repair and/or replace, as required, all temporary and permanent erosion control structures per Wisconsin Construction Site Best Management Practices.

- Inspect and repair all eroded areas on interior and exterior TMA 1 berm slopes.

- Prepare sub-base grade for low permeability soil (P40) by removing boulders and cobbles, regrading to sub-base grade elevations, recompacting and proof rolling.

- Place and compact low permeability soil layer (P40 layer) on interior 3H:1V slopes.

- Place and compact P40 layer on TMA base.

- Maintain P40 moisture content until GCL is placed.

- Geosynthetics contractor to start preparation for geosynthetics installation and:
  - preparation of geomembrane storage area in construction staging area;
  - unloading and storing of geomembrane in construction staging area;
  - place GCL on prepared low permeability soil layer (P40);
  - deploying of geomembrane panels as per panel layout plan, and achieve simultaneous placement with GCL;
  - welding of geomembrane panels;
  - install geocomposite on sideslopes;
  - completion of required quality assurance (QA) and quality control (QC); activities, including destructive and non-destructive testing and completion of required QA/QC reporting;
  - prepare construction documentation report as per department plan of operation review letter; and
  - cover constructed geomembrane with geocomposite and processed till soils on the interior berm and drainage layer at the cell base.

- Install leachate collection system, including:
  - install geotextile on the base (top of geomembrane);
  - install drainage layer on the base;
  - install perforated leachate collection system pipe;
  - install cleanout risers for leachate collection system piping;
  - construct and install sideslope riser (SSR) and sideslope riser sump;
  - backfill leachate collection system piping, SSR's and cleanouts;
  - place till layer over base area; and
  - place riprap over area covered by the leachate collection system.

- Install tailings distribution pipelines on shelf on interior tailings berm slope, including:
  - tailings distribution lines including required valves, spigots, and spigot pipes;
  - reclaim water return pipeline including required valves and fittings;
  - leachate transfer pipeline including required valves and fittings; and
  - a lined ditch or double encased pipelines where pipes are outside of the lined area.

- Construct required electric power service at TMA.

- Construct, install, and commission reclaim basin barge and pump.

- Install and commission SSR pump and control.

- Startup and commission all mechanical equipment, including:
  - SSR pumps;
  - SSR liquid level transducers;
  - return water decant pump and controls; and
  - valves and controls.

Upon completion of the activities outlined above, and the submission and approval by WDNR of the Construction Documentation Report, the facility will be ready to operate. The first step in starting TMA 1 Stage I is to fill the cell with a sufficient quantity of water to start the mill. This is approximately the amount of water needed to cover the high point in the center of TMA 1 Stage I. Water would be pumped to the TMA through the tailings pipeline and distributed in the cell by opening the two valves at the corners of the cells which are designed for end dumping (refer to mass discharge lines on Drawing 17). After the cell has been filled with water, tailings can be deposited in the cell by alternating the spigot lines as described in Section 6.2 of the Feasibility Report (Foth & Van Dyke, 1995).

# 15 Financial Assurance, NR 182.16 and NR 182.17

## 15.1 Financial Responsibility for Closure

To meet the requirements of NR 182.16, financial responsibilities for closure are outlined in Section 3 of the MPA (Foth & Van Dyke, 1995/1998a).

## 15.2 Financial Responsibility for Long-Term Care

To meet the requirements of NR 182.17, long-term care financial responsibilities are outlined in Section 3 and 10 of the MPA (Foth & Van Dyke, 1995/1998a).

## 15.3 Waste Management Fund, NR 182.18

NR 182.18 requires that all licensed mine waste facilities pay the WDNR a tonnage fee for each ton of waste received and placed in the facility, or a minimum waste management base fee of $100. NMC will provide the WDNR with the proof of financial responsibility described in Wis. Stat. s. 289.41(4)-(6) Status (i.e., net worth method), and therefore the waste management fee is based on NR 182.18(3)(c).

### 15.3.1 Waste Management Fund

It is NMC's intent to establish the annual mine waste volume by field measurement of the active tailings cell. The volume then would be converted to weight by multiplying the volume by the average density of 93 pounds per cubic foot (2511 pounds per cubic yard). Based on NR 182.18(3)(c) and Table 2, the following calculation is representative of a typical annual contribution to the Waste Management Fund and includes a 25 percent increase in tonnage fee as required by NR 182.18(3)(c). This figure will vary based on factors such as mining rate, ore production rate, percent recovery, etc. For tailings with a density of 93 pounds per cubic foot, the Waste Management Fund would be calculated for the average annual tailings generation rate during the zinc production period as follows:

$$\frac{0.309 \times 10^6 \text{cy}}{\text{year}} \times \frac{27 \text{ cf}}{\text{cy}} \times \frac{93 \text{ lbs}}{\text{cf}} \times \frac{1 \text{ ton}}{2000 \text{ lbs}} \times \frac{\$0.002}{\text{ton}} \times 1.25 \approx \frac{\$970}{\text{year}}$$

or approximately $970 (1998 $) annually.

The total tailings production over the 28 year operating period has been estimated at approximately 11.8 million cy. The total contribution to the waste management fund then could be calculated as:

$$\frac{11.8 \times 10^6 \text{ cy}}{\text{year}} \times \frac{27 \text{ cf}}{\text{cy}} \times \frac{93 \text{ lbs}}{\text{cf}} \times \frac{1 \text{ ton}}{2000 \text{ lbs}} \times \frac{\$0.002}{\text{ton}} \times 1.25 \approx \$37{,}000$$

or approximately $37,000 (1998 $).

Waste rock likely will be placed in the facility throughout the life of the TMA. This estimate assumes the production and dispositions of waste rock as per Table 4-5 of the MPA (Foth & Van Dyke, 1995/1998a).

Total estimated waste rock deposition is 730,000 tons, which includes 526,000 tons during the first three years of production. The annual contribution to the waste management fund for waste rock for the first three years, then, can be calculated as follows:

$$526{,}000 \text{ tons} \times \frac{1}{3 \text{ yrs}} \times \frac{\$0.001}{\text{ton}} \times 1.25 \approx \$220$$

or approximately $220 (1998 $) annually.

The total contribution to the waste management fund as related to waste rock over the 28 year production life of the facility can be calculated as follows:

$$730{,}000 \text{ tons} \times \frac{\$0.001}{\text{ton}} \times 1.25 \approx \$913$$

or approximately $913 (1998 $) over the life of the site.

Wastewater treatment plant solids production is conservatively estimated at approximately 140,000 tons for the life of the site (28 years). The annual waste management fee for these solids, would then be:

$$\frac{140{,}000 \text{ tons}}{28 \text{ years}} \times \frac{\$.005}{\text{ton}} \times 1.25 \approx \$31$$

or approximately $31 (1998 $) annually.

The total waste management fee for the TMA during the initial three-year production period is estimated (in 1998 $) at:

| | | |
|---|---|---|
| Tailings | $970/yr x 3 yrs | $2,910 |
| Mine Waste Rock | $220/yr x 3 yrs | 660 |
| WWTP Solids | $31/yr x 3 yrs | 93 |
| | | $3,663 |

The total waste management fee for the TMA during the remaining 25 years of production, including the 25 percent increase in tonnage fees required by NR 182.18(3)(c) (in 1998 $) is as follows:

| | | |
|---|---|---|
| Tailings | $970/yr x 25 yrs | $24,250.00 |
| Mine Waste Rock | 204,000 tons x $0.001/ton | 204.00 |
| WWTP Solids | 125,000 tons x $0.005/ton | 625.00 |
| | | $25,079.00 |
| Factor | | x 1.25 |
| | | $31,349.00 |

NMC can expect to contribute on a typical year approximately $1,254 annually to the Waste Management Fund in the final 25 years of production.

### 15.3.2 Groundwater Fund

Additionally, Wis. Stat. s. 289.63 assesses a groundwater fee of one cent per ton for every ton of mine waste including waste rock, tailings, and wastewater treatment solids. Based on the assumption made to calculate the Waste Management Fund, the groundwater fund fee could be calculated as follows for the first three years.

Tailings (First 3 Years of Production)

$$3 \text{ yrs} \times \frac{0.309 \times 10^6 \text{ cy}}{\text{year}} \times \frac{27 \text{ cf}}{\text{cy}} \times \frac{93 \text{ lbs}}{\text{cf}} \times \frac{1 \text{ ton}}{2000 \text{ lbs}} \times \frac{\$0.01}{\text{ton}} \approx \$11{,}638 \text{ (1998 \$)}$$

Waste Rock (First 3 Years of Production)

$$526{,}000 \text{ tons} \times \frac{0.01}{\text{ton}} = \$5{,}260 \text{ (1998 \$)}$$

WWTP Solids (First 3 Years of Production)

$$3 \text{ yrs} \times \frac{140{,}000 \text{ tons}}{28 \text{ yrs}} \times \frac{\$0.01}{\text{ton}} = \$150 \text{ (1998 \$)}$$

The total for the first three years, then, would be

$$\$11{,}638 + \$5{,}260 + \$150 = \$17{,}048 \text{ (1998 \$)}$$

For the remaining 25 years the groundwater fee could be calculated as follows:

Zinc Tailings

$$\frac{0.309 \times 10^6 \text{ cy}}{\text{year}} \times \frac{27 \text{ cf}}{\text{cy}} \times \frac{93 \text{ lbs}}{\text{cf}} \times \frac{1 \text{ ton}}{2{,}000 \text{ lbs}} \times \frac{\$0.01}{\text{ton}} \times 13 \text{ years} \approx \$50{,}435 \text{ (1998 \$)}$$

Copper Tailings

$$\frac{0.569 \times 10^6 \text{ cy}}{\text{year}} \times \frac{27 \text{ cf}}{\text{cy}} \times \frac{93 \text{ lbs}}{\text{cf}} \times \frac{1 \text{ ton}}{2{,}000 \text{ lbs}} \times \frac{\$0.01}{\text{ton}} \times 12 \text{ years} \approx \$85{,}725$$

Waste Rock

$$204{,}000 \text{ tons} \times \frac{0.01}{\text{ton}} = \$2{,}040 \text{ (1998 \$)}$$

WWTP Solids

$$25 \text{ yrs} \times \frac{140{,}000 \text{ tons}}{28 \text{ yrs}} \times \frac{\$0.01}{\text{ton}} = \$1{,}250 \text{ (1998 \$)}$$

The total would equal $50,435 + $85,725 + 2,040 + $1,250 = $139,450, or approximately $5,578/yr (1998 $) for the final 25 years.

### 15.3.3 Environmental Repair Fee

Additionally, Wis. Stat. s. 289.67 (environmental repair fee and surcharge) assesses a fee under s. 289.67(1)(d) of one cent per ton for all prospecting or mining wastes, including tailings solids, sludge, or waste rock. This fee is the same as the groundwater fees calculated in Section 15.3.2, which are as follows:

Total cost for the first 3 years of production:

$11,638 (tailings) + $5,260 (waste rock) + $150 (WWTP solids) = $17,048 (1998 $)

Total cost for the remaining 25 years of production:

$136,160 (tailings) + $2,040 (waste rock) + $1,250 (WWTP solids) = $139,450 (1998 $)

or approximately $5,578/yr (1998 $) for the remaining 25 years of production.

### 15.3.4 Summary

The total estimated fees for the Waste Management Fund, Groundwater Fund, and Environmental Repair Fee are as follows:

First 3 Years:

Waste Management Fund + Groundwater Fee + Environmental Repair Fee = Total

$3,663 + $17,048 + $17,048 = $37,759 (1998 $)

The total estimated fees for the Waste Management Fund, Groundwater Fund, and Environmental Repair Fee for the final 25 years are:

Waste Management Fund + Groundwater Fee + Environmental Repair Fee = Total

$31,349 + $139,450 + $139,450 = $310,249 (1998 $)

Total fees then are:

$35,012 + $156,498 + $156,498 = $348,008 (1998 $)

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# FIGURES FOR ADDENDUM NO. 5 TO THE MAY 1995 TAILINGS MANAGEMENT AREA FEASIBILITY REPORT/PLAN OF OPERATION

2282000 E
2284000 E
2286000 E
2288000 E
2290000 E
118000 N
116000 N
114000 N
112000 N

CONSTRUCTION STAGING/
STOCKPILE/BORROW AREA
RUNOFF BASIN 13
RUNOFF BASIN 12
RUNOFF BASIN 14
RUNOFF BASIN 11
RUNOFF BASIN 9
RUNOFF BASIN 10
TMA SETBACK ALTERNATIVE #2 DISTURBANCE BOUNDARY
1998 PROPOSED TMA RECLAIM POND
1998 PREFERRED TMA FOOTPRINT DISTURBANCE BOUNDARY

F12 F15 F16 F17 F27 F28 F29 F30 F31 F32 F33 F63 F64 F65 F66 F81
M1 M2 M3 M4 M5 M6
N1
K1 K2 K3 L1
13 14 15 18 19 20

HEMLOCK CREEK
DUCK LAKE

N

LEGEND

- WETLAND
- F15 WETLAND ID NUMBER
- STREAMS
- LAKES
- 1998 PREFERRED TMA FOOTPRINT DISTURBANCE BOUNDARY
- SETBACK ALTERNATIVE NO. 2 DISTURBANCE BOUNDARY
- CONSTRUCTION STAGING/ STOCKPILE/BORROW AREA
- WATERSHED BOUNDARY

NOTES:

1. BASE MAP DIGITIZED FROM 1" = 1000' SCALE, MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

Foth & Van Dyke

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| APPROVED BY: | GWS | DATE: | DEC. '98 |

Nicolet Minerals COMPANY

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**FIGURE 4.4-1**

1998 PREFERRED TMA FOOTPRINT

Scale: 0 400' 800' | Date: DECEMBER, 1998

Prepared By: Foth & Van Dyke | By: JRB2 | 93C049

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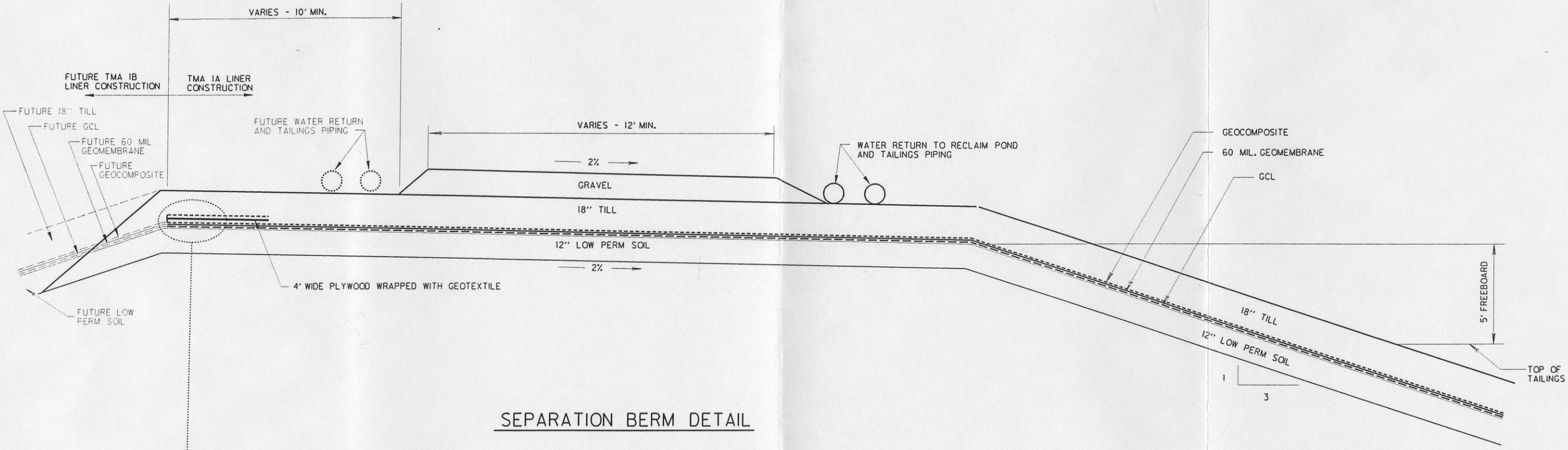
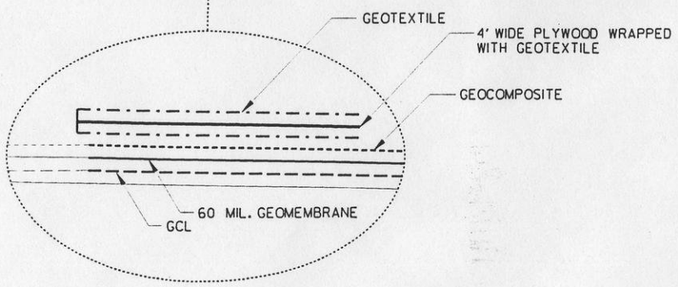



## SEPARATION BERM DETAIL

NOTE: PLYWOOD AND CUSHIONING GEOTEXTILE AROUND PLYWOOD TO BE REMOVED WHEN LINER SPLICE BETWEEN TMA 1A AND 1B IS MADE.




TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

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| APPROVED BY: | GWS | DATE: | DEC. '98 |

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**FIGURE 4.4-2**
TMA 1A/1B
SEPARATION BERM DETAIL

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| Prepared By: Foth & Van Dyke | By: JRB2 | 93C049 | |

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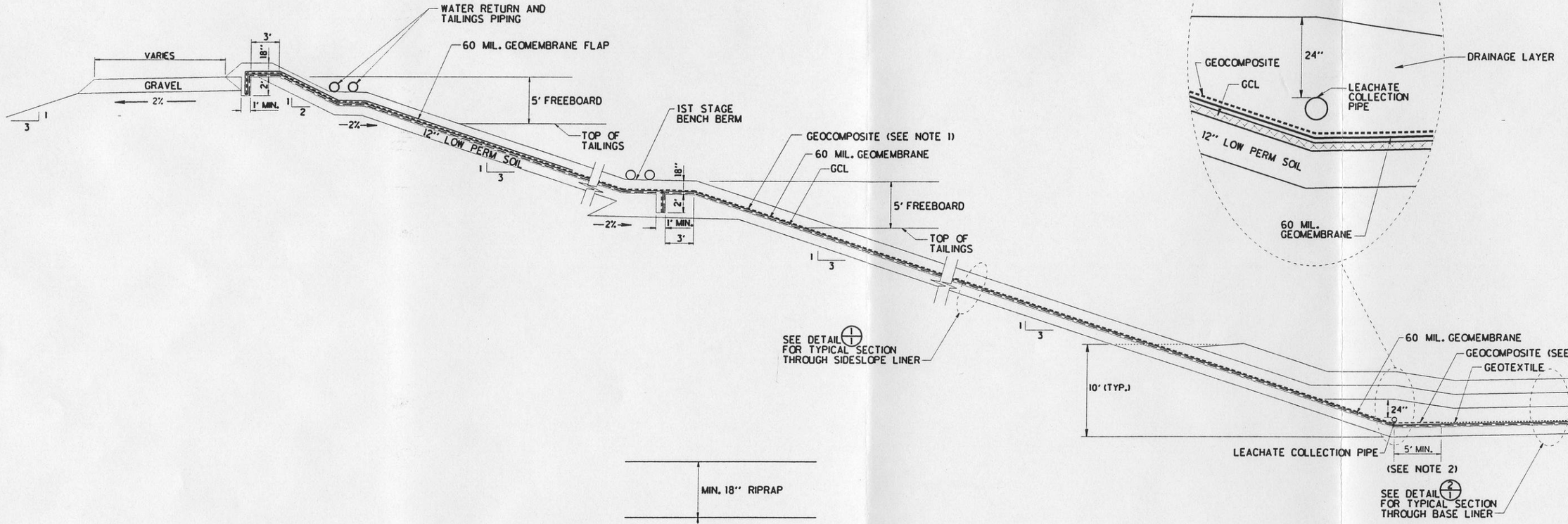
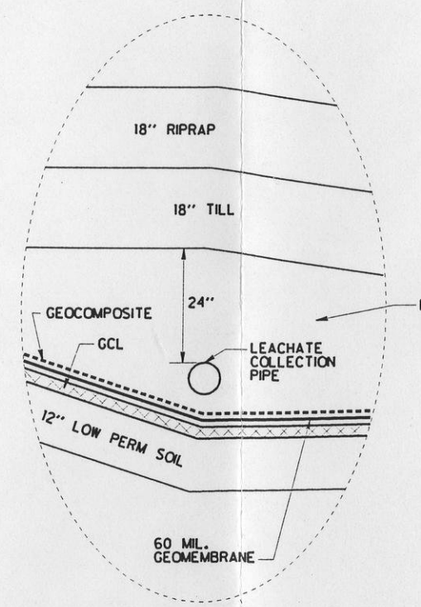
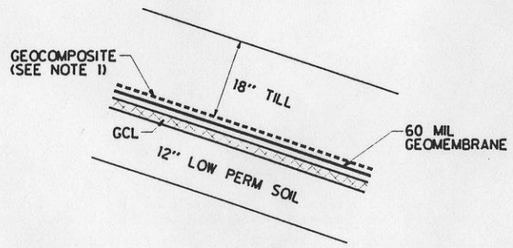
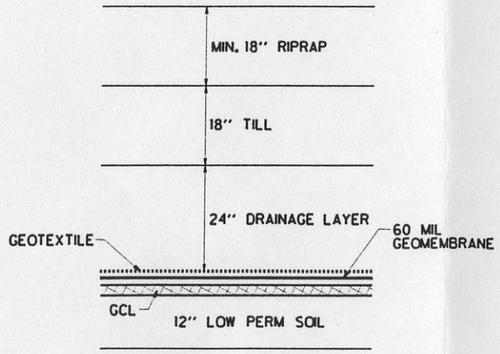



1/1 SIDESLOPE DETAIL




2/1 BASE DETAIL

NOTES:

1. GEOCOMPOSITE CONSISTS OF A GEONET WITH A NON-WOVEN GEOTEXTILE HEAT BONDED TO ITS TOP AND BOTTOM.
2. GEOCOMPOSITE EXTENDED A MINIMUM OF FIVE FEET HORIZONTALLY INTO THE DRAINAGE LAYER AT THE CELL BASE.

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

Foth & Van Dyke

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| APPROVED BY: | GWS | DATE: | DEC. '98 |

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# FIGURE 5.3-1

TYPICAL LINER WITH 18 INCH TILL LAYER DETAIL

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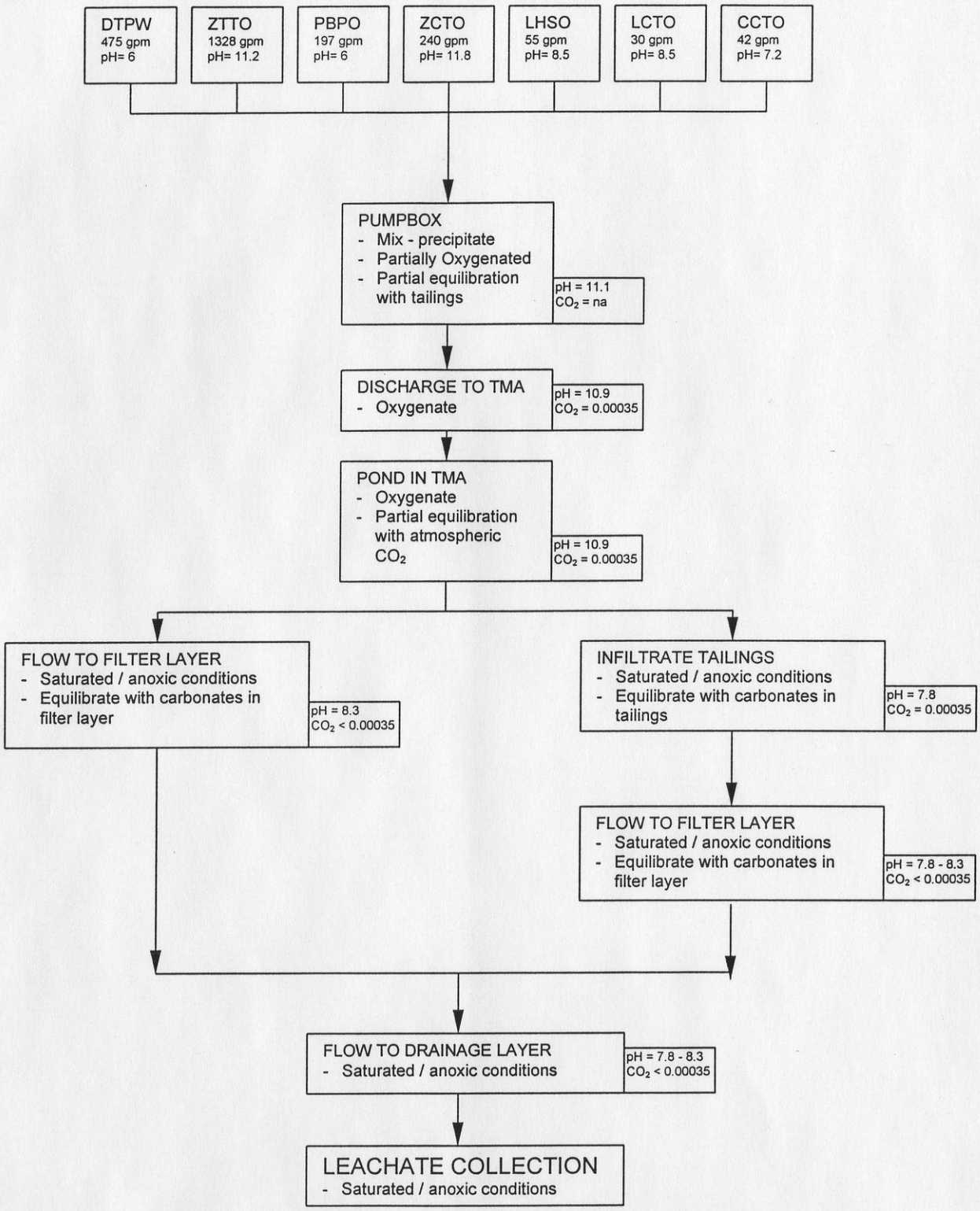


TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

Foth & Van Dyke

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| APPROVED BY: | GWS | DATE: | DEC. '98 |

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**FIGURE 5.4-1**

OPERATIONAL CONDITIONS: DIAGRAMMATIC REPRESENTATION OF TAILINGS PROCESS WATER FLOW PATHS AND GEOCHEMICAL CONTROLS

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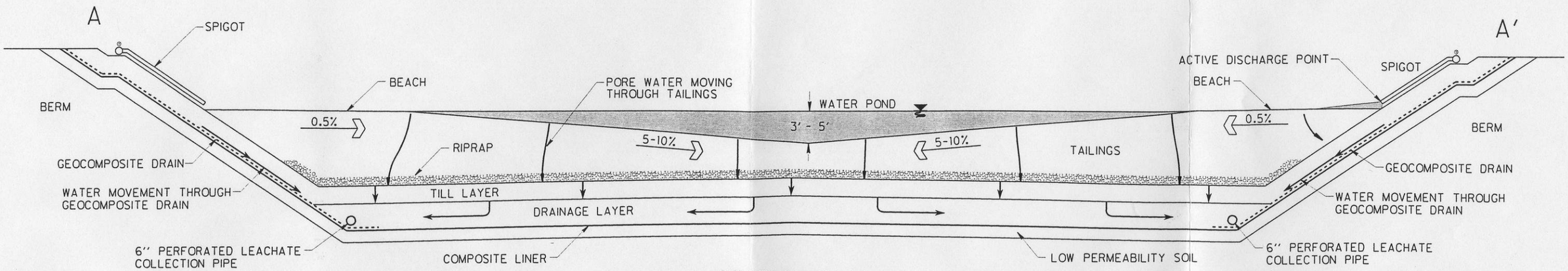
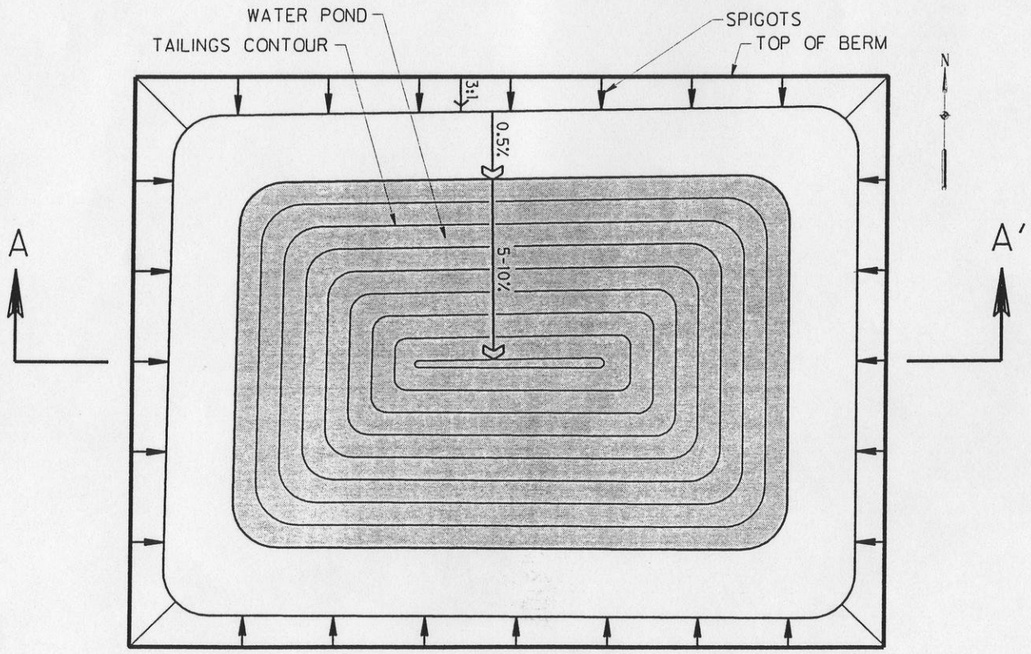



## SECTION A-A'

NOT TO SCALE

NOTE: TAILINGS DEPOSITION IS SUBAERIAL RING DISCHARGE RESULTING IN A CENTRAL WATER POND.




## TYPICAL TMA PLAN VIEW

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

Foth & Van Dyke

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| APPROVED BY: | GWS | DATE: | DEC. '98 |

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**FIGURE 5.4-2**

SCHEMATIC OF WATER MOVEMENT TO FILTER AND DRAINAGE LAYERS

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| Prepared By: Foth & Van Dyke | By: JRB2 | 93C049 | |

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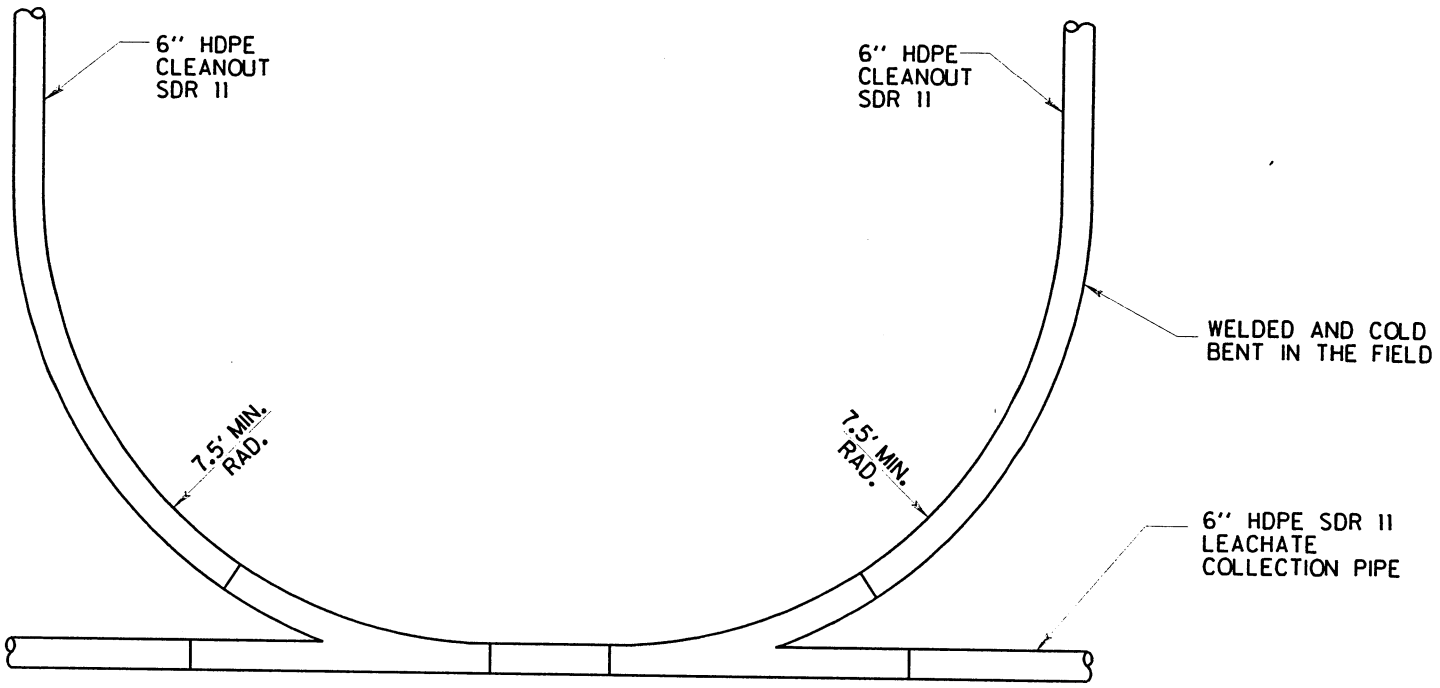


TYPICAL REPRESENTATION:
REFINEMENTS MAY BE MADE
PRIOR TO CONSTRUCTION

Foth & Van Dyke

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| APPROVED BY: | DMR | DATE: | NOV.'97 |
| APPROVED BY: | GWS | DATE: | NOV.'97 |

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# FIGURE 6.5-1

## TYPICAL DOUBLE CLEANOUT DETAIL

| | | | |
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| Scale: NOT TO SCALE | | Date: NOVEMBER, 1997 | |
| Prepared By: Foth & Van Dyke | | By: JOW | 93C049 |

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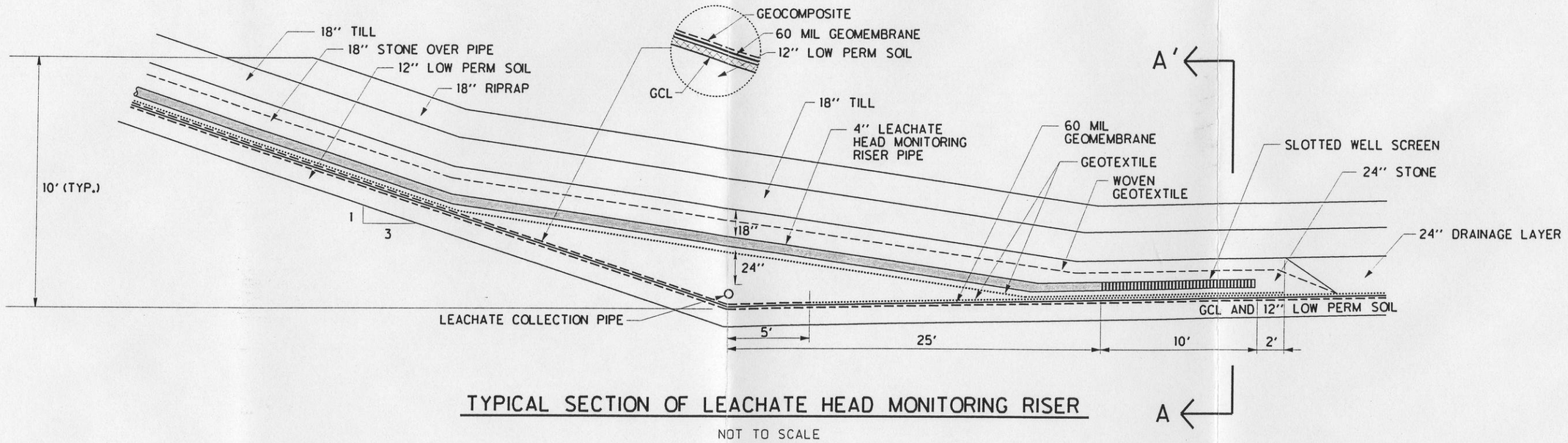
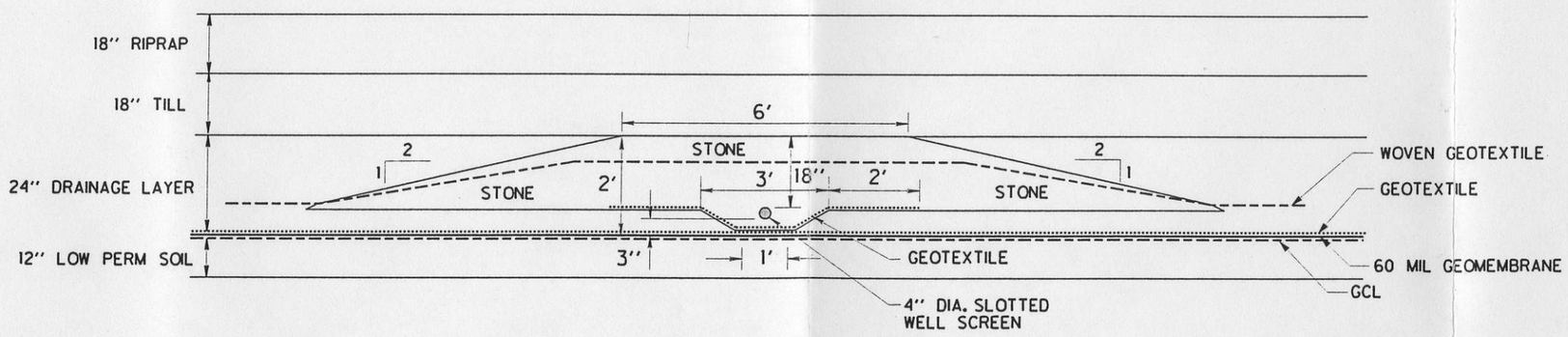



## TYPICAL SECTION OF LEACHATE HEAD MONITORING RISER

NOT TO SCALE




## SECTION A-A' LEACHATE HEAD MONITORING RISER

NOT TO SCALE

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

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| APPROVED BY: | NXP | DATE: | DEC. '98 |
| APPROVED BY: | GWS | DATE: | DEC. '98 |

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FIGURE 6.5-2

LEACHATE HEAD MONITORING RISER DETAIL

| | | | |
|---|---|---|---|
| Scale: NOT TO SCALE | Date: DECEMBER, 1998 | | |
| Prepared By: Foth & Van Dyke | By: JRB2 | 93C049 | |

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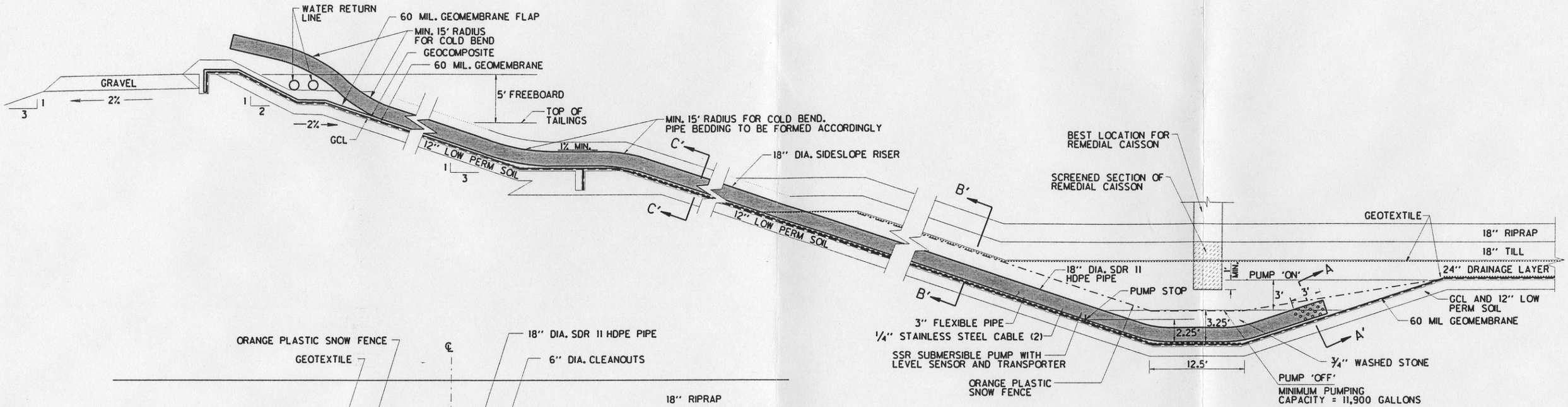
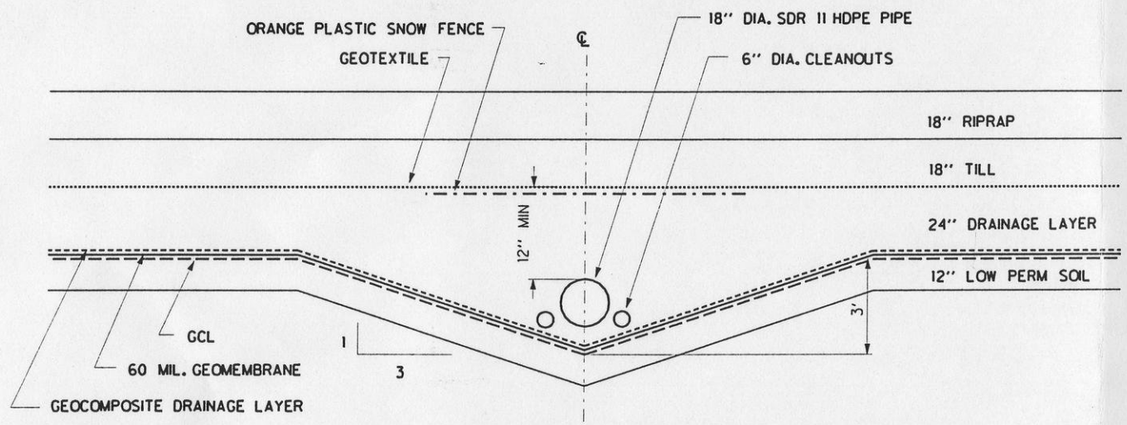
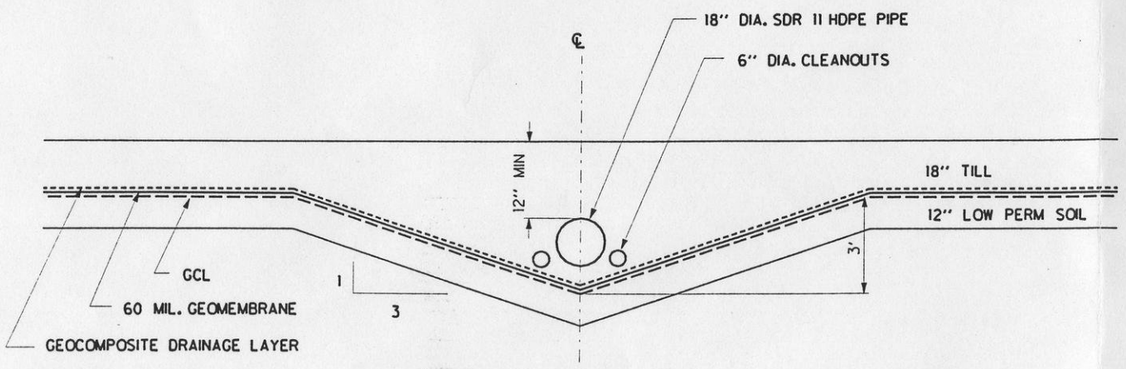


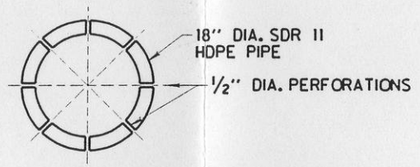

## SECTION B-B'

NOTE: WHEN SSR IS LOCATED OUTSIDE CELL CORNERS
NOT TO SCALE




## SECTION C-C'

NOTE: WHEN SSR IS LOCATED OUTSIDE CELL CORNERS
NOT TO SCALE




## SECTION A-A' PIPE PERFORATION DETAIL

NOT TO SCALE

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

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| APPROVED BY: | NXP | DATE: | DEC. '98 |
| APPROVED BY: | GWS | DATE: | DEC. '98 |

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**FIGURE 6.6-1**

SIDESLOPE RISER SSR-1 AND SSR-4 DETAIL

| | | | |
|---|---|---|---|
| Scale: NOT TO SCALE | | Date: DECEMBER, 1998 | |
| Prepared By: Foth & Van Dyke | By: JRB2 | | 93C049 |

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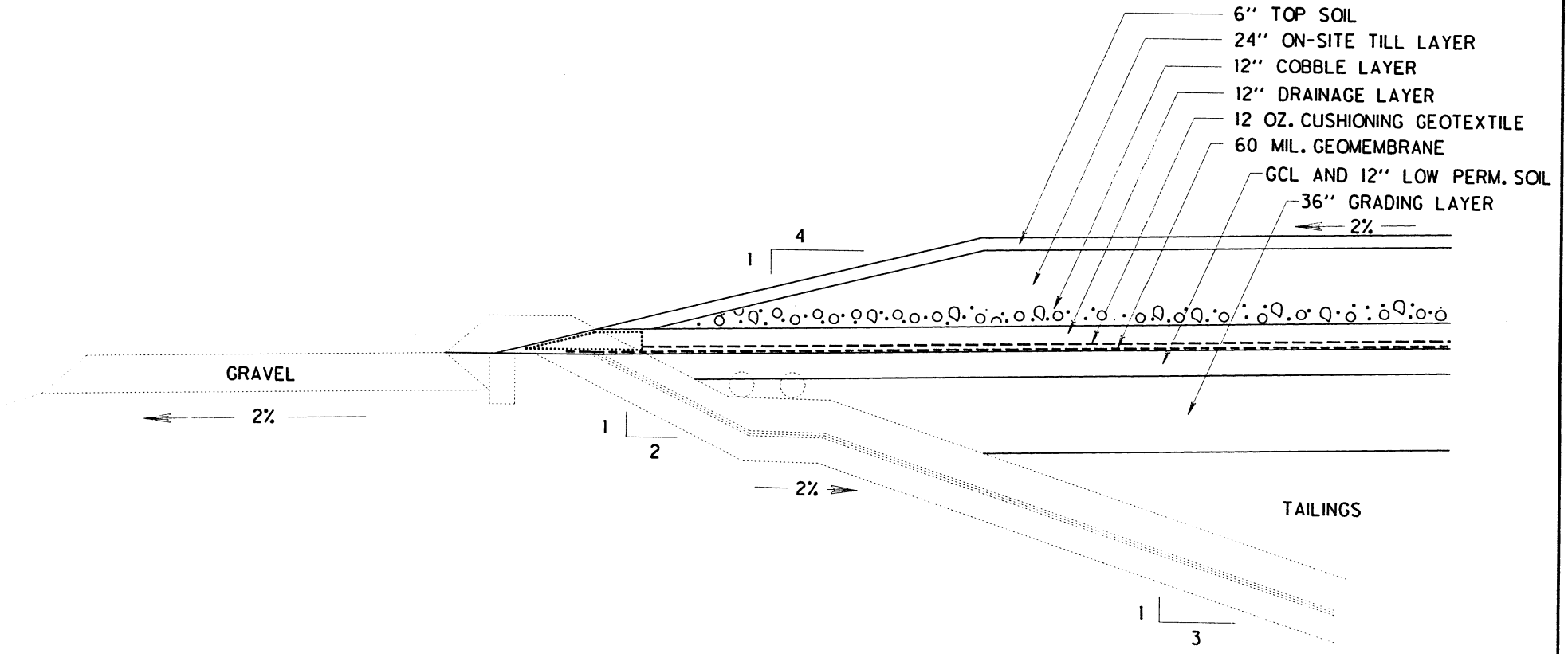


TYPICAL REPRESENTATION:
REFINEMENTS MAY BE MADE
PRIOR TO CONSTRUCTION

Foth & Van Dyke

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| APPROVED BY: | NXP | DATE: | DEC. '98 |
| APPROVED BY: | GWS | DATE: | DEC. '98 |

Nicolet Minerals COMPANY

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**FIGURE 7.1-1**

REVISED PERIMETER TOP BERM
AND FINAL COVER DETAIL 2/28

| | | | |
|---|---|---|---|
| Scale: NOT TO SCALE | | Date: DECEMBER, 1998 | |
| Prepared By: Foth & Van Dyke | By: JRB2 | 93C049 | |

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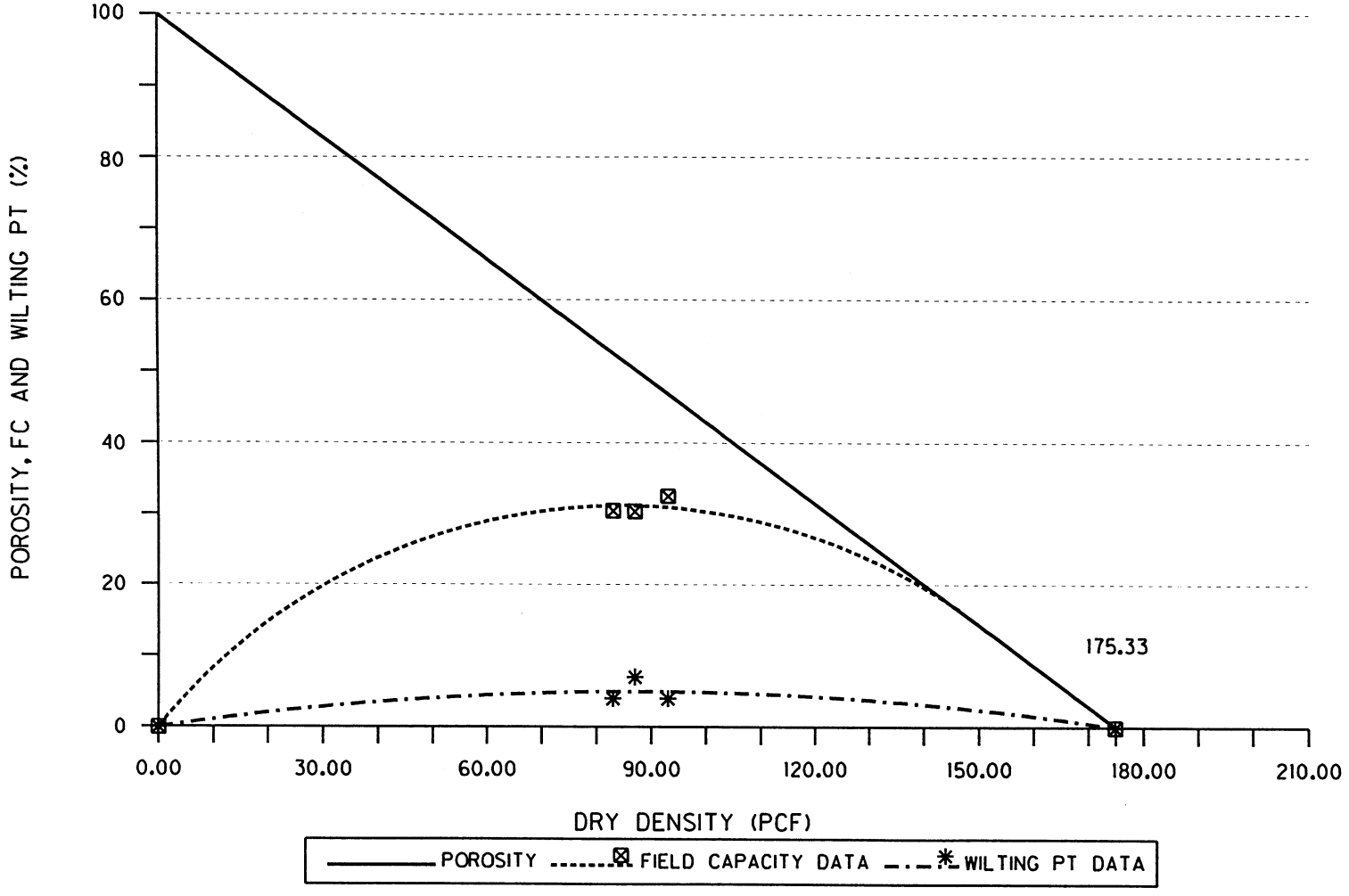


TYPICAL REPRESENTATION:
REFINEMENTS MAY BE MADE
PRIOR TO CONSTRUCTION

Foth & Van Dyke

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| APPROVED BY: | NXP | DATE: | DEC. '98 |
| APPROVED BY: | GWS | DATE: | DEC. '98 |

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**FIGURE 8.2-1**

TMA TAILINGS POROSITY, FIELD CAPACITY AND WILTING POINT VS. DENSITY

| | | | |
|---|---|---|---|
| Scale: | AS SHOWN | Date: | DECEMBER, 1998 |
| Prepared By: Foth & Van Dyke | | By: JOW | 93C049 |

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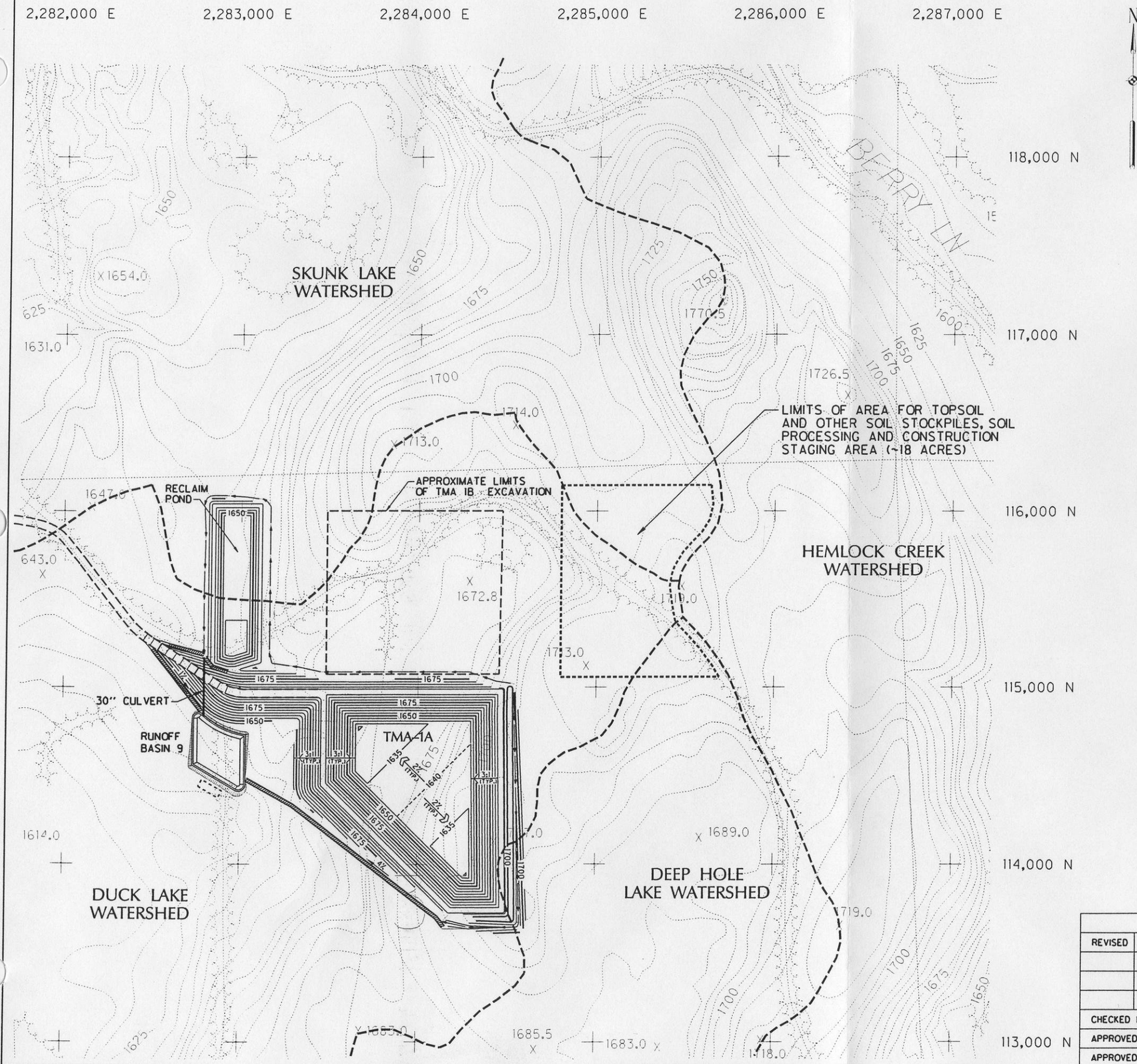


## LEGEND

- EXISTING ROAD
- 1675 — EXISTING CONTOUR
- X 1726.5 — SPOT ELEVATION
- SECTION LINE
- 1700 — PROPOSED CONTOUR
- PROPOSED TEMPORARY DRAINAGE FLOW
- 2% — PROPOSED DRAINAGE DIVERSION BERM
- 2% — PROPOSED SLOPE DIRECTION
- 3:1 — PROPOSED SLOPE RATIO
- WATERSHED BOUNDARY
- PROPOSED CULVERT

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. PROPOSED CONTOURS DEPICTED REPRESENT SITE BASE GRADES. (TOP OF 1' LOW PERM SOIL)

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

Foth & Van Dyke

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| APPROVED BY: | NXP | DATE: | DEC '98 |
| APPROVED BY: | GWS | DATE: | DEC '98 |

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**FIGURE 9.1-1**

TMA 1A

STAGE I CONSTRUCTION

Scale: 0 300' 600' | Date: DECEMBER, 1998

Prepared By: Foth & Van Dyke | By: JRB | 93C049

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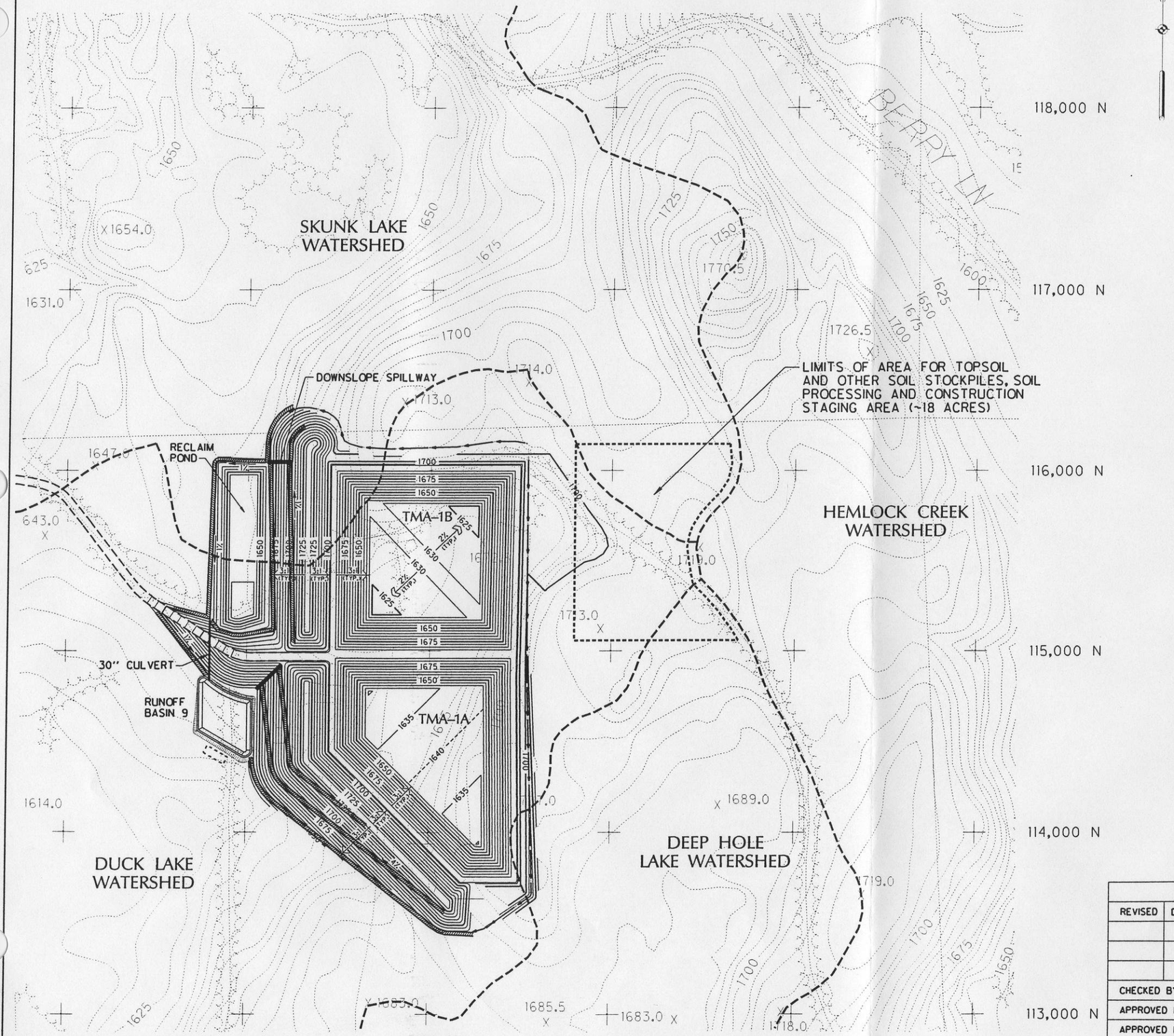


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## LEGEND

- EXISTING ROAD
- 1675 EXISTING CONTOUR
- X 1726.5 SPOT ELEVATION
- SECTION LINE
- 1700 PROPOSED CONTOUR
- PROPOSED TEMPORARY DRAINAGE FLOW
- 2% PROPOSED DRAINAGE DIVERSION BERM
- 2% PROPOSED SLOPE DIRECTION
- 3:1 PROPOSED SLOPE RATIO
- WATERSHED BOUNDARY
- PROPOSED CULVERT
- PROPOSED DOWNSLOPE SPILLWAY

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. PROPOSED CONTOURS DEPICTED REPRESENT SITE BASE GRADES. (TOP OF 1' LOW PERM SOIL)

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

Foth & Van Dyke

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| APPROVED BY: | NXP | DATE: | DEC. '98 |
| APPROVED BY: | GWS | DATE: | DEC. '98 |

Nicolet Minerals COMPANY

FIGURE 9.1-2
TMA 1B
STAGE II CONSTRUCTION

Scale: 0 300' 600' | Date: DECEMBER, 1998

Prepared By: Foth & Van Dyke | By: JRB | 93C049

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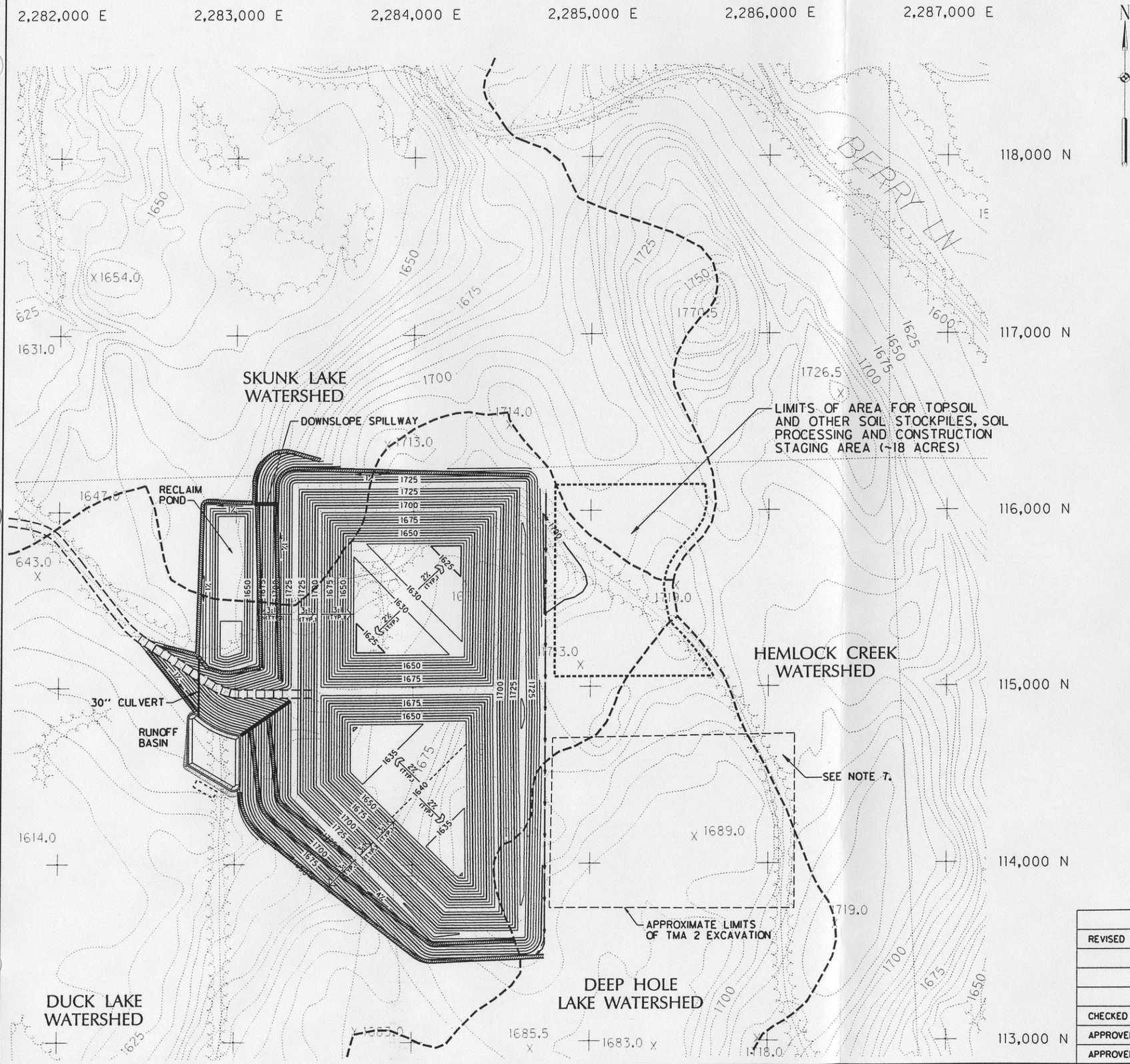


## LEGEND

- EXISTING ROAD
- EXISTING CONTOUR
- SPOT ELEVATION
- SECTION LINE
- 1700 — PROPOSED CONTOUR
- PROPOSED TEMPORARY DRAINAGE FLOW
- 2% — PROPOSED DRAINAGE DIVERSION BERM
- 2% — PROPOSED SLOPE DIRECTION
- 3:1 — PROPOSED SLOPE RATIO
- WATERSHED BOUNDARY
- PROPOSED CULVERT
- PROPOSED DOWNSLOPE SPILLWAY

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. PROPOSED CONTOURS DEPICTED REPRESENT SITE BASE GRADES. (TOP OF 1' LOW PERM SOIL)
7. THE PORTION OF TMA 2 TO BE EXCAVATED IN THE HEMLOCK CREEK WATERSHED WILL NOT OCCUR UNTIL TMA 2 STAGE IV CONSTRUCTION COMMENCES.

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

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| APPROVED BY: | GWS | DATE: | DEC. '98 |

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**FIGURE 9.1-3**

TMA 1
STAGE III CONSTRUCTION

Scale: 0 300' 600' | Date: DECEMBER, 1998

Prepared By: Foth & Van Dyke | By: JRB | 93C049

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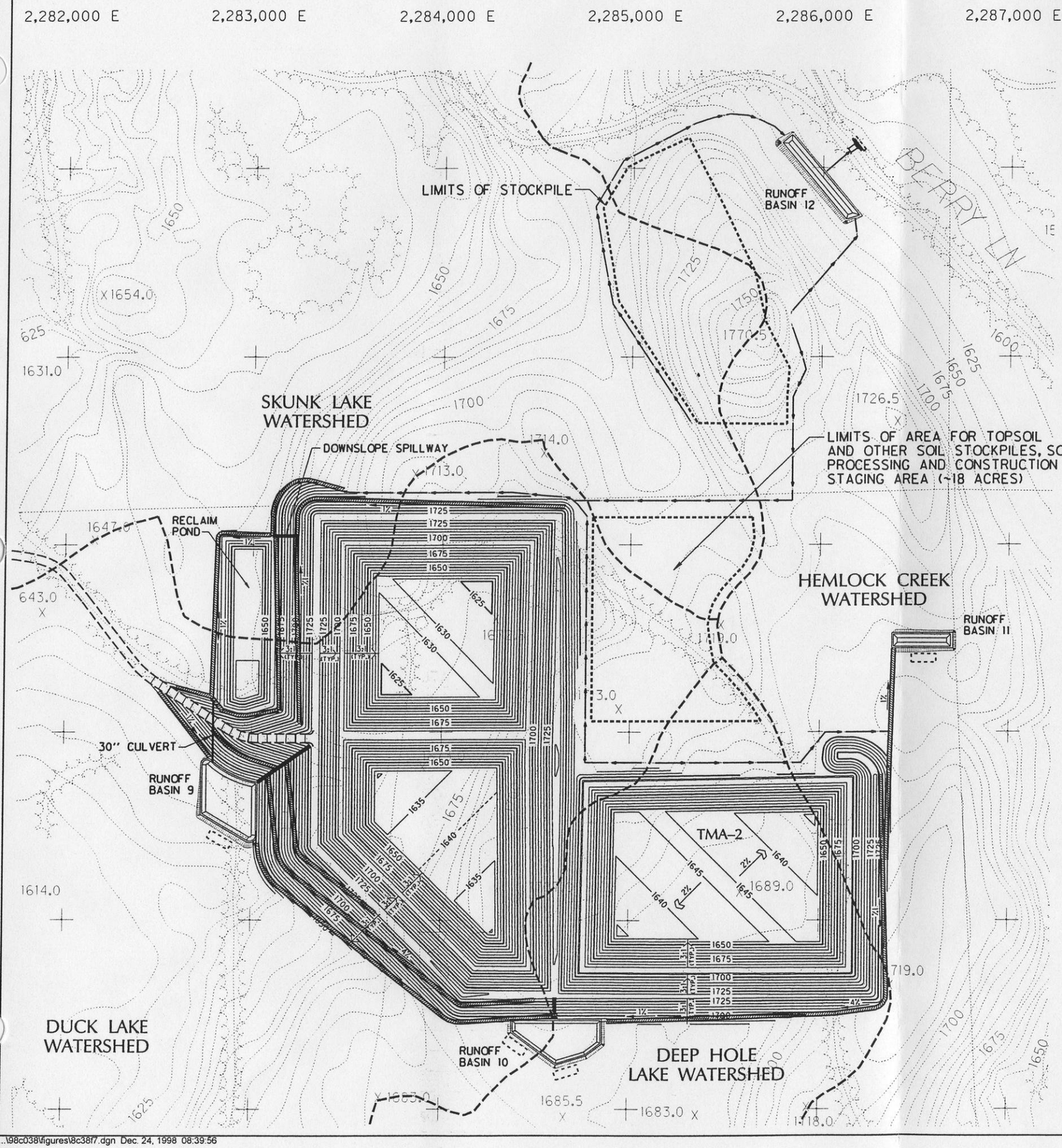


## LEGEND

- EXISTING ROAD
- 1675 EXISTING CONTOUR
- X 1726.5 SPOT ELEVATION
- SECTION LINE
- 1700 PROPOSED CONTOUR
- PROPOSED TEMPORARY DRAINAGE FLOW
- 2% PROPOSED DRAINAGE DIVERSION BERM
- 2% PROPOSED SLOPE DIRECTION
- 3:1 PROPOSED SLOPE RATIO
- WATERSHED BOUNDARY
- PROPOSED CULVERT
- PROPOSED DOWNSLOPE SPILLWAY

## 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. PROPOSED CONTOURS DEPICTED REPRESENT SITE BASE GRADES. (TOP OF 1' LOW PERM SOIL)

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

Foth & Van Dyke

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| APPROVED BY: | GWS | DATE: | DEC. '98 |

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# FIGURE 9.1-4

TMA 2
STAGE IV CONSTRUCTION

Scale: 0 300' 600' | Date: DECEMBER, 1998

Prepared By: Foth & Van Dyke | By: JRB | 93C049

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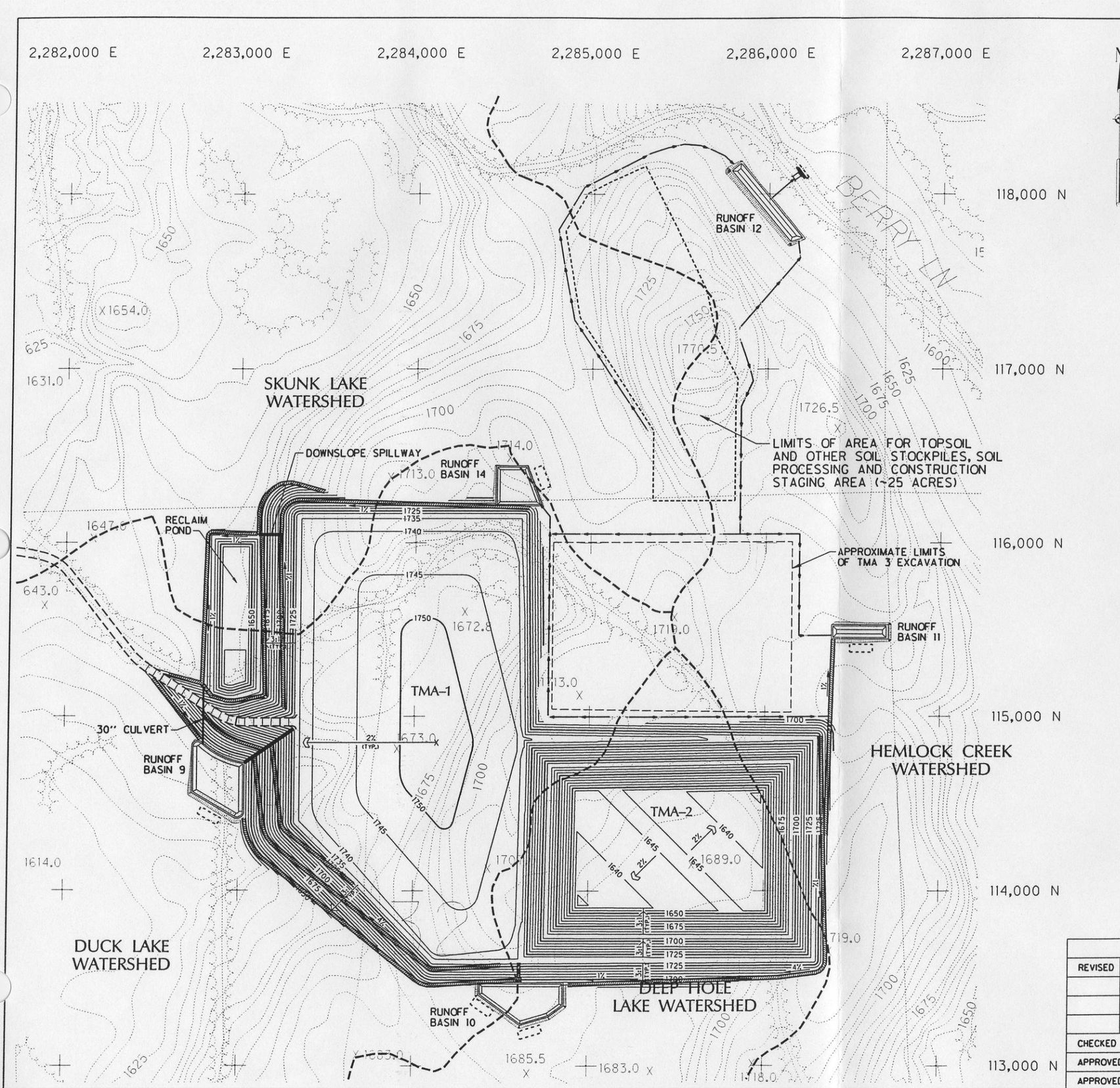


## LEGEND

- EXISTING ROAD
- 1675 — EXISTING CONTOUR
- X 1726.5 — SPOT ELEVATION
- SECTION LINE
- 1700 — PROPOSED CONTOUR
- PROPOSED TEMPORARY DRAINAGE FLOW
- 2% — PROPOSED DRAINAGE DIVERSION BERM
- 2% — PROPOSED SLOPE DIRECTION
- 3:1 — PROPOSED SLOPE RATIO
- WATERSHED BOUNDARY
- PROPOSED CULVERT
- PROPOSED DOWNSLOPE SPILLWAY

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. PROPOSED CONTOURS DEPICTED REPRESENT SITE BASE GRADES. (TOP OF 1' LOW PERM SOIL)

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

Foth & Van Dyke

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| APPROVED BY: | GWS | DATE: | DEC. '98 |

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**FIGURE 9.1-5**

TMA 2 STAGE V CONSTRUCTION
TMA1 FINAL GRADES

Scale: 0 300' 600' | Date: DECEMBER, 1998

Prepared By: Foth & Van Dyke | By: JRB | 93C049

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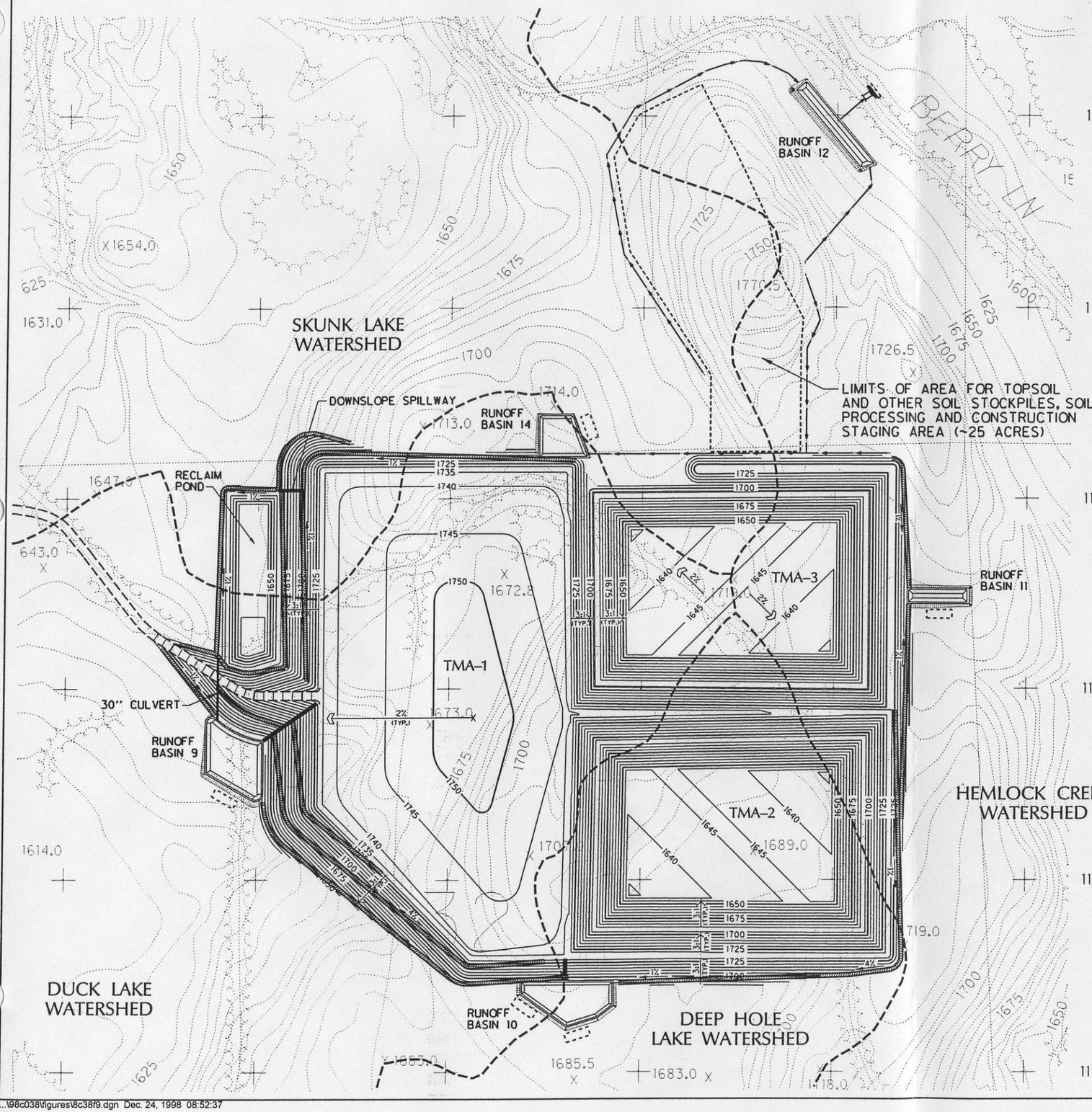


LEGEND

- EXISTING ROAD
- 1675 — EXISTING CONTOUR
- X 1726.5 — SPOT ELEVATION
- SECTION LINE
- 1700 — PROPOSED CONTOUR
- PROPOSED TEMPORARY DRAINAGE FLOW
- 2% — PROPOSED DRAINAGE DIVERSION BERM
- 2% — PROPOSED SLOPE DIRECTION
- 3:1 — PROPOSED SLOPE RATIO
- WATERSHED BOUNDARY
- PROPOSED CULVERT
- PROPOSED DOWNSLOPE SPILLWAY

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. PROPOSED CONTOURS DEPICTED REPRESENT SITE BASE GRADES. (TOP OF 1' LOW PERM SOIL)

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

Foth & Van Dyke

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| APPROVED BY: | NXP | DATE: | DEC. '98 |
| APPROVED BY: | GWS | DATE: | DEC. '98 |

Nicolet Minerals COMPANY

FIGURE 9.1-6
TMA 3
STAGE VI CONSTRUCTION

Scale: 0 300' 600' | Date: DECEMBER, 1998

Prepared By: Foth & Van Dyke | By: JRB | 93C049

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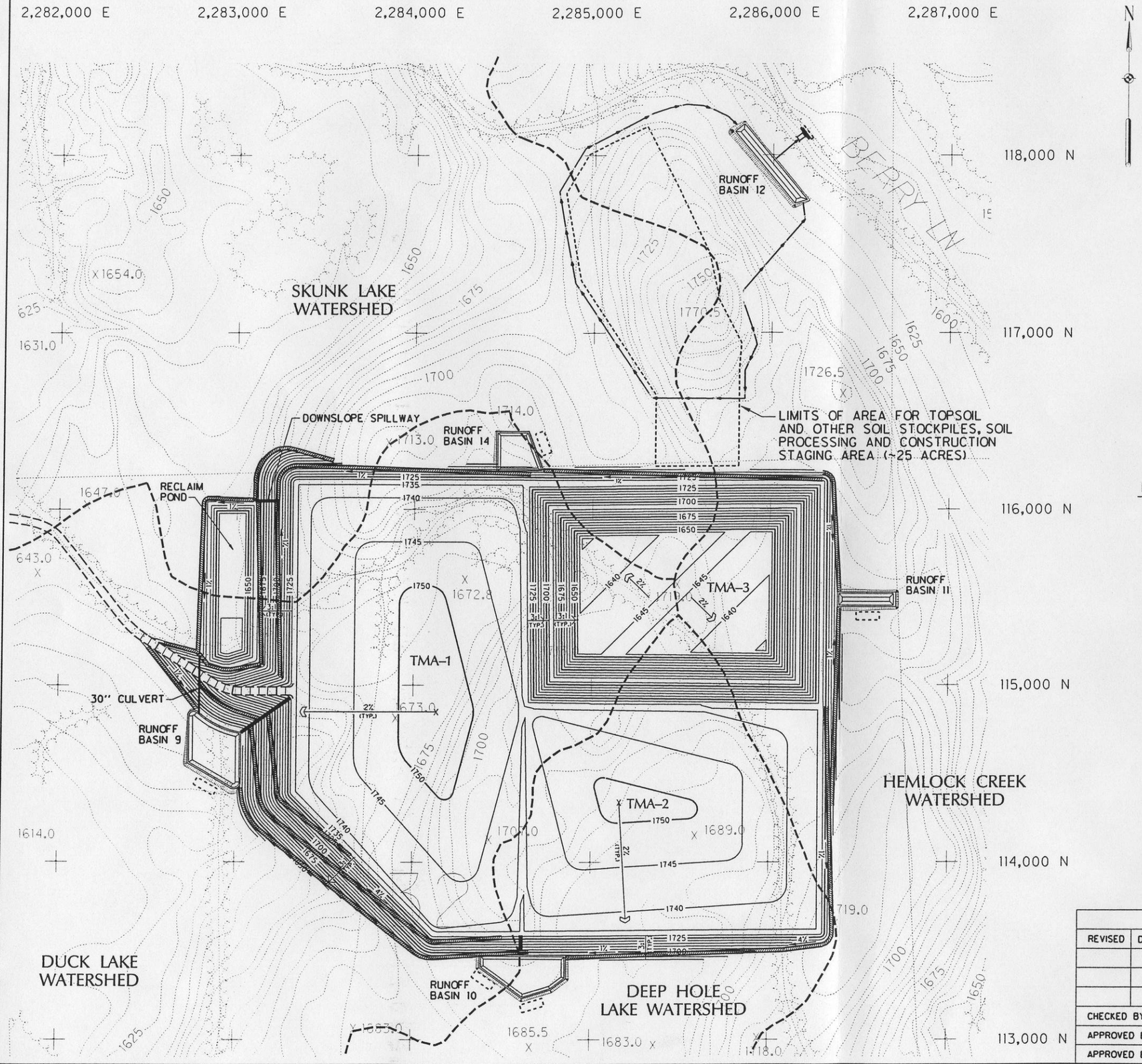


## LEGEND

- EXISTING ROAD
- 1675 — EXISTING CONTOUR
- X 1726.5 — SPOT ELEVATION
- SECTION LINE
- 1700 — PROPOSED CONTOUR
- PROPOSED TEMPORARY DRAINAGE FLOW
- 2% — PROPOSED DRAINAGE DIVERSION BERM
- 2% — PROPOSED SLOPE DIRECTION
- 3:1 — PROPOSED SLOPE RATIO
- WATERSHED BOUNDARY
- PROPOSED CULVERT
- PROPOSED DOWNSLOPE SPILLWAY

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. PROPOSED CONTOURS DEPICTED REPRESENT SITE BASE GRADES. (TOP OF 1' LOW PERM SOIL)

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

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FIGURE 9.1-7

TMA 3 STAGE VII CONSTRUCTION
TMA 2 FINAL GRADES

Scale: 0 300' 600'

Date: DECEMBER, 1998

Prepared By: Foth & Van Dyke | By: JRB | 93C049

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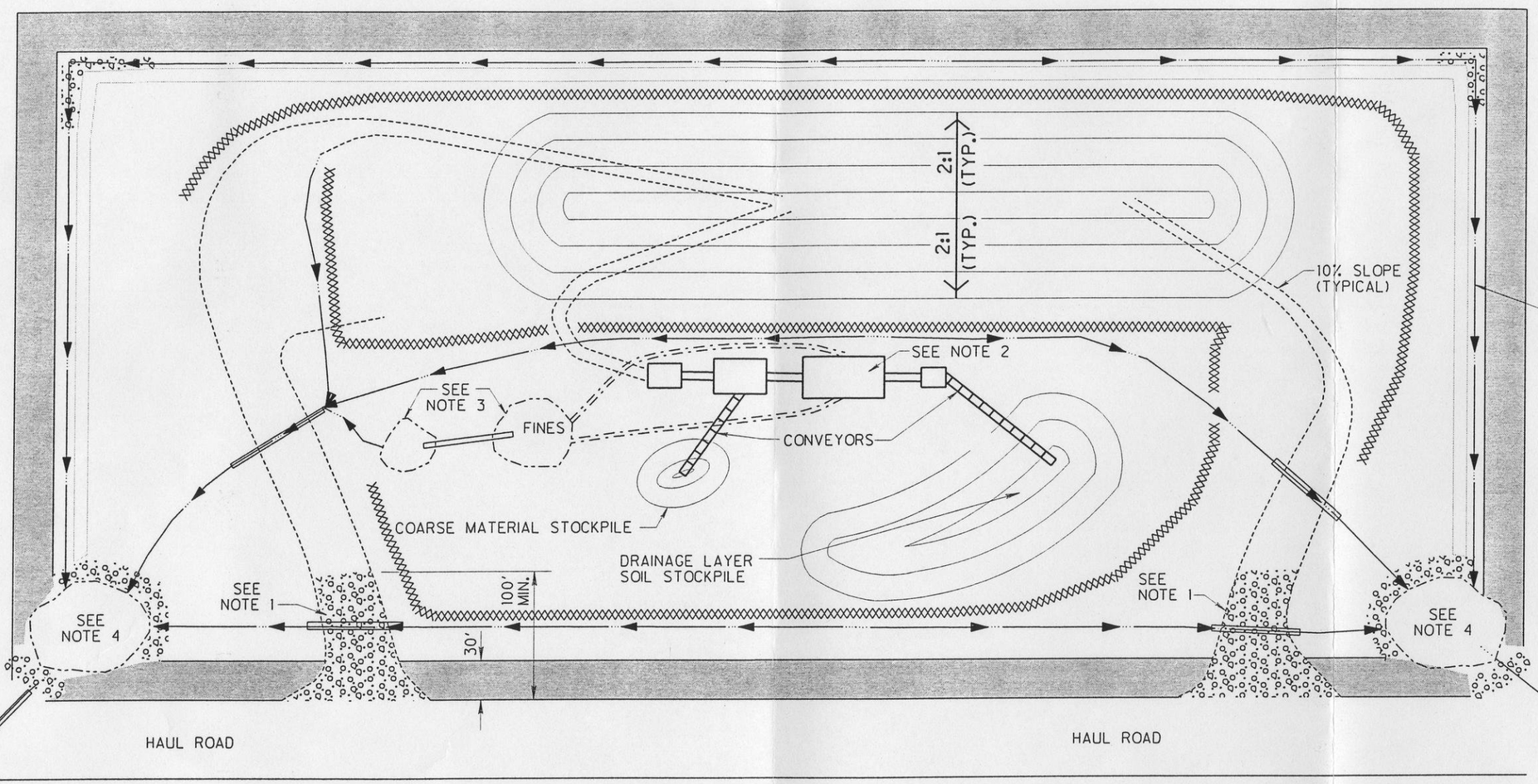
SEE FIGURE 9.2-2
FOR SECTION VIEW

A

A'




SEE FIGURE 9.2-3
FOR DETAILS

TYPICAL EXTERIOR
SLOPE DIRECTION

## LEGEND

- RIPRAP
- CULVERT
- ROCK BERM (FIGURE 9.2-2) OR SILT FENCE (FIGURE 9.2-4)
- UNDISTURBED AREA
- DRAINAGE DITCH AND FLOW DIRECTION
- 2:1 SLOPE
- ACCESS ROAD
- RUNOFF BASIN

## NOTES:

1. AT ENTRANCE AND EXIT TO STOCKPILING AND SOIL PROCESSING AREA PROVIDE A MINIMUM 100 FOOT LENGTH OF 2" TO 3" CLEAR STONE.
2. SOIL PROCESSING PLANT INCLUDING VIBRATING GRIZZLY FEEDER, SCREENING PLANT, JAW CRUSHER AND SCREEN AND WASH PLANT WITH DUST COLLECTION AND WATER SPRAYER TO CONTROL POTENTIAL DUST EMISSIONS.
3. SETTLING PONDS WITH WATER RECIRCULATED TO WASH PLANT. EXCESS WATER, IF ANY, DISCHARGED TO SITE DITCHING.
4. TEMPORARY OR PERMANENT RUNOFF BASINS DESIGNED FOR 25 YEAR, 24 HOUR RAINFALL EVENT FROM STOCKPILE AREA.
5. DISCHARGE TO PERMANENT SITE DITCH WHICH FLOWS TO PERMANENT RUNOFF BASINS.

TYPICAL REPRESENTATION:
REFINEMENTS MAY BE MADE
PRIOR TO CONSTRUCTION

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**FIGURE 9.2-1**
TYPICAL STOCKPILE
AND SOIL PROCESSING LAYOUT

| | | | |
|---|---|---|---|
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| Prepared By: Foth & Van Dyke | By: JOW | | 93C049 |

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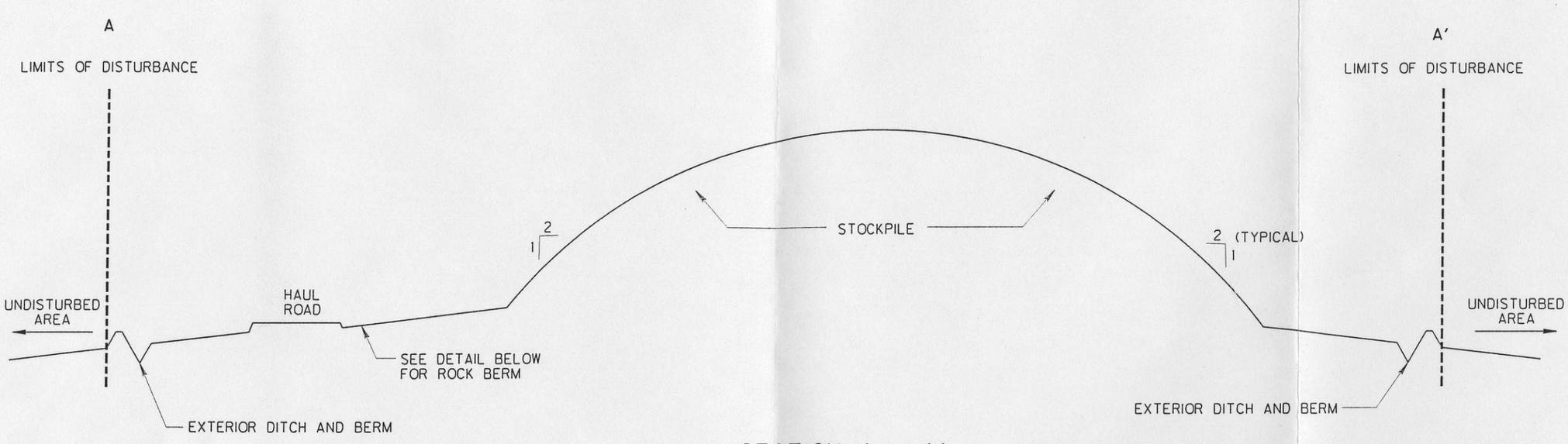
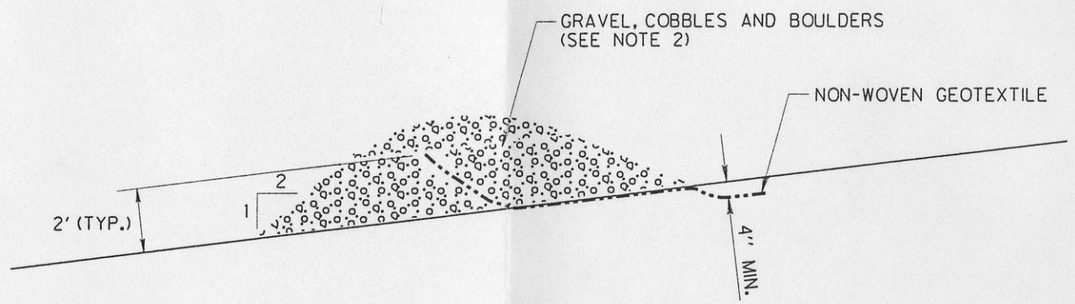



## SECTION A - A'




## TYPICAL ROCK BERM

NOTES:

1. TOE IN GEOTEXTILE A MINIMUM OF 4 INCHES BELOW THE EXISTING UP SLOPE GRADE.
2. MATERIAL COARSER THAN 2 INCH FROM SOIL PROCESSING.
3. SILT FENCE AS PER FIGURE 9.2-4 CAN BE SUBSTITUTED FOR THE ROCK BERM.

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

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FIGURE 9.2-2

CROSS SECTION A - A'

| | | | |
|---|---|---|---|
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| Prepared By: Foth & Van Dyke | By: JOW | | 93C049 |

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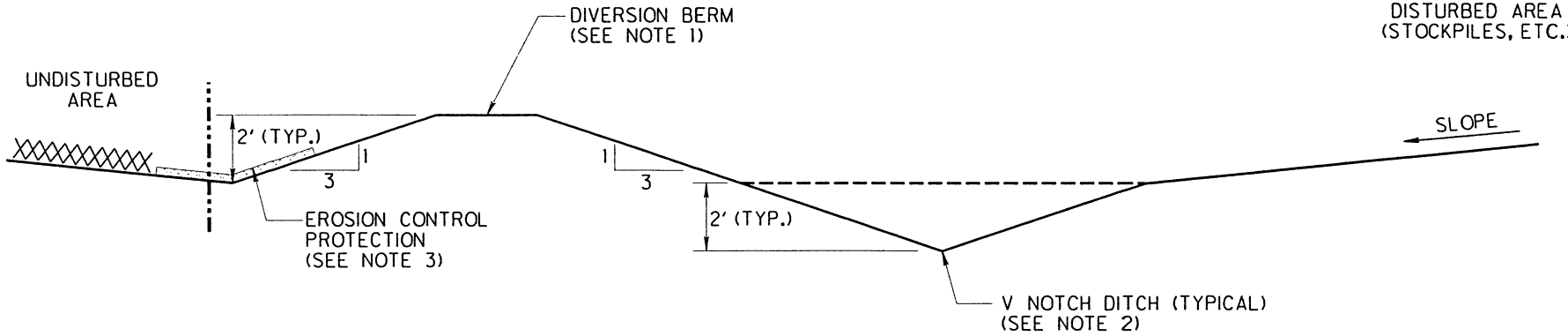


NOTES:

1. DIVERSION BERM AROUND THE STOCKPILE AREA TO BE CONSTRUCTED PRIOR TO STOCKPILING SOIL. DIVERSON BERM REQUIRED ONLY WHERE UNDISTURBED AREA SLOPES TOWARD THE STOCKPILE.

2. CONSTRUCT DIVERSION BERM WHERE REQUIRED WITH MATERIAL EXCAVATED FROM DITCH. PROVIDE EROSION CONTROL PROTECTION IN DITCH WHERE CALCULATIONS SHOW IT IS REQUIRED. FERTILIZE, SEED AND MULCH ENTIRE DITCH AND BERM.

3. PROVIDE EROSION CONTROL PROTECTION ON OUTER FACE OF DIVERSION BERM WHERE CALCULATIONS SHOW IT IS REQUIRED.

TYPICAL REPRESENTATION:
REFINEMENTS MAY BE MADE
PRIOR TO CONSTRUCTION

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| APPROVED BY: | GWS | DATE: | JAN, '97 |

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**FIGURE 9.2-3**

TYPICAL DIVERSION BERM
AND DITCH DETAIL

| | | | |
|---|---|---|---|
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| Prepared By: Foth & Van Dyke | | By: JOW | 93C049 |

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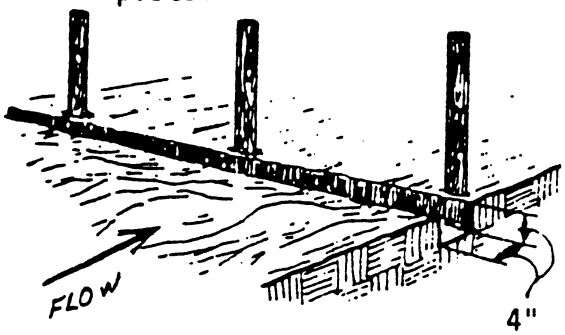
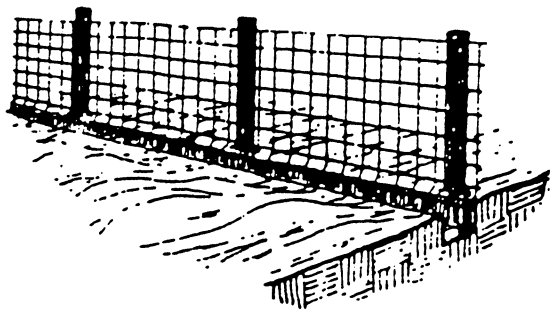
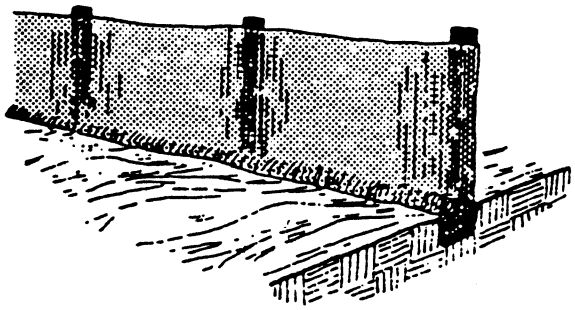
1. Set posts and excavate a 4"x4" trench upslope along the line of posts.



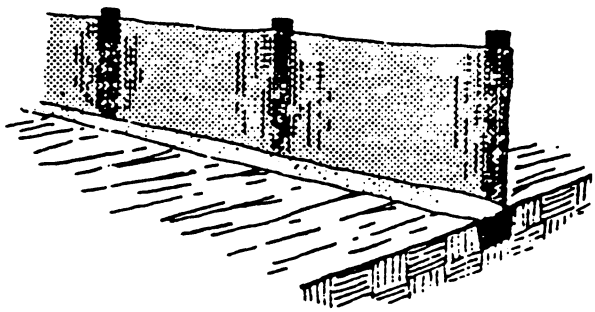

2. Staple wire fencing to the posts.



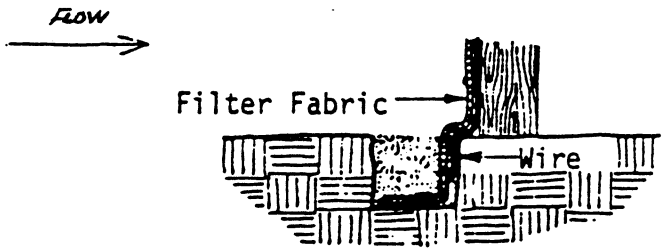
3. Attach the filter fabric to the wire fence and extend it into the trench.



4. Backfill and compact the excavated soil.



Extension of fabric and wire into the trench.




SOURCE:
ADAPTED FROM INSTALLATION OF STRAW AND FABRIC FILTER BARRIERS FOR SEDIMENT CONTROL, SHERWOOD AND WYANT

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

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FIGURE 9.2-4

TYPICAL CONSTRUCTION OF A SILT FENCE

| | | | |
|---|---|---|---|
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| Prepared By: Foth & Van Dyke | By: JOW | 93C049 | |

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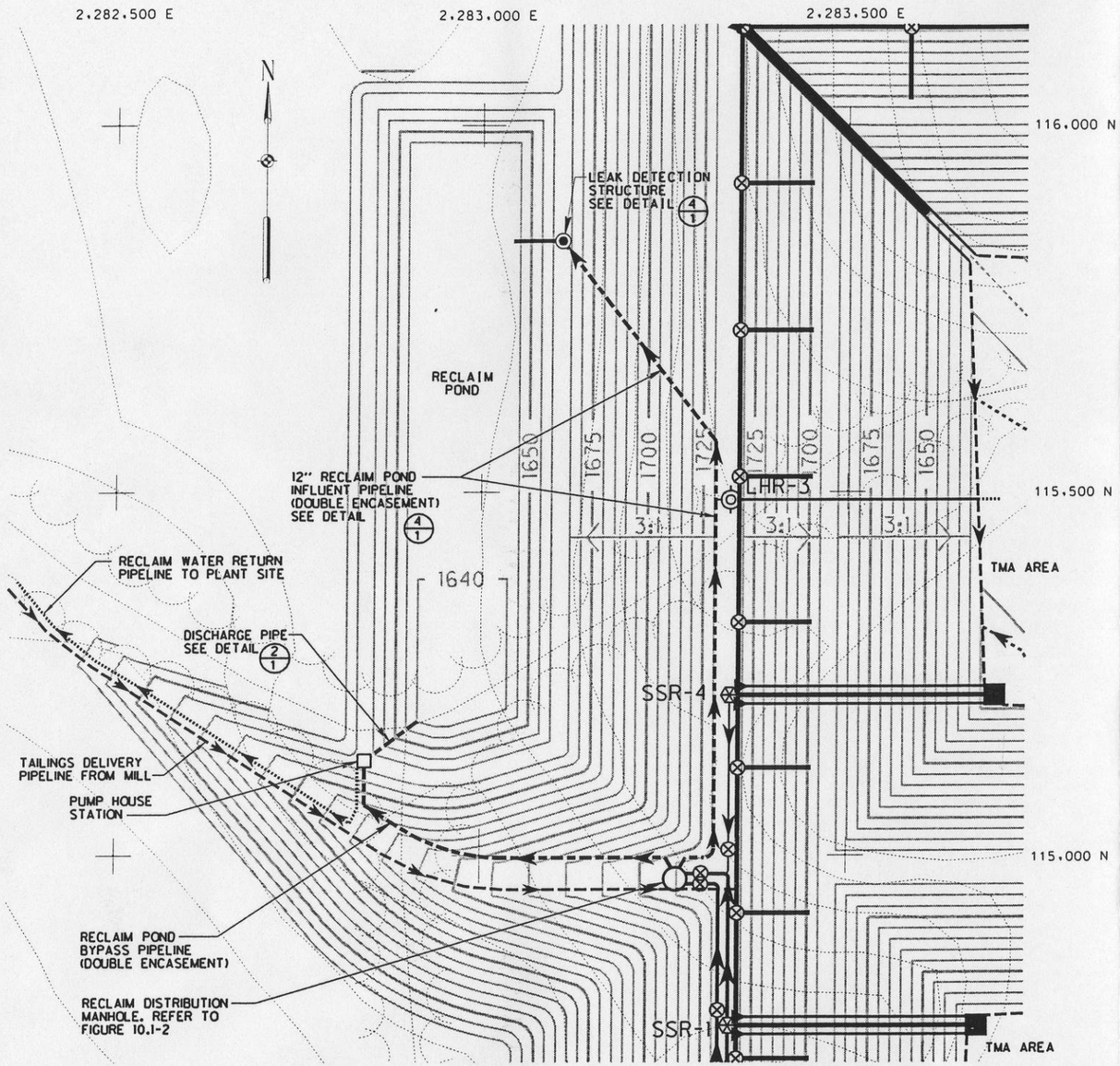
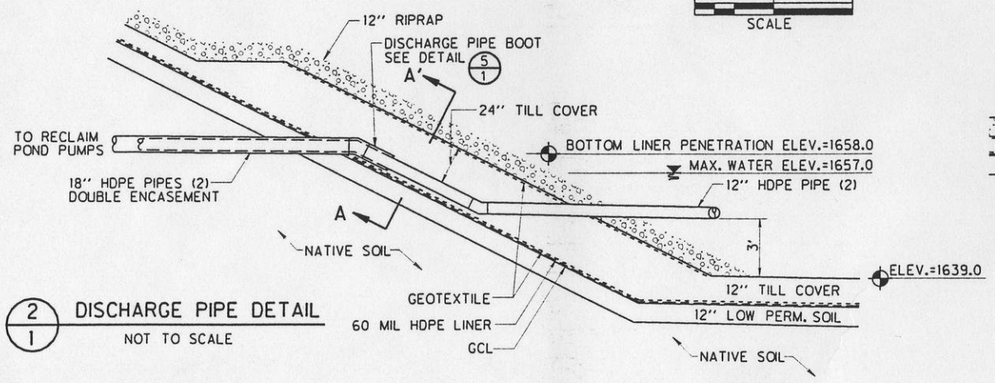


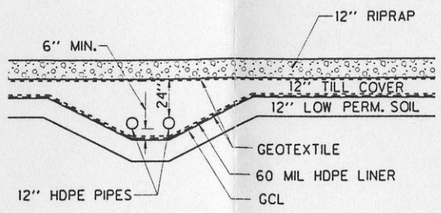

1/1 RECLAIM POND PLAN VIEW

0 100' 200'
SCALE



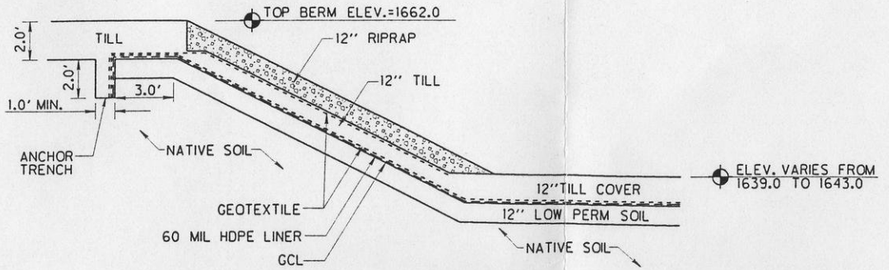

2/1 DISCHARGE PIPE DETAIL

NOT TO SCALE



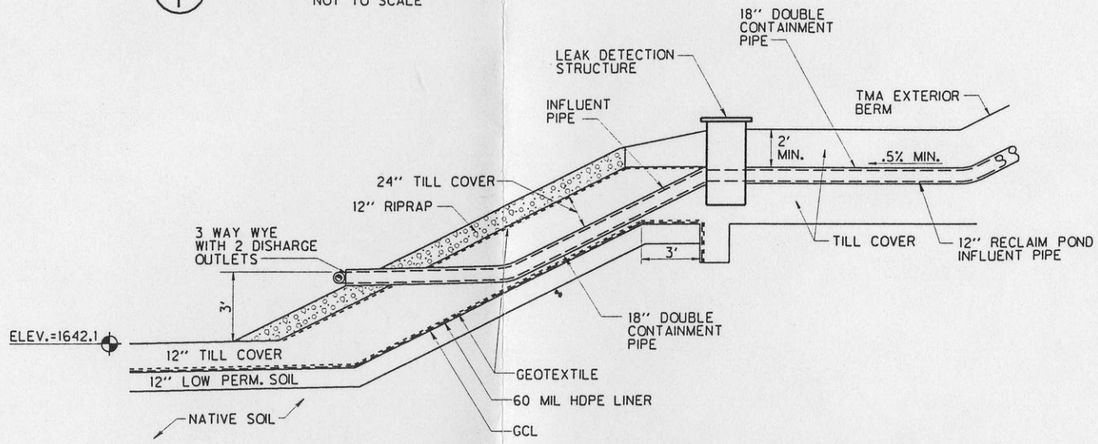

SECTION A - A'

NOT TO SCALE



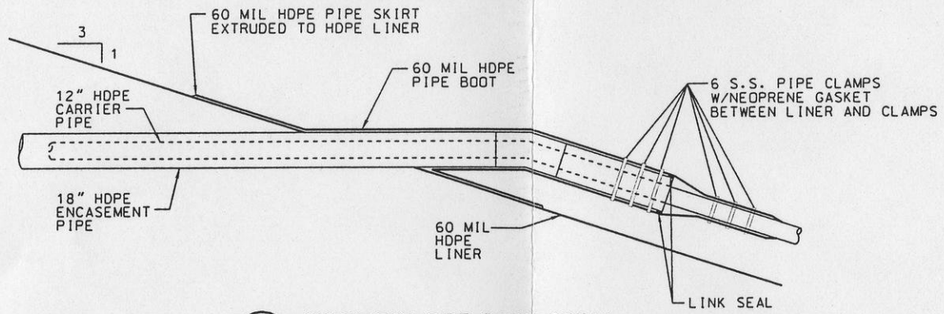

3/1 RECLAIM POND LINER DETAIL

NOT TO SCALE




4/1 RECLAIM POND INFLUENT PIPE DETAIL

NOT TO SCALE




5/1 DISCHARGE PIPE BOOT DETAIL

NOT TO SCALE

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

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# FIGURE 10.1-1

RECLAIM POND LINER AND PIPING PLAN

| | | | |
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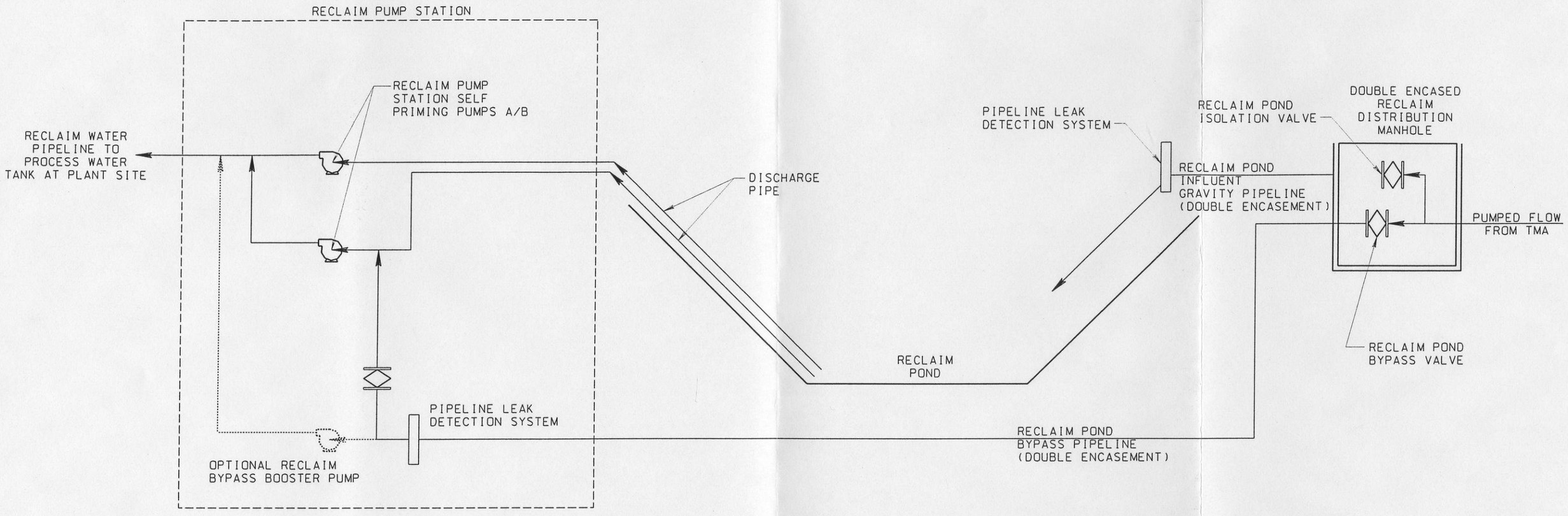


NOTE:

RECLAIM POND BYPASS MAY USE RECLAIM PUMPS AS AN ALTERNATIVE TO BOOSTER PUMP DEPENDING ON FINAL HYDRAULICS.

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

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FIGURE 10.1-2

PUMP STATION AND DISCHARGE PIPING

| | | | |
|---|---|---|---|
| Scale: NOT TO SCALE | | Date: OCTOBER, 1997 | |
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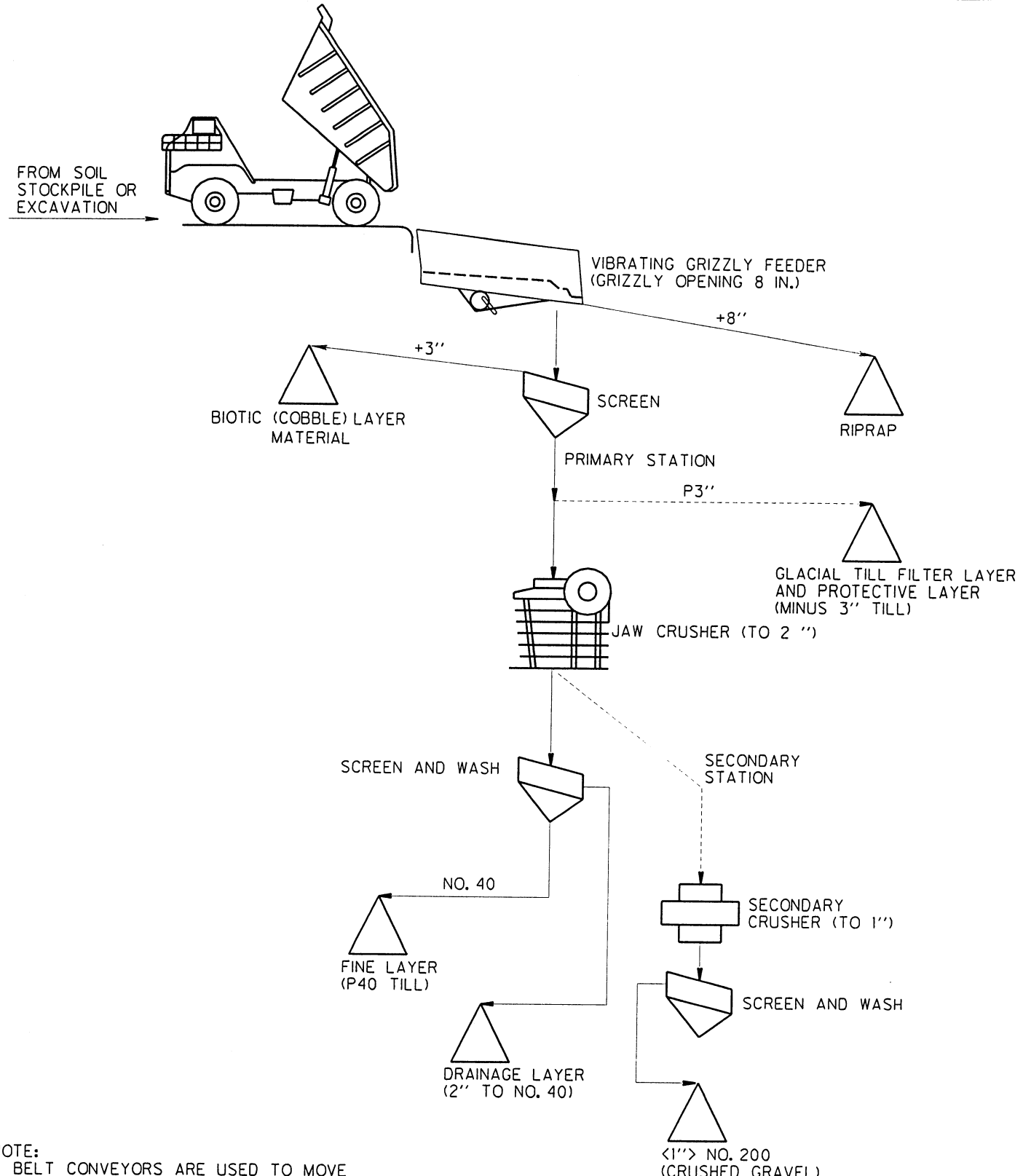


NOTE:
BELT CONVEYORS ARE USED TO MOVE MATERIALS BETWEEN PROCESSES AND STACK MATERIALS AT THE END OF EACH PROCESS LINE.

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

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FIGURE 12.2-1

TMA
FLOW CHART FOR SOIL PROCESSING

| | | | |
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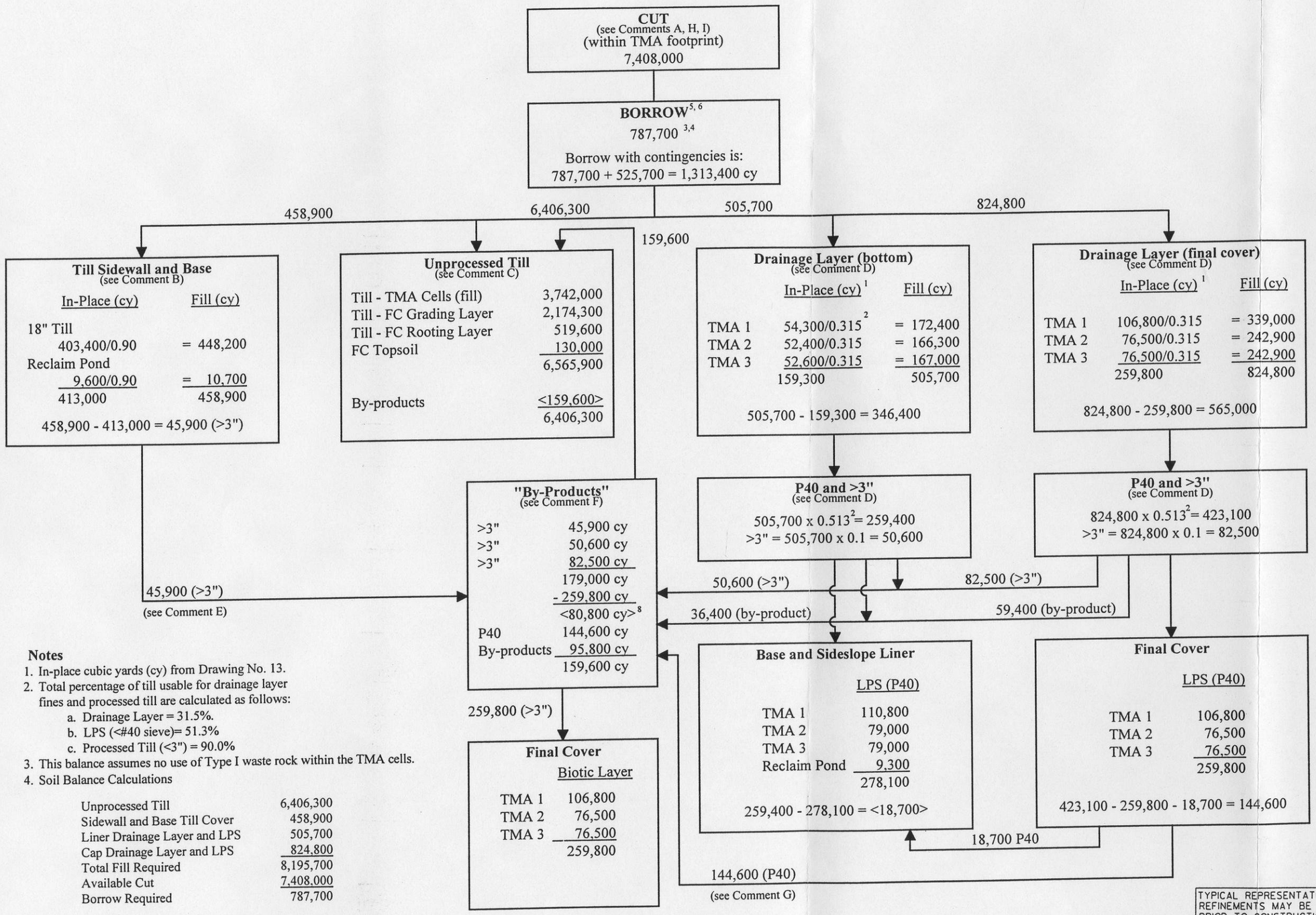


**Notes**

1. In-place cubic yards (cy) from Drawing No. 13.
2. Total percentage of till usable for drainage layer fines and processed till are calculated as follows:
   a. Drainage Layer = 31.5%.
   b. LPS (<#40 sieve)= 51.3%
   c. Processed Till (<3") = 90.0%
3. This balance assumes no use of Type I waste rock within the TMA cells.
4. Soil Balance Calculations

| | |
|---|---|
| Unprocessed Till | 6,406,300 |
| Sidewall and Base Till Cover | 458,900 |
| Liner Drainage Layer and LPS | 505,700 |
| Cap Drainage Layer and LPS | 824,800 |
| Total Fill Required | 8,195,700 |
| Available Cut | 7,408,000 |
| Borrow Required | 787,700 |

5. Contingency Calculations

Drainage Layer (processed soils)

| | |
|---|---|
| Final Cover | 824,800 |
| Liner LCS | 505,700 |
| | 1,330,500 x 0.15 = 199,600 |

Final Cover Soil (grading layer only)

Grading Layer, TMA 1-3
2,174,300 x 0.15 = 326,100
525,700

6. This earthwork balance is conservative since waste rock and demolition waste have not been considered as part of the available borrow materials of final cover and other uses.
7. LPS = Low Permeability Soil (P40)
8. Biotic layer shortage to be processed from 808,000 cy of unprocessed till.

**Comments**

A. Total cut from Table on Drawing No. 13.

B. Till screened to remove >3". Quantities from Drawing No. 13.

C. Quantity of unprocessed till required for construction of TMA and reclaim pond and closure of TMA. Includes a reduction in the quantity by the amount of "by-products" from soil processing.

D. Drainage layer and LPS (P40) quantities from Drawing No. 13. Calculation of soil required to manufacture drainage layer from Addendum No. 2, Attachment 11 (Foth & Van Dyke, 1996b).

E. >3" by-products to be used as fill.

F. Total by-products available for use as fill.

G. Excess P40 from processing (i.e., by-products) available for use as fill.

H. It is assumed that in-place densities prior to excavation will be achieved in the facilities.

I. Construction losses are negligible.

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

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FIGURE 12.2-2
TMA TOTAL EARTHWORK
BALANCE FLOW CHART

| | | | |
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# DRAWINGS FOR ADDENDUM NO. 5 TO THE MAY 1995 TAILINGS MANAGEMENT AREA FEASIBILITY REPORT/PLAN OF OPERATION

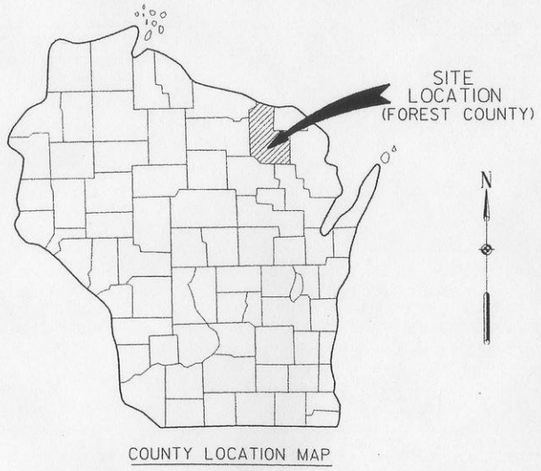
Nicolet Minerals COMPANY

# CRANDON PROJECT
# ADDENDUM NO. 5 TO THE FEASIBILITY REPORT / PLAN OF OPERATION
# TAILINGS MANAGEMENT AREA

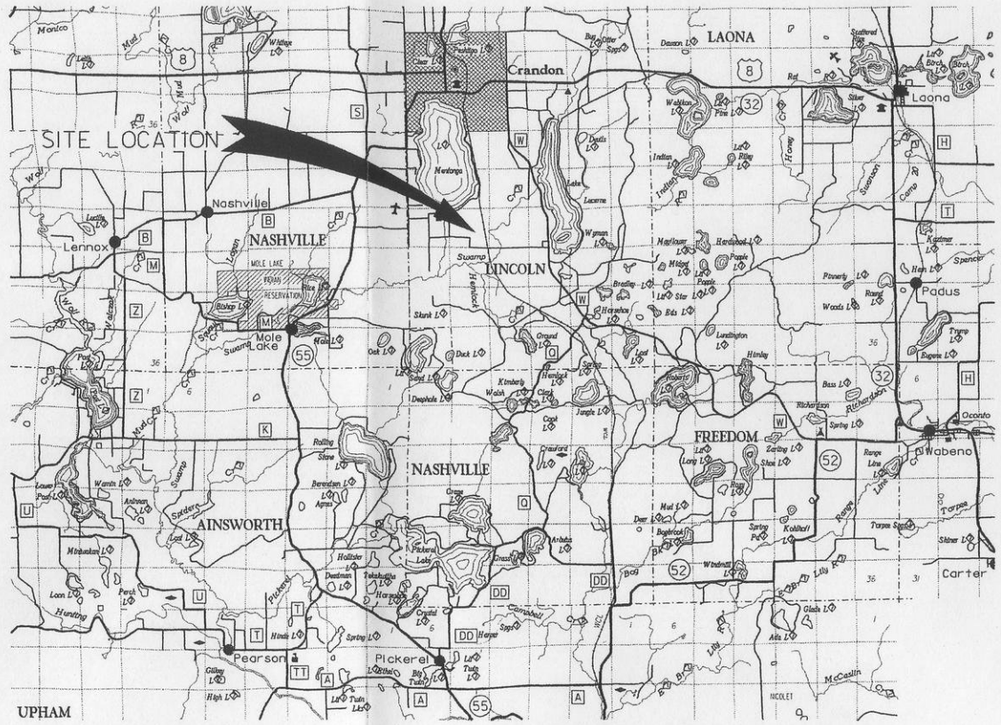
FOREST COUNTY, WISCONSIN

DECEMBER, 1998

**Foth & Van Dyke**




COUNTY LOCATION MAP




SITE LOCATION MAP

APPROX. SCALE: 1"=10,000'

| INDEX | |
|---|---|
| DRAWING NO. | DESCRIPTION |
| * 1 | TITLE SHEET |
| * 2 | EXISTING CONDITIONS - CRANDON PROJECT |
| * 3 | EXISTING CONDITIONS - TMA |
| 4 | GROUNDWATER TABLE CONTOUR MAP OCTOBER, 1994 |
| 5 | GEOLOGIC CROSS SECTION LOCATION MAP |
| 6 | GEOLOGIC CROSS SECTION F''-F''' |
| 7 | GEOLOGIC CROSS SECTION G''-G''' |
| 8 | GEOLOGIC CROSS SECTION H''-H''' |
| 9 | GEOLOGIC CROSS SECTION J''-J''' |
| 10 | GEOLOGIC CROSS SECTION K''-K''' |
| 11 | GEOLOGIC CROSS SECTION L''-L''' |
| 12 | GEOLOGIC CROSS SECTION O''-O''' |
| * 13 | SITE SEQUENCING PLAN |
| * 14 | SUBBASE GRADES |
| * 15 | BASE GRADES |
| * 16 | PIPING PLAN |
| * 17 | TOP OF TILL GRADES AND TAILINGS DISTRIBUTION PIPING |
| * 18 | FINAL GRADES |
| 19 | TMA-1, STAGE I PHASING PLAN |
| 20 | TMA-1, STAGE II PHASING PLAN |
| 21 | TMA-1, FINAL GRADES AND TMA-2, BASE GRADES |
| * 22 | DRAINAGE PLAN |
| * 23 | ENGINEERING CROSS SECTIONS |
| * 24 | ENGINEERING CROSS SECTIONS |
| * 25 | ENGINEERING CROSS SECTIONS |
| * 26 | ENGINEERING CROSS SECTIONS |
| * 27 | ENGINEERING CROSS SECTIONS |
| 28 | DETAILS |
| 29 | DETAILS |
| 30 | DETAILS |
| * 31 | DETAILS |

* DENOTES REVISED DRAWINGS AND FIGURES FOR ADDENDUM NO. 5 INCLUDED AS PART OF THIS DRAWING SET. DRAWINGS WITHOUT * ARE AS IN THE ORIGINAL FEASIBILITY REPORT/PLAN OF OPERATION OR AS MODIFIED BY SUBSEQUENT ADDENDA TO THAT REPORT.

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DENIS M. ROZNOWSKI
E-26946
DE PERE, WI
PROFESSIONAL ENGINEER
12-24-98

WISCONSIN
Nandakumaran Paruvakat
E-25845
Green Bay, Wis.
PROFESSIONAL ENGINEER
12-24-98

TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION



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LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- EXISTING CONTOUR
- SPOT ELEVATION
- SECTION LINE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- PROJECT AREA

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1"=1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS FIVE FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
5. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

0 2000' 4000'
SCALE

Foth & Van Dyke

| REVISED | DATE | BY | DESCRIPTION |
|---|---|---|---|
| | | | |

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

Nicolet Minerals COMPANY

TITLE
EXISTING CONDITIONS - CRANDON PROJECT

| | | | | | |
|---|---|---|---|---|---|
| SCALE AS SHOWN | STATE: WISCONSIN | | COUNTY FOREST | | |
| DRAWN BY JRB2 | DATE 12/98 | CHECKED BY DMR | DATE 12/98 | | |
| APPROVED BY NXP | DATE 12/98 | APPROVED BY NXP | DATE 12/98 | | |
| APPROVED BY GWS | DATE 12/98 | NICOLET MINERALS COMPANY KPB | DATE 12/98 | | |
| DRAWING NO. 2 | SHEET 2 OF 31 | REVISION NO. | | | |

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23 DEC 98 Jow

2,283,000 E

2,285,000 E

2,287,000 E

117,000 N

115,000 N

113,000 N

PROPOSED TMA ACCESS ROAD AND UTILITY CORRIDOR SEE NOTE NO. 6

PROPOSED TMA WATER SUPPLY WELL

TMA

DUCK

## 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)
- OXYGEN BOREHOLES NUMBER AND LOCATION
- TMA DISTURBANCE BOUNDARY

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.

0 300' 600'
SCALE

Nicolet Minerals COMPANY

Foth & Van Dyke

| REVISED | DATE | BY | DESCRIPTION |
|---|---|---|---|
| | | | |

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

TITLE: EXISTING CONDITIONS - TMA

| | | | |
|---|---|---|---|
| SCALE AS SHOWN | STATE: WISCONSIN | COUNTY FOREST | |
| DRAWN BY JRB2 | DATE 12/98 | CHECKED BY DMR | DATE 12/98 |
| APPROVED BY NXP | DATE 12/98 | APPROVED BY NXP | DATE 12/98 |
| APPROVED BY GWS | DATE 12/98 | NICOLET MINERALS COMPANY KPB | DATE 12/98 |
| DRAWING NO. 3 | | SHEET 3 OF 31 | REVISION NO. |

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23 DEC 98 jow

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## SITE PREPARATION /OPERATION

| CELL | STAGE | MINE WASTE VOLUME (CY) | EARTHWORK (CY) CUT (1) | EARTHWORK (CY) FILL | 12" LPS LAYER (CY) | GEOMEMBRANE AND GCL (SF) (3) | GEOTEXTILE (CUSHIONING) (SF) | 24" DRAINAGE LAYER (CY) | GEOCOMPOSITE (DRAINAGE) (SF) | 18" TILL LAYER (CY) | 18" RIPRAP LAYER (CY) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1A | I | 1,000,000 | 1,217,000 | 430,000 | 37,400 | 1,011,100 | 369,500 | 27,400 | 641,500 | 56,100 | 25,100 |
| 1B | II | 1,220,000 | 1,131,000 | 1,624,900 | 38,600 | 1,043,500 | 362,500 | 26,900 | 681,000 | 57,900 | 24,300 |
| 1 | III | 3,840,000 | 767,700 | 713,100 | 34,800 | 938,800 | N.A. | N.A. | 936,800 | 52,200 | N.A. |
| 2 | IV | 1,390,000 | 1,418,300 | 461,000 | 52,100 | 1,407,900 | 707,200 | 52,400 | 700,700 | 78,200 | 45,200 |
| 2 | V | 2,630,000 | 563,800 | 194,000 | 26,900 | 725,900 | N.A. | N.A. | 725,900 | 40,400 | N.A. |
| 3 | VI | 1,400,000 | 2,307,200 | 223,600 | 52,300 | 1,412,000 | 709,700 | 52,600 | 702,300 | 78,500 | 45,300 |
| 3 | VII | 2,620,000 | 3,000 | 95,400 | 26,700 | 721,600 | N.A. | N.A. | 721,600 | 40,100 | N.A. |
| RECLAIM POND | | N.A. | (2) | (2) | 9,300 | 250,000 | N.A. | N.A. | N.A. | 9,600 (4) | 7,600 (5) |
| TOTALS | | 14,100,000 | 7,408,000 | 3,742,000 | 278,100 | 7,510,800 | 2,148,900 | 159,300 | 5,109,800 | 413,000 | 147,500 |

(CY) - CUBIC YARDS
(SF) - SQUARE FEET
GCL - GEOSYNTHETIC CLAY LINER
LPS - LOW PERMEABILITY SOILS
N.A. - NOT APPLICABLE

ALL VALUES ARE IN-PLACE QUANTITIES W/O CONTINGENCIES

(1) INCLUDES TOPSOIL

(2) RECLAIM POND EARTHWORK QUANTITIES ARE INCLUDED IN CELL 1A, STAGE I QUANTITIES

(3) GEOMEMBRANE AND GCL HAVE THE SAME AREA

(4) TILL COVER IN RECLAIM POND IS 12 INCHES AT THE BASE AND ON THE SIDE WALLS EXCEPT OVER DISCHARGE PIPE

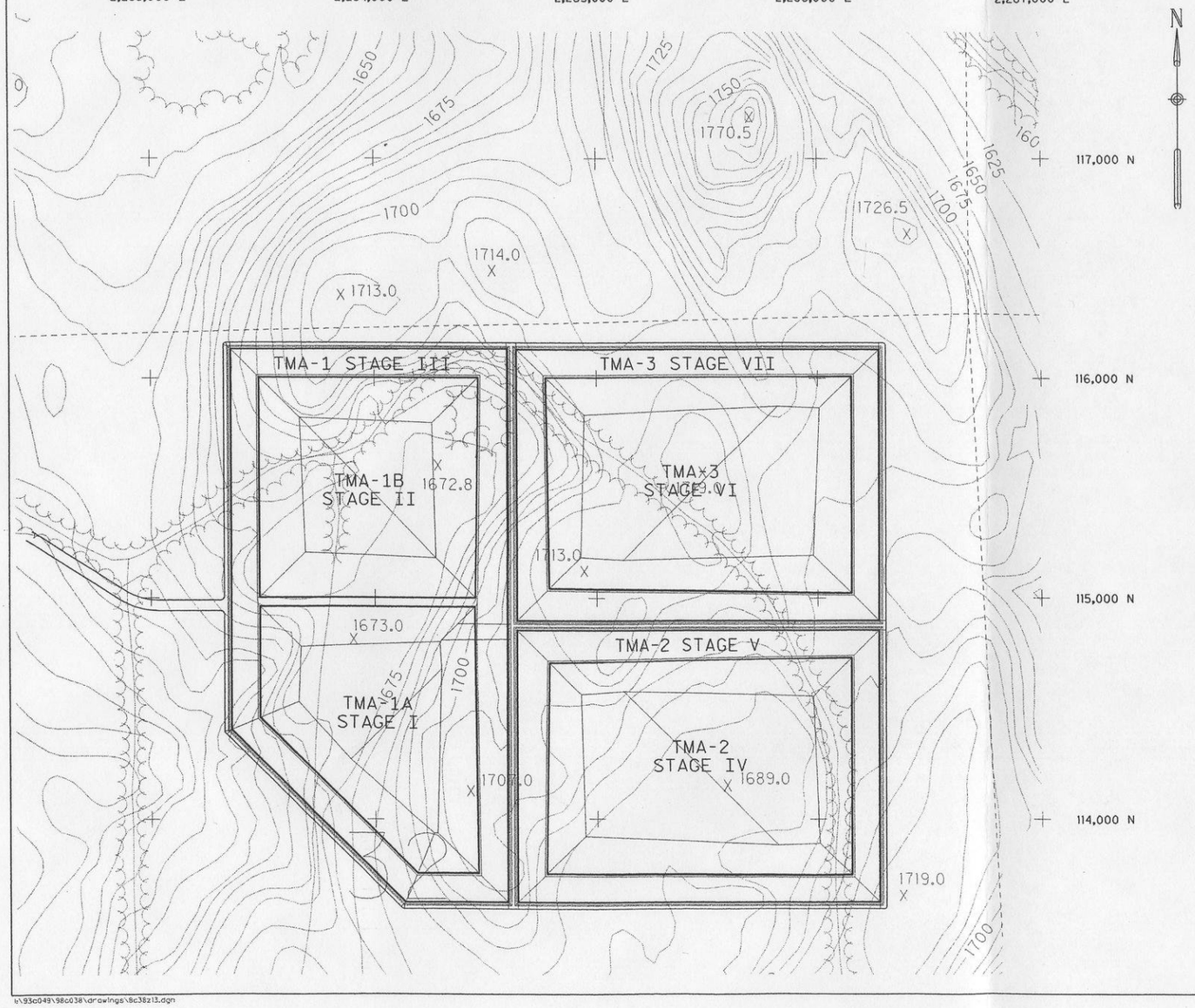
(5) RIPRAP IN RECLAIM POND IS ON THE SIDE WALLS ONLY (18 IN). 136,000 SF OF GEOTEXTILE IS REQUIRED BENEATH RIPRAP.

## CLOSURE

| CELL | STAGE | GRADING LAYER (CY) (1) | 12" LPS LAYER (CY) | GEOMEMBRANE (SF) | GEOTEXTILE (SF) | 12" DRAINAGE LAYER (CY) | 12" BIOTIC LAYER (CY) | 24" ROOTING LAYER (CY) | 6" TOPSOIL LAYER (CY) |
|---|---|---|---|---|---|---|---|---|---|
| 1A | I | N.A. | N.A. | N.A. | N.A. | N.A. | N.A. | N.A. | N.A. |
| 1B | II | N.A. | N.A. | N.A. | N.A. | N.A. | N.A. | N.A. | N.A. |
| 1 | III | 913,500 | 106,800 | 2,883,000 | 2,883,000 | 106,800 | 106,800 | 213,600 | 53,400 |
| 2 | IV | N.A. | N.A. | N.A. | N.A. | N.A. | N.A. | N.A. | N.A. |
| 2 | V | 630,400 | 76,500 | 2,065,000 | 2,065,000 | 76,500 | 76,500 | 153,000 | 38,300 |
| 3 | VI | N.A. | N.A. | N.A. | N.A. | N.A. | N.A. | N.A. | N.A. |
| 3 | VII | 630,400 | 76,500 | 2,065,000 | 2,065,000 | 76,500 | 76,500 | 153,000 | 38,300 |
| TOTALS | | 2,174,300 | 259,800 | 7,013,000 | 7,013,000 | 259,800 | 259,800 | 519,600 | 130,000 |

(1) GRADING LAYER MATERIAL MAY INCLUDE WASTE ROCK, TILL SOIL OR OTHER MATERIALS.

(CY) - CUBIC YARDS
(SF) - SQUARE FEET
LPS - LOW PERMEABILITY SOILS
N.A. - NOT APPLICABLE




NOTES:

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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
- SECTION LINE

SCALE
0 300' 600'

Foth & Van Dyke

| REVISED | DATE | BY | DESCRIPTION |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

Nicolet Minerals COMPANY

TITLE: SITE SEQUENCING PLAN

| | | | |
|---|---|---|---|
| SCALE: AS SHOWN | STATE: WISCONSIN | COUNTY: FOREST | |
| DRAWN BY: JRB2 | DATE: 12/98 | CHECKED BY: DMR | DATE: 12/98 |
| APPROVED BY: NXP | DATE: 12/98 | APPROVED BY: NXP | DATE: 12/98 |
| APPROVED BY: GWS | DATE: 12/98 | NICOLET MINERALS COMPANY: KPB | DATE: 12/98 |
| DRAWING NO.: 13 | SHEET 13 OF 31 | | REVISION NO. |

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23 DEC 98 jrb2

2,283,000 E
2,284,000 E
2,285,000 E
2,286,000 E
117,000 N
116,000 N
115,000 N
114,000 N

RECLAIM POND

PROPOSED SEPARATION BERM
SEE FIGURE 4.4-2

PROPOSED SUMP
SEE FIGURE 6.6-1

PROPOSED INTERIOR BERM
SEE DETAIL 5/28

PROPOSED PERIMETER BERM
SEE DETAIL 1/28

PROPOSED BENCH BERM
SEE DETAILS 3/28 4/28

LEGEND

- STREAMS
- EXISTING ROAD
- 1675 EXISTING CONTOUR
- 1692.0 X SPOT ELEVATION
- SECTION LINE
- 1725 PROPOSED CONTOUR (SUBBASE GRADE)
- 3:1 PROPOSED SLOPE RATIO (TYP.)
- 2% PROPOSED SLOPE (TYP.)
- 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 SUBBASE GRADES. (BOTTOM OF 1' LOW PERMEABILITY SOIL LAYER).

SCALE
0 200' 400'

Foth & Van Dyke

| REVISED | DATE | BY | DESCRIPTION |
|---|---|---|---|
| | | | |

TYPICAL REPRESENTATION:
REFINEMENTS MAY BE MADE
PRIOR TO CONSTRUCTION

Nicolet Minerals COMPANY

TITLE
SUBBASE GRADES

| | | | | | |
|---|---|---|---|---|---|
| SCALE AS SHOWN | STATE: WISCONSIN | | COUNTY FOREST | | |
| DRAWN BY JRB2 | DATE 12/98 | CHECKED BY DMR | DATE 12/98 | | |
| APPROVED BY NXP | DATE 12/98 | APPROVED BY NXP | DATE 12/98 | | |
| APPROVED BY GWS | DATE 12/98 | NICOLET MINERALS COMPANY KPB | DATE 12/98 | | |
| DRAWING NO. 14 | SHEET 14 OF 31 | REVISION NO. | | | |

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23 DEC 98 Jow

2,283,000 E | 2,284,000 E | 2,285,000 E | 2,286,000 E

117,000 N | 116,000 N | 115,000 N | 114,000 N

N

## LEGEND

- STREAMS
- EXISTING ROAD
- 1675 — EXISTING CONTOUR
- 1692.0 X — SPOT ELEVATION
- SECTION LINE
- 1725 — PROPOSED CONTOUR (BASE GRADE)
- 3:1 — PROPOSED SLOPE RATIO (TYP.)
- 2% — PROPOSED SLOPE (TYP.)
- ■ PROPOSED SUMP LOCATION

RECLAIM POND

PROPOSED INTERIOR BERM SEE DETAIL 5/28

PROPOSED PERIMETER BERM SEE DETAIL 1/28

PROPOSED BENCH BERM SEE DETAILS 3/28 4/28

PROPOSED SEPARATION BERM SEE FIGURE 4.4-2

PROPOSED SUMP SEE FIGURE 6.6-1

1647.0 X | 1714.0 X | 1713.0 X | 1726.5 X | 1719.0 X | 1673.0 X | 1689.0 X | 1683.0 X | 1685.5 X | 1683.0 X | 1718.0 X | 1719.0 X

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).

SCALE
0 200' 400'

Nicolet Minerals COMPANY

Foth & Van Dyke

| REVISED | DATE | BY | DESCRIPTION |
|---|---|---|---|
| | | | |

TYPICAL REPRESENTATION:
REFINEMENTS MAY BE MADE
PRIOR TO CONSTRUCTION

TITLE: BASE GRADES

| | | | | | |
|---|---|---|---|---|---|
| SCALE: AS SHOWN | STATE: WISCONSIN | | COUNTY: FOREST | | |
| DRAWN BY: JRB2 | DATE: 12/98 | CHECKED BY: DMR | DATE: 12/98 | | |
| APPROVED BY: NXP | DATE: 12/98 | APPROVED BY: NXP | DATE: 12/98 | | |
| APPROVED BY: GWS | DATE: 12/98 | NICOLET MINERALS COMPANY: KPB | DATE: 12/98 | | |
| DRAWING NO.: 15 | SHEET 15 OF 31 | REVISION NO. | | | |

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2,283,000 E
2,284,000 E
2,285,000 E
2,286,000 E
117,000 N
116,000 N
115,000 N
114,000 N

PROPOSED RECLAIM POND INFLUENT PIPELINE (DOUBLE ENCASEMENT) SEE FIGURE 10.1-1

PROPOSED SIDESLOPE RISER AND SUMP SEE FIGURE 6.6-1

PROPOSED PUMP HOUSE STATION

PROPOSED RECLAIM POND BYPASS PIPELINE (DOUBLE ENCASED)

PROPOSED RECLAIM DISTRIBUTION MANHOLE. REFER TO FIGURE 10.1-2

PROPOSED RECLAIM PIPING AT PERIMETER BERM SEE DETAIL 6/29

PROPOSED TYPICAL DOUBLE LEACHATE CLEANOUT. REFER TO FUGURE 6.5-1

PROPOSED RECLAIM PIPE SEE DETAIL 3/28

PROPOSED 6" PERFORATED LEACHATE COLLECTION PIPE FIGURE 5.3-1

PROPOSED 4" LEACHATE COLLECTION LATERAL SEE DETAIL 7/29

PROPOSED DECANT STRUCTURE SEE DETAIL 3/30

PROPOSED 4" LEACHATE FORCEMAIN SEE DETAIL 5/28

PROPOSED SIDE SLOPE RISER SEE DETAILS 1/30

PROPOSED LEACHATE HEAD MONITORING RISER. REFER TO FIGURE 6.5-2

RECLAIM POND

SSR-1 SSR-2 SSR-3 SSR-4 SSR-5 SSR-6 SSR-7 SSR-8

LHR-1 LHR-2 LHR-3 LHR-4 LHR-5 LHR-6 LHR-7 LHR-8

1647.0 X
1714.0 X
1713.0 X
1726.5 X
1719.0 X
1683.0 X
1685.5 X
1718.0 X

## LEGEND

- EXISTING ROAD
- 1675 EXISTING CONTOUR
- 1692.0 X SPOT ELEVATION
- SECTION LINE
- 1725 PROPOSED CONTOUR (BASE GRADE)
- 3:1 PROPOSED SLOPE RATIO (TYP.)
- 2% PROPOSED SLOPE (TYP.)
- PROPOSED RECLAIM PIPE
- PROPOSED LEACHATE FORCEMAIN
- PROPOSED 4" LEACHATE PIPE
- PROPOSED 6" PERFORATED LEACHATE COLLECTION PIPE
- PROPOSED DECANT STRUCTURE
- PROPOSED VALVE
- LHR-8 PROPOSED LEACHATE HEAD MONITORING RISER
- SSR-8 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.
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3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS FIVE FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
5. THIS DRAWING SHOWS CONTOURS DEPICTING SITE BASE GRADES. (TOP OF 1' LOW PERMEABILITY SOIL LAYER).

SCALE
0 200' 400'

Nicolet Minerals COMPANY

Foth & Van Dyke

| REVISED | DATE | BY | DESCRIPTION |
|---|---|---|---|
| | | | |

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

TITLE: PIPING PLAN

| | | | | | |
|---|---|---|---|---|---|
| SCALE AS SHOWN | STATE: WISCONSIN | | COUNTY FOREST | | |
| DRAWN BY JRB2 | DATE 12/98 | CHECKED BY DMR | DATE 12/98 | | |
| APPROVED BY NXP | DATE 12/98 | APPROVED BY NXP | DATE 12/98 | | |
| APPROVED BY GWS | DATE 12/98 | NICOLET MINERALS COMPANY KPB | DATE 12/98 | | |
| DRAWING NO. 16 | SHEET 16 OF 31 | REVISION NO. | | | |

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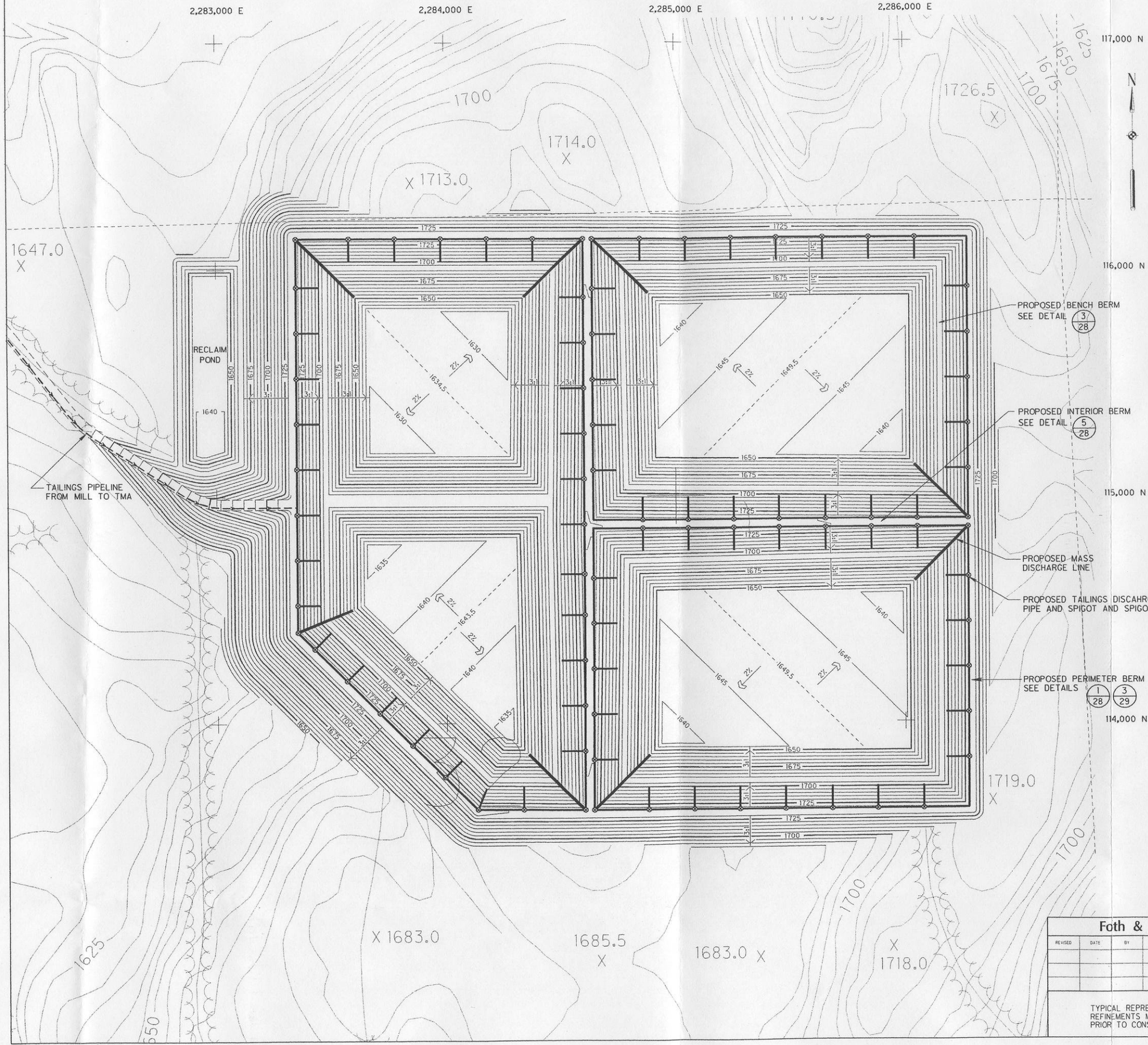


LEGEND

- STREAMS
- EXISTING ROAD
- 1675 — EXISTING CONTOUR
- 1692.0 X — SPOT ELEVATION
- SECTION LINE
- 1725 — PROPOSED CONTOUR (TOP OF TILL GRADE)
- 3:1 — PROPOSED SLOPE RATIO (TYP.)
- 2% — PROPOSED SLOPE (TYP.)
- ⊗ PROPOSED VALVE
- PROPOSED MASS DISCHARGE LINE
- PROPOSED TAILINGS DISCHARGE PIPELINE AND SPIGOT ARRANGEMENT
- PROPOSED TAILINGS PIPELINE FROM MILL TO TMA

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1"=1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
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3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS FIVE FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
5. THIS DRAWING SHOWS CONTOURS DEPICTING SITE TOP OF TILL GRADES. (TOP OF 18" TILL LAYER).

SCALE
0 200' 400'

TYPICAL REPRESENTATION:
REFINEMENTS MAY BE MADE
PRIOR TO CONSTRUCTION

Foth & Van Dyke

| REVISED | DATE | BY | DESCRIPTION |
|---|---|---|---|
| | | | |

Nicolet Minerals COMPANY

TITLE
TOP OF TILL GRADES AND
TAILINGS DISTRIBUTION PIPING

| | | | | | |
|---|---|---|---|---|---|
| SCALE AS SHOWN | STATE: WISCONSIN | | COUNTY FOREST | | |
| DRAWN BY JRB2 | DATE 12/98 | CHECKED BY DMR | DATE 12/98 | | |
| APPROVED BY NXP | DATE 12/98 | APPROVED BY NXP | DATE 12/98 | | |
| APPROVED BY GWS | DATE 12/98 | NICOLET MINERALS COMPANY KPB | DATE 12/98 | | |
| DRAWING NO. 17 | SHEET 17 OF 31 | REVISION NO. | | | |

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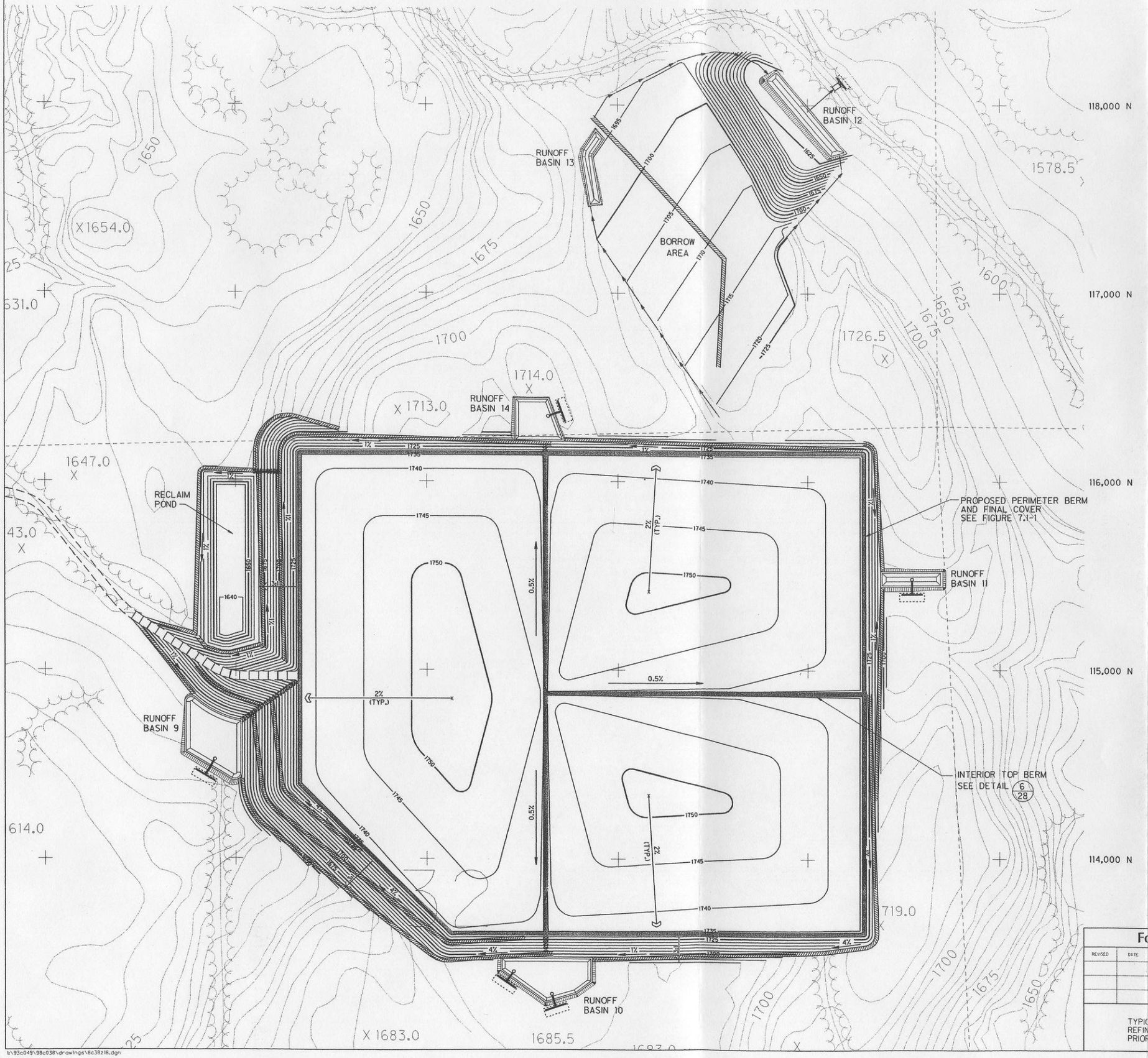
23 DEC 98 jrb2

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## LEGEND

- EXISTING ROAD
- 1675 — EXISTING CONTOUR
- 1692.0 X — SPOT ELEVATION
- SECTION LINE
- 1725 — PROPOSED CONTOUR (FINAL GRADE)
- 3:1 — PROPOSED SLOPE RATIO (TYP.)
- 2% — PROPOSED SLOPE (TYP.)
- PROPOSED SPILLWAY
- PROPOSED SURFACE WATER DIVERSION BERM

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1"=1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
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3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS FIVE FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
5. THIS DRAWING SHOWS CONTOURS DEPICTING SITE FINAL GRADES. (TOP OF FINAL COVER).

SCALE
0 250' 500'

Nicolet Minerals COMPANY

Foth & Van Dyke

| REVISED | DATE | BY | DESCRIPTION |
|---|---|---|---|
| | | | |

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

TITLE: FINAL GRADES

| | | | | | |
|---|---|---|---|---|---|
| SCALE AS SHOWN | STATE: WISCONSIN | | COUNTY FOREST | | |
| DRAWN BY JRB2 | DATE 12/98 | CHECKED BY DMR | DATE 12/98 | | |
| APPROVED BY NXP | DATE 12/98 | APPROVED BY NXP | DATE 12/98 | | |
| APPROVED BY GWS | DATE 12/98 | NICOLET MINERALS COMPANY KPB | DATE 12/98 | | |
| DRAWING NO. 18 | SHEET 18 OF 31 | REVISION NO. | | | |

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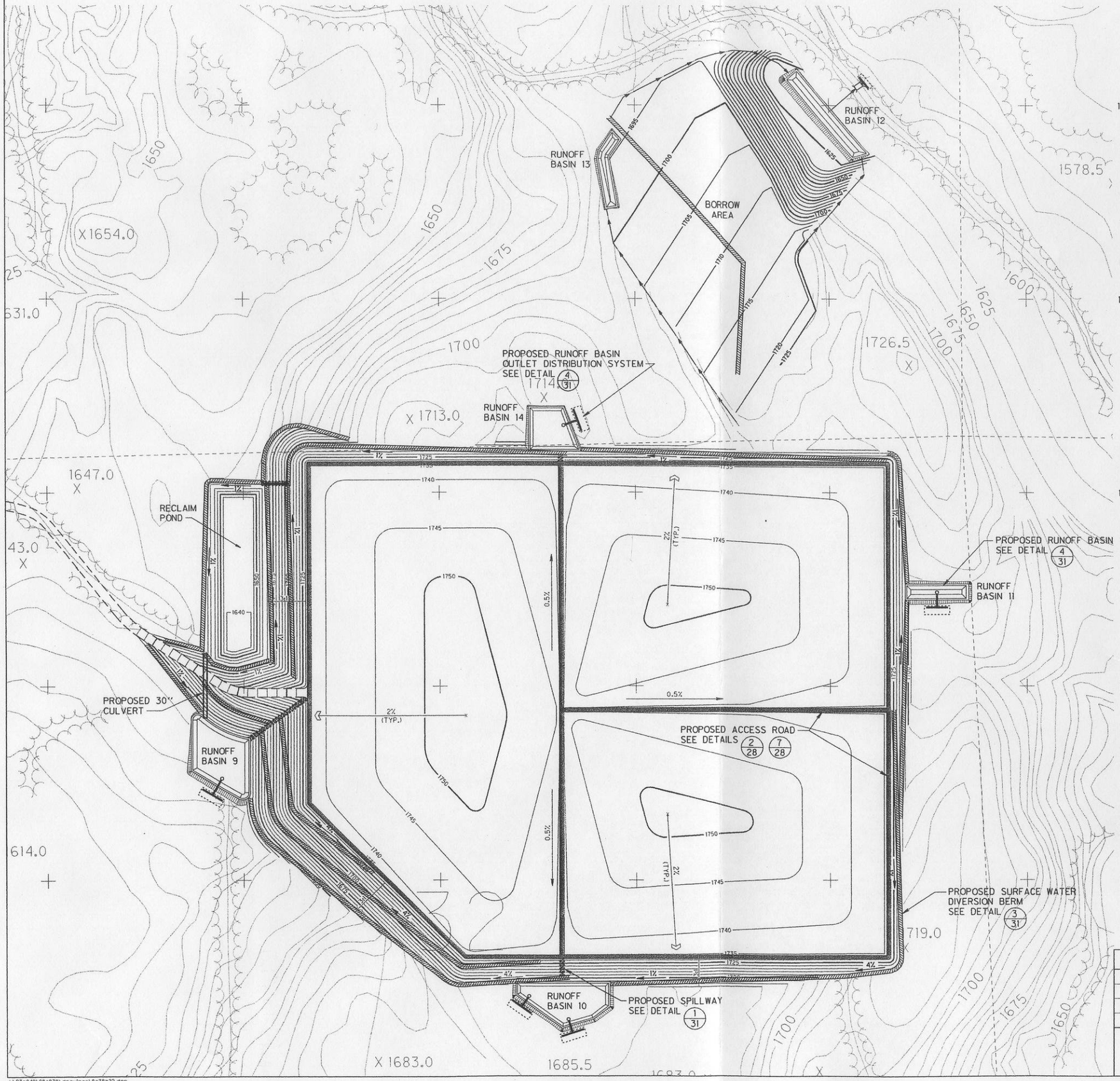
23 DEC 98 jrb2




N

## LEGEND

- EXISTING ROAD
- 1675 — EXISTING CONTOUR
- 1692.0 X — SPOT ELEVATION
- SECTION LINE
- 1725 — PROPOSED CONTOUR (FINAL GRADE)
- 3:1 — PROPOSED SLOPE RATIO (TYP.)
- 2% — PROPOSED SLOPE (TYP.)
- PROPOSED SURFACE WATER DIVERSION BERM
- PROPOSED SPILLWAY
- PROPOSED DRAINAGE OUTLET
- 0.5% — FLOW DIRECTION
- PROPOSED RUNOFF BASIN PIPING DISTRIBUTION FIELD
- PROPOSED CULVERT

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 FINAL GRADES. (TOP OF FINAL COVER).

0 250' 500'
SCALE

Nicolet Minerals COMPANY

Foth & Van Dyke

| REVISED | DATE | BY | DESCRIPTION |
|---|---|---|---|
| | | | |

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

TITLE: DRAINAGE PLAN

| | | | |
|---|---|---|---|
| SCALE AS SHOWN | STATE: WISCONSIN | | COUNTY: FOREST |
| DRAWN BY: JRB2 | DATE: 12/98 | CHECKED BY: DMR | DATE: 12/98 |
| APPROVED BY: NXP | DATE: 12/98 | APPROVED BY: NXP | DATE: 12/98 |
| APPROVED BY: GWS | DATE: 12/98 | NICOLET MINERALS COMPANY: KPB | DATE: 12/98 |
| DRAWING NO.: 22 | | SHEET 22 OF 31 | REVISION NO. |

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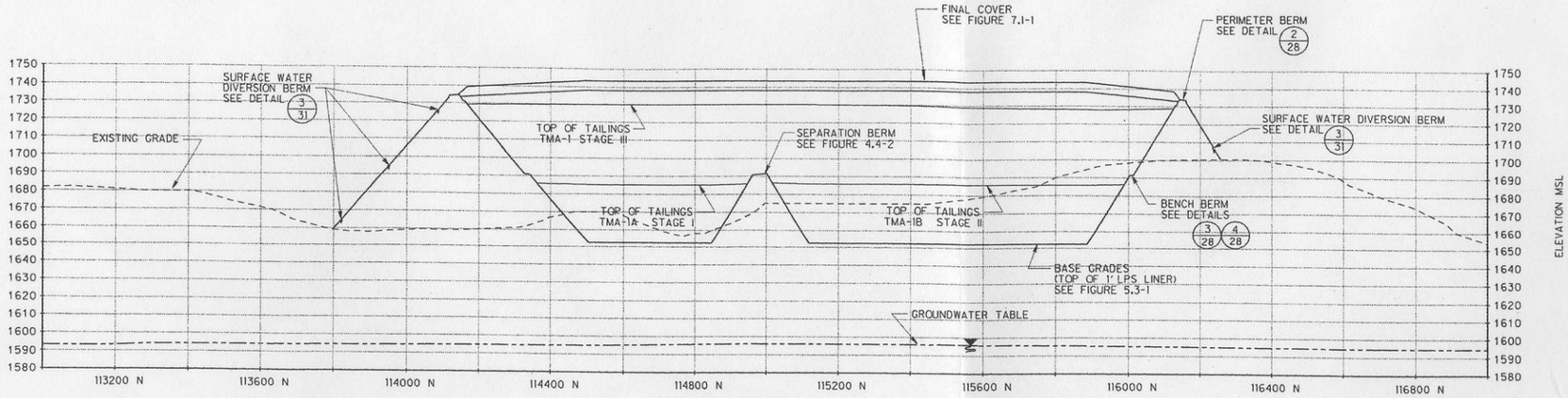
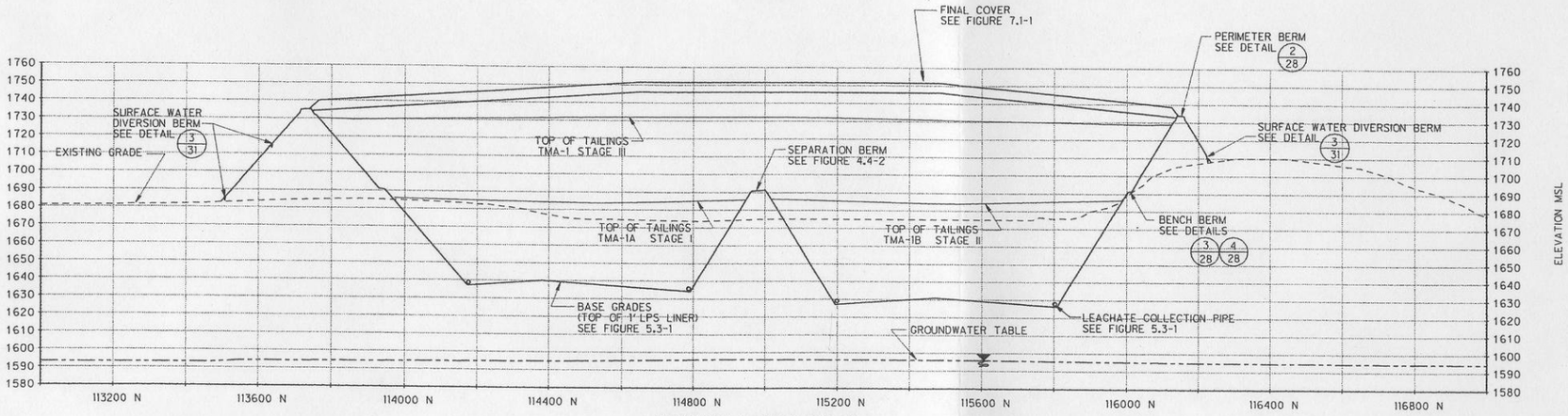
23 DEC 98 jrg2




SECTION 2,283,600 E

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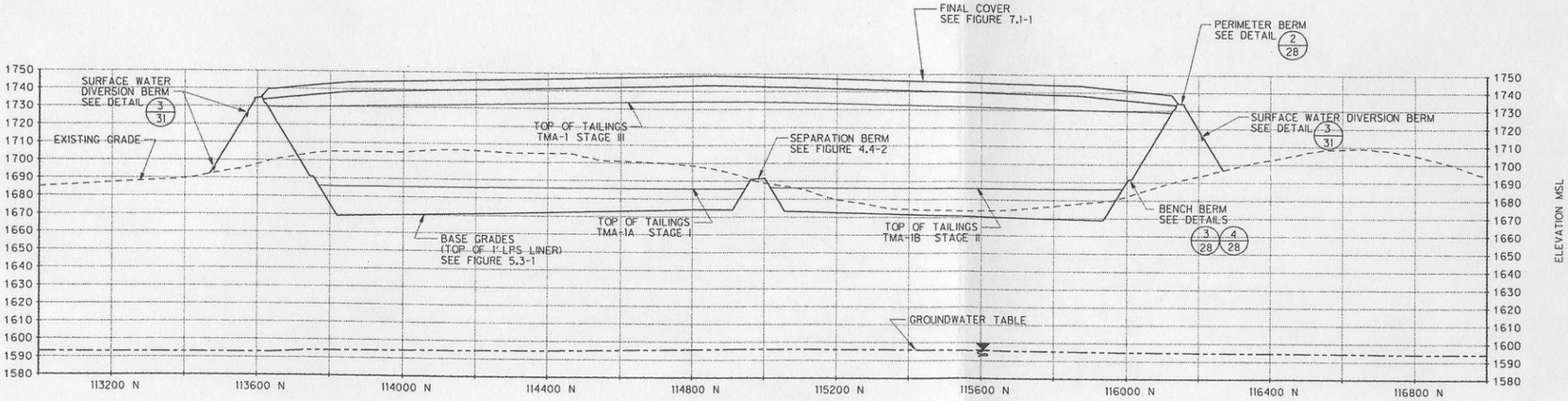


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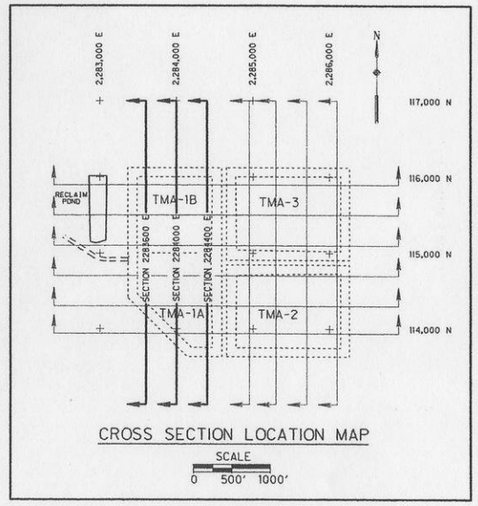
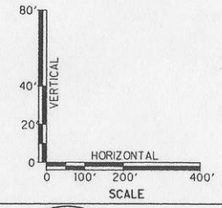



CROSS SECTION LOCATION MAP

SCALE
0 500' 1000'




SCALE

Nicolet Minerals COMPANY

Foth & Van Dyke

| REVISED | DATE | BY | DESCRIPTION |
|---|---|---|---|
| | | | |

TYPICAL REPRESENTATION:
REFINEMENTS MAY BE MADE
PRIOR TO CONSTRUCTION

TITLE
ENGINEERING CROSS SECTIONS

| | | | | | |
|---|---|---|---|---|---|
| SCALE AS SHOWN | STATE: WISCONSIN | | COUNTY FOREST | | |
| DRAWN BY JRB2 | DATE 12/98 | CHECKED BY DMR | DATE 12/98 | | |
| APPROVED BY NXP | DATE 12/98 | APPROVED BY NXP | DATE 12/98 | | |
| APPROVED BY GWS | DATE 12/98 | NICOLET MINERALS COMPANY KPB | DATE 12/98 | | |
| DRAWING NO. 23 | SHEET 23 OF 31 | REVISION NO. | | | |

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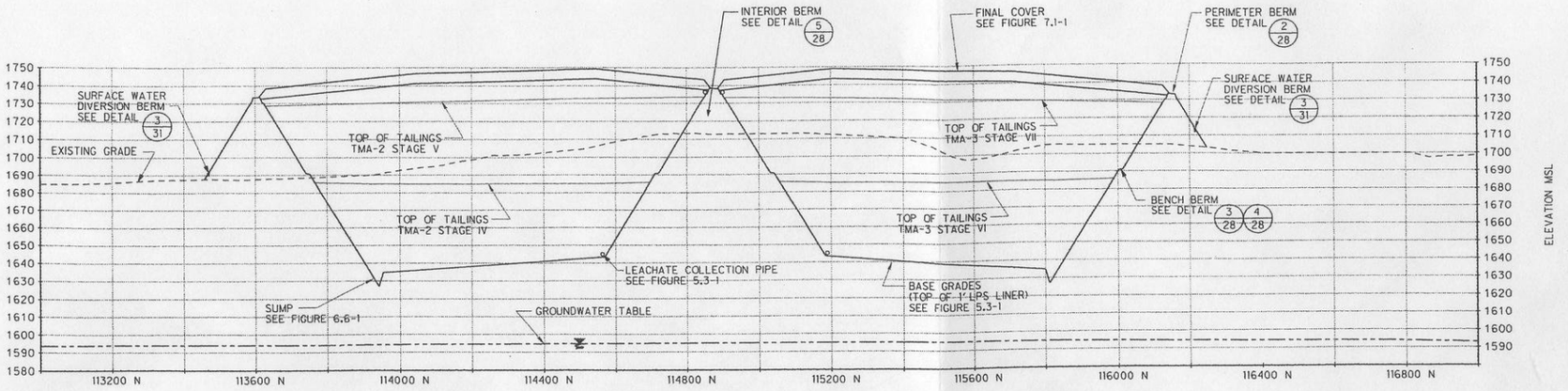
23 DEC 98 jow

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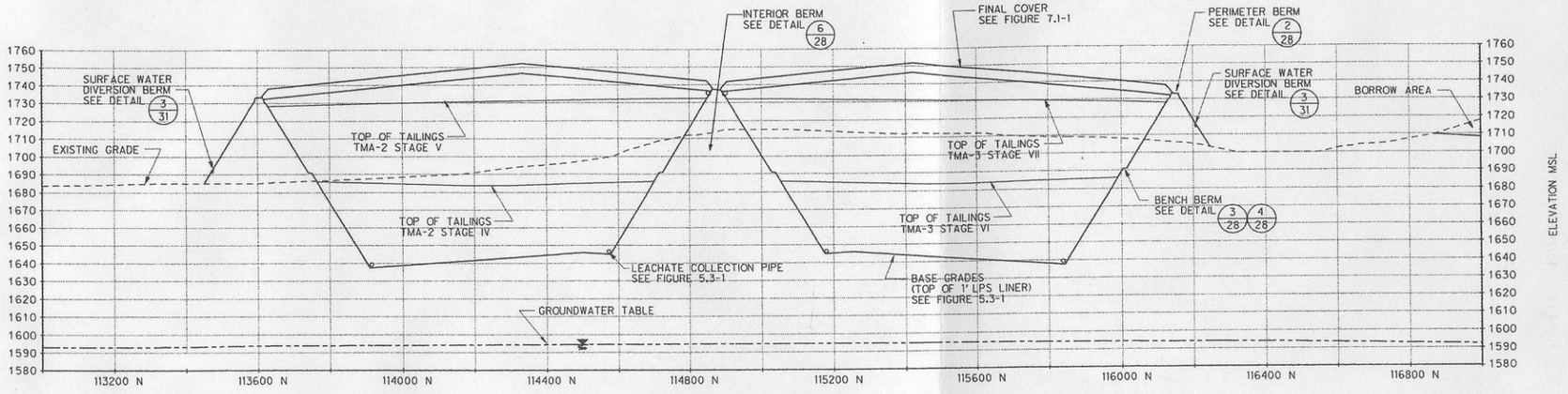
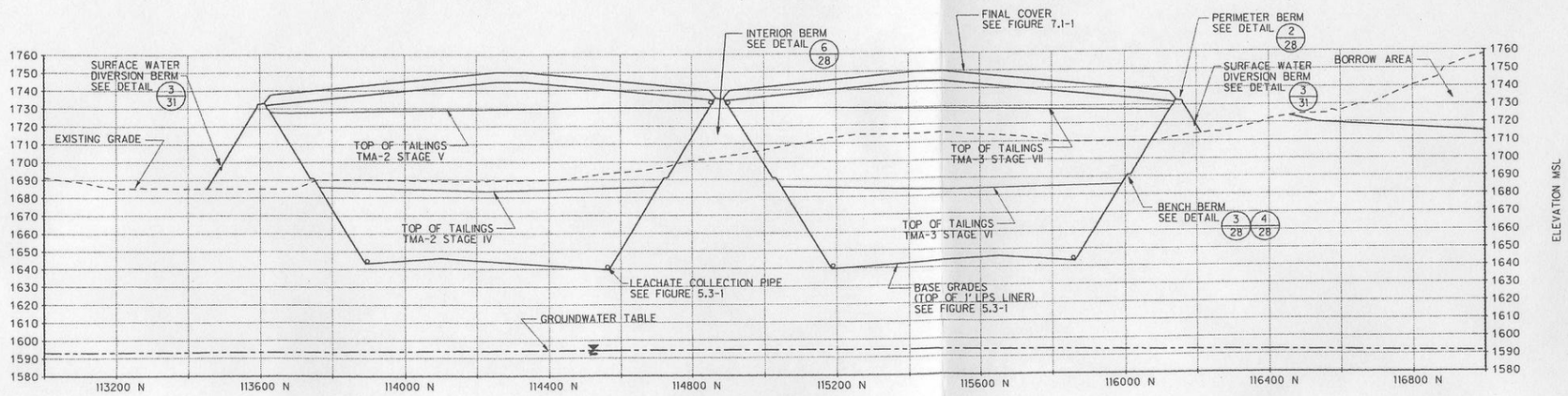
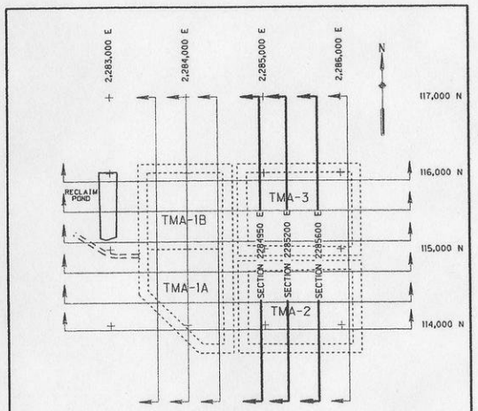



SECTION 2,285,200 E

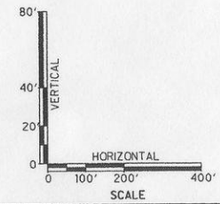



SECTION 2,285,600 E




CROSS SECTION LOCATION MAP

SCALE
0 500' 1000'




SCALE

Nicolet Minerals COMPANY

Foth & Van Dyke

| REVISED | DATE | BY | DESCRIPTION |
|---|---|---|---|
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TYPICAL REPRESENTATION:
REFINEMENTS MAY BE MADE
PRIOR TO CONSTRUCTION

TITLE
ENGINEERING CROSS SECTIONS

| | | | | | |
|---|---|---|---|---|---|
| SCALE AS SHOWN | STATE: WISCONSIN | | COUNTY FOREST | | |
| DRAWN BY JRB2 | DATE 12/98 | CHECKED BY DMR | DATE 12/98 | | |
| APPROVED BY NXP | DATE 12/98 | APPROVED BY NXP | DATE 12/98 | | |
| APPROVED BY GWS | DATE 12/98 | NICOLET MINERALS COMPANY KPB | DATE 12/98 | | |
| DRAWING NO. 24 | SHEET 24 OF 31 | REVISION NO. | | | |

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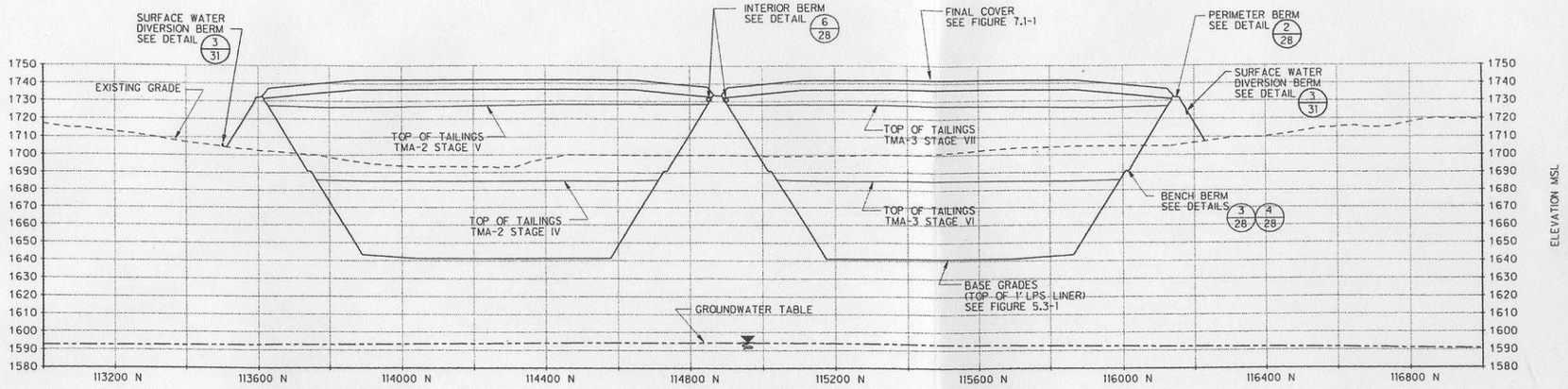
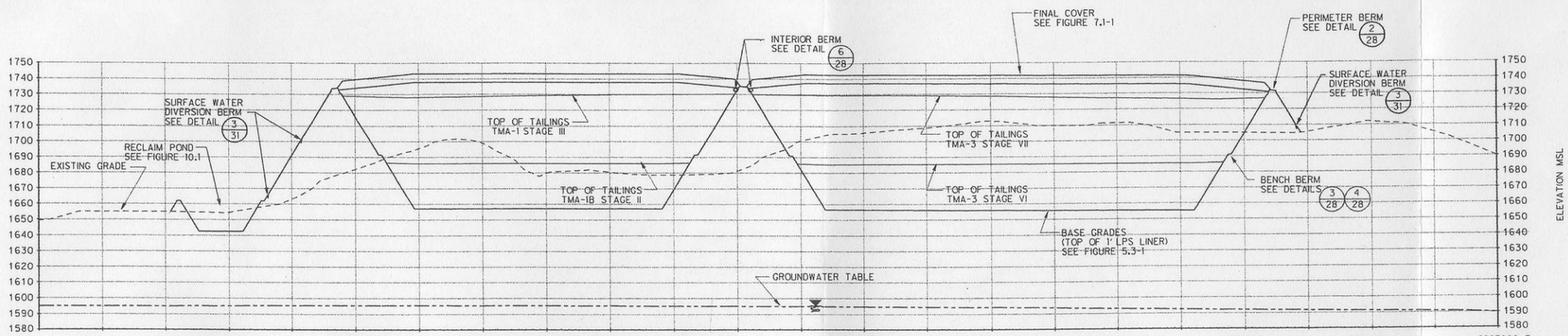
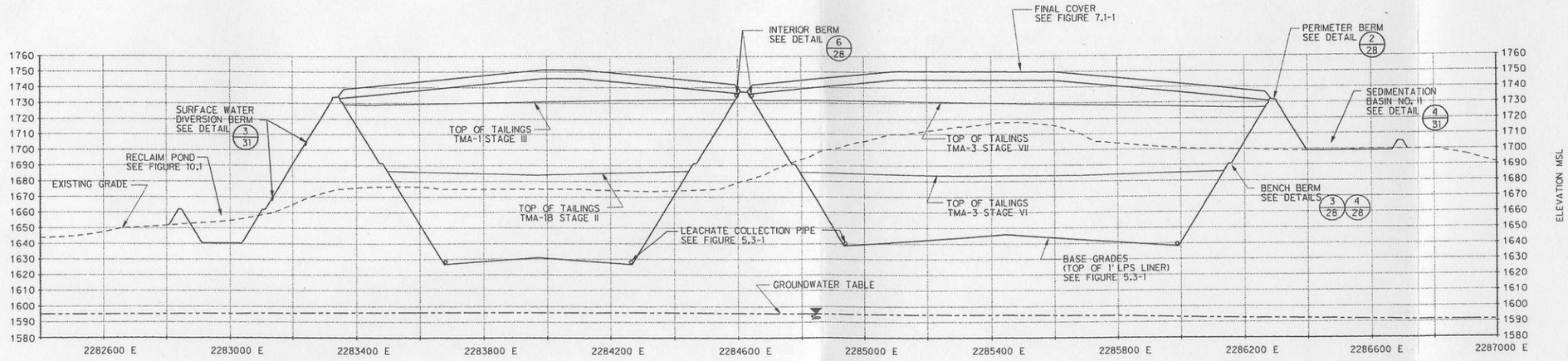
23 DEC 98 mjo3




SECTION 2,286,000 E




SECTION 115,900 N

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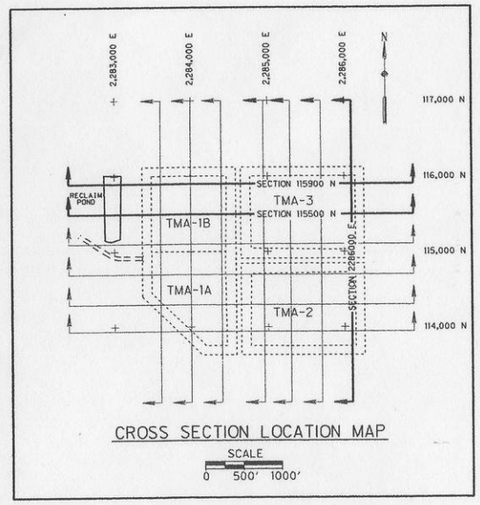
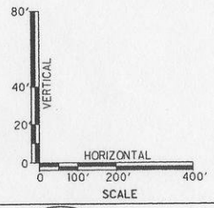



CROSS SECTION LOCATION MAP

SCALE

0 500' 1000'




Nicolet Minerals COMPANY

Foth & Van Dyke

| REVISED | DATE | BY | DESCRIPTION |
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TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

TITLE

ENGINEERING CROSS SECTIONS

| | | | | | |
|---|---|---|---|---|---|
| SCALE AS SHOWN | STATE: WISCONSIN | | COUNTY FOREST | | |
| DRAWN BY JRB2 | DATE 12/98 | CHECKED BY DMR | DATE 12/98 | | |
| APPROVED BY NXP | DATE 12/98 | APPROVED BY NXP | DATE 12/98 | | |
| APPROVED BY GWS | DATE 12/98 | NICOLET MINERALS COMPANY KPB | DATE 12/98 | | |
| DRAWING NO. 25 | SHEET 25 OF 31 | REVISION NO. | | | |

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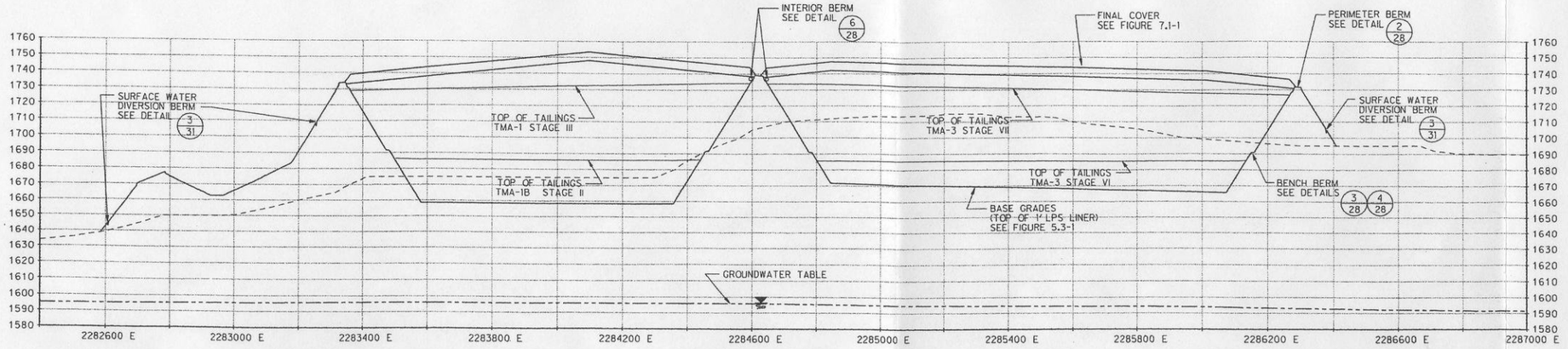
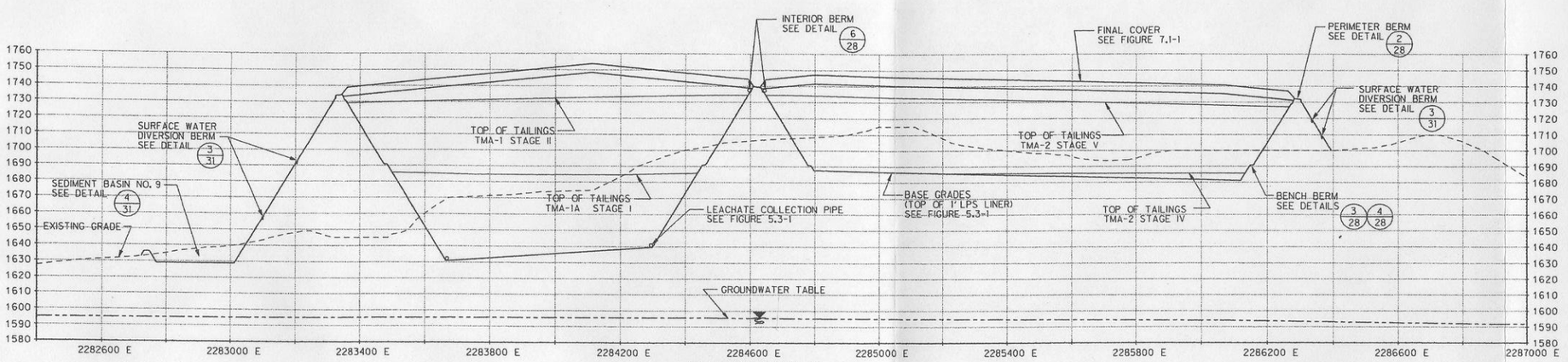
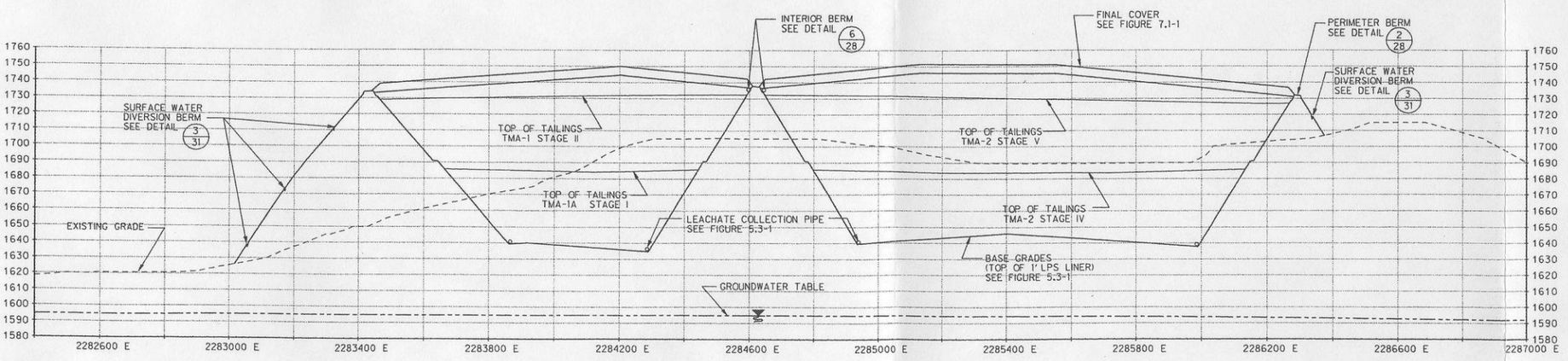


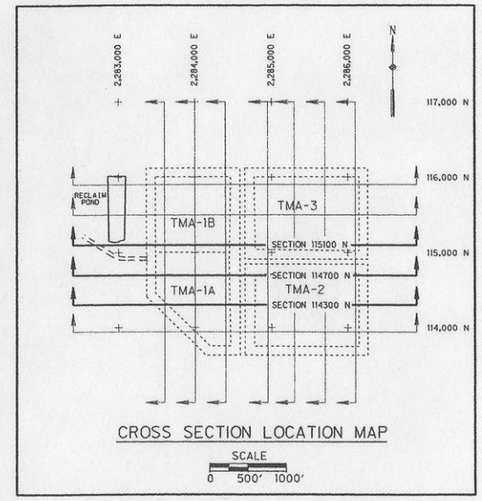

SECTION 115,100 N




SECTION 114,700 N

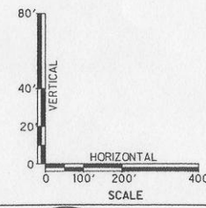



SECTION 114,300 N




CROSS SECTION LOCATION MAP

SCALE
0 500' 1000'




SCALE

Nicolet Minerals COMPANY

Foth & Van Dyke

| REVISED | DATE | BY | DESCRIPTION |
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TYPICAL REPRESENTATION:
REFINEMENTS MAY BE MADE
PRIOR TO CONSTRUCTION

TITLE
ENGINEERING CROSS SECTIONS

| | | | | | |
|---|---|---|---|---|---|
| SCALE AS SHOWN | STATE WISCONSIN | | COUNTY FOREST | | |
| DRAWN BY JRB2 | DATE 12/98 | CHECKED BY DMR | DATE 12/98 | | |
| APPROVED BY NXP | DATE 12/98 | APPROVED BY NXP | DATE 12/98 | | |
| APPROVED BY GWS | DATE 12/98 | NICOLET MINERALS COMPANY KPB | DATE 12/98 | | |
| DRAWING NO. 26 | SHEET 26 OF 31 | REVISION NO. | | | |

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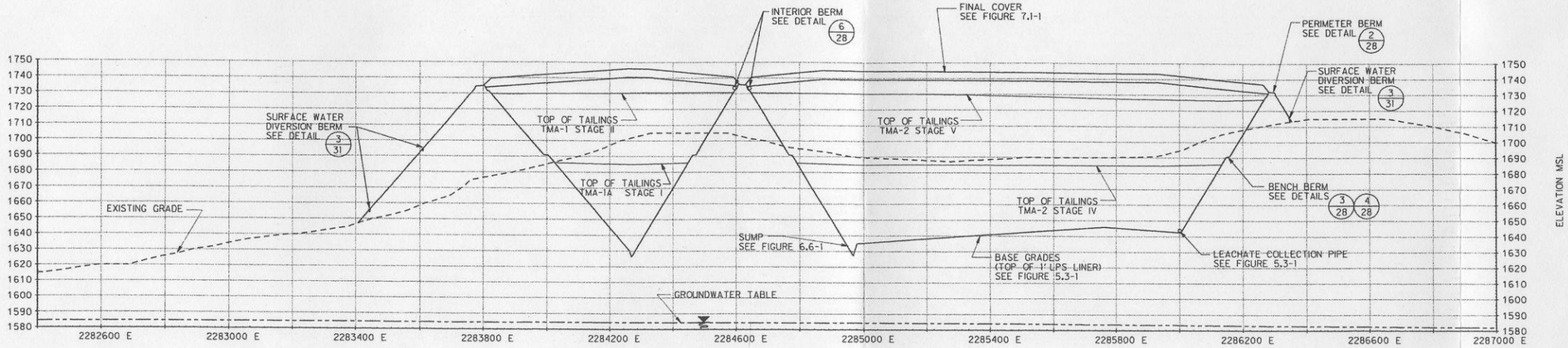
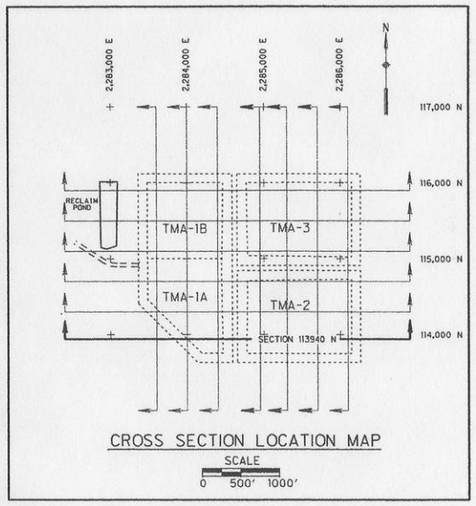
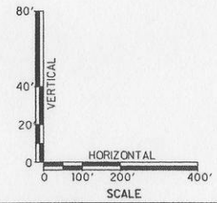



SECTION 113,940 N




CROSS SECTION LOCATION MAP

SCALE
0 500' 1000'




Nicolet Minerals COMPANY

Foth & Van Dyke

| REVISED | DATE | BY | DESCRIPTION |
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TYPICAL REPRESENTATION:
REFINEMENTS MAY BE MADE
PRIOR TO CONSTRUCTION

TITLE
ENGINEERING CROSS SECTIONS

| | | | | | |
|---|---|---|---|---|---|
| SCALE AS SHOWN | STATE: WISCONSIN | | COUNTY FOREST | | |
| DRAWN BY JRB2 | DATE 12/98 | CHECKED BY DMR | DATE 12/98 | | |
| APPROVED BY NXP | DATE 12/98 | APPROVED BY NXP | DATE 12/98 | | |
| APPROVED BY GWS | DATE 12/98 | NICOLET MINERALS COMPANY KPB | DATE 12/98 | | |
| DRAWING NO. 27 | SHEET 27 OF 31 | REVISION NO. | | | |

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23 DEC 98 jow

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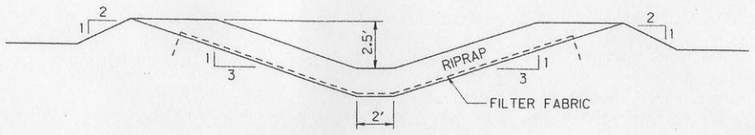
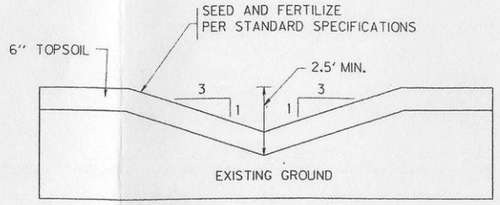


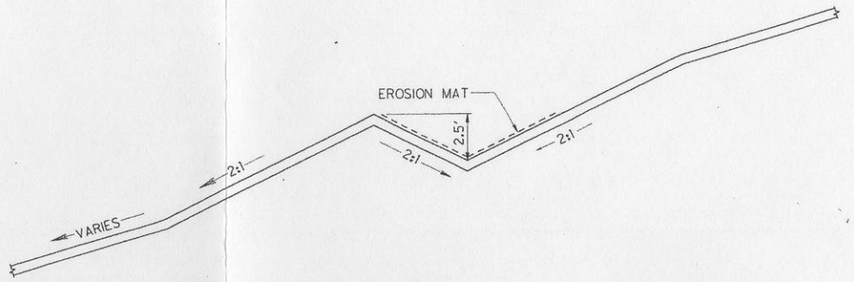

1/31 TYPICAL RIPRAPPED SPILLWAY

NOT TO SCALE



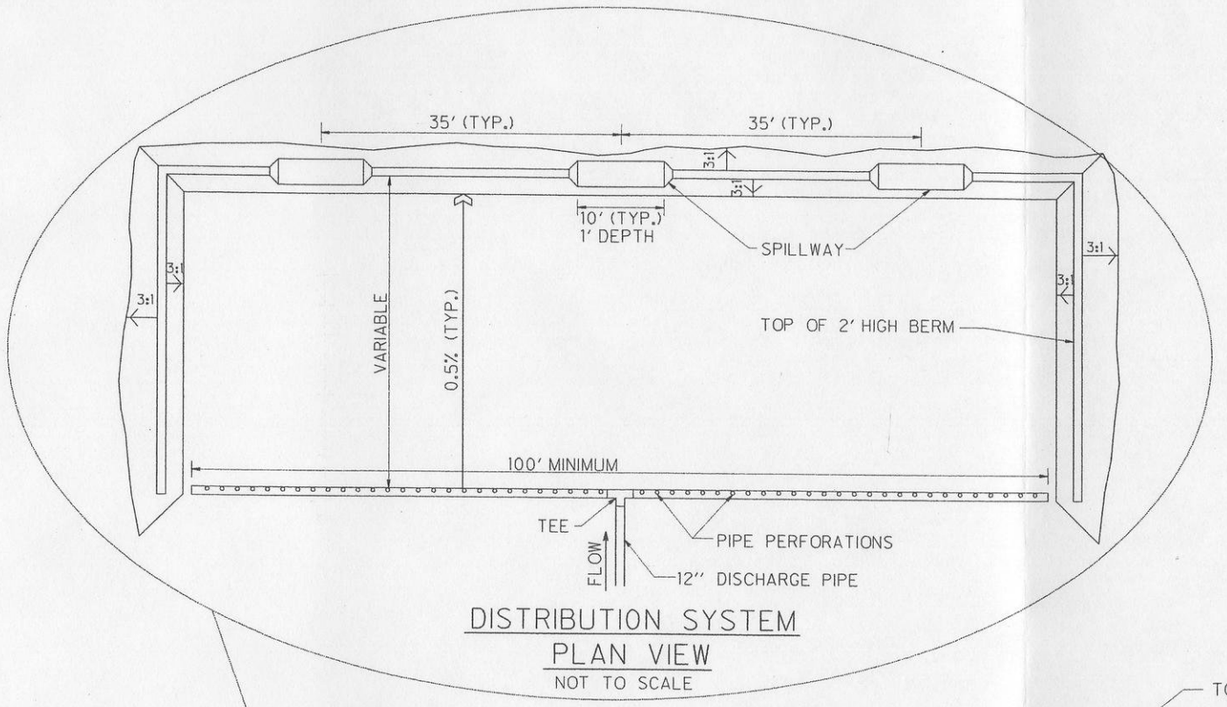

2/31 DRAINAGE DITCH DETAIL "V" NOTCH

NOT TO SCALE




3/31 TYPICAL SURFACE WATER DIVERSION BERM

NOT TO SCALE

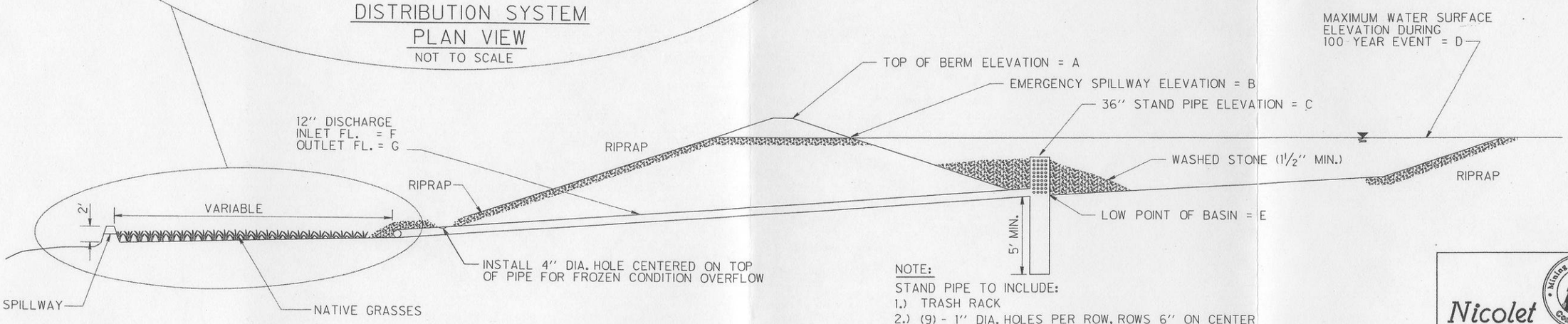



DISTRIBUTION SYSTEM
PLAN VIEW

NOT TO SCALE

| | DESIGN STORM EVENT (24 HR) | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|---|
| RUNOFF BASIN 9 | 100 YEAR | 1636.00 | 1635.30 | 1634.00 | 1635.25 | 1622.00 | 1622.00 | 1620.00 |
| RUNOFF BASIN 10 | 100 YEAR | 1695.00 | 1694.60 | 1693.90 | 1694.59 | 1690.00 | 1690.00 | 1689.00 |
| RUNOFF BASIN 11 | 100 YEAR | 1705.00 | 1704.00 | 1703.00 | 1703.07 | 1698.00 | 1698.00 | 1697.00 |
| RUNOFF BASIN 12 | 100 YEAR | 1625.00 | 1624.50 | N.A. | 1624.52 | 1618.00 | N.A. | N.A. |
| RUNOFF BASIN 13* | 100 YEAR | 1695.00 | 1694.50 | N.A. | 1694.58 | 1690.00 | N.A. | N.A. |
| RUNOFF BASIN 14 | 100 YEAR | 1715.00 | 1714.00 | 1713.00 | 1713.73 | 1710.00 | 1710.00 | 1709.00 |

N.A. - STAND PIPE AND DISCHARGE STRUCTURES ARE NOT APPLICABLE TO RUNOFF BASIN 12 & 13
* BASIN 13 HAS A 30 FOOT WIDE WEIR OUTLET AND NO DISTRIBUTION SYSTEM




NOTE:
STAND PIPE TO INCLUDE:
1.) TRASH RACK
2.) (9) - 1" DIA. HOLES PER ROW, ROWS 6" ON CENTER
3.) WRAP WITH AKSD ENKADRAIN 9120 OR EQUAL

4/31 TYPICAL SECTION - RUNOFF BASIN

NOT TO SCALE

Foth & Van Dyke

| REVISED | DATE | BY | DESCRIPTION |
|---|---|---|---|
| | | | |

TYPICAL REPRESENTATION:
REFINEMENTS MAY BE MADE
PRIOR TO CONSTRUCTION

Nicolet Minerals COMPANY

TITLE: DETAILS

| | | | | | |
|---|---|---|---|---|---|
| SCALE: AS SHOWN | STATE: WISCONSIN | | COUNTY: FOREST | | |
| DRAWN BY: JRB2 | DATE: 12/98 | CHECKED BY: DMR | DATE: 12/98 | | |
| APPROVED BY: NXP | DATE: 12/98 | APPROVED BY: NXP | DATE: 12/98 | | |
| APPROVED BY: GWS | DATE: 12/98 | NICOLET MINERALS COMPANY: KPB | DATE: 12/98 | | |
| DRAWING NO.: 31 | SHEET: 31 OF 31 | REVISION NO. | | | |

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23 DEC 98 Jaw

# Appendix A

# Pyrite Marketing Update

# NICOLET MINERALS COMPANY

104 W. MADISON STREET
P.O. BOX 336
CRANDON, WI 54520
PH# 715/478-3393 FAX#715/478-3641


## MEMO

**TO:** G. Reid

**CC:** J. Sevick
K. Black

**FROM:** B. Arthur

**DATE:** October 27, 1998

**RE:** Pyrite Marketing Update

---

Further to the April 1995 Crandon Project Pyrite Marketing Update by Market Access International, Inc., the market for pyrite was again reviewed in 1998. The conclusion from the 1995 report was that there was no identifiable U.S. market for Crandon pyrite concentrates. The purpose of the 1998 review was to determine if there has been any change in market conditions over the past three years.

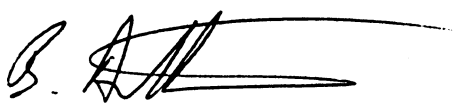
The market for sulfuric acid in the Saskatchewan, Canada uranium mines was reviewed in April/May by Mr. John Nightingale of Nightingale Consulting. It was determined that this market is small and that costs of producing and transporting acid from Crandon would be greater than present costs. Nightingale Consulting's Report is attached.

A second investigation consisting of a preliminary analysis (copy attached) to determine the potential of constructing a roaster in Chile for production of sulfuric acid from Crandon pyrite concentrate was made by Hatch Associates Ltd. for NMC. The basis of the study was production of sulfuric acid from 150,000, 300,000 and 1,000,000 tons of pyrite near Iquique in Chile. Potentially this could result in a saving to Rio Algom in the cost of acid currently used at the Cerro Colorado Mine and in the future at the Spence Mine. Transportation costs were assumed at $60/tonne while the current acid price in Iquique was assumed at $50/tonne.

For acid production from pyrite at a rate of 150,000 tons per tear, capital costs were estimated at about $55 million with operating costs of $22/tonne of acid. This cost does not include transportation nor disposal costs for the roaster residue. When adding the transportation cost, the price would be higher than the current price. This same result applies to the 300,000 and 1,000,000 ton scenarios. It was therefore concluded that production of sulfuric acid in Chile from Crandon pyrite concentrate is not economically viable.

Further support to the conclusion that there is currently no market for pyrite or acid produced from pyrite was provided in work conducted by N. A. Degerstrom, Inc. 1998 for Thompson Creek Mine in Idaho. In the May 1998 Thompson Creek Mine Draft Supplemental Environmental Impact Statement issued by USDA Forest Service, it is stated "The current market for pyrite concentrates for sulfur extraction is non-existent due to the low price for elemental sulfur from natural gas processing and the increased availability of smelter acid." A copy of the relevant portion of the USDA document is attached.

B. Arthur



John A. Nightingale
*President*

# *Nightingale Consulting*

Bruce Arthur,
Nicolet Mining Inc.,
Crandon Wis

May 11 1998

Dear Bruce: (This is the copy I was trying to print last week)

I have done some checking into the sulphuric acid situation at the Uranium mines in Saskatchewan, as you requested.

There are three operating mines; Key Lake who produce 14 million pounds U3O8 per year and have their own 200 ton per day acid plant; Rabbit Lake mine which produces 12 million pounds U3O8 per year and has an old but good acid plant, and Cluff Lake which produce 5 million pounds U3O8 per year and purchases acid from Marsulex in Fort Saskatchewan (Edmonton). Acid price at the Edmonton plant is presently $79 per ton. The cost of transportation to Cluff Lake is considerably more than the cost of the acid FOB Edmonton.

The new mines coming on stream all have their construction licences now and one would assume they will be able to get operating licences when the time comes in 1999 and 2001.

McArthur River will come on stream in late 1999 and eventually produce at 18 million pounds per year. Their ore will be transported to Key Lake for processing, because the Key Lake ore bodies are now mined out and the mill will be available. The original Key Lake acid plant turned out to be about 40% larger than necessary so they probably will have enough acid production for the mill when it is expanded to 18 mm lbs.U3O8/yr.

McLean Lake will come on, perhaps a little earlier and the ore will be processed at the McLean Lake mill which is designed for 24 million pounds per year, I believe. This mill will have it's own acid plant, -- produced from sulphur hauled in.

Cigar Lake mine will come on stream at 18 mm lbs./yr in 2001 and the ore will be hauled to McLean Lake for processing.

It seems that only the small Cluff Lake mine, will continue to purchase sulphuric acid. This mine is in the far northwest of Saskatchewan. I would think that the transportation costs from Crandon would be greater than Cluff Lake's present delivered cost. The acid is brought in at 96%, so there is no advantage to be gained in that area.

I trust this is the information you need. Let me know if I can do anything further.

Best regards to you, Don and staff.

John

Box 13, Site 305, R.R. #3, Saskatoon, SK S7K 3J6
Phone: (306) 931-9638 • Fax: (306) 242-9342 • j.nightingale@sk.sympatico.ca

June 23, 1998

NICOLET MINERALS COMPANY
PYRITE ROASTING AND ACID PRODUCTION STUDY

DISTRIBUTION

B. Arthur - Nicolet
M. Grundy - Rio Algom
F. Porretta - HA
W. Thoburn - HA
B. Wasmund - HA

# ORDER OF MAGNITUDE COST ESTIMATE

## 1. INTRODUCTION

The Nicolet Minerals Company is evaluating the feasibility of shipping a pyrite concentrate from their operation in Wisconsin to a new roasting and sulphuric acid production facility located in Iquique Chile. Hatch has been requested to prepare an order of magnitude cost estimate for three concentrate processing rates: 150,000 tpy, 300,000 tpy and 1,000,000 tpy.

## 2. PROCESS FLOWSHEET

A conceptual process flowsheet is presented in Figure 1.

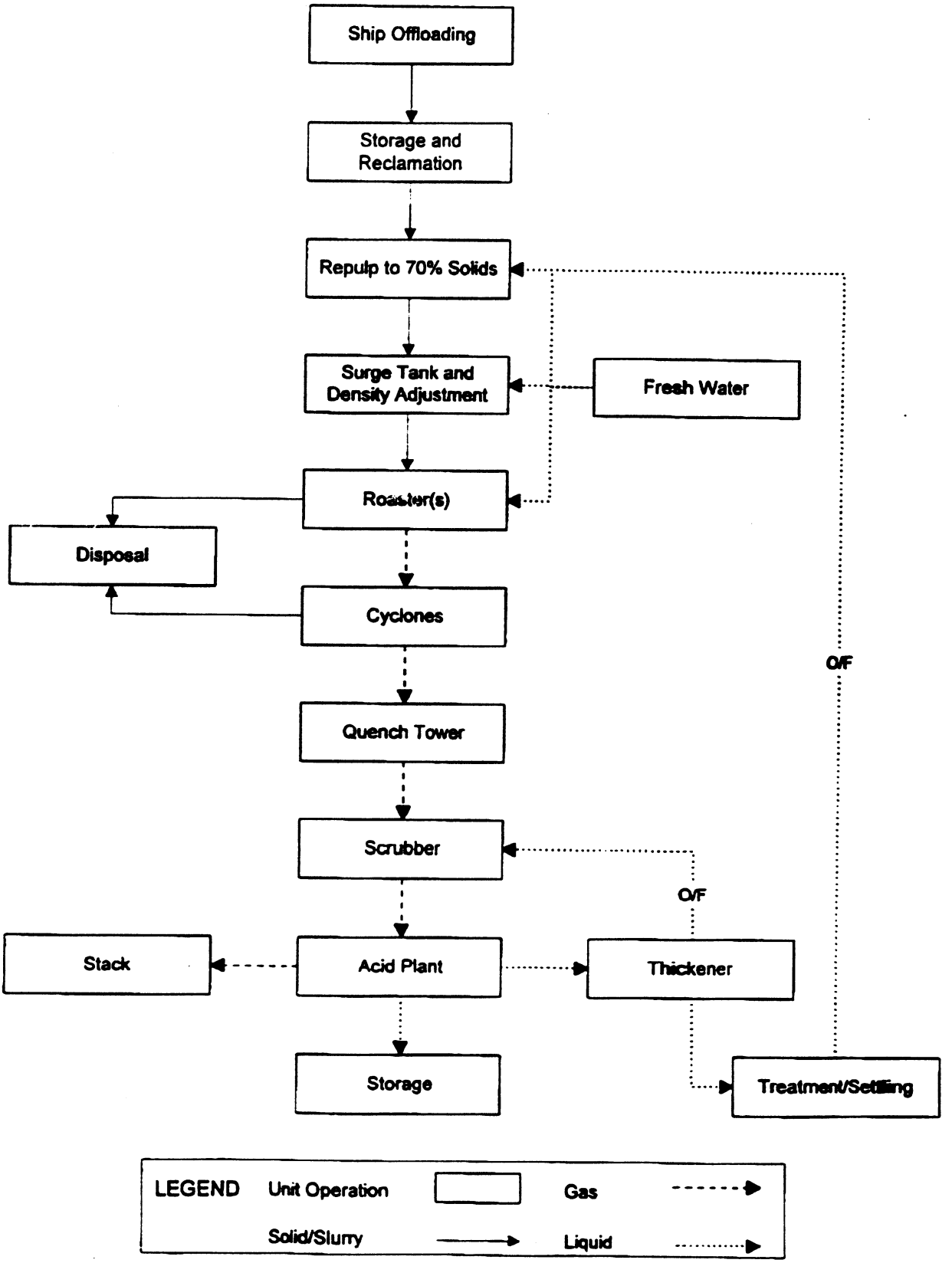
For the purposes of this estimate, the following flow of materials is assumed: At the Port of Iquique, self-unloading ships deposit the concentrate into a dock-side bin. The concentrate is conveyed from the bin to covered storage. From covered storage, concentrate is conveyed to a day bin. The day bin feeds a lump breaker, which in turn feeds a loss-in-weight mass flow control system. Concentrate is fed to the repulp tank from a loss-in-weight system via a screw conveyor. Slurry is pumped to the roaster feed tank. A second set of pumps supply slurry to the fluidized bed roaster.

Off-gas from the roaster passes through cyclones, a quench chamber and scrubber and finally into an acid plant. Product acid is stored on-site in large storage tanks. Off-specification acid is stored in a separate tank. Cyclone dust is combined with calcine from the roaster, repulped and deposited in a disposal pond. Tail gas from the acid plant is vented to atmosphere. Weak acid from the acid plant is neutralised using lime and treated in a settling pond. Overflow from this pond can be re-used to repulp concentrate.



If you disagree with any information contained herein, please advise immediately.

Figure 1: Flowsheet for Nicolet Pyrite Roasting



## 3. DESIGN BASIS

A summary of the design basis is presented below:

Table 1: Design Basis

| | Pyrite Treatment Rate (tpy) | | | |
|---|---|---|---|---|
| | 150,000 | 300,000 | 1,000,000 | Units |
| Roaster Feed | | | | |
| Pyrite Concentrate | 18.75 | 37.5 | 125 | tonne/hr |
| Slurry water @ 70.0% solids | 8.04 | 16.07 | 53.57 | tonne/hr |
| Slurry volume | 12 | 24 | 80 | $m^3$/hr |
| Roaster Air | 42521 | 85042 | 283472 | $Nm^3$/hr |
| Cooling water required | 6.4 | 12.8 | 42.8 | $m^3$/hr |
| Roaster Products | | | | |
| Calcine | 13.47 | 26.94 | 89.80 | tonne/hr |
| Wet Flue gas volume | 58170 | 116340 | 387800 | $Nm^3$/hr |
| | 228632 | 457263 | 1524210 | $Am^3$/hr |
| Dry Flue gas volume | 40307 | 80615 | 268716 | $Nm^3$/hr |
| | 158424 | 316849 | 1056162 | $Am^3$/hr |
| Acid Production @ 96% recovery | | | | |
| 100.0% H2SO4 | 198450 | 396900 | 1323000 | tonne/yr |
| Roaster Sizing | | | | |
| Roaster hearth area | 46.42 | 92.85 | 309.49 | $m^2$ |
| @ 1m/s space velocity | | | | |
| Roaster diameter | 7.7 | 10.9 | 11.5 | m |
| No of roasters | 1 | 1 | 3 | |
| Additional Assumptions | | | | |
| Concentrate Bulk Density | | | 1600 | $kg/m^3$ |
| Ship Load Size | | | 25000 | tonne |
| Ship Offloading Rate | | | 500 | tonne/hr |

## 4. CAPITAL AND OPERATING COSTS

Capital and operating costs were factored from Hatch in-house information and globally compared with costs for similar projects. An order of magnitude estimate of capital and operating costs for the three concentrate feed rate scenarios is presented below:

Table 2: Capital and Operating Cost Estimates

| Pyrite Treatment Rate | (tpy) | 150,000 | 300,000 | 1,000,000 | |
|---|---|---|---|---|---|
| Capital Cost | (US$) | 55,114,000 | 93,146,000 | 294,512,000 | 1 |
| Operating Cost | (US$) | 4,407,000 | 7,514,000 | 23,192,000 | 1 |
| | (US$/tonne 100% $H_2SO_4$) | 22.21 | 18.93 | 17.53 | 1 |

TJS:pc:tjs

Tracey Jeffs-Schonewille, P. Eng.

***2.2.3.5 Option 5 – Basin Above Hawk's Nest/On-site, Dry Disposal.*** This area, located northwest and upslope of the Hawk's Nest, requires dry pyrite concentrate disposal (see Figure 2-2). The basin topography is not overly steep and is covered with dense lodgepole pine. It would require a RCRA-type lined containment area and an enhanced pyrite reduction facility to further reduce pyrite volumes. An intermittent spring would be impacted.

***Screening Result: Eliminated From Further Study.*** This option ranked comparatively high in most screening categories. However, the site has limited storage capacity and would not hold the volume of material, even with an enhanced pyrite reduction circuit.

***2.2.3.6 Option 6 – Twin Apex/On-site Dry, Disposal.*** The Twin Apex site encompasses a spring-fed drainage located south of the existing tailings impoundment between the impoundment and the milling facilities (see Figure 2-2). Unlike the other sites, there is ample storage capacity (even for the 13 percent pyrite concentrate). Development of this site would require removal of riparian and wetland areas, construction of a low-level 1,500- to 2,000-foot-wide dam, development of a RCRA-type lined containment facility, diversion of drainage around the site, and relocation of existing power lines. A portion of this site lies on private land not controlled by TCMC.

***Screening Result: Eliminated From Further Study.*** This option ranked relatively low, due to potential environmental effects on the wetland area, diversion of the existing drainage, availability of the private land and relocation of existing power lines.

***2.2.3.7 Option 7 – Mine Pit.*** The Mine Pit option involves temporary storage of the pyrite concentrate in a dry location until mining is completed and then relocation of the concentrates to the mine pit (see Figure 1). After the pyritic concentrate is moved to the pit, it would be capped with inert material and/or flooded to prevent oxidation.

***Screening Result: Eliminated From Further Study.*** This option ranked low because it requires temporary storage of the pyrite until the mine ceases operation. The temporary dry storage facility would create additional surface disturbance and secondary handling of the pyrite concentrate thus exposing it to additional oxidizing conditions. This option also ranked low because of the practicality of temporary storage for the volume of pyrite concentrates. The temporary storage (possibly at one of the sites discussed previously) would require a RCRA-type lined containment facility prior to being exhumed for final transport and deposition in the mine pit.

***2.2.3.8 Option 8 – Sale of Pyrite Concentrates for Off-site Use.*** Pyrite concentrates would be sold for off-site use such as sulfuric acid, fertilizer manufacturing, refractory ore processing, or recovery of precious metals.

***Screening Result: Eliminated From Further Study.*** This option would require the addition of an enhanced pyrite reduction circuit or similar system to produce a concentrated pyrite product. A market for the concentrates has not been identified.

The current market for pyrite concentrates for sulfur extraction is non-existent due to the low price for elemental sulfur from natural gas processing and the increased availability of smelter sulfuric acid. Even if a market for pyrite existed, the 32 percent sulfur content pyrite from Thompson Creek would render it too low-grade to be marketable. (N.A. Degerstrom, Inc. 1998).

***2.2.3.9 Option 9 – Little Antelope Flats/Off-site Pyrite Dry Disposal.*** The lead agency, with assistance from the BLM, identified an area southeast of Challis, Idaho, in the Little Antelope Flats area as a possible off-site location for pyrite disposal. (See Figure 2-3). The area is administered by the Bureau of Land Management, Challis Resource Area.

The offsite disposal of pyrite addresses some of the limitations of the onsite dry pyrite disposal locations, including topographic constraints, proximity to streams

# Appendix B

## Depyritized Tailings Test Data

- Depyritized Tailings Physical Testing and Density
- Depyritized Tailings Moisture Regime Testing
- Depyritized Tailings Hydraulic Conductivity Testing

# Depyritized Tailings Physical Testing and Density

STEFFEN ROBERTSON AND KIRSTEN
Consulting Engineers and Scientists

Suite 3000
7175 W. Jefferson Ave.
Lakewood, CO
USA 80235
E-mail: denver@srk.com
URL: http://www.srk.com/
Tel: (303) 985-1333
Fax: (303) 985-9947

# TECHNICAL MEMORANDUM

**TO:** Foth & Van Dyke

**ATTENTION:** Jerry Sevick

**FROM:** Dave Hallman DEH FOR DH

**DATE:** August 6, 1998

**SUBJECT:** **Tailings Testing and Density Projections for the Crandon Project**

**PROJ/PROP NO.** **71503**

**CC:** Daryl Hockley

## 1.0 INTRODUCTION

Testing of de-pyritized tailings from the Crandon Project has been performed by Steffen Robertson and Kirsten (U.S.) Inc. (SRK). The purpose of the testing program was to develop data for use in the design of the tailings management facility for the project. The results are indicative of the anticipated range of densities that may be achieved under various operating conditions and are valid for prediction of the in situ tailings densities under actual operating conditions. The test data has also been reviewed and evaluated with respect to previous studies and test results.

## 2.0 TAILINGS SAMPLE

A sample of approximately 40 lbs of tailings slurry was received from Lakefield Research Ltd. This sample consisted of the solid tailings product as well as process water containing residual process reagents.

## 3.0 TEST PROGRAM

The tailings sample was subjected to standard index property testing consisting of grain size analysis (sieve and hydrometer) and specific gravity determination, as well as standard geotechnical properties including hydraulic conductivity measurements, consolidometer testing, and time-rate of consolidation. In addition, a suite of non-standardized tests was performed in order to provide the density data for various operating scenarios. These specialized tests

Mr. Jerry Sevick
August 6, 1998

included column settled density, with and without bottom drainage, and pan evaporation tests. The individual test results are presented as an attachment to this technical memorandum and summarized in the following section.

## 4.0 TEST PROCEDURES

The standard index and geomechanical testing was done in accordance with ASTM procedures. For the consolidation test, the sample was prepared by carefully pouring tailings slurry, consisting of approximately 32.4 percent solids by weight, into the consolidometer ring fitted over a funnel with filter paper in the bottom of the funnel. The slurry was placed in a series of approximately 10 lifts, while being allowed to drain between lifts. Once filled with settled tailings, the ring was carefully transferred to the consolidometer and placed under a seating load of 1 psi prior to testing. Prepared in this fashion, the sample was in the loosest condition practical for testing.

The non-standardized test procedures have been developed by SRK specifically for testing tailings materials.

Two types of column settled density tests were performed, one with and one without bottom drainage. These tests are designed to model the initial settling of the solid tailings particles from the tailings slurry. The test without bottom drainage simulates conditions which exist within areas where a free water surface exists. The test with bottom drainage simulates conditions which exist in exposed "beach" areas above the phreatic level in the impoundment.

The tailings sample was re-slurried to approximately 30 percent solids by weight. This slurry was then poured into a 2.5 inch diameter plastic cylinder. The tailings were placed in three separate lifts of approximately 6 inches each and allowed to settle between placement of each lift. The height of the settled tailings was measured for each lift, which with the known weight of the slurry introduced, yields the initial settled density. The density for each lift as well as the overall average density was carefully recorded. For the bottom drainage case, a filter paper was placed over a drain hole in the base of the cylinder prior to introducing the slurry. The column was allowed to drain until the level of the process water in the cylinder was below the top of the settled tailings. During drainage, the apparatus was carefully weighed to determine the volume of solution drained versus time. These data were used to calculate the hydraulic conductivity.

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Due to the limited volume of process water in the tailings samples received, the solution was carefully collected during the tests and re-used to slurry subsequent lifts of tailings. Thus the results accurately reflect settling of the tailings particles from the tailings slurry containing process water and residual reagents.

The pan evaporation test is designed to model the density increase which occurs within tailings exposed on the beach as the pore fluid evaporates and capillary tension develops in the deposit. The tailings slurry was poured into a 12 in. x 12 in. metal pan and allowed to dry. The excess solution was decanted after the tailings settled and the sample and pan were weighed periodically to monitor the moisture lost versus time. At the point where the incremental weight loss reduces significantly or desiccation cracks develop, the test is completed and a sample is collected from an area containing no obvious cracks for determination of the dry density.

Two pan evaporation tests were performed; one in which the initial tailings slurry contained 30.5 percent solids by weight and a second in which the solids content was 58.5 percent.

## 5.0 TEST RESULTS

The laboratory test results are contained in an attachment to this memorandum and summarized as follows. The tailings sample grain size distribution results are presented in Table 1. The results of the remaining standard laboratory tests are presented in Table 2.

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**Table 1**
**Grain Size Distribution**

| U.S. Standard Sieve | Grain Size (mm) | Percent Finer |
|---|---|---|
| 50 | 0.297 | 100 |
| 100 | 0.149 | 99.2 |
| 200 | 0.074 | 89.2 |
| | 0.0511 | 73.0 |
| | 0.0383 | 63.6 |
| | 0.0287 | 52.6 |
| | 0.0214 | 41.6 |
| | 0.0119 | 24.2 |
| | 0.0086 | 18.0 |
| | 0.0062 | 11.7 |
| | 0.0045 | 7.7 |
| | 0.0032 | 5.4 |
| | 0.0013 | 2.2 |

**Table 2**
**Standard Laboratory Test Results**

| Property | Test Conditions | Results |
|---|---|---|
| Specific Gravity | NA | 2.81 |
| Hydraulic Conductivity | Dry Unit Weight = 81.4 pcf | $1.4 \times 10^{-4}$ cm/sec |
| Consolidation | Load 541 psf | Void ratio 0.916 |
| | 1084 psf | 0.902 |
| | 2164 psf | 0.883 |
| | 4320 psf | 0.859 |
| | 8637 psf | 0.825 |
| Coeff. Of Consolidation ($C_v$) | Normal Load: 541 psf | $1.28 \times 10^{-4}$ ft$^2$/sec |
| | 1084 psf | $1.06 \times 10^{-4}$ ft$^2$/sec |
| | 2164 psf | $1.15 \times 10^{-4}$ ft$^2$/sec |
| | 4320 psf | $1.01 \times 10^{-4}$ ft$^2$/sec |
| | 8637 psf | $8.97 \times 10^{-5}$ ft$^2$/sec |

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The results of the specialized density tests are presented in Table 3.

**Table 3**
**Laboratory Density Test Results**

| Test | Dry Density (pcf) | Comments |
|---|---|---|
| Drained Column | 82.42 | Used avg. 30.6% solids slurry |
| Undrained Column | 70.25 | Used avg. 28.5% solids slurry |
| Pan Evaporation No. 1 | 93.6 | Used 30.6% solids slurry |
| Pan Evaporation No. 2 | 105.8 | Used 58.5% solids slurry |
| Consolidation Test, 1084 psf | 92.2 | Equivalent to approximately 20 ft of tailings |
| Consolidation Test, 4320 psf | 94.3 | Equivalent to approximately 70 ft of tailings |

In the first pan evaporation test, a plot of the weight lost (i.e. amount of water evaporated) versus time showed no clear break in slope nor significant desiccation cracks as is typical, yet the sample was almost completely dried. Thus a second pan evaporation test was performed, however, there was insufficient process water remaining to re-slurry the tailings to the target solids content of 30 to 35 percent. Although this test yielded better results in terms of a plot of the weight loss versus time and degree of desiccation cracking, the results appear to be inordinately high as a result of the thickened slurry used in the test. The results of the first test appear to be more indicative of the actual desiccated density which may be achieved in the beach tailings.

The time rate of consolidation test data was also used to estimate the hydraulic conductivity of the tailings material at higher densities. These data are presented in Table 4.

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**Table 4**
**Hydraulic Conductivity Estimates**

| Dry Unit Weight (pcf)[1] | Hydraulic Conductivity (cm/sec) |
|---|---|
| 92.2 | $2.6 \times 10^{-6}$ |
| 93.1 | $2.0 \times 10^{-6}$ |
| 94.3 | $1.1 \times 10^{-6}$ |
| 96.1 | $7.2 \times 10^{-7}$ |

[1]Note: Dry unit weight represents the final dry unit weight for the load interval over which the hydraulic conductivity was estimated due to the rapid consolidation that occurred during the test.

## 6.0 CONCLUSIONS

Grain size analyses for the de-pyritized tailings indicate a gradation which is similar to the whole tailings tested in 1994. In general, the de-pyritized tailings and whole tailings from 1994 are almost identical in the coarser portions, while the de-pyritized are somewhat coarser in the finer portions. This may be due to variations in the process solutions present within the tailings, which affect the settling rate in the hydrometer analysis, as much as any real variations in the particle size distribution. Approximately 90 percent of the material is finer than a No. 200 sieve (0.074mm) and the $d_{50}$ size is about 0.03mm. The de-pyritized tailings exhibited a $d_{10}$ size of 0.0055 mm whereas the whole tailings tested in 1994 exhibited a $d_{10}$ size of 0.0015mm.

The de-pyritized tailings exhibit hydraulic conductivity, compression, and consolidation characteristics which are typical of published results of metaliferous mine tailings (Vick, 1983) and SRK project experience.

The column settled density test results provide data indicative of the initial deposition densities. The undrained test resulted in a dry density of 70.25 pcf (e = 1.496) which is applicable to initial deposition within the free water pool. When adjusted for the specific gravity of the solids (2.81), this is actually slightly denser than the 1994 test data for the whole tailings, i.e. the void ratio is lower. The drained test resulted in a dry density of 82.4 pcf (e = 1.127) which is applicable to initial deposition in the exposed beach area. When adjusted for the specific gravity of the solids (2.81), this is also denser than the 1994 test data for the whole tailings.

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August 6, 1998

The pan evaporation test results reflect the maximum density which is likely to be achieved in the beach tailings as a result of desiccation. The results for a slurry initially placed at 30 percent solids content indicate a dry density of 93.6 pcf. Once again, when adjusted for specific gravity, this is denser than indicated by the test results from the 1994 program (e = 0.873 versus e = 0.969). The results for a thickened slurry initially placed at 59% solids content indicate a dry density of 105.8 pcf following desiccation. The reason for the much higher dry density which resulted from this slurry is not clear. The results for the slurry initially placed at 30 percent solids content are believed to more accurately reflect the actual conditions which will occur.

The consolidation test results indicate a fully consolidated dry density of 91.6 pcf at a depth of 10 ft for fully saturated conditions, an ultimate final average dry density of 93.2 pcf for the 80 ft deep tailings deposits. However, it should be noted that these densities will be achieved only after the tailings have completely consolidated under self weight, and do not include the effect of capping materials. Figure 1 presents a graph of final tailings dry densities versus depth as predicted from the consolidation test results.

The process of tailings deposition results in a layered deposit which is increasing in thickness over time as the material is consolidating under self weight. This process makes it difficult to predict the actual average tailings density within the deposit prior to complete consolidation using conventional geomechanical approaches. In lieu of conducting complex finite difference or finite element modeling incorporating large strain consolidation theory, we have found that acceptable results can be achieved using the moving-boundary consolidation solution of Gibson (1958), as presented in the 1994 study. This approach has also been adopted in the present study. A description of an application of this method to mine tailings impoundments is presented by Mittal and Morgenstern (1976), and discussed by Vick (1983).

The proposed tailings deposition plan for TMA 1 Stage 1 North area results in continuous tailings placement as Stage 2 deposition will immediately follow Stage 1 in this area. The tailings placement in the Stage 1 South area will be interrupted over a period of approximately 3.5 years while tailings are deposited in the Stage 1 North area. Although the Stage 1 tailings deposition in the North and South areas will be at a similar rate, the overall rate of tailings placement in the North area will be greatest. The overall rate of tailings placement in the TMA 1 North area results in a tailings thickness, in feet, that can be approximated as a function of 20 times the square root of time in years. Utilizing the average coefficient of consolidation from the

laboratory test results, 1.08 x $10^{-4}$ $ft^2$/sec, and this function to represent the rate of tailings placement for TMA 1, Gibson's approach for the case of bottom drainage indicates very low excess pore water pressures during deposition and the material would be essentially normally consolidated with an average dry density of 93.2 pcf.

The proposed filling rate is greater for TMA 2 and 3. The filling rate for these two TMA's is quite rapid during the initial filling period of about 6 months with a rate of rise of about 20 ft/year. The filling rate then decreases as a function of time with a rate of about 14 ft/year after 12 months and 7.7 ft/year in the final stages of filling. The tailings level in TMA 2 and 3, and hence rate of rise, after the initial filling period can be reasonably approximated by the following function:

$$H = (38.2 \times \sqrt{T}) - 21$$

Where: H = tailings level in ft

T = time in years

Assuming similar tailings material properties and performing a similar analyses using this function to represent the rate of tailings placement, Gibson's approach for the case of bottom drainage also indicates that the tailings would be essentially normally consolidated. At the end of deposition in TMA 2 and 3, the tailings deposit is indicated to be in excess of 99 percent consolidated with an average dry density of 93.1 pcf.

Based upon the test results it appears that an initial average dry density of between 75 and 80 pcf will occur. The tailings are indicated to essentially consolidate as rapidly as they are placed and result in a final average dry density on the order of 93 pcf.

## 7.0 REFERENCES CITED

Gibson, R.E., 1958, *"The Progress of Consolidation in a Clay Layer Increasing in Thickness with Time,"* Géotechnique, Vol. VIII, pg 171-182.

Mittal, H.K., and Morgenstern, N.R., 1976; *"Seepage Control in Tailings Dams,"* Canadian Geotechnical Journal, Vol. 13, pp 277 – 293.

Vick, S.G., 1983, *"Planning, Design, and Analysis of Tailings Dams,"* Wiley Series in Geotechnical Engineering, John Wiley & Sons, Inc.

## Ultimate Dry Density vrs Depth

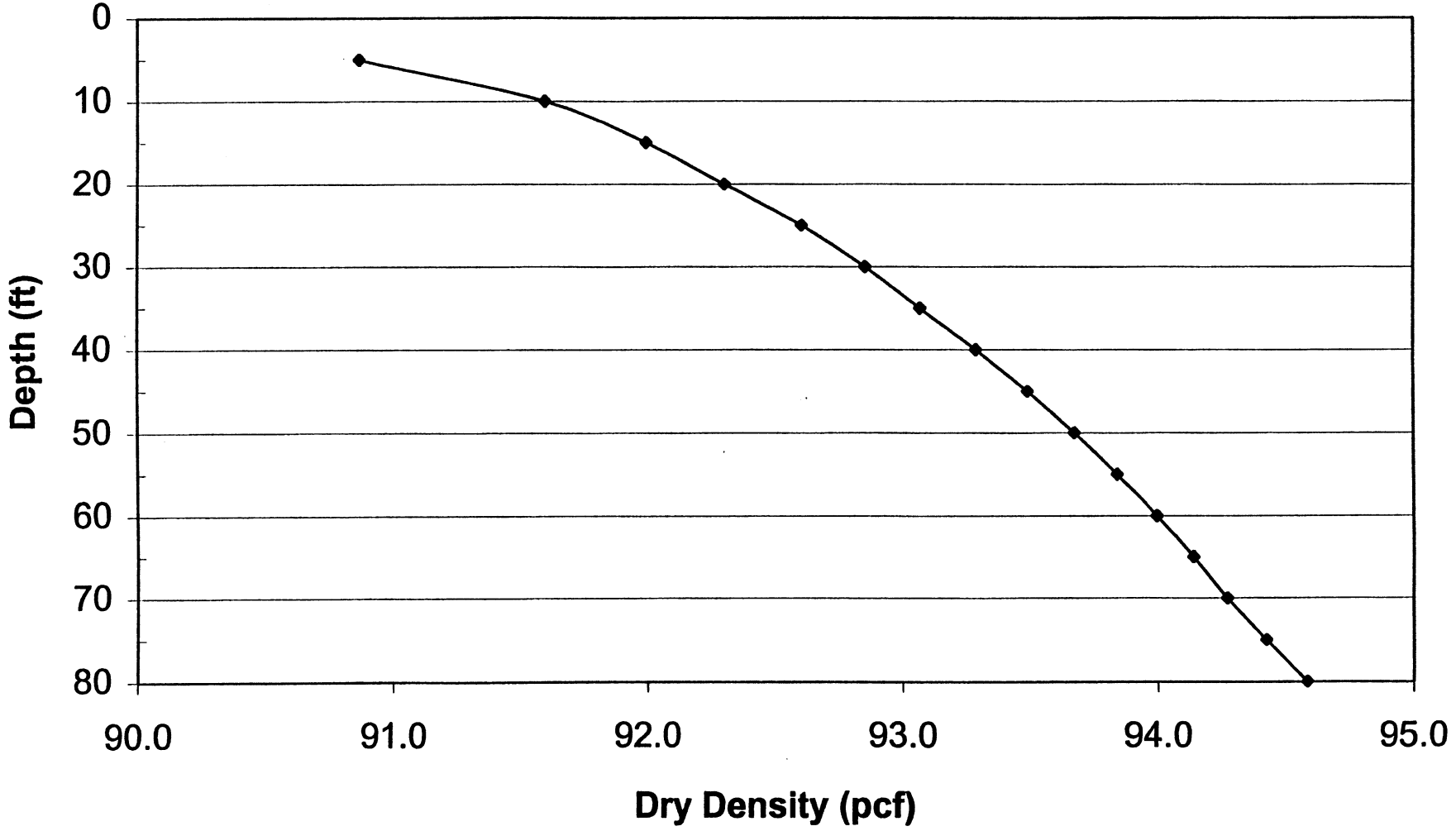
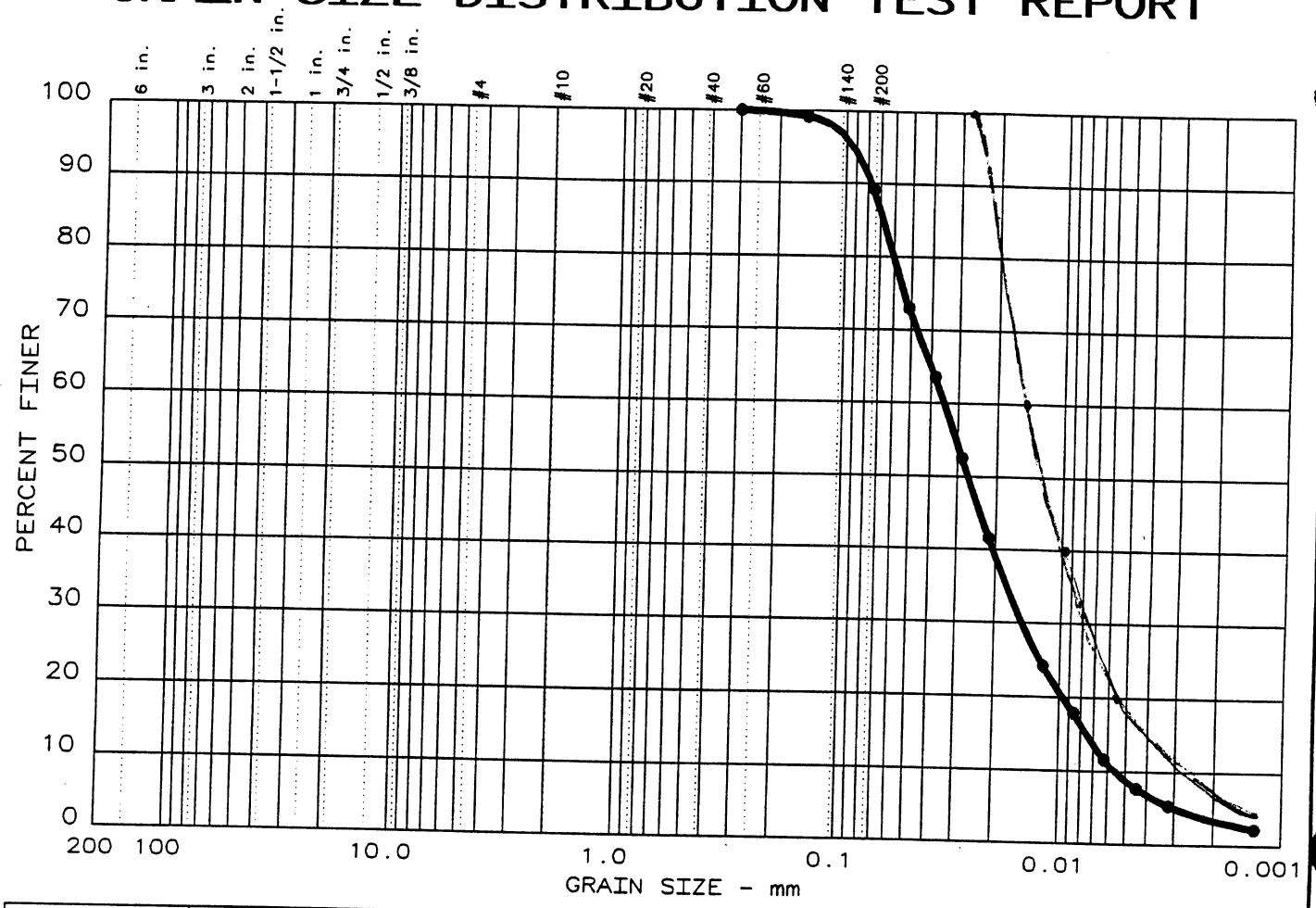



**Figure 1**

# GRAIN SIZE DISTRIBUTION TEST REPORT




| | % +3" | % GRAVEL | % SAND | % SILT | % CLAY |
|---|---|---|---|---|---|
| ● | 0.0 | 0.0 | 10.8 | 80.4 | 8.8 |

| | LL | PI | $D_{85}$ | $D_{60}$ | $D_{50}$ | $D_{30}$ | $D_{15}$ | $D_{10}$ | $C_c$ | $C_u$ |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | | | | | 0.0269 | 0.0149 | 0.0074 | 0.0055 | 1.16 | 6.2 |

| MATERIAL DESCRIPTION | USCS | AASHTO |
|---|---|---|
| ● SILT, dark gray | ML | A-4(0.0) |

Project No.: 71503
Project: Nicolet Minerals Company
● Location: KB-1, Crandon Tailing Slurry

Date: 5/20/98

GRAIN SIZE DISTRIBUTION TEST REPORT
**STEFFEN ROBERTSON AND KIRSTEN (U.S.) INC.**
**Consulting Engineers and Scientists**

Remarks:

Fig. No.: _____

STEFFEN ROBERTSON & KIRSTEN (US) INC.
Consulting Engineers & Scientists

Project: Nicolet Minerals Company - 71503
Date: 5/4/98
Sample: KB-1, Crandon Tailing Slurry

# CONSOLIDATION TEST RESULTS
ASTM D2435

| Sample Data | Before Test | After Test |
|---|---|---|
| Wet Weight (g) | 81.35 | 97.53 |
| Dry Weight (g) | 80.32 | 80.32 |
| Height (in) | 0.993 | 0.968 |
| Diameter (in) | 1.939 | 1.939 |
| Area (in2) | 2.953 | 2.953 |
| Volume (in3) | 2.933 | 2.857 |
| Moisture Content | 1.3% | 21.4% |
| Dry Unit Weight (pcf) | 104.34 | 107.09 |
| Void Ratio (e) | 0.6805 | 0.6374 |
| Height (in) | 0.993 | 0.968 |

Specific Gravity 2.81

| Load (psf) | Log Pressure | Adj. Con (in/in) | Void Ratio | Unit Wt. (pcf) |
|---|---|---|---|---|
| 558 | 2.747 | -0.0009 | 0.679 | 104.43 |
| 1074 | 3.031 | -0.0049 | 0.672 | 104.86 |
| 2153 | 3.333 | -0.0101 | 0.663 | 105.41 |
| 3756 | 3.575 | -0.0169 | 0.652 | 106.15 |
| 8083 | 3.908 | -0.0324 | 0.626 | 107.86 |
| 3756 | 3.575 | -0.0310 | 0.628 | 107.70 |
| 2153 | 3.333 | -0.0292 | 0.631 | 107.50 |
| 1074 | 3.031 | -0.0275 | 0.634 | 107.31 |
| 558 | 2.747 | -0.0255 | 0.637 | 107.09 |

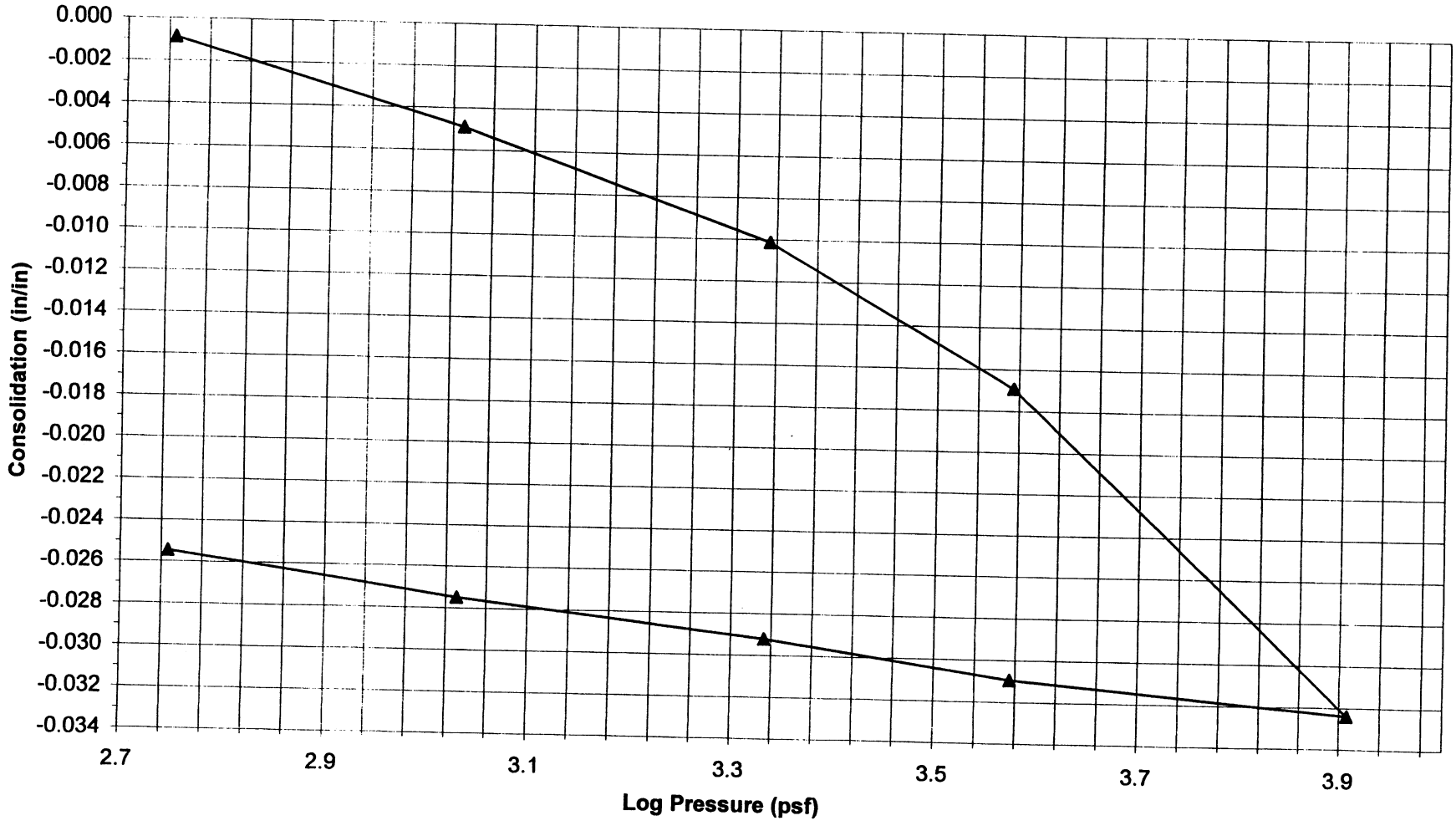
% Solids Content= 58.45

Calibration Hanger #1

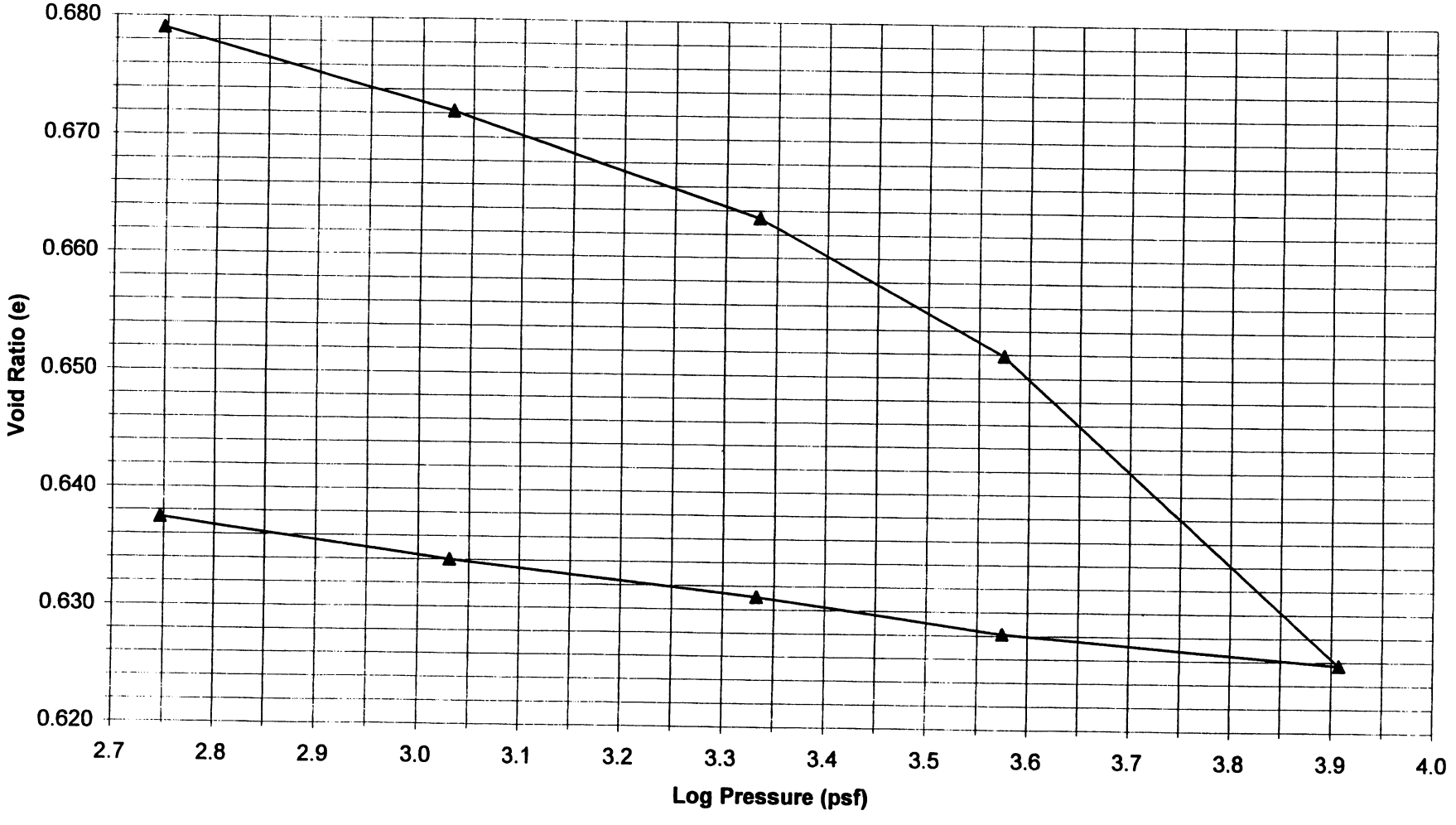
| Seat load | 0.175 | 0.0069 |
|---|---|---|
| Load (psf) | Dial Reading | Deflect (in) |
| 0 | 0.000 | 0.0000 |
| 558 | 0.075 | -0.0030 |
| 1074 | 0.140 | -0.0055 |
| 2153 | 0.200 | -0.0079 |
| 3756 | 0.270 | -0.0106 |
| 8083 | 0.360 | -0.0142 |
| 3756 | 0.310 | -0.0122 |
| 2153 | 0.280 | -0.0110 |
| 1074 | 0.240 | -0.0094 |
| 558 | 0.215 | -0.0085 |

| Load (psf) | Dial Reading | Deflect (in) |
|---|---|---|
| 0 | 0.0000 | 0.0000 |
| 558 | 0.0900 | -0.0035 |
| 1074 | 0.2250 | -0.0089 |
| 2153 | 0.3750 | -0.0148 |
| 3756 | 0.5625 | -0.0221 |
| 8083 | 0.9200 | -0.0362 |
| 3756 | 0.8450 | -0.0333 |
| 2153 | 0.7850 | -0.0309 |
| 1074 | 0.7150 | -0.0281 |
| 558 | 0.6550 | -0.0258 |

**CONSOLIDATION TEST DATA**
**Nicolet Minerals Company - 71503**
**Sample KB-1**
**Crandon Tailing Slurry**



**CONSOLIDATION TEST DATA**
**Nicolet Minerals Company - 71503**
**Sample KB-1**
**Crandon Tailing Slurry**



# PAN EVAPORATION TEST #1

| | | | |
|---|---|---|---|
| Project | Nicolet Minerals Company | Project No. | 71503 |
| Sample No. | KB-1 | Tested By | SDD |
| Description | SILT, dark gray | Checked By | DH |
| Sample Type | Crandon Tailing Slurry | Date | 04/29/98 |

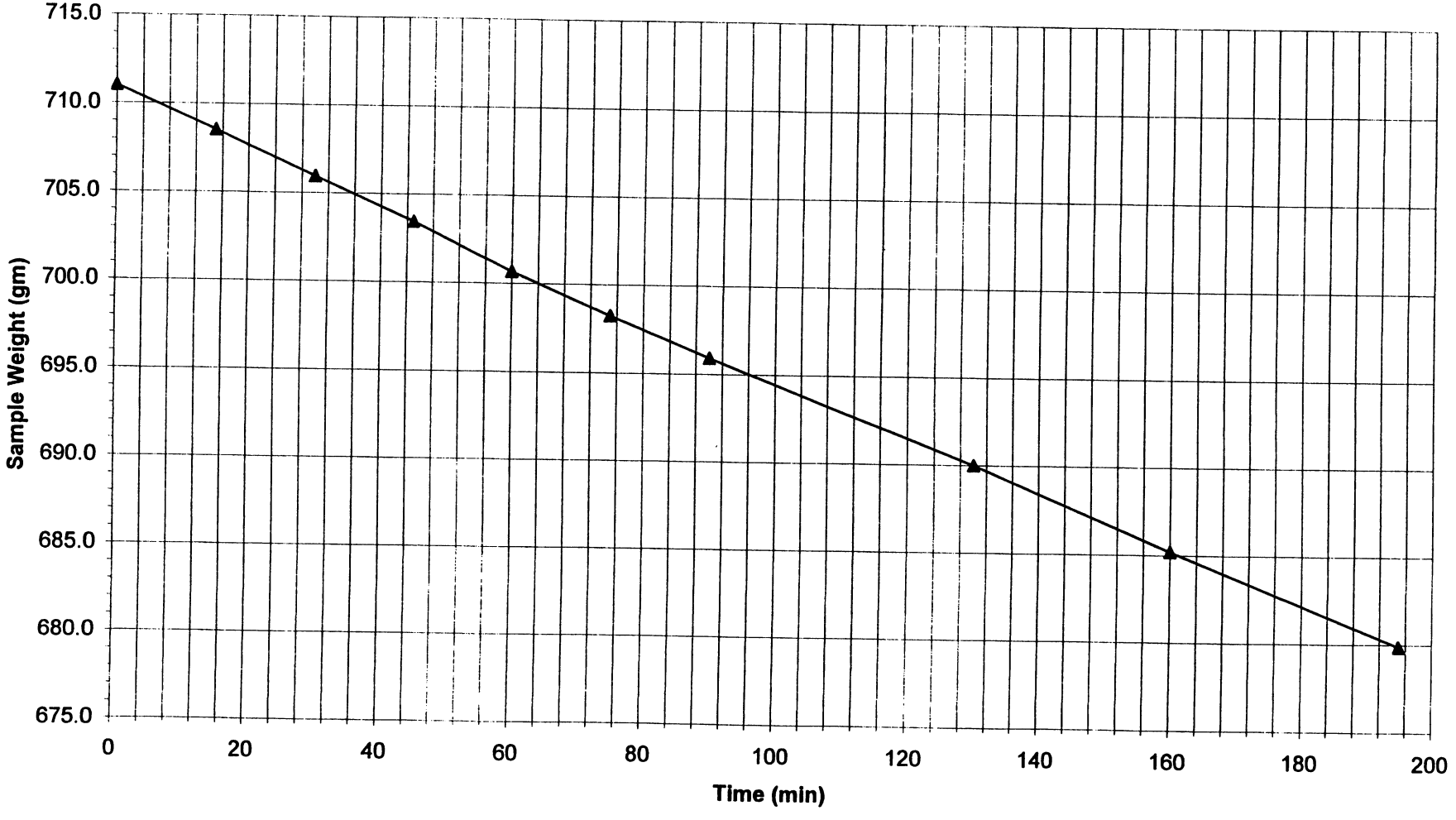
| INITIAL SAMPLE DATA - 1 | | | |
|---|---|---|---|
| Sample Dia (cm) | 4.86 | Specific Gravity | 2.81 |
| Init. Ht. (cm) | 3.76 | Assumed? | No |
| Init. Vol ($cm^3$) | 69.73 | Init. Void Ratio | 0.847 |
| Init. Sample Wet Wt. (g) | 117.75 | Initial Porosity | 0.458 |
| Init. Moisture Content | 11.0% | Init. Dry Density (pcf) | 95.0 |
| | | Initial Calculated Saturation | 36.5% |
| FINAL SAMPLE DATA | | | |
| Final Wet Wt. + Pan (g) | 326.58 | | |
| Final Dry Wt. + Pan (g) | 314.90 | | |
| Pan Wt. Only (g) | 208.82 | | |
| Final Moisture Content | 11.0% | | |

| INITIAL SAMPLE DATA - 2 | | | |
|---|---|---|---|
| Sample Dia (cm) | 4.86 | Specific Gravity | 2.81 |
| Init. Ht. (cm) | 3.64 | Assumed? | No |
| Init. Vol ($cm^3$) | 67.48 | Init. Void Ratio | 0.900 |
| Init. Sample Wet Wt. (g) | 110.51 | Initial Porosity | 0.474 |
| Init. Moisture Content | 10.8% | Init. Dry Density (pcf) | 92.3 |
| | | Initial Calculated Saturation | 33.7% |
| FINAL SAMPLE DATA | | | |
| Final Wet Wt. + Pan (g) | 338.58 | | |
| Final Dry Wt. + Pan (g) | 327.82 | | |
| Pan Wt. Only (g) | 228.07 | | |
| Final Moisture Content | 10.8% | | |

**Average Density (pcf) =** 93.61

**% Solids Content =** 30.55

## PAN EVAPORATION TEST #1
## Nicolet Minerals Company - 51703
## Tailing Slurry



# PAN EVAPORATION TEST #2

| | | | |
|---|---|---|---|
| Project | Nicolet Minerals Company | Project No. | 71503 |
| Sample No. | KB-1 | Tested By | SDD |
| Description | SILT, dark gray | Checked By | DH |
| Sample Type | Crandon Tailing Slurry | Date | 05/05/98 |

## INITIAL SAMPLE DATA - A

| | | | |
|---|---|---|---|
| Sample Dia (cm) | 4.87 | Specific Gravity | 2.81 |
| Init. Ht. (cm) | 2.88 | Assumed? | No |
| Init. Vol ($cm^3$) | 53.53 | Init. Void Ratio | 0.654 |
| Init. Sample Wet Wt. (g) | 110.49 | Initial Porosity | 0.396 |
| Init. Moisture Content | 21.6% | Init. Dry Density (pcf) | 106.0 |
| | | Initial Calculated Saturation | 92.6% |

## FINAL SAMPLE DATA

| | |
|---|---|
| Final Wet Wt. + Pan (g) | 319.38 |
| Final Dry Wt. + Pan (g) | 299.74 |
| Pan Wt. Only (g) | 208.84 |
| Final Moisture Content | 21.6% |

## INITIAL SAMPLE DATA - B

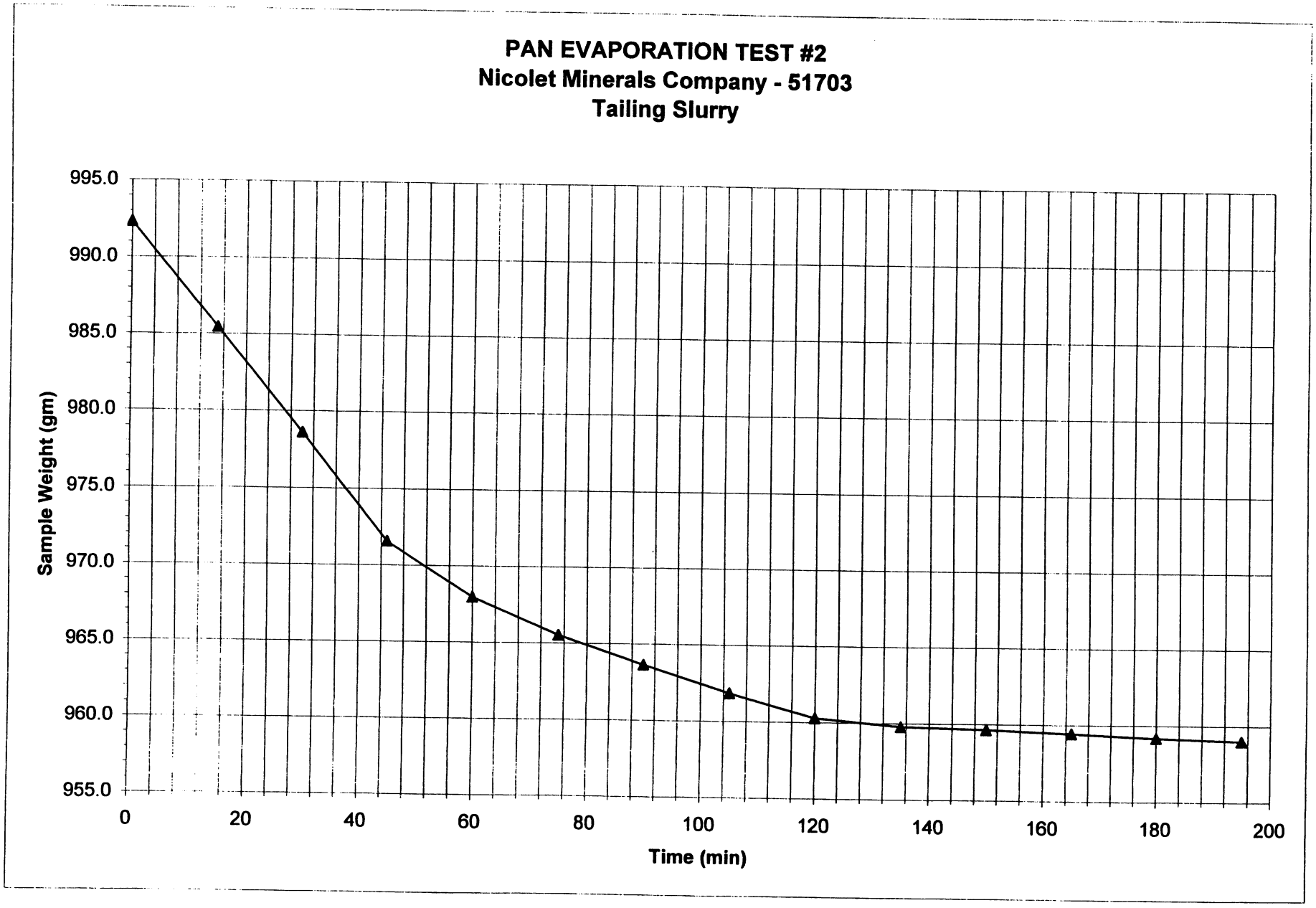
| | | | |
|---|---|---|---|
| Sample Dia (cm) | 4.87 | Specific Gravity | 2.81 |
| Init. Ht. (cm) | 2.88 | Assumed? | No |
| Init. Vol ($cm^3$) | 53.61 | Init. Void Ratio | 0.660 |
| Init. Sample Wet Wt. (g) | 110.67 | Initial Porosity | 0.398 |
| Init. Moisture Content | 22.0% | Init. Dry Density (pcf) | 105.6 |
| | | Initial Calculated Saturation | 93.7% |

## FINAL SAMPLE DATA

| | |
|---|---|
| Final Wet Wt. + Pan (g) | 340.68 |
| Final Dry Wt. + Pan (g) | 320.75 |
| Pan Wt. Only (g) | 230.05 |
| Final Moisture Content | 22.0% |

**Average Density (pcf) =** 105.80

**% Solids Content =** 58.45


PAN EVAPORATION TEST #2
Nicolet Minerals Company - 51703
Tailing Slurry
Sample Weight (gm)
995.0
990.0
985.0
980.0
975.0
970.0
965.0
960.0
955.0
0
20
40
60
80
100
120
140
160
180
200
Time (min)

NICOLET MINERALS COMPANY
UNDRAINED SETTLED DENSITY RESULTS
CRANDON TAILING SLURRY - JOB # 71503

| Lift | Slurry Wt. (gm) | Solids Dry Wt. (gm) | Height (cm) | Area (cm2) | Volume (cm3) | Density (pcf) | Porosity (%) |
|---|---|---|---|---|---|---|---|
| 1 | 2118.0 | 562.30 | 17.40 | 31.67 | 551.04 | 63.67 | 64.32% |
| 1 & 2 | | 562.30 | 16.00 | 31.67 | 506.71 | 69.25 | 61.20% |
| 1,2 & 3 | | 562.30 | 15.80 | 31.67 | 500.37 | 70.12 | 60.71% |
| 2 | 1451.4 | 425.76 | 13.10 | 31.67 | 414.87 | 64.04 | 64.12% |
| 2 & 3 | | 425.76 | 12.50 | 31.67 | 395.87 | 67.11 | 62.39% |
| 3 | 1659.5 | 491.54 | 13.50 | 31.67 | 427.53 | 71.74 | 59.80% |
| Total Sample | 5228.9 | 1490.24 | 41.80 | 31.67 | 1323.77 | 70.25 | 60.64% |

| Lift No. | % Solids |
|---|---|
| 1 | 26.55 |
| 2 | 29.33 |
| 3 | 29.62 |
| **Average =** | 28.50 |

NICOLET MINERALS COMPANY
DRAINED SETTLED DENSITY RESULTS
CRANDON TAILING SLURRY - JOB # 71503

| Lift | Slurry Wt. (gm) | Solids Dry Wt. (gm) | Height (cm) | Area (cm2) | Volume (cm3) | Density (pcf) | Porosity (%) |
|---|---|---|---|---|---|---|---|
| 1 | 2011.50 | 607.36 | 15.10 | 31.16 | 470.58 | 80.54 | 54.87% |
| 1 & 2 | | 607.36 | 14.80 | 31.16 | 461.24 | 82.17 | 53.96% |
| 1,2 & 3 | | 607.36 | 14.80 | 31.16 | 461.24 | 82.17 | 53.96% |
| 2 | 2021.50 | 645.38 | 15.10 | 31.16 | 470.58 | 85.58 | 52.05% |
| 2 & 3 | | 645.38 | 14.90 | 31.16 | 464.35 | 86.73 | 51.40% |
| 3 | 2076.50 | 615.43 | 15.70 | 31.16 | 489.28 | 78.49 | 56.02% |
| Total Sample | 6109.50 | 1868.90 | 45.40 | 31.16 | 1414.87 | 82.42 | 53.81% |

| Lift No. | % Solids |
|---|---|
| 1 | 30.19 |
| 2 | 31.93 |
| 3 | 29.64 |
| **Average =** | 30.59 |

## HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS
## SETTLED DENSITY COLUMN - DRAINED

| | | | |
|---|---|---|---|
| Project | Nicolet Minerals Company | Project No. | 71503 |
| Sample No. | KB-1 | Tested By | SDD |
| Description | SILT, dark gray | Checked By | TM |
| Sample Type | Crandon Tailing Slurry | Date | 05/08/98 |

| INITIAL SAMPLE DATA | | | |
|---|---|---|---|
| Sample Dia (cm) | 6.30 | Specific Gravity | 2.81 |
| Init. Ht. (cm) | 46.00 | Assumed? | No |
| Init. Vol ($cm^3$) | 1433.57 | Init. Void Ratio | 1.155 |
| Init. Sample Wet Wt. (g) | 2652.89 | Initial Porosity | 0.536 |
| Init. Moisture Content | 41.9% | Init. Dry Density (pcf) | 81.4 |
| | | Initial Calculated Saturation | 102.1% |
| **CONSOLIDATION DATA** | | | |
| Back Pressure (psi) | 0.0 | Final Area ($cm^2$) | 31.165 |
| Confining Pressure (psi) | 0.0 | Height Change (cm) | 0.00 |
| Volume Change (cc) | 0.00 | Final Ht. (cm) | 46.00 |
| **FINAL SAMPLE DATA** | | | |
| Final Wet Wt. + Pan (g) | 2652.89 | Final Void Ratio | 1.155 |
| Final Dry Wt. + Pan (g) | 1868.90 | Final Volume ($cm^3$) | 1433.57 |
| Pan Wt. Only (g) | 0.00 | Final Dry Density (pcf) | 81.4 |
| Final Moisture Content | 41.9% | Final Calculated Saturation | 100.0% |
| | | Final Porsity | 0.536 |

**TEST DATA**

| Elapsed Time (min) | Flow Q (cc) | Length (cm) | $H_1$ (cm) | $H_2$ (cm) | ln ($H_1/H_2$) | Permeability k (cm/sec) |
|---|---|---|---|---|---|---|
| 90 | 30.10 | 46.0 | 58.40 | 57.43 | 1.67E-02 | 1.4E-04 |
| 90 | 29.90 | 46.0 | 57.40 | 56.44 | 1.69E-02 | 1.4E-04 |
| 90 | 29.20 | 46.0 | 56.50 | 55.56 | 1.67E-02 | 1.4E-04 |
| 90 | 29.40 | 46.0 | 55.50 | 54.56 | 1.71E-02 | 1.5E-04 |
| | | | | | Average = | 1.4E-04 |

STEFFEN ROBERTSON & KIRSTEN (US) INC.
Consulting Engineers & Scientists

Project: Nicolet Minerals Co. - 71503
Date: 5/27/98
Sample: KB-1, Crandon Tailing Slurry

# CONSOLIDATION TEST RESULTS
## ASTM D2435

| Sample Data | Before Test | After Test |
|---|---|---|
| Wet Weight (g) | 88.74 | 83.98 |
| Dry Weight (g) | 64.70 | 64.70 |
| Height (in) | 0.930 | 0.880 |
| Diameter (in) | 1.935 | 1.939 |
| Area (in2) | 2.941 | 2.953 |
| Volume (in3) | 2.735 | 2.600 |
| Moisture Content | 37.2% | 29.8% |
| Dry Unit Weight (pcf) | 90.12 | 94.80 |
| Void Ratio (e) | 0.9456 | 0.8495 |
| Height (in) | 0.930 | 0.880 |

Specific Gravity 2.81

| Load (psf) | Log Pressure | Adj. Con (in/in) | Void Ratio | Unit Wt. (pcf) |
|---|---|---|---|---|
| 541 | 2.733 | -0.0144 | 0.916 | 91.54 |
| 1084 | 3.035 | -0.0208 | 0.902 | 92.19 |
| 2164 | 3.335 | -0.0300 | 0.883 | 93.13 |
| 4320 | 3.635 | -0.0412 | 0.859 | 94.30 |
| 8637 | 3.936 | -0.0575 | 0.825 | 96.06 |
| 4320 | 3.635 | -0.0563 | 0.828 | 95.93 |
| 2164 | 3.335 | -0.0550 | 0.831 | 95.78 |
| 1084 | 3.035 | -0.0520 | 0.837 | 95.47 |
| 541 | 2.733 | -0.0495 | 0.842 | 95.20 |

% Solids Content = 32.44

STEFFEN ROBERTSON & KIRSTEN (US) INC.
Consulting Engineers & Scientists

Project: Nicolet Minerals Co. - 71503
Date: 5/27/98
Sample: KB-1, Crandon Tailing Slurry

# CONSOLIDATION TEST RESULTS
## ASTM D2435

Seat Load 1psi - 144pcf

| Elapsed Time (min) | SQRT Time (min) | Dial Reading | Deflection (inches) | Sample Height |
|---|---|---|---|---|
| 0.00 | 0.00 | 0.000 | 0.0000 | 0.9300 |
| 20.00 | 4.47 | 0.175 | -0.0069 | 0.9231 |
| 60.00 | 7.75 | 0.180 | -0.0071 | 0.9229 |
| 1200.00 | 34.64 | 0.210 | -0.0083 | 0.9217 |
| 2190.00 | 46.80 | 0.220 | -0.0087 | 0.9213 |
| 3105.00 | 55.72 | 0.223 | -0.0088 | 0.9212 |

3.75 psi - 541 pcf

| Elapsed Time (min) | SQRT Time (min) | Dial Reading | Deflection (inches) | Sample Height |
|---|---|---|---|---|
| 0.00 | 0.00 | 0.223 | -0.0088 | 0.9212 |
| 0.12 | 0.34 | 0.380 | -0.0150 | 0.9063 |
| 0.25 | 0.50 | 0.390 | -0.0154 | 0.9059 |
| 0.50 | 0.71 | 0.395 | -0.0156 | 0.9057 |
| 1.00 | 1.00 | 0.400 | -0.0157 | 0.9055 |
| 2.00 | 1.41 | 0.410 | -0.0161 | 0.9051 |
| 4.00 | 2.00 | 0.415 | -0.0163 | 0.9049 |
| 8.00 | 2.83 | 0.420 | -0.0165 | 0.9047 |
| 15.00 | 3.87 | 0.430 | -0.0169 | 0.9043 |
| 30.00 | 5.48 | 0.440 | -0.0173 | 0.9039 |
| 60.00 | 7.75 | 0.445 | -0.0175 | 0.9037 |
| 120.00 | 10.95 | 0.450 | -0.0177 | 0.9035 |
| 240.00 | 15.49 | 0.455 | -0.0179 | 0.9033 |
| 480.00 | 21.91 | 0.465 | -0.0183 | 0.9029 |
| 560.00 | 23.66 | 0.467 | -0.0184 | 0.9028 |
| 1440.00 | 37.95 | 0.4750 | -0.0187 | 0.9025 |

7.5 psi - 1084 pcf

| Elapsed Time (min) | SQRT Time (min) | Dial Reading | Deflection (inches) | Sample Height |
|---|---|---|---|---|
| 0.00 | 0.00 | 0.475 | -0.0187 | 0.9025 |
| 0.12 | 0.34 | 0.590 | -0.0232 | 0.8793 |
| 0.25 | 0.50 | 0.610 | -0.0240 | 0.8785 |
| 0.50 | 0.71 | 0.620 | -0.0244 | 0.8781 |
| 1.00 | 1.00 | 0.625 | -0.0246 | 0.8779 |
| 2.00 | 1.41 | 0.630 | -0.0248 | 0.8777 |
| 4.00 | 2.00 | 0.633 | -0.0249 | 0.8776 |
| 8.00 | 2.83 | 0.638 | -0.0251 | 0.8774 |
| 15.00 | 3.87 | 0.642 | -0.0253 | 0.8772 |
| 30.00 | 5.48 | 0.650 | -0.0256 | 0.8769 |
| 60.00 | 7.75 | 0.655 | -0.0258 | 0.8767 |
| 120.00 | 10.95 | 0.660 | -0.0260 | 0.8765 |
| 240.00 | 15.49 | 0.665 | -0.0262 | 0.8763 |
| 480.00 | 21.91 | 0.675 | -0.0266 | 0.8759 |
| 1440.00 | 37.95 | 0.685 | -0.0270 | 0.8756 |

15 psi - 2164 pcf

| Elapsed Time (min) | SQRT Time (min) | Dial Reading | Deflection (inches) | Sample Height |
|---|---|---|---|---|
| 0.00 | 0.00 | 0.685 | -0.0270 | 0.8756 |
| 0.12 | 0.34 | 0.865 | -0.0341 | 0.8415 |
| 0.25 | 0.50 | 0.875 | -0.0344 | 0.8411 |
| 0.50 | 0.71 | 0.885 | -0.0348 | 0.8407 |
| 1.00 | 1.00 | 0.890 | -0.0350 | 0.8405 |
| 2.00 | 1.41 | 0.895 | -0.0352 | 0.8403 |
| 4.00 | 2.00 | 0.903 | -0.0356 | 0.8400 |
| 8.00 | 2.83 | 0.909 | -0.0358 | 0.8398 |
| 15.00 | 3.87 | 0.913 | -0.0359 | 0.8396 |
| 30.00 | 5.48 | 0.920 | -0.0362 | 0.8393 |
| 60.00 | 7.75 | 0.930 | -0.0366 | 0.8389 |
| 120.00 | 10.95 | 0.937 | -0.0369 | 0.8387 |
| 240.00 | 15.49 | 0.945 | -0.0372 | 0.8383 |
| 480.00 | 21.91 | 0.955 | -0.0376 | 0.8380 |
| 1440.00 | 37.95 | 0.970 | -0.0382 | 0.8374 |

STEFFEN ROBERTSON & KIRSTEN (US) INC.
Consulting Engineers & Scientists

Project: Nicolet Minerals Co. - 71503
Date: 5/27/98
Sample: KB-1, Crandon Tailing Slurry

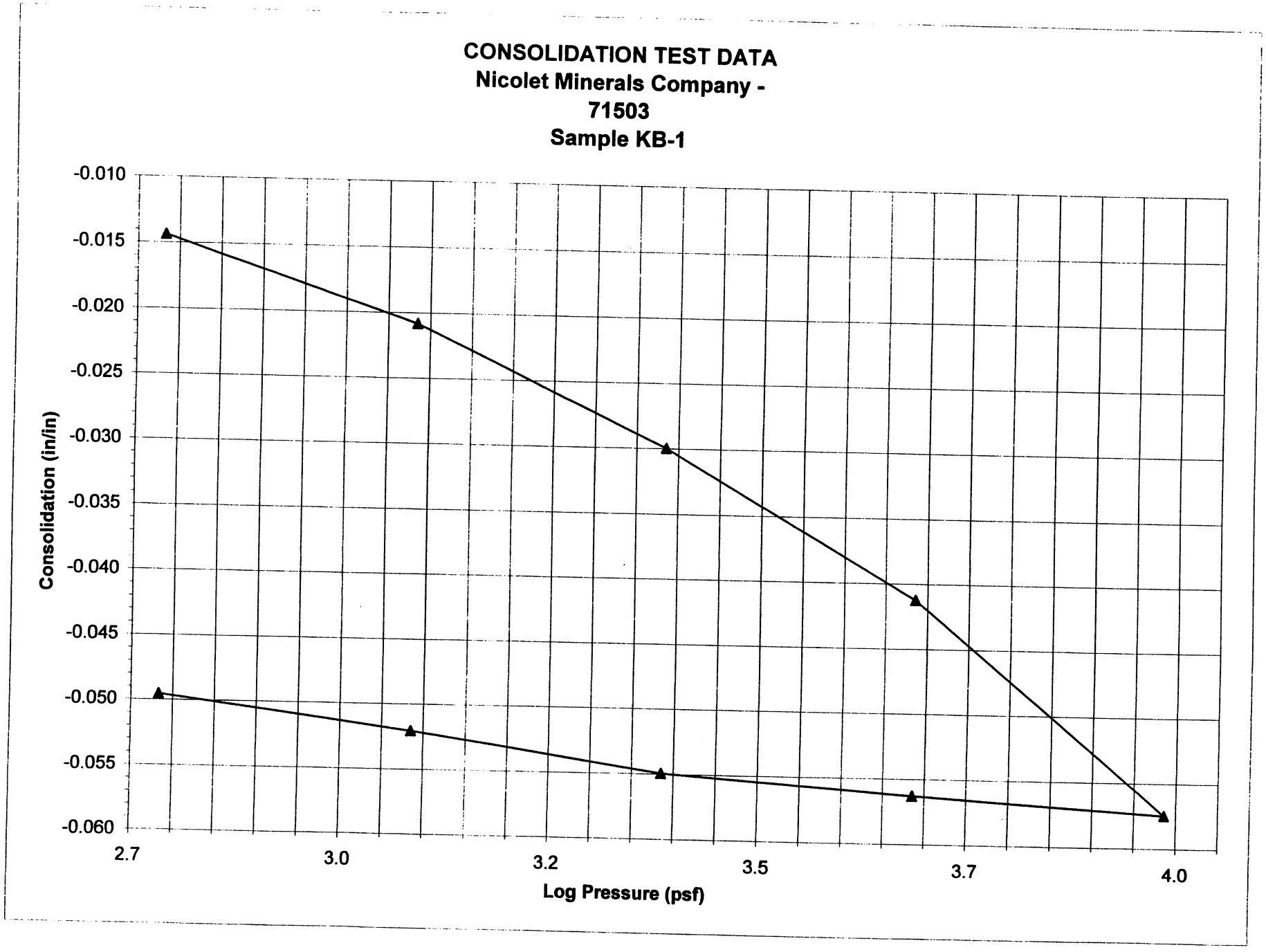
# CONSOLIDATION TEST RESULTS
## ASTM D2435

30 psi - 4320 pcf

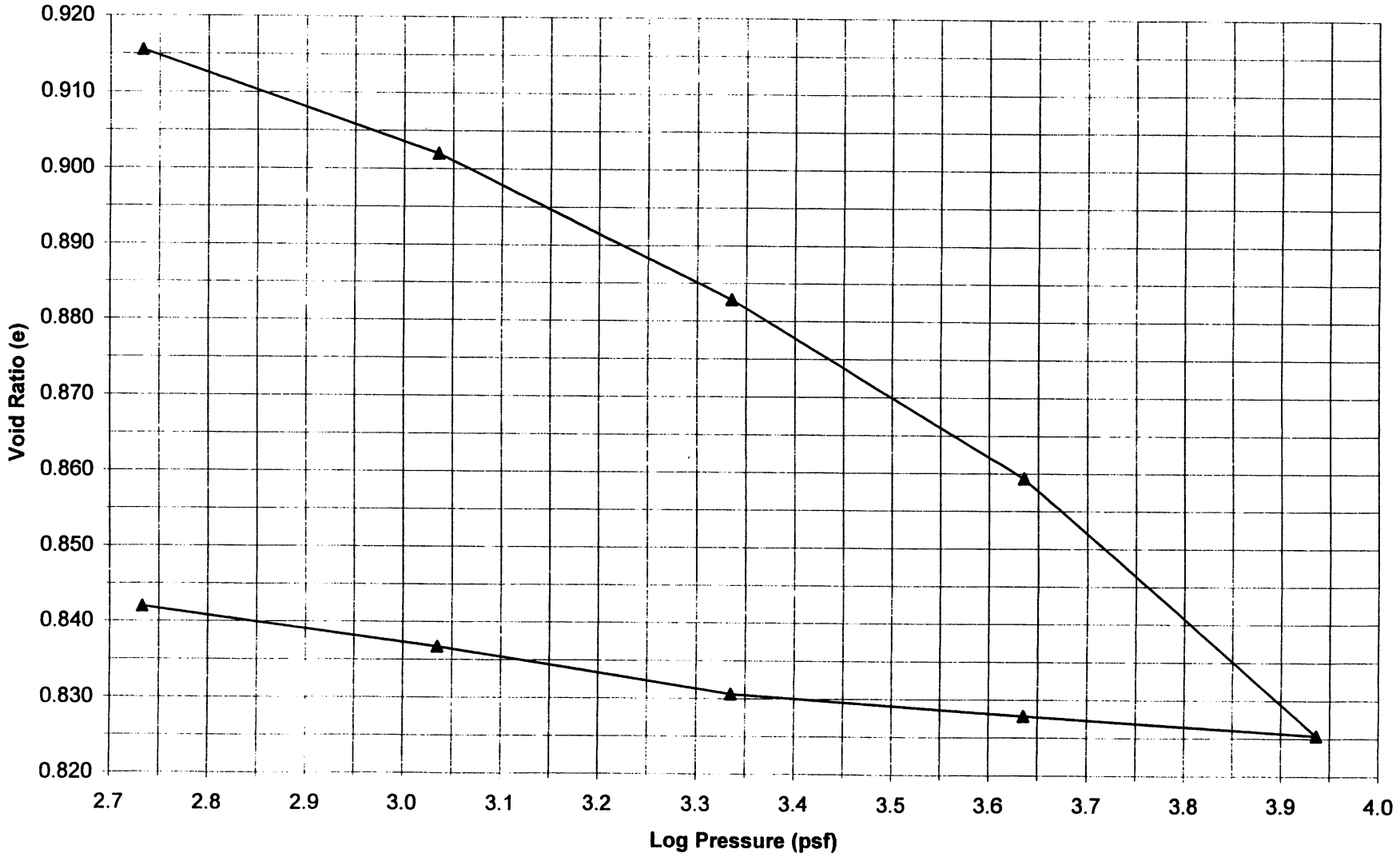
| Elapsed Time (min) | SQRT Time (min) | Dial Reading | Deflection (inches) | Sample Height |
|---|---|---|---|---|
| 0.00 | 0.00 | 0.970 | -0.0382 | 0.8374 |
| 0.12 | 0.34 | 1.205 | -0.0474 | 0.7899 |
| 0.25 | 0.50 | 1.215 | -0.0478 | 0.7895 |
| 0.50 | 0.71 | 1.225 | -0.0482 | 0.7891 |
| 1.00 | 1.00 | 1.233 | -0.0485 | 0.7888 |
| 2.00 | 1.41 | 1.240 | -0.0488 | 0.7885 |
| 4.00 | 2.00 | 1.245 | -0.0490 | 0.7883 |
| 8.00 | 2.83 | 1.252 | -0.0493 | 0.7881 |
| 15.00 | 3.87 | 1.260 | -0.0496 | 0.7878 |
| 30.00 | 5.48 | 1.265 | -0.0498 | 0.7876 |
| 60.00 | 7.75 | 1.274 | -0.0502 | 0.7872 |
| 120.00 | 10.95 | 1.283 | -0.0505 | 0.7869 |
| 240.00 | 15.49 | 1.290 | -0.0508 | 0.7866 |
| 480.00 | 21.91 | 1.303 | -0.0513 | 0.7861 |
| 1470.00 | 38.34 | 1.320 | -0.0520 | 0.7854 |

60 psi - 8637 pcf

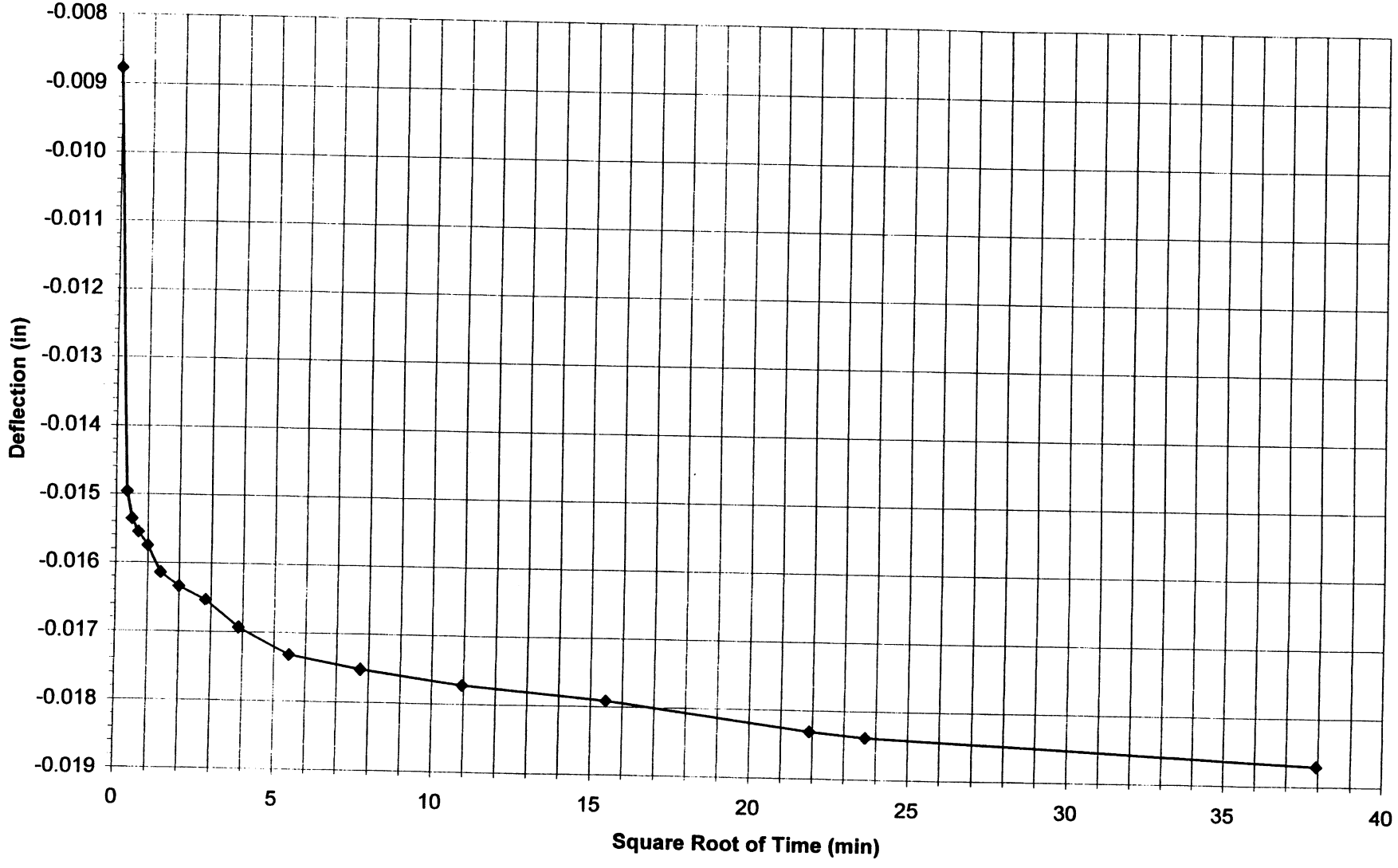
| Elapsed Time (min) | SQRT Time (min) | Dial Reading | Deflection (inches) | Sample Height |
|---|---|---|---|---|
| 0.00 | 0.00 | 1.320 | -0.0520 | 0.7854 |
| 0.12 | 0.34 | 1.630 | -0.0642 | 0.7212 |
| 0.25 | 0.50 | 1.645 | -0.0648 | 0.7206 |
| 0.50 | 0.71 | 1.660 | -0.0654 | 0.7200 |
| 1.00 | 1.00 | 1.668 | -0.0657 | 0.7197 |
| 2.00 | 1.41 | 1.675 | -0.0659 | 0.7194 |
| 4.00 | 2.00 | 1.682 | -0.0662 | 0.7192 |
| 8.00 | 2.83 | 1.690 | -0.0665 | 0.7189 |
| 15.00 | 3.87 | 1.700 | -0.0669 | 0.7185 |
| 30.00 | 5.48 | 1.710 | -0.0673 | 0.7181 |
| 60.00 | 7.75 | 1.720 | -0.0677 | 0.7177 |
| 120.00 | 10.95 | 1.730 | -0.0681 | 0.7173 |
| 240.00 | 15.49 | 1.740 | -0.0685 | 0.7169 |
| 480.00 | 21.91 | 1.755 | -0.0691 | 0.7163 |
| 1620.00 | 40.25 | 1.773 | -0.0698 | 0.7156 |
| 3960.00 | 62.93 | 1.785 | -0.0703 | 0.7151 |
| 5520.00 | 74.30 | 1.795 | -0.0707 | 0.7147 |


CONSOLIDATION TEST DATA
Nicolet Minerals Company -
71503
Sample KB-1
-0.010
-0.015
-0.020
-0.025
-0.030
-0.035
-0.040
-0.045
-0.050
-0.055
-0.060
Consolidation (in/in)
2.7
3.0
3.2
3.5
3.7
4.0
Log Pressure (psf)

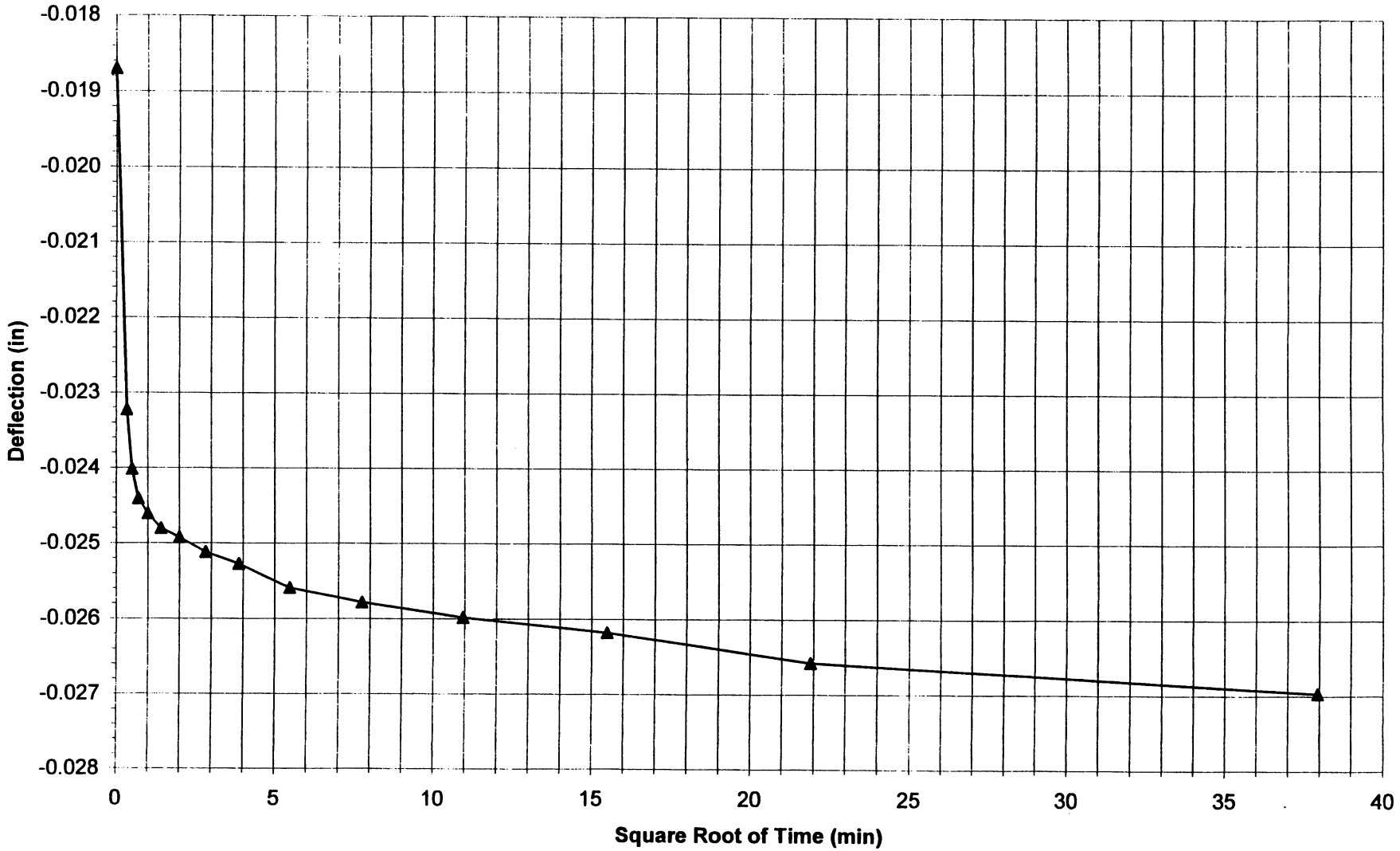
**CONSOLIDATION TEST DATA**
**Nicolet Minerals Company - 71503**
**Sample KB-1**
**Crandon Tailing Slurry**



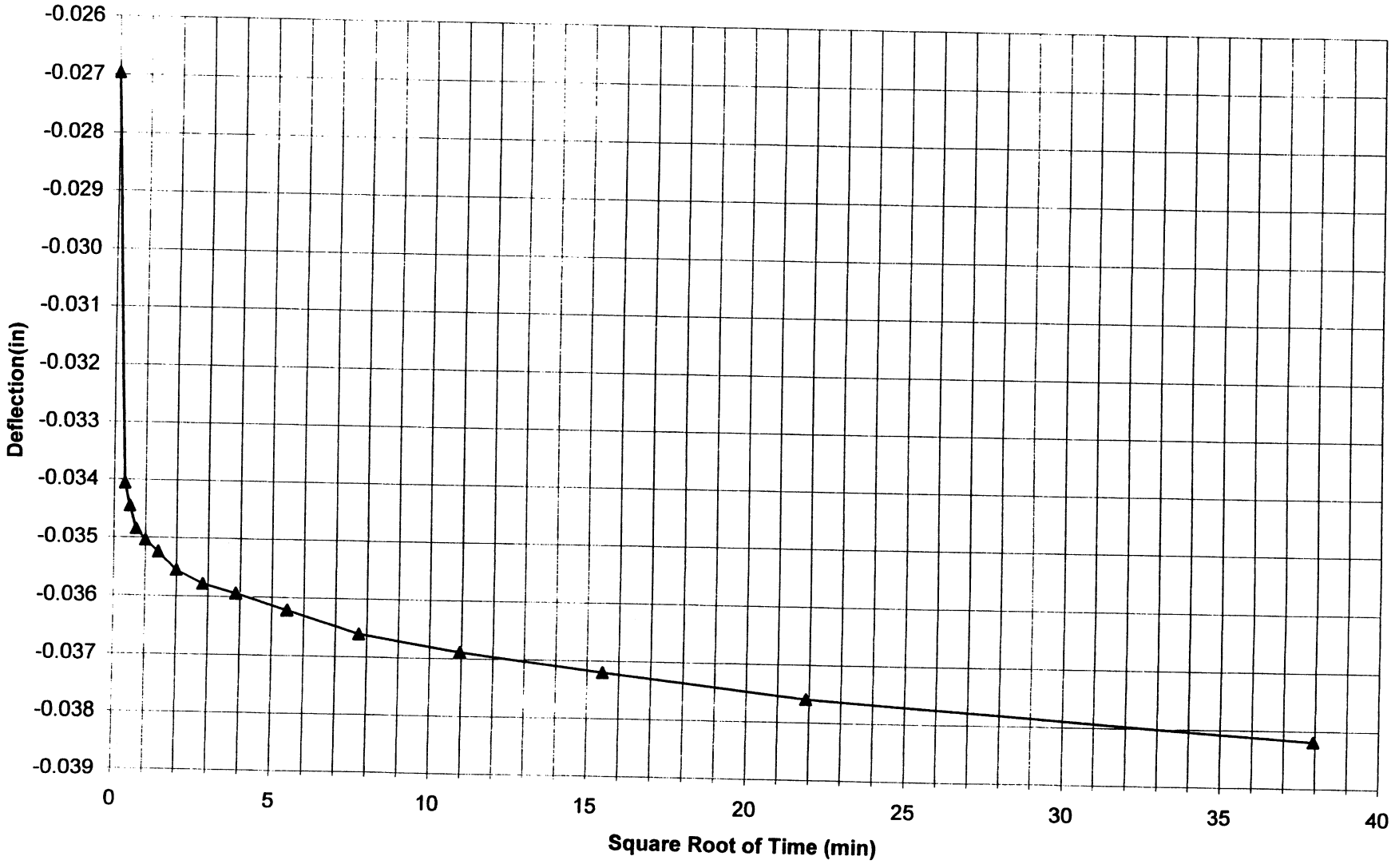
**CONSOLIDATION TEST DATA**
**Nicolet Minerals Company - 71503**
**Sample KB-1, 541 psf**



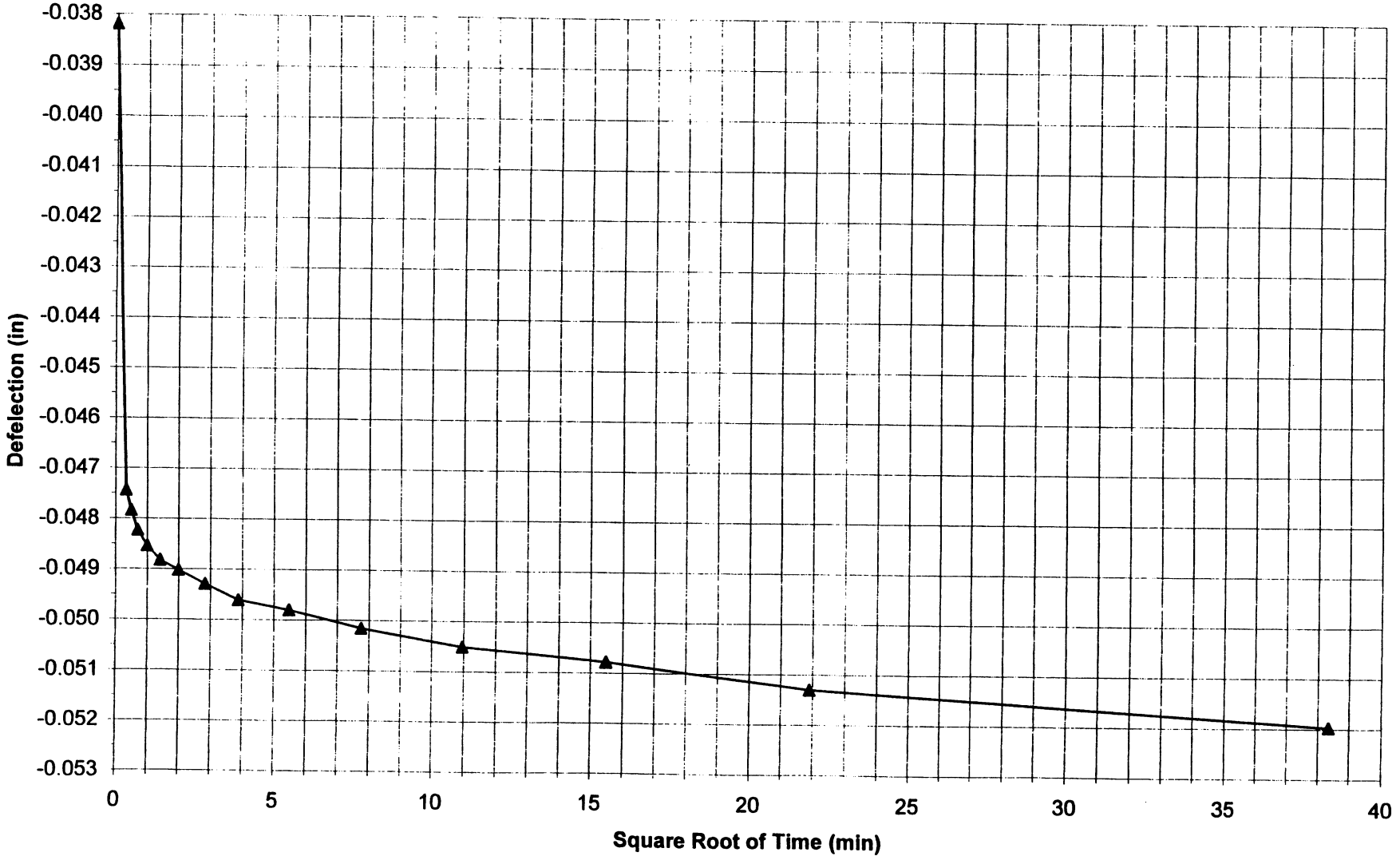
**CONSOLIDATION TEST DATA**
**Nicolet Minerals Company - 71503**
**Sample KB-1, 1084 psf**



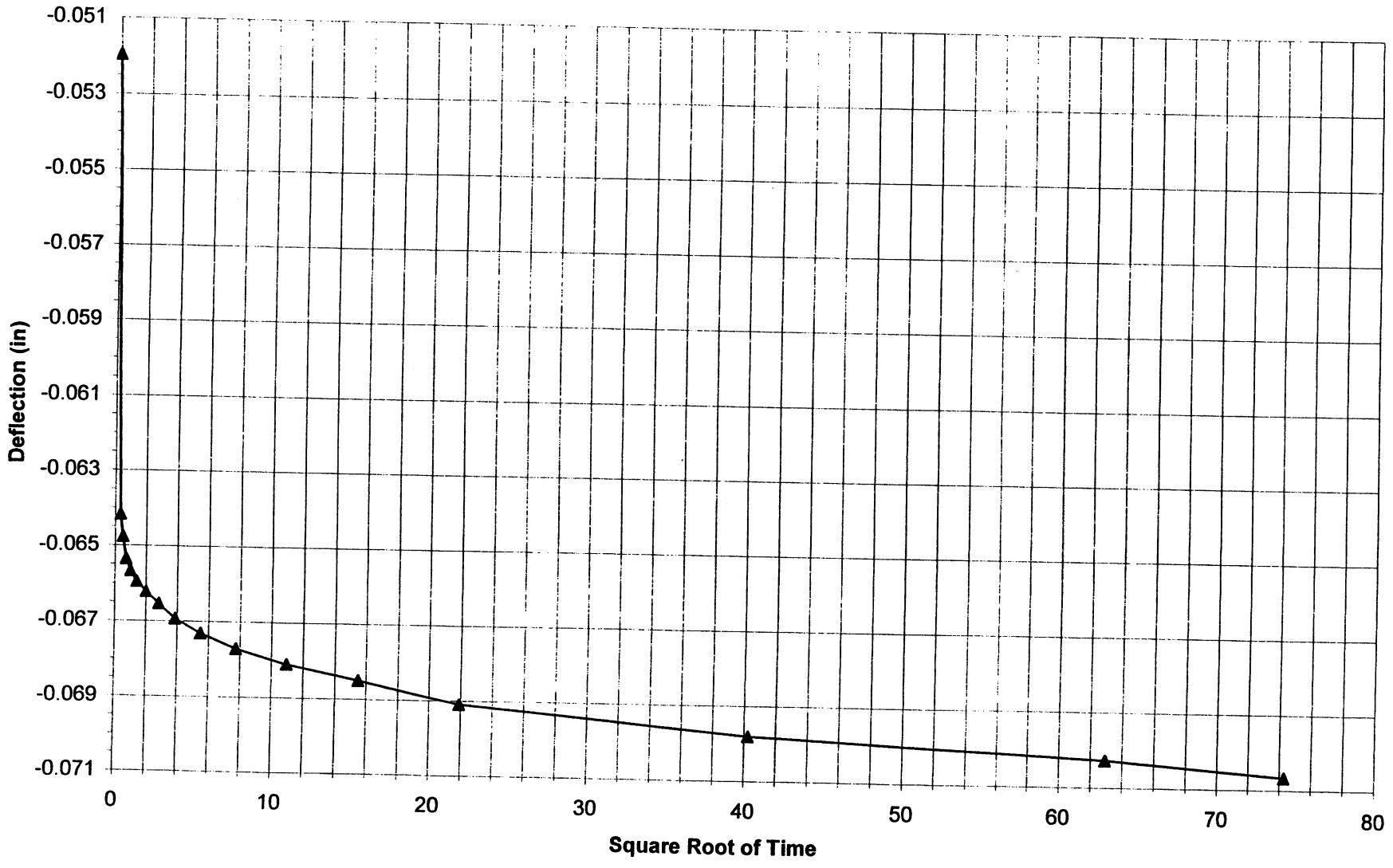
## CONSOLIDATION TEST DATA
## Nicolet Minerals Company - 71503
## Sample KB-1, 2164 psf



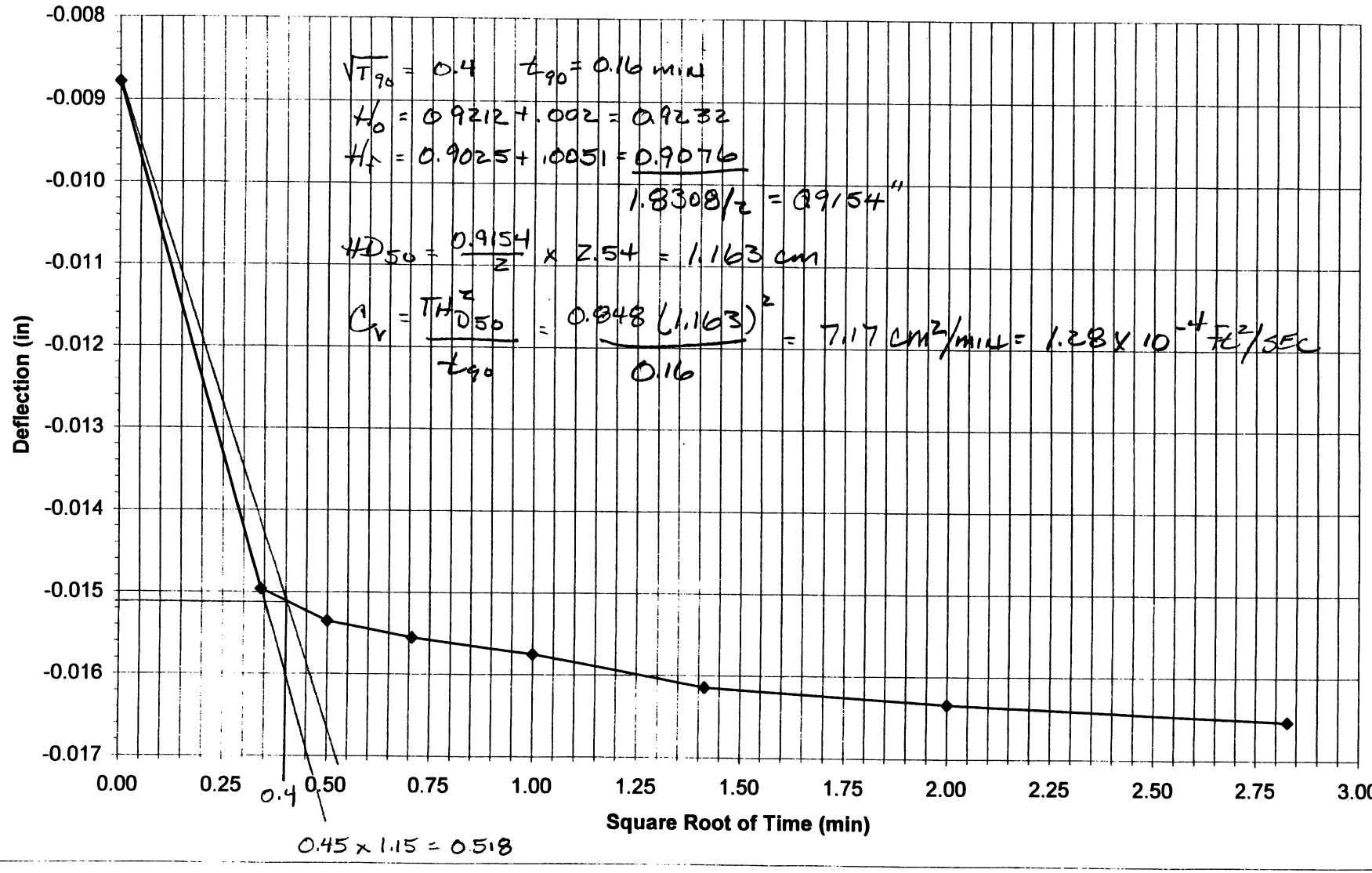
## CONSOLIDATION TEST DATA
## Nicolet Minerals Company - 71503
## Sample KB-1, 4320 psf



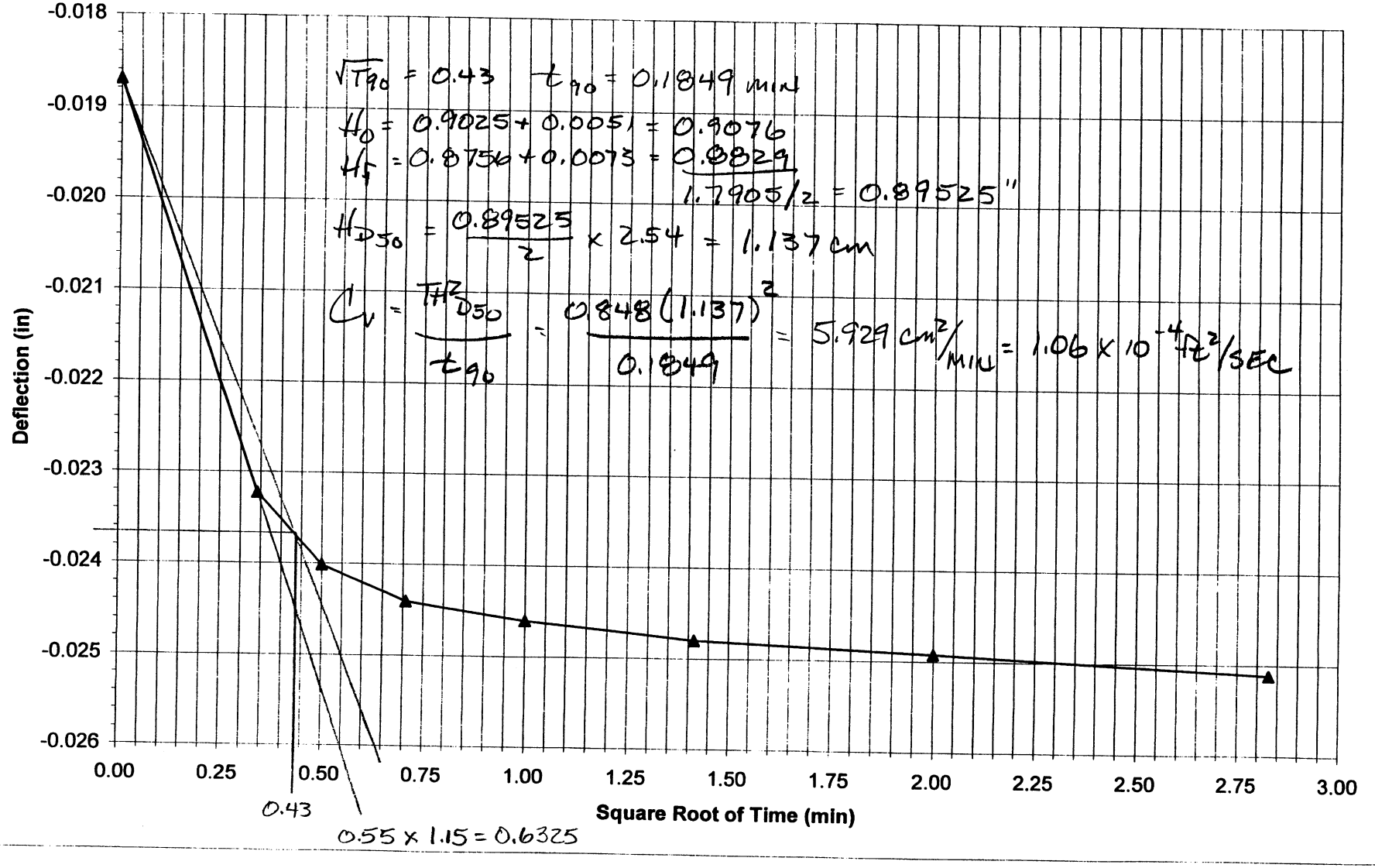
## CONSOLIDATION TEST DATA
## Nicolet Minerals Company - 71503
## Sample KB-1, 8637 psf



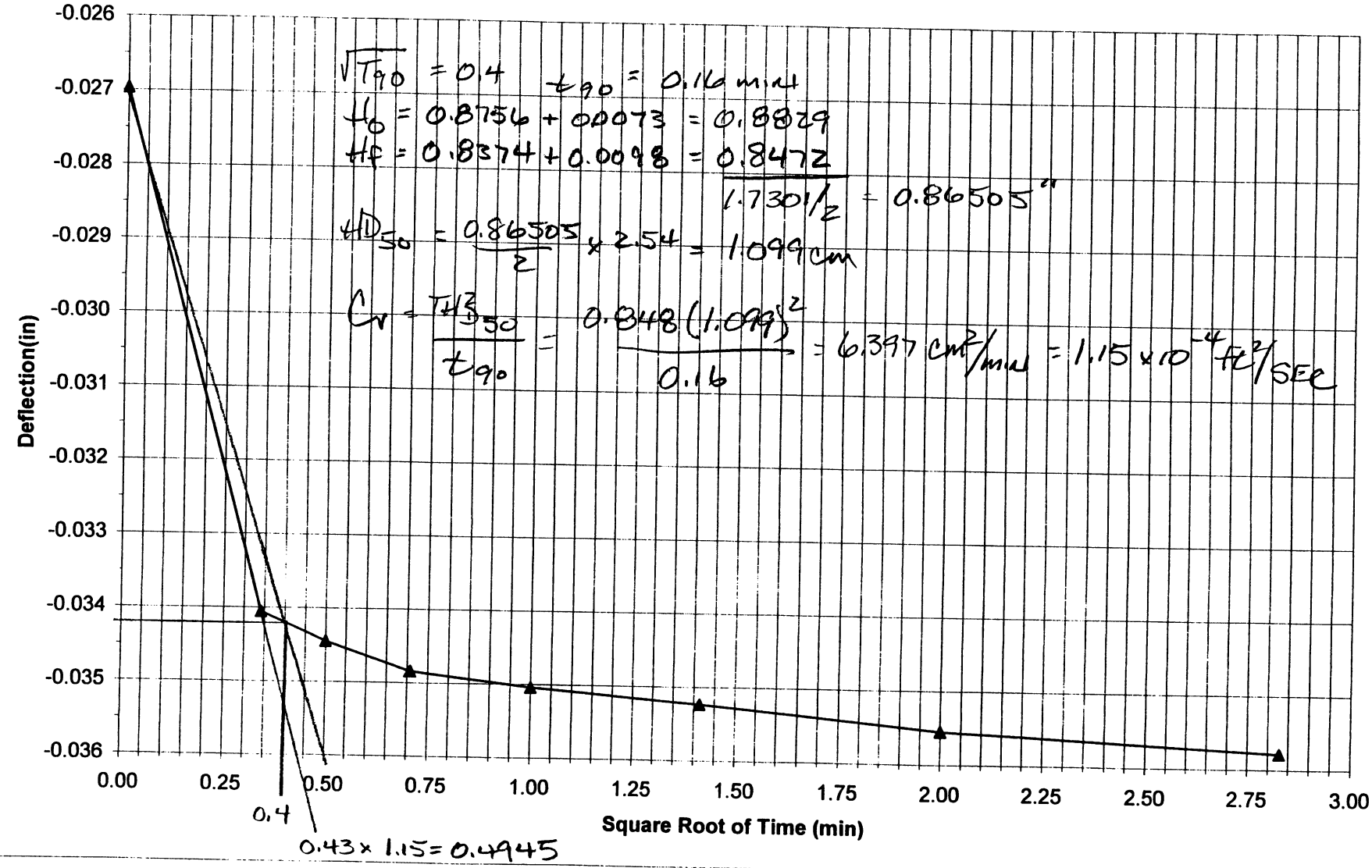
**CONSOLIDATION TEST DATA**
**Nicolet Minerals Company - 71503**
**Sample KB-1, 541 psf**



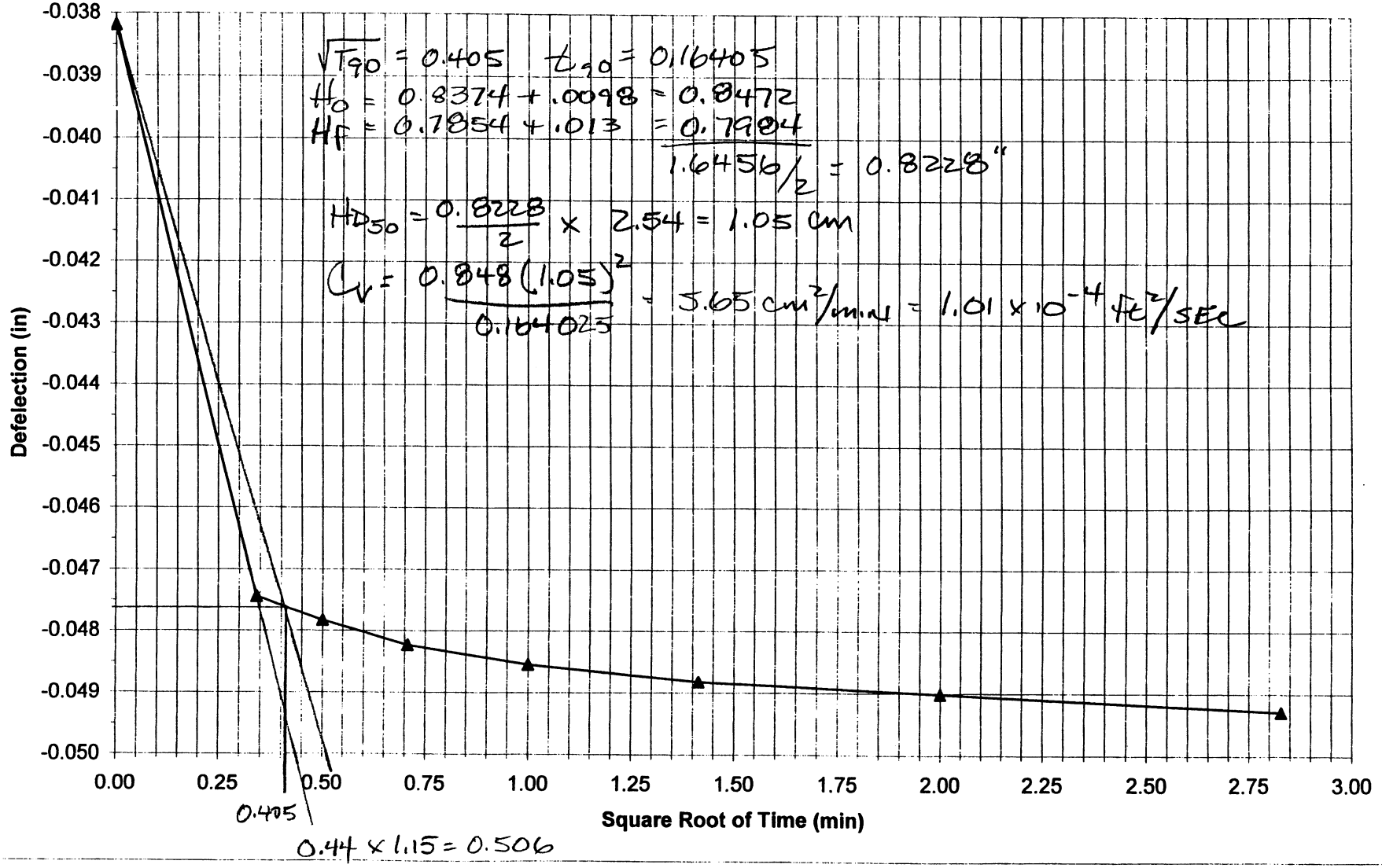
**CONSOLIDATION TEST DATA**
**Nicolet Minerals Company - 71503**
**Sample KB-1, 1084 psf**



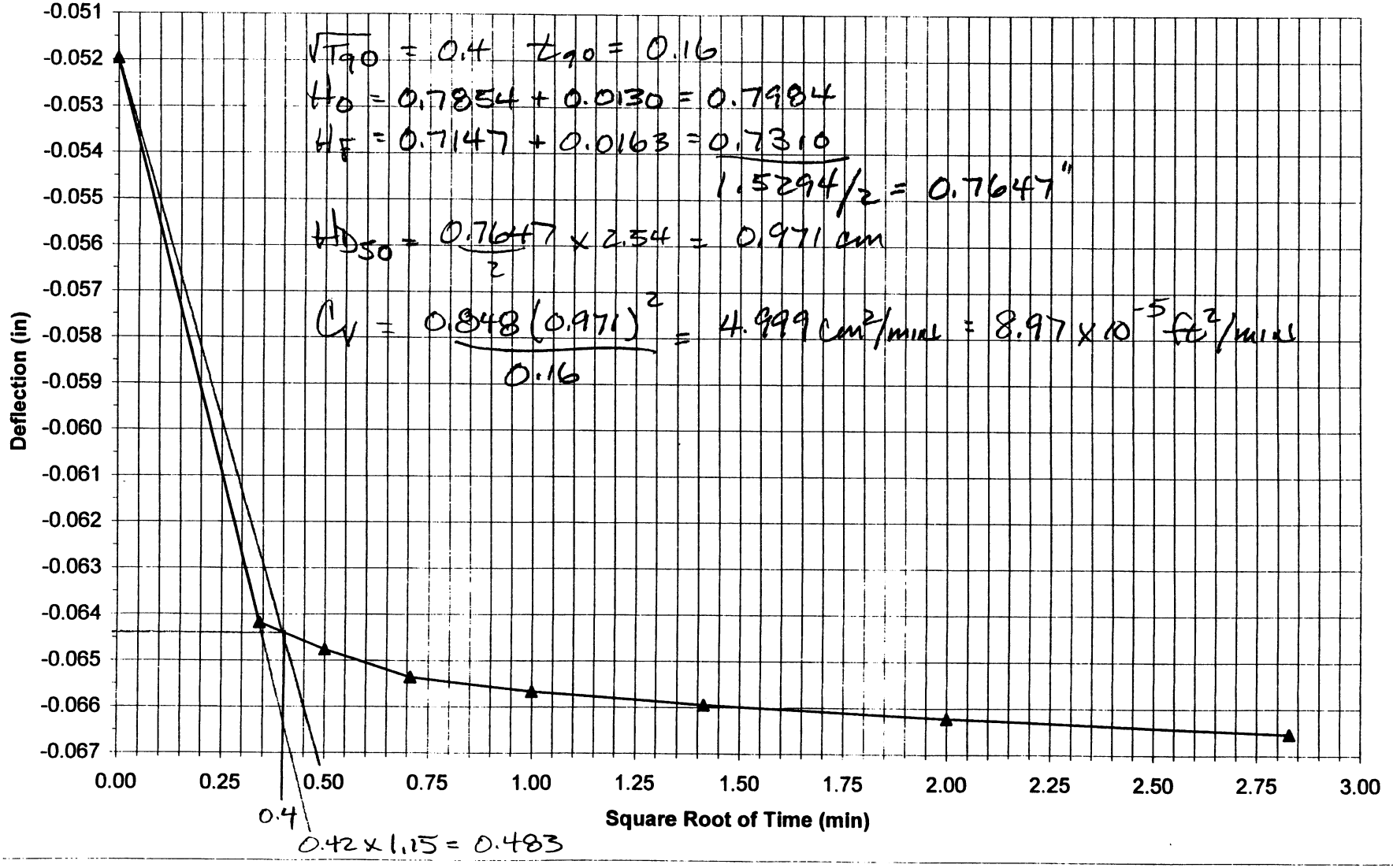
## CONSOLIDATION TEST DATA
**Nicolet Minerals Company - 71503**
**Sample KB-1, 2164 psf**



**CONSOLIDATION TEST DATA**
**Nicolet Minerals Company - 71503**
**Sample KB-1, 4320 psf**



**CONSOLIDATION TEST DATA**
**Nicolet Minerals Company - 71503**
**Sample KB-1, 8637 psf**



# Depyritized Tailings Moisture Regime Testing

STEFFEN, ROBERTSON AND KIRSTEN
Consulting Engineers and Scientists

Suite 800
580 Hornby Street
Vancouver, B.C.
Canada V6C 3B6
E-mail: vancouver@srk.com
URL: http://www.srk.com/
Tel: (604) 681-4196
Fax: (604) 687-5532

# MEMORANDUM

**TO:** Jerry Sevick (FVD)

**COPY TO:** Nandu Paruvakat (FVD), Daryl Hockley (SRK), Kelly Sexsmith (SRK)

**FROM:** Jason Smolensky

**DATE:** 26 October 1998

**SUBJECT:** Summary of Pressure Plate Testing on Nicolet Tailings Samples

---

SRK (Denver) undertook Pressure Membrane testing of Crandon project depyritized tailings samples produced from locked cycle testing to determine their capillary-moisture relationships. Tests were conducted for recompacted densities of 83, 87 and 93 PCF (pounds per cubic foot). The tests were performed according to the procedures outlined in ASTM D 3152-72 (reapproved 1994).

The first set of testing commenced on August 24th, 1998. Four samples (one for each density plus one duplicate) were made from dry, depyritized tailings samples provided by Foth and Van Dyke. The samples were remolded to the target densities at a known moisture content. The samples were then placed into a Soilmoisture 15 bar ceramic plate extractor, Model #1500 for pressure testing. After completion of the tests, the samples were air dried in a 110 C oven for determination of final moisture contents.

The results of this first set of testing are provided in Attachment 1 and plotted in Figure 1. A discrepancy between the duplicate sample and the three others was observed. In addition, the moisture contents at the last suction pressure (6000 cm/ 200 ft.) were lower than expected leading to oddly shaped retention curves. The technician who conducted the tests had an unexpected delay in taking the final test reading that could have led to additional evaporative losses. Due to the questionable nature of the results SRK recommended a second round of testing.

A second set of fresh depyritized tailings samples were provided by Foth and Van Dyke and testing was initiated on September 23rd, 1998. Again, four samples were tested using the same procedure as outlined above. The results for these tests are provided in Attachment 2 and displayed graphically in Figure 2. The shapes of the curves show a more expected pattern of approaching a final residual saturation. Again, a discrepancy between the 93 PCF sample and the 93 PCF duplicate sample is observed. There is no obvious explanation for this discrepancy other than experimental variation.

We recommend that the results from the second set of pressure tests be used as a basis for further modelling work.

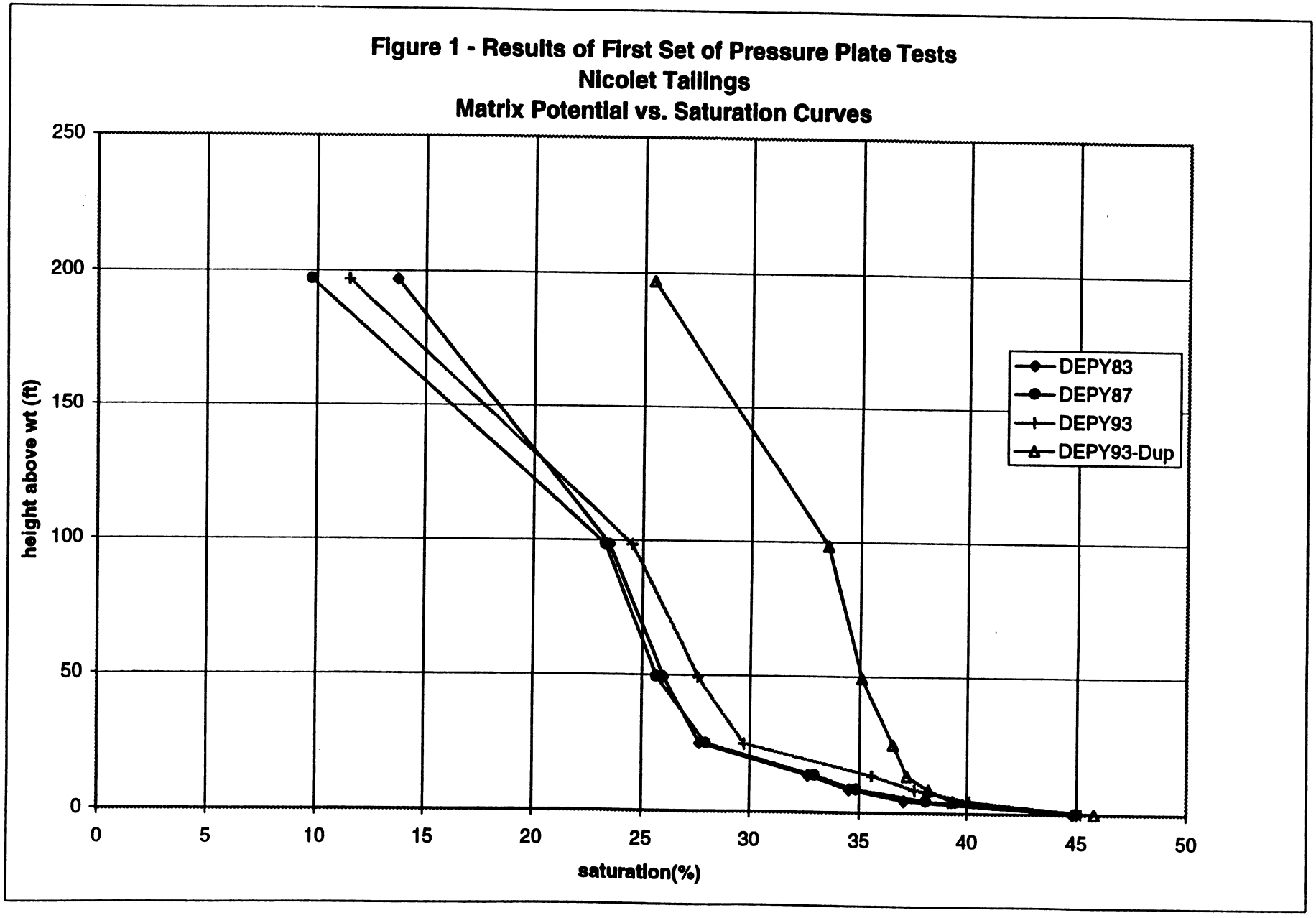


Figure 1 - Results of First Set of Pressure Plate Tests
Nicolet Tailings
Matrix Potential vs. Saturation Curves
height above wt (ft)
saturation(%)
0
50
100
150
200
250
0
5
10
15
20
25
30
35
40
45
50
DEPY83
DEPY87
DEPY93
DEPY93-Dup

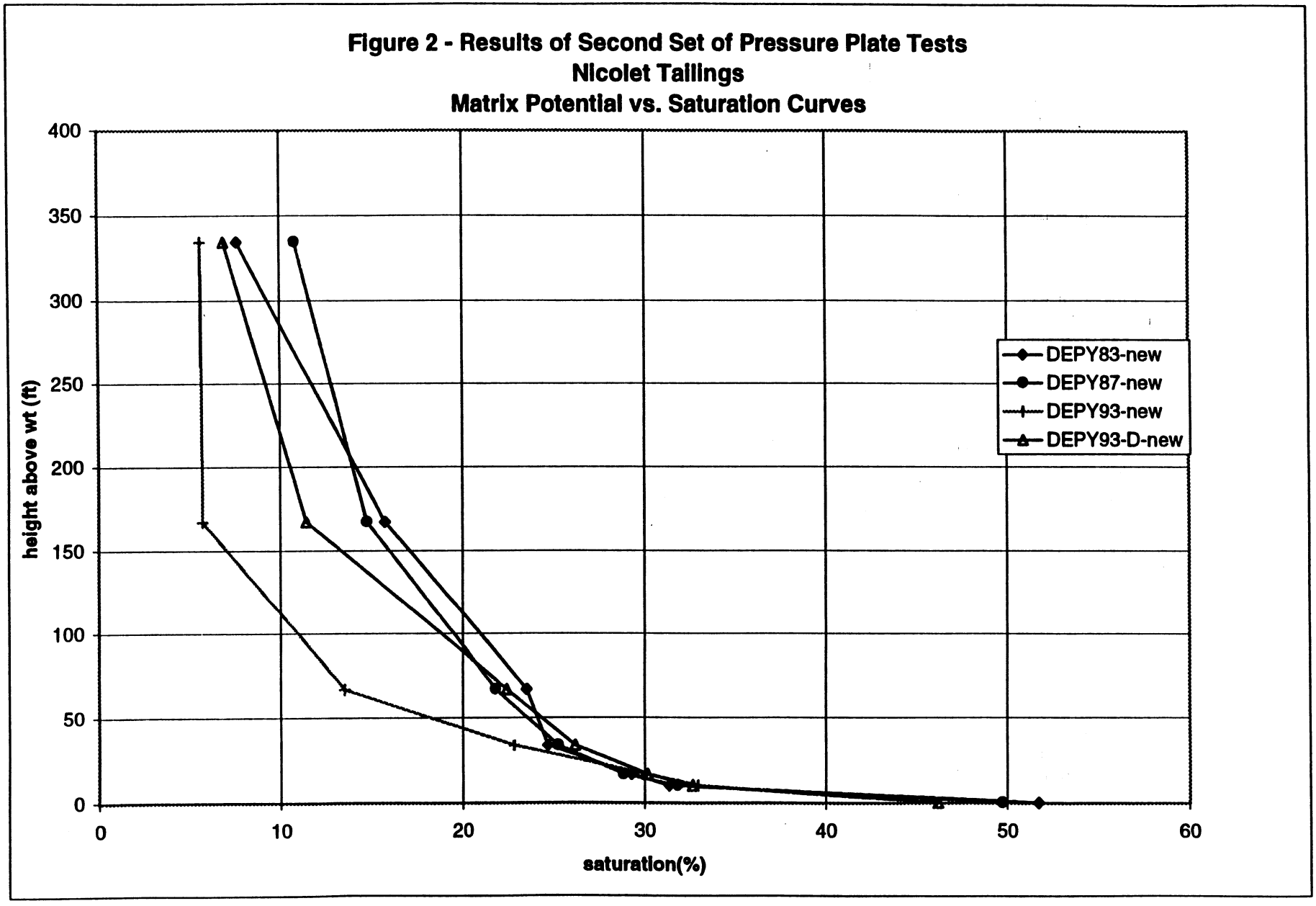


Figure 2 - Results of Second Set of Pressure Plate Tests
Nicolet Tailings
Matrix Potential vs. Saturation Curves
height above wt (ft)
saturation(%)
0
50
100
150
200
250
300
350
400
0
10
20
30
40
50
60
DEPY83-new
DEPY87-new
DEPY93-new
DEPY93-D-new

# Attachment 1

# Results of the First Set of Pressure Plate Tests

STEFFEN, ROBERTSON AND KIRSTEN
Consulting Engineers and Scientists

# Laboratory Services

Oxford / Santa Fe Business Park
4111 S. Natches Court, Unit D
Englewood, Colorado 80110

Phone: (303) 783-3609
Fax: (303) 783-3610

## *MEMO*

TO: Kelly Sexsmith
DATE: October 27, 1998
FROM: Scott D. Duncan
PROJECT: Nicolet
SUBJECT: Capillary Moisture Retention - Crandon Depyritized Tailing

Kelly,

Enclosed are the results from the capillary moisture retention tests performed on the Crandon depyritized tailing samples received from Foth & Van Dyke on August 21, 1998.

The tailing samples were remolded to 93, 87 and 83 pcf @ 24.27% moisture. The samples were then placed into a Soilmoisture 15 bar ceramic plate extractor, Model #1500. After completion of all suction pressures the samples were then air dried in a 110-degree centigrade oven for final moisture contents. All testing was performed in accordance with ASTM standard D 3152-72 (reapproved 1994).

A laboratory access problem prevented a subsequent final pressure reading associated with the test. Due to this delayed reading the final pressure moisture data may have been erroneous.

If you have any questions, please don't hesitate to call.

Regards,

Scott D. Duncan

## CAPILLARY MOISTURE RETENTION TEST - ASTM D2325 - 94

***Preliminary Results***

| | | | | | |
|---|---|---|---|---|---|
| Project: | Nicolet | Started: | 08/24/98 | Tested By: | SDD |
| Project No: | 1US004.01 | Finished: | 09/08/98 | Checked By: | TM |

| Ring No. | 16 | 14 | 11 | 21 |
|---|---|---|---|---|
| Ring Vol (cc) | 18.53278 | 18.53798 | 18.10090 | 18.31597 |
| PCF | 83 | 87 | 93 | 93 |

| Sample | Ring Mass g | Initial Mass g | Sat. Mass g | 127 cm Mass g | 250 cm Mass g | 400 cm Mass g | 750 cm Mass g | 1500 cm Mass g | 3000 cm Mass g | 6000 Mass g | Dry Mass Filter + Ring + Dish g | Dish Wt. g |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Filter Only | – | 0.342 | 1.266 | 0.767 | 0.713 | 0.667 | 0.609 | 0.553 | 0.484 | 0.483 | 11.319 | 10.991 |
| DEPY 83 | 11.427 | 42.079 | 45.730 | 43.790 | 43.272 | 42.879 | 41.893 | 41.523 | 40.988 | 39.177 | 47.746 | 11.248 |
| DEPY 87 | 11.301 | 42.913 | 46.425 | 44.650 | 43.998 | 43.601 | 42.617 | 42.130 | 41.624 | 39.118 | 47.969 | 10.824 |
| DEPY 93 | 11.268 | 44.956 | 47.947 | 46.533 | 46.013 | 45.610 | 44.561 | 44.048 | 43.422 | 41.066 | 49.602 | 10.757 |
| DEPY 93 (D) | 11.255 | 45.161 | 48.396 | 46.714 | 46.448 | 46.222 | 46.044 | 45.721 | 45.371 | 43.885 | 50.163 | 11.079 |

| Sample | Dry Mass g | Unit Wt. g/cc | Sat. Mass g | Total H20 g | Sat. MC | | 127 cm | | | 250 cm | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | % DM | % Vol. | Ret H20 | % DM | % Vol. | Ret H20 | % DM | % Vol. |
| DEPY 83 | 24.729 | 1.33432 | 33.037 | 8.308 | 33.60% | 44.83% | 6.867 | 27.77% | 37.06% | 6.403 | 25.89% | 34.55% |
| DEPY 87 | 25.522 | 1.37672 | 33.858 | 8.336 | 32.66% | 44.97% | 7.060 | 27.66% | 38.09% | 6.462 | 25.32% | 34.86% |
| DEPY 93 | 27.235 | 1.50460 | 35.413 | 8.178 | 30.03% | 45.18% | 7.263 | 26.67% | 40.13% | 6.797 | 24.96% | 37.55% |
| DEPY 93 (D) | 27.467 | 1.50069 | 35.875 | 8.388 | 30.52% | 45.80% | 7.205 | 26.21% | 39.34% | 6.993 | 25.44% | 38.18% |

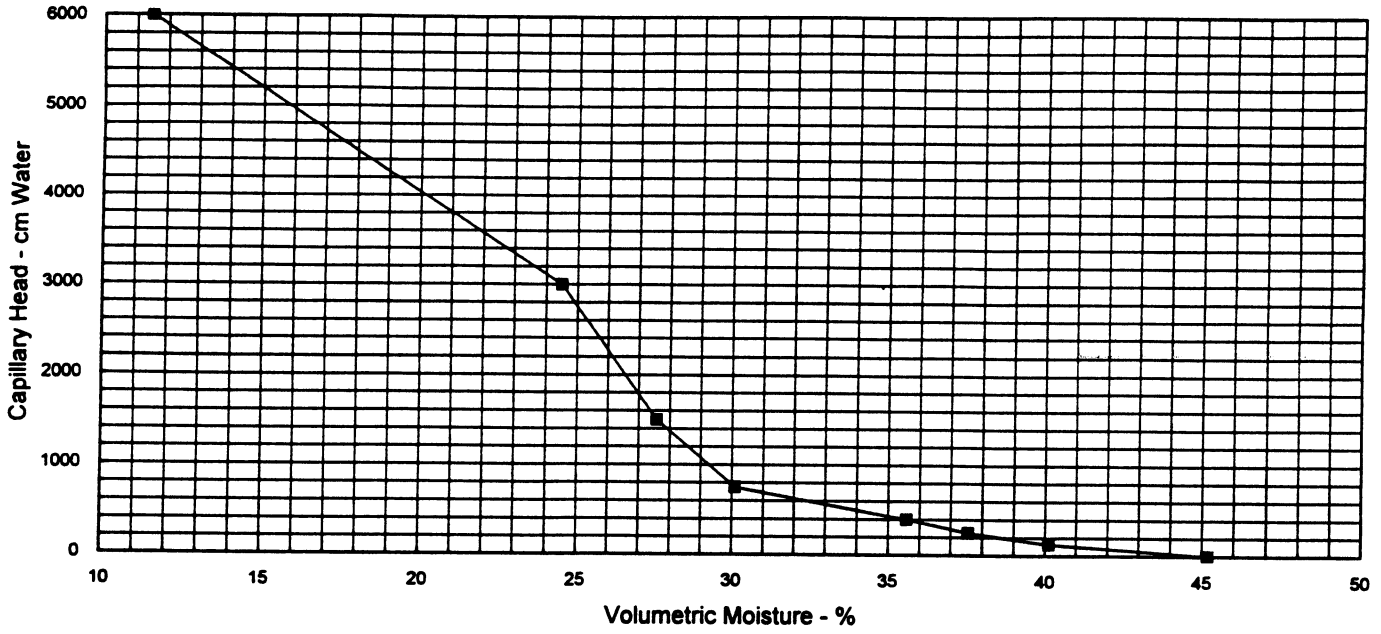
| Sample | 400 cm | | | 750 cm | | | 1500 cm | | | 3000 cm | | | 6000 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ret H20 | % DM | % Vol. | Ret H20 | % DM | % Vol. | Ret H20 | % DM | % Vol. | Ret H20 | % DM | % Vol. | Ret H20 | % DM | % Vol. |
| DEPY 83 | 6.056 | 24.49% | 32.68% | 5.128 | 20.74% | 27.67% | 4.814 | 19.47% | 25.98% | 4.348 | 17.58% | 23.46% | 2.538 | 10.27% | 13.70% |
| DEPY 87 | 6.111 | 23.95% | 32.97% | 5.185 | 20.32% | 27.97% | 4.754 | 18.63% | 25.65% | 4.317 | 16.92% | 23.29% | 1.812 | 7.10% | 9.78% |
| DEPY 93 | 6.440 | 23.65% | 35.58% | 5.449 | 20.01% | 30.11% | 4.992 | 18.33% | 27.58% | 4.435 | 16.29% | 24.50% | 2.080 | 7.64% | 11.49% |
| DEPY 93 (D) | 6.813 | 24.79% | 37.20% | 6.693 | 24.35% | 36.54% | 6.426 | 23.38% | 35.09% | 6.145 | 22.36% | 33.55% | 4.660 | 16.96% | 25.44% |

| Sample | Vol. MC (%) Sat. | Vol. MC (%) 127 | Vol. MC (%) 250 | Vol. MC (%) 400 | Vol. MC (%) 750 | Vol. MC (%) 1500 | Vol. MC (%) 3000 | Vol. MC (%) 6000 |
|---|---|---|---|---|---|---|---|---|
| DEPY 83 | 44.83 | 37.06 | 34.55 | 32.68 | 27.67 | 25.98 | 23.46 | 13.70 |
| DEPY 87 | 44.97 | 38.09 | 34.86 | 32.97 | 27.97 | 25.65 | 23.29 | 9.78 |
| DEPY 93 | 45.18 | 40.13 | 37.55 | 35.58 | 30.11 | 27.58 | 24.50 | 11.49 |
| DEPY 93 (D) | 45.80 | 39.34 | 38.18 | 37.20 | 36.54 | 35.09 | 33.55 | 25.44 |

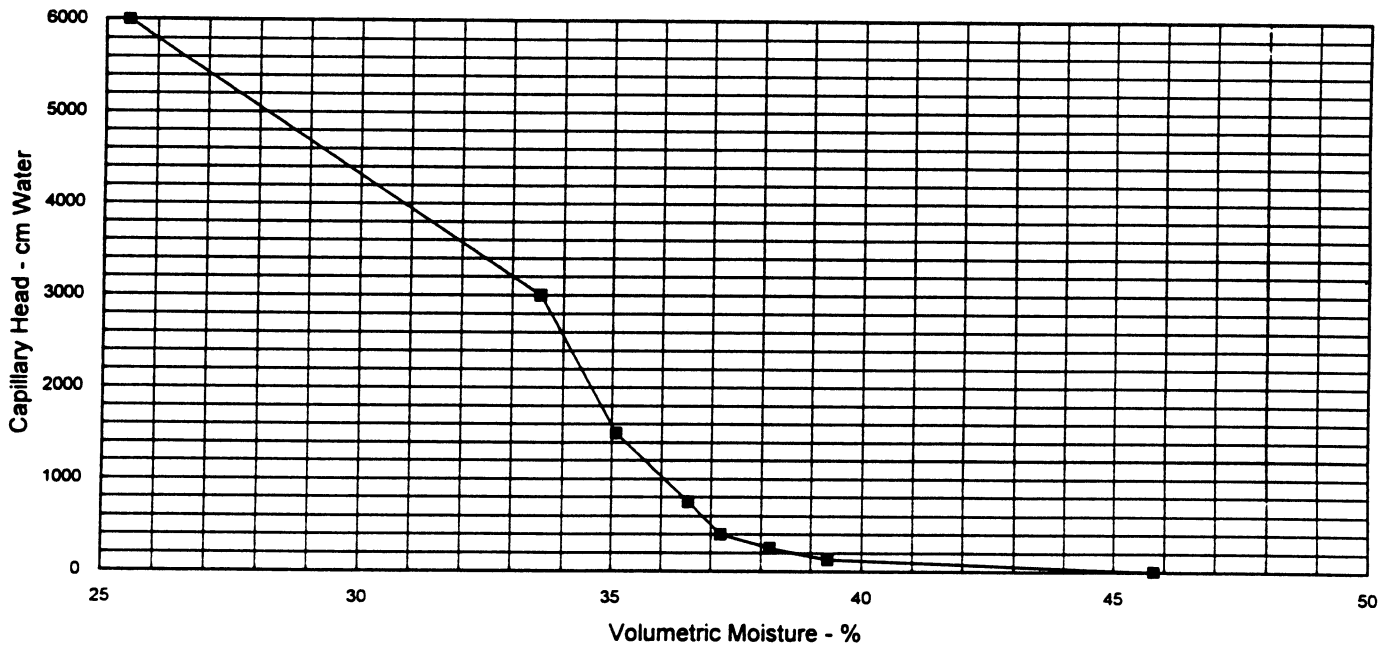
| Heads Used | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| psi | 0.00 | 1.81 | 3.56 | 5.69 | 10.67 | 21.33 | 42.67 | 85.34 |
| cm H20 | 0 | 127 | 250 | 400 | 750 | 1500 | 3000 | 6000 |

%DM = Moisture Content By Dry Mass
%Vol = Volumetric Moisture Content

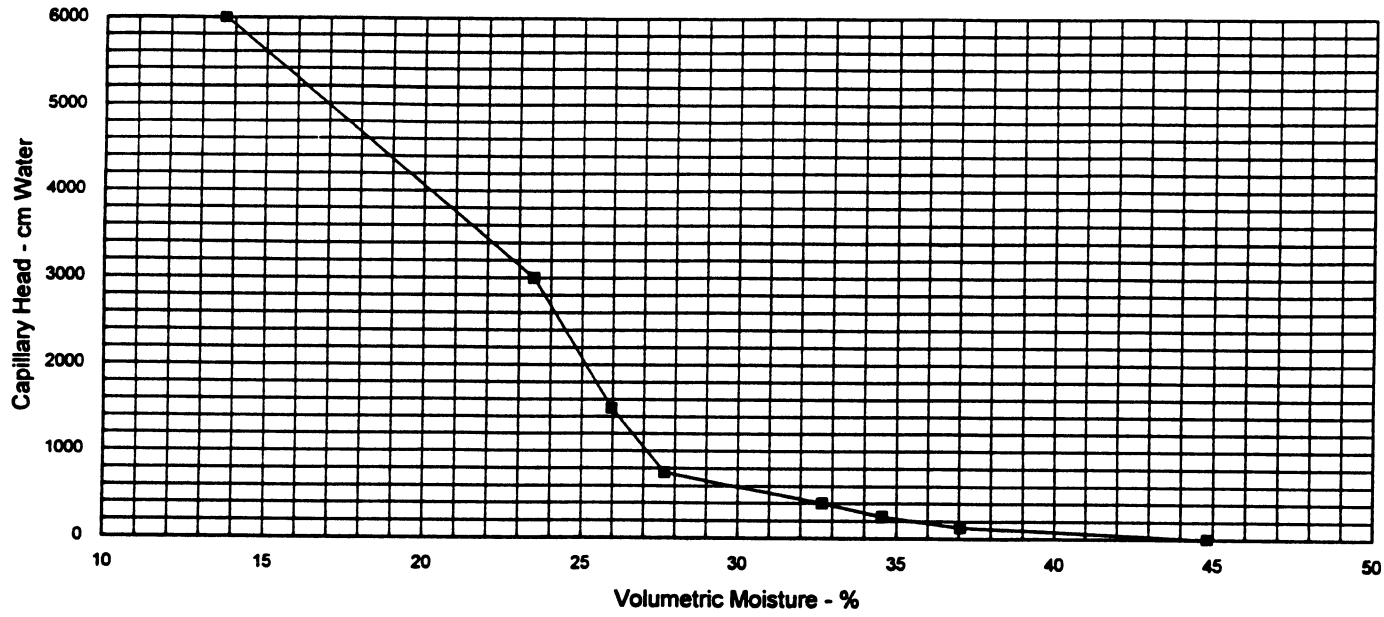
## CAPILLARY MOISTURE RETENTION CURVE
## DEPY. TAILS @ 93 PCF



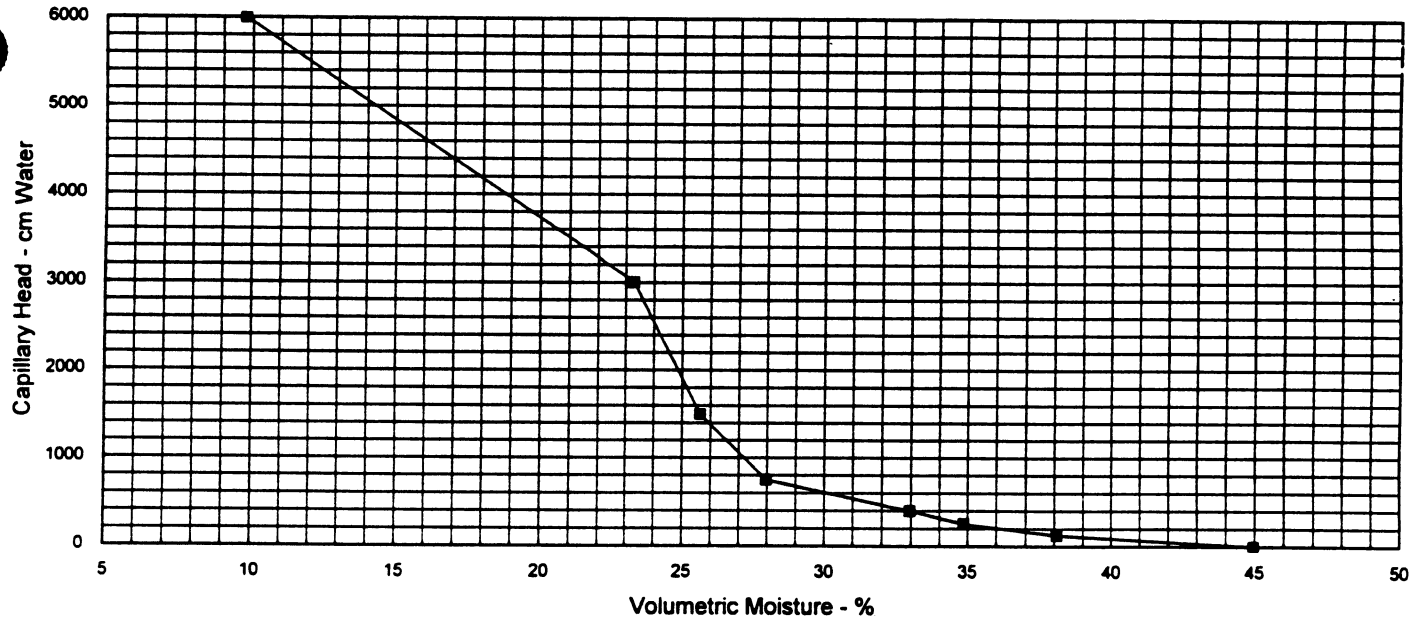

## CAPILLARY MOISTURE RETENTION CURVE
## DEPY. TAILS @ 93 PCF (Duplicate)



## CAPILLARY MOISTURE RETENTION CURVE
## DEPY TAILS @ 83 PCF




## CAPILLARY MOISTURE RETENTION CURVE
## DEPY. TAILS @ 87 PCF



# Attachment 2

# Results of the Second Set of Pressure Plate Tests

**STEFFEN, ROBERTSON AND KIRSTEN**
*Consulting Engineers and Scientists*

# Laboratory Services

Oxford / Santa Fe Business Park
4111 S. Natches Court, Unit D
Englewood, Colorado 80110

Phone: (303) 783-3609
Fax: (303) 783-3610

## *MEMO*

TO: Kelly Sexsmith
DATE: October 15, 1998
FROM: Scott D. Duncan
PROJECT: Nicolet
SUBJECT: Capillary Moisture Retention - Crandon Depyritized Tailing

Kelly,

Enclosed are the results from the capillary moisture retention tests performed on the Crandon depyritized tailing samples received from Foth & Van Dyke on September 23, 1998.

The tailing samples were remolded to 93, 87 and 83 pcf @ 23.01% moisture. The samples were then placed into a Soilmoisture 15 bar ceramic plate extractor, Model #1500. After completion of all suction pressures the samples were then air dried in a 110-degree centigrade oven for final moisture contents. All testing was performed in accordance with ASTM standard D 3152-72 (reapproved 1994).

If you have any questions, please don't hesitate to call.

Regards,

Scott D. Duncan

## CAPILLARY MOISTURE RETENTION TEST - ASTM D3152 - 94

***Preliminary Results***

Project: Nicolet
Project No: 1US004.01

Started: 09/23/98
Finished: 10/02/98

Tested By: SDD
Checked By: PK

| | | | | |
|---|---|---|---|---|
| Ring No. | 15 | 20 | 13 | 17 |
| Ring Vol: (cc) | 18.04818 | 18.37038 | 19.04239 | 18.51053 |
| PCF | 83 | 87 | 93 | 93 |

| Sample | Ring Mass g | Initial Mass g | Sat. Mass g | 0.3 Bar Mass g | 0.5 Bar Mass g | 1 Bar Mass g | 2 Bar Mass g | 5 Bar Mass g | 10 Bar Mass g | Dry Mass Filter + Ring + Dish g | Dish Wt. g |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Filter Only | – | 0.341 | 1.287 | 0.614 | 0.564 | 0.526 | 0.502 | 0.486 | 0.479 | 11.325 | 10.991 |
| DEPY 83 | 11.131 | 41.290 | 45.858 | 41.499 | 41.080 | 40.216 | 39.980 | 38.556 | 37.092 | 46.393 | 10.823 |
| DEPY 87 | 11.340 | 43.494 | 47.486 | 43.518 | 42.928 | 42.229 | 41.575 | 40.259 | 39.532 | 48.480 | 11.078 |
| DEPY 93 | 10.595 | 46.187 | 49.192 | 46.018 | 45.426 | 44.009 | 42.210 | 40.699 | 40.679 | 50.228 | 10.757 |
| DEPY 93 (D) | 11.436 | 46.044 | 48.993 | 45.815 | 45.300 | 44.535 | 43.814 | 41.763 | 40.915 | 50.745 | 11.247 |

| Sample | Dry Mass g | Unit Wt. g/cc | Sat. Mass g | Total H20 g | Sat. MC | | 0.3 Bar | | | 0.5 Bar | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | % DM | % Vol. | Ret H20 | % DM | % Vol. | Ret H20 | % DM | % Vol. |
| DEPY 83 | 24.098 | 1.33520 | 33.440 | 9.342 | 38.77% | 51.76% | 5.656 | 23.47% | 31.34% | 5.287 | 21.94% | 29.29% |
| DEPY 87 | 25.721 | 1.40013 | 34.859 | 9.138 | 35.53% | 49.74% | 5.843 | 22.72% | 31.81% | 5.303 | 20.62% | 28.87% |
| DEPY 93 | 28.535 | 1.49849 | 37.310 | 8.775 | 30.75% | 46.06% | 6.274 | 21.99% | 32.95% | 5.732 | 20.09% | 30.10% |
| DEPY 93 (D) | 27.721 | 1.49757 | 36.270 | 8.549 | 30.84% | 46.19% | 6.044 | 21.80% | 32.65% | 5.579 | 20.13% | 30.14% |

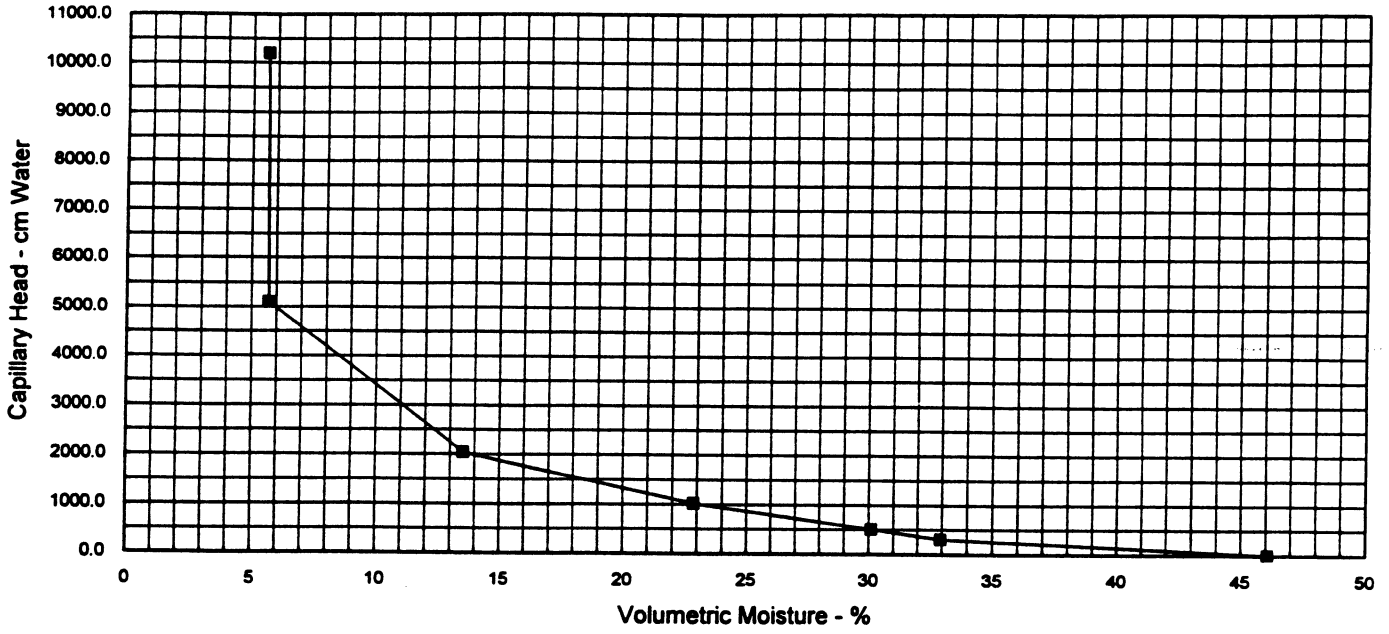
| Sample | 1 Bar | | | 2 Bar | | | 5 Bar | | | 10 Bar | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ret H20 | % DM | % Vol. | Ret H20 | % DM | % Vol. | Ret H20 | % DM | % Vol. | Ret H20 | % DM | % Vol. |
| DEPY 83 | 4.461 | 18.51% | 24.72% | 4.249 | 17.63% | 23.54% | 2.841 | 11.79% | 15.74% | 1.384 | 5.74% | 7.67% |
| DEPY 87 | 4.642 | 18.05% | 25.27% | 4.012 | 15.60% | 21.84% | 2.712 | 10.54% | 14.76% | 1.992 | 7.75% | 10.84% |
| DEPY 93 | 4.353 | 15.26% | 22.86% | 2.578 | 9.03% | 13.54% | 1.083 | 3.80% | 5.69% | 1.070 | 3.75% | 5.62% |
| DEPY 93 (D) | 4.852 | 17.50% | 26.21% | 4.155 | 14.99% | 22.45% | 2.120 | 7.65% | 11.45% | 1.279 | 4.61% | 6.91% |

| Sample | Vol. MC (%) Sat. | Vol. MC (%) 0.3 Bar | Vol. MC (%) 0.5 Bar | Vol. MC (%) 1 Bar | Vol. MC (%) 2 Bar | Vol. MC (%) 5 Bar | Vol. MC (%) 10 Bar |
|---|---|---|---|---|---|---|---|
| DEPY 83 | 51.76 | 31.34 | 29.29 | 24.72 | 23.54 | 15.74 | 7.67 |
| DEPY 87 | 49.74 | 31.81 | 28.87 | 25.27 | 21.84 | 14.76 | 10.84 |
| DEPY 93 | 46.08 | 32.95 | 30.10 | 22.86 | 13.54 | 5.69 | 5.62 |
| DEPY 93 (D) | 46.19 | 32.65 | 30.14 | 26.21 | 22.45 | 11.45 | 6.91 |

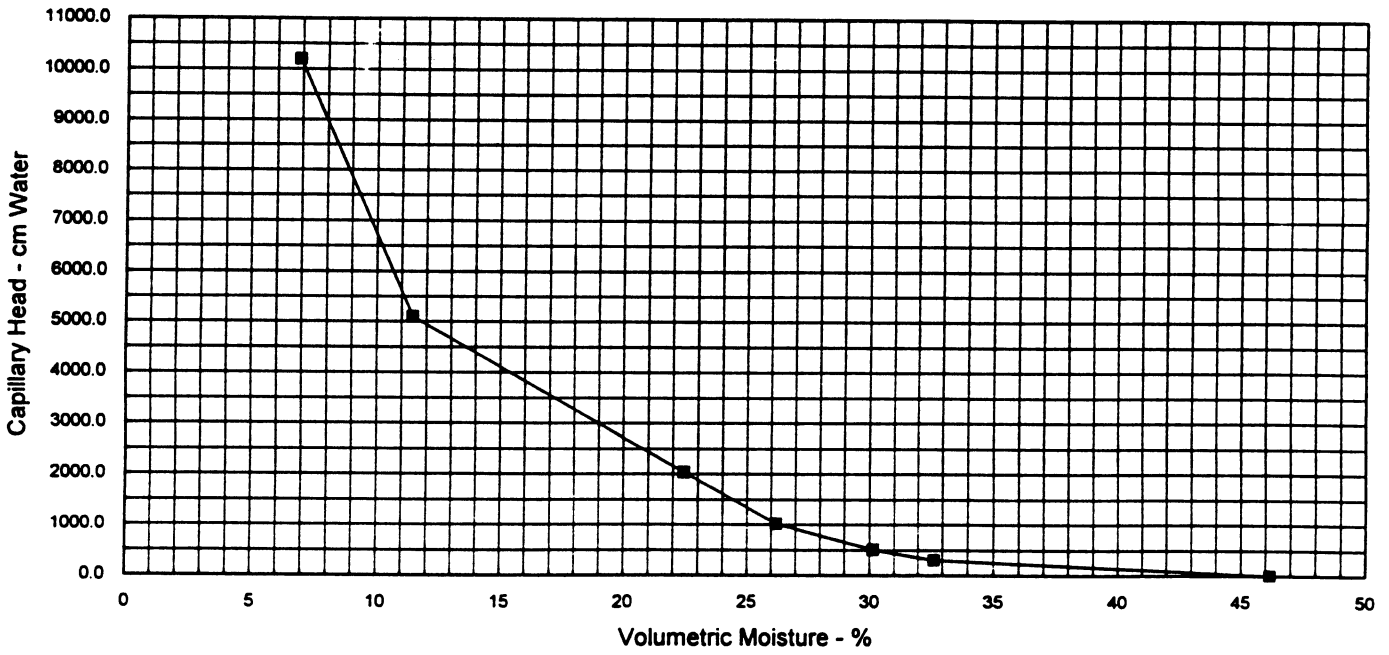
| Heads Used | | | | | | | |
|---|---|---|---|---|---|---|---|
| Bar | 0.0 | 0.3 | 0.5 | 1.0 | 2.0 | 5.0 | 10.0 |
| cm H20 | 0.0 | 305.9 | 509.9 | 1019.7 | 2039.4 | 5098.6 | 10197.2 |

%DM = Moisture Content By Dry Mass
%Vol. = Volumetric Moisture Content

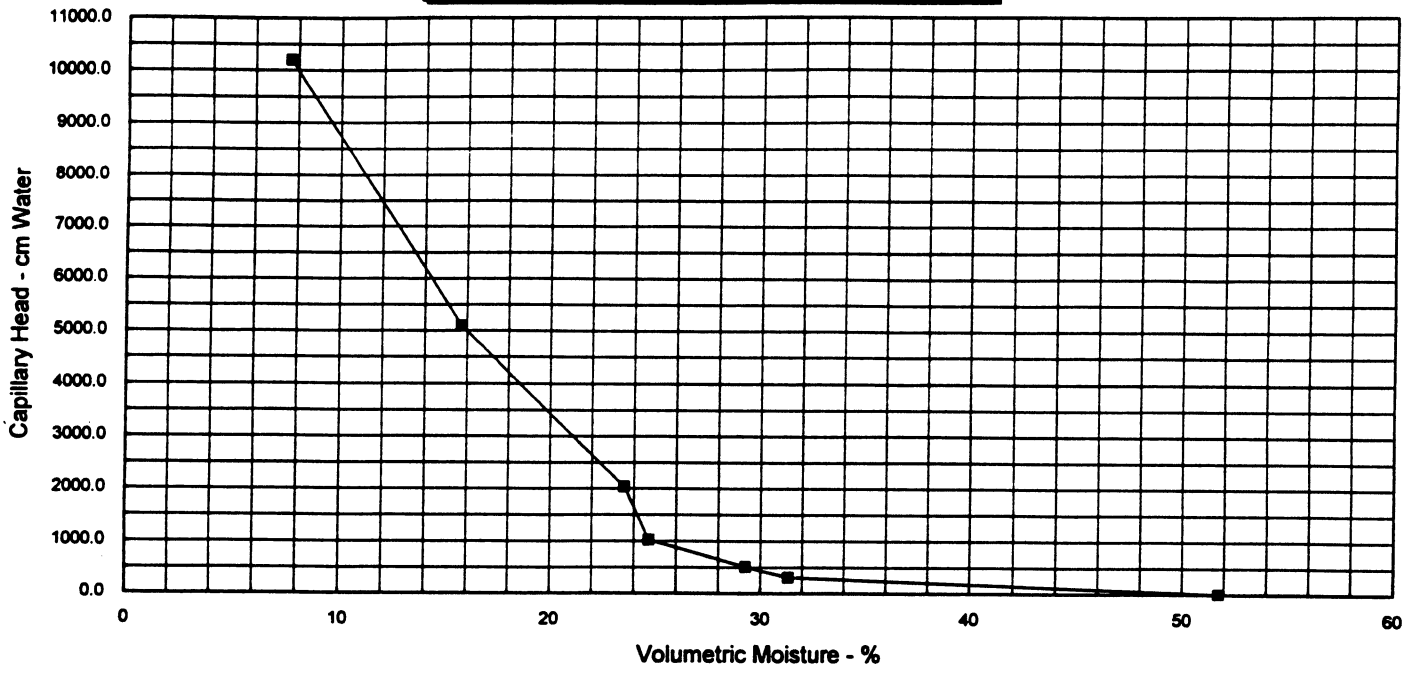
## CAPILLARY MOISTURE RETENTION CURVE
## DEPY. TAILS @ 93 PCF



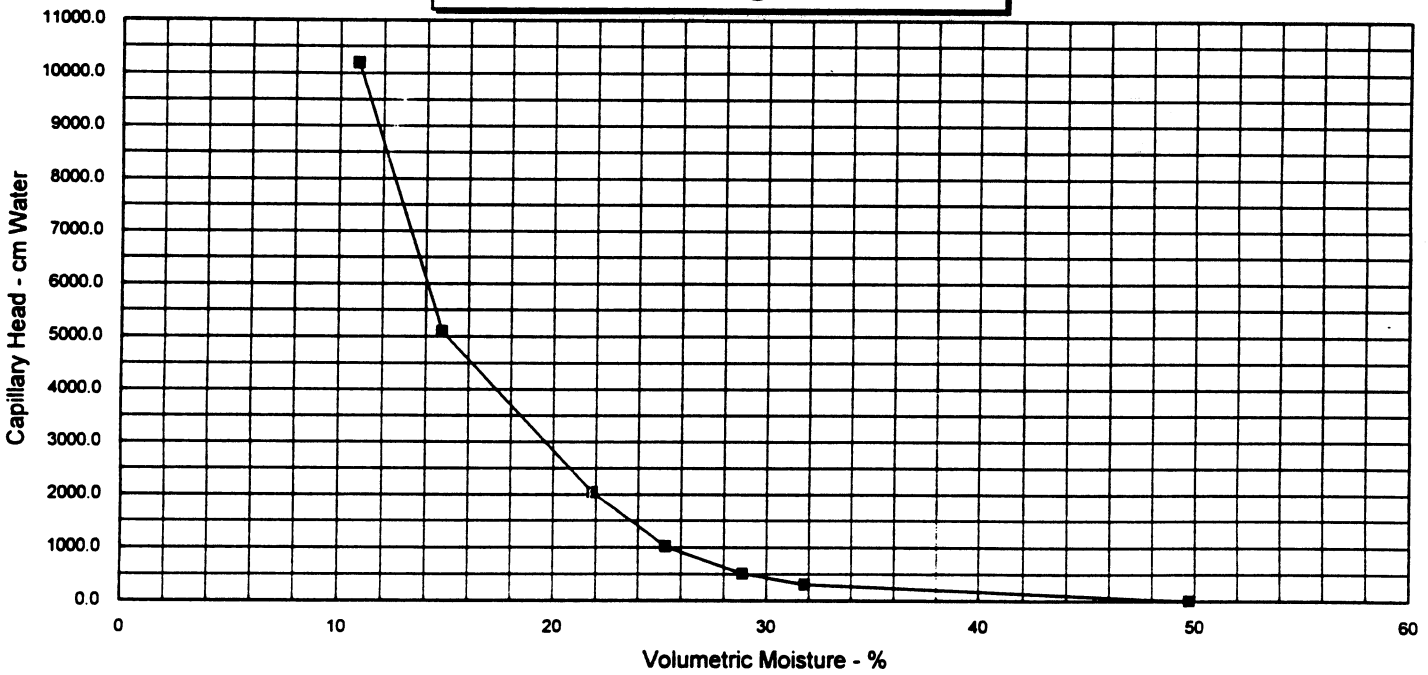

## CAPILLARY MOISTURE RETENTION CURVE
## DEPY. TAILS @ 93 PCF (Duplicate)



## CAPILLARY MOISTURE RETENTION CURVE
## DEPY TAILS @ 83 PCF




## CAPILLARY MOISTURE RETENTION CURVE
## DEPY. TAILS @ 87 PCF



# Depyritized Tailings Hydraulic Conductivity Testing

STS PROJECT NO.: 24394

PROJECT: NICOLET MINERALS CO.

DATE: 10/16/98

## SUMMARY OF TEST RESULTS

SAMPLE NO. 1

LOCATION

CLASSIFICATION 0.85% S TAILINGS (90 PCF)

| | INITIAL | FINAL |
|---|---|---|
| DRY UNIT WEIGHT (pcf) | 89.6 | 105.5 |
| WATER CONTENT (%) | 23.3 | 20.5 |
| DIAMETER (cm) | 4.76 | 4.63 |
| LENGTH (cm) | 4.76 | 4.10 |
| HYDRAULIC GRADIENT (MAXIMUM) | | 11.6 |
| PERCENT SATURATION | 71.833043 | 93.169568 |
| HYDRAULIC CONDUCTIVITY k (cm/sec) | | 6.53E-06 |

STS Consultants, Ltd.

HYDRAULIC CONDUCTIVITY DETERMINATIC
Rising tailwater method in a triaxial permeameter
ASTM D 5084, Method C (EM-1110-2-1906 7)

**Project Name:** NICOLET MINERALS CO.
**Project No.:** 24394
**Project Location:** CRANDON, WI.
**Sample No.:** 1
**Sample Location:**

**Sample Description:** 0.85% S TAILINGS (90 PCF)

Cell No.: 5

**Date Sampled:**
**Date Received:** 10/14/98

| MOISTURE CONTENT | INITIAL | FINAL |
|---|---|---|
| Container No. | 1 | 2 |
| Wet Sample & Tare (g) | 63.83 | 247.31 |
| Dry Sample & Tare (g) | 54.40 | 223.38 |
| Wt. Water (g) | 9.43 | 23.93 |
| Wt. Tare (g) | 13.96 | 106.72 |
| Wt. Dry Soil (g) | 40.44 | 116.66 |
| Water Content, w (%) | 23.3 | 20.5 |

**SATURATION DATA**

| Initial Cell Pressure (psi) | Final Cell Pressure (psi) | Initial PWP (psi) | Final PWP (psi) | B Value |
|---|---|---|---|---|
| 23.0 | 24.0 | 21.8 | 22.8 | 1.00 |
| | | | | |
| | | | | |

Final B value = 1.00

| SPECIMEN INFORMATION | INITIAL | FINAL |
|---|---|---|
| Avg. Diameter (cm) | 4.76 | 4.63 |
| Avg. Height, L (cm) | 4.76 | 4.10 |
| X-Section Area, A ($cm^2$) | 17.795 | 16.837 |
| Specimen wet wt. (g) | 150.00 | 140.59 |
| Specimen Dry wt., $W_s$ (g) | 121.64 | 116.66 |
| Total Volume, V ($cm^3$) | 84.71 | 69.03 |
| Dry Unit Weight ($lbs/ft^3$) | 89.6 | 105.5 |
| $G_s$ estimated (Y or N)? | Y | |
| Specific Gravity, $G_s$ | 2.700 | 2.700 |
| Volume Solids, $V_s$ ($cm^3$) | 45.14 | 43.29 |
| Pore Volume ($cm^3$) | 39.56 | 25.74 |
| Void Ratio, e | 0.876 | 0.594 |
| Degree of Saturation | 71.8 | 93.2 |

COMMENTS:

$$\text{Volume Solids} = \frac{W_s}{(G_s)(\text{Water Density})}$$

$$\text{Void Ratio} = \frac{V - V_s}{V_s}$$

$$\text{Degree of Saturation} = \frac{(w)(G_s)}{e}$$

**Proj Name:** NICOLET MINERALS CO.
**Proj No.:** 24394
**Sample:** 1

| k (cm/sec) | Max i |
|---|---|
| $10^{-3}$ to $10^{-4}$ | 2 |
| $10^{-4}$ to $10^{-5}$ | 5 |
| $10^{-5}$ to $10^{-6}$ | 10 |
| $10^{-6}$ to $10^{-7}$ | 20 |
| less than $10^{-7}$ | 30 |

Hydraulic Gradient, i, Guidlines as per ASTM D5084, section 8.5.1

**TEST CONDITIONS**

| Influent Burette Area $a_{in}$ ($cm^2$) | Effluent Burette Area $a_{out}$ ($cm^2$) | # ascend as burette empties? (Y or N) |
|---|---|---|
| 1.00 | 1.00 | y |

| Cell Pressure (psi) | Headwater Pressure (psi) | Tailwater Pressure (psi) | Driving Head (psi) | Hydraulic Gradient Max | Hydraulic Gradient Min |
|---|---|---|---|---|---|
| 56.8 | 22.0 | 21.5 | 0.5 | 11.6 | 4.9 |

**TEST DATA**

| Date/Time (M/D/YY H:MM) | Temp. °C | Elapsed Time, t (sec) | Influent Reading (cm) | Effluent Reading (cm) | Total Change (cm) | Inflow to Outflow Ratio | Hydraulic Head, h (cm) | k, Hydraulic Conductivity (cm/sec) | $k_{20}$ corrected for temperature (cm/sec) |
|---|---|---|---|---|---|---|---|---|---|
| 10/15/98 12:10 | 21.0 | 0 | 2.2 | 22.2 | 0.0 | 0.00 | 55.2 | 0 | 0 |
| 10/15/98 12:20 | 21.0 | 600 | 3.1 | 21.1 | 0.2 | 0.82 | 53.2 | 8.23E-06 | 8.04E-06 |
| 10/15/98 12:35 | 21.0 | 900 | 4.3 | 19.6 | 0.3 | 0.80 | 50.5 | 7.75E-06 | 7.56E-06 |
| 10/15/98 12:50 | 21.0 | 900 | 5.5 | 18.3 | 0.1 | 0.92 | 48.0 | 7.55E-06 | 7.37E-06 |
| 10/15/98 13:40 | 21.0 | 3000 | 9.4 | 14.3 | 0.1 | 0.98 | 40.1 | 8.03E-06 | 7.83E-06 |
| 10/15/98 14:35 | 21.0 | 3300 | 11.7 | 10.9 | 1.1 | 0.68 | 34.4 | 6.22E-06 | 6.07E-06 |
| 10/15/98 14:40 | 21.0 | 300 | 12.0 | 10.6 | 0.0 | 1.00 | 33.8 | 7.86E-06 | 7.67E-06 |
| 10/15/98 15:05 | 21.0 | 1500 | 13.0 | 9.3 | 0.3 | 0.77 | 31.5 | 6.29E-06 | 6.14E-06 |
| 10/15/98 15:20 | 21.0 | 900 | 13.6 | 8.6 | 0.1 | 0.86 | 30.2 | 6.27E-06 | 6.12E-06 |
| 10/15/98 15:35 | 21.0 | 900 | 14.2 | 7.9 | 0.1 | 0.86 | 28.9 | 6.55E-06 | 6.39E-06 |
| 10/15/98 15:55 | 21.0 | 1200 | 15.0 | 7.0 | 0.1 | 0.89 | 27.2 | 6.77E-06 | 6.61E-06 |
| 10/15/98 16:15 | 21.0 | 1200 | 15.8 | 6.2 | 0.0 | 1.00 | 25.6 | 6.77E-06 | 6.61E-06 |
| 10/15/98 16:45 | 21.0 | 1800 | 16.9 | 5.1 | 0.0 | 1.00 | 23.4 | 6.69E-06 | 6.53E-06 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | (0.75-1.25) | | Final Value = | 6.53E-06 |

$$k_{20} = \frac{(a_{in})(a_{out})L[\ln(h_{n-1}/h_n)]*R_T}{At(a_{in} + a_{out})}$$

Total Change = $(Eff_{n-1} - Eff_n) - (Inf_n - Inf_{n-1})$

"Hydraulic Head" incorporates the difference in head as well as the added driving head pressure.
"Total Change" is the difference between the Effluent change from $t_0$ to $t_1$ and the Influent change from $t_0$ to $t_1$.

Notate temperature to the nearest half a degree. The correction calculation averages the two consecutive readings.
k is multiplied by the temperature correction, $R_T$, which is the ratio of the viscosity of water at test temperature to the viscosity of water at 20° C. Temperature range may be between 19° and 25° for formula calculation.
"Final Value" is the average of 4 consecutive readings of which none are less than or greater than 25% of their average. (50% of average if < 1 x $10^{-8}$)

STS Consultants, Ltd.

HYDRAULIC CONDUCTIVITY DETERMINATION
ASTM D 5084, METHOD C
RISING TAILWATER LEVEL

STS PROJECT NO.: 24394

PROJECT: NICOLET MINERALS CO.

DATE: 10/16/98

## SUMMARY OF TEST RESULTS

SAMPLE NO. 1A

LOCATION

CLASSIFICATION 0.85% S TAILINGS (95 PCF)

| | INITIAL | FINAL |
|---|---|---|
| DRY UNIT WEIGHT (pcf) | 95.6 | 111.8 |
| WATER CONTENT (%) | 23.3 | 18.7 |
| DIAMETER (cm) | 4.76 | 4.43 |
| LENGTH (cm) | 4.76 | 4.50 |
| HYDRAULIC GRADIENT (MAXIMUM) | | 11.6 |
| PERCENT SATURATION | 82.929727 | 100.27748 |
| HYDRAULIC CONDUCTIVITY k (cm/sec) | | 7.27E-06 |

STS Consultants, Ltd.

HYDRAULIC CONDUCTIVITY DETERMINATI(
Rising tailwater method in a triaxial permeameter
ASTM D 5084, Method C (EM-1110-2-1906 7)

**Project Name:** NICOLET MINERALS CO.
**Project No.:** 24394
**Project Location:** CRANDON, WI.
**Sample No.:** 1A
**Sample Location:**

**Sample Description:** 0.85% S TAILINGS (95 PCF)

Cell No.: 4

**Date Sampled:**
**Date Received:** 10/14/98

| MOISTURE CONTENT | INITIAL | FINAL |
|---|---|---|
| Container No. | 1 | 2 |
| Wet Sample & Tare (g) | 63.83 | 252.05 |
| Dry Sample & Tare (g) | 54.40 | 228.79 |
| Wt. Water (g) | 9.43 | 23.26 |
| Wt. Tare (g) | 13.96 | 104.52 |
| Wt. Dry Soil (g) | 40.44 | 124.27 |
| Water Content, w (%) | 23.3 | 18.7 |

SATURATION DATA

| Initial Cell Pressure (psi) | Final Cell Pressure (psi) | Initial PWP (psi) | Final PWP (psi) | B Value |
|---|---|---|---|---|
| 20.0 | 22.0 | 19.0 | 21.0 | 1.00 |
| | | | | |
| | | | | |
| | | | Final B value = | 1.00 |

| SPECIMEN INFORMATION | INITIAL | FINAL |
|---|---|---|
| Avg. Diameter (cm) | 4.76 | 4.43 |
| Avg. Height, L (cm) | 4.76 | 4.50 |
| X-Section Area, A ($cm^2$) | 17.795 | 15.413 |
| Specimen wet wt. (g) | 160.00 | 147.53 |
| Specimen Dry wt., $W_s$ (g) | 129.75 | 124.27 |
| Total Volume, V ($cm^3$) | 84.71 | 69.36 |
| Dry Unit Weight ($lbs/ft^3$) | 95.6 | 111.8 |
| $G_s$ estimated (Y or N)? | Y | |
| Specific Gravity, $G_s$ | 2.700 | 2.700 |
| Volume Solids, $V_s$ ($cm^3$) | 48.15 | 46.12 |
| Pore Volume ($cm^3$) | 36.56 | 23.24 |
| Void Ratio, e | 0.759 | 0.504 |
| Degree of Saturation | 82.9 | 100.3 |

COMMENTS:

$$\text{Volume Solids} = \frac{W_s}{(G_s)(\text{Water Density})}$$

$$\text{Void Ratio} = \frac{V - V_s}{V_s}$$

$$\text{Degree of Saturation} = \frac{(w)(G_s)}{e}$$

**Proj Name:** NICOLET MINERALS CO.
**Proj No.:** 24394
**Sample:** 1A

| k (cm/sec) | Max i |
|---|---|
| $10^{-3}$ to $10^{-4}$ | 2 |
| $10^{-4}$ to $10^{-5}$ | 5 |
| $10^{-5}$ to $10^{-6}$ | 10 |
| $10^{-6}$ to $10^{-7}$ | 20 |
| less than $10^{-7}$ | 30 |

Hydraulic Gradient, i, Guidlines as per ASTM D5084, section 8.5.1

**TEST CONDITIONS**

| Influent Burette Area $a_{in}$ ($cm^2$) | Effluent Burette Area $a_{out}$ ($cm^2$) | # ascend as burette empties? (Y or N) |
|---|---|---|
| 1.00 | 1.00 | y |

| Cell Pressure (psi) | Headwater Pressure (psi) | Tailwater Pressure (psi) | Driving Head (psi) | Hydraulic Gradient Max | Hydraulic Gradient Min |
|---|---|---|---|---|---|
| 53.8 | 19.0 | 18.5 | 0.5 | 11.6 | 3.7 |

**TEST DATA**

| Date/Time (M/D/YY H:MM) | Temp. °C | Elapsed Time, t (sec) | Influent Reading (cm) | Effluent Reading (cm) | Total Change (cm) | Inflow to Outflow Ratio | Hydraulic Head, h (cm) | k, Hydraulic Conductivity (cm/sec) | $k_{20}$ corrected for temperature (cm/sec) |
|---|---|---|---|---|---|---|---|---|---|
| 10/15/98 10:21 | 21.0 | 0 | 3.0 | 23.0 | 0.0 | 0.00 | 55.2 | 0 | 0 |
| 10/15/98 10:30 | 21.0 | 540 | 3.6 | 22.2 | 0.2 | 0.75 | 53.8 | 6.37E-06 | 6.22E-06 |
| 10/15/98 10:40 | 21.0 | 600 | 4.4 | 21.4 | 0.0 | 1.00 | 52.2 | 6.74E-06 | 6.58E-06 |
| 10/15/98 10:50 | 21.0 | 600 | 5.1 | 20.7 | 0.0 | 1.00 | 50.8 | 6.07E-06 | 5.92E-06 |
| 10/15/98 11:50 | 21.0 | 3600 | 9.4 | 16.5 | -0.1 | 1.02 | 42.3 | 6.81E-06 | 6.65E-06 |
| 10/15/98 12:40 | 21.0 | 3000 | 12.6 | 13.4 | -0.1 | 1.03 | 36.0 | 7.20E-06 | 7.03E-06 |
| 10/15/98 13:40 | 21.0 | 3600 | 15.8 | 10.3 | -0.1 | 1.03 | 29.7 | 7.16E-06 | 6.99E-06 |
| 10/15/98 14:20 | 21.0 | 2400 | 17.6 | 8.5 | 0.0 | 1.00 | 26.1 | 7.21E-06 | 7.04E-06 |
| 10/15/98 15:05 | 21.0 | 2700 | 19.5 | 6.7 | -0.1 | 1.06 | 22.4 | 7.59E-06 | 7.41E-06 |
| 10/15/98 15:20 | 21.0 | 900 | 20.0 | 6.2 | 0.0 | 1.00 | 21.4 | 6.80E-06 | 6.64E-06 |
| 10/15/98 15:35 | 21.0 | 900 | 20.5 | 5.7 | 0.0 | 1.00 | 20.4 | 7.13E-06 | 6.96E-06 |
| 10/15/98 15:55 | 21.0 | 1200 | 21.2 | 5.0 | 0.0 | 1.00 | 19.0 | 7.94E-06 | 7.75E-06 |
| 10/15/98 16:15 | 21.0 | 1200 | 21.9 | 4.4 | -0.1 | 1.17 | 17.7 | 7.92E-06 | 7.73E-06 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | (0.75-1.25) | | Final Value = | 7.27E-06 |

$$k_{20} = \frac{(a_{in})(a_{out})L[\ln(h_{n-1}/h_n)]*R_T}{At(a_{in} + a_{out})}$$

Total Change = $(Eff_{n-1} - Eff_n) - (Inf_n - Inf_{n-1})$

"Hydraulic Head" incorporates the difference in head as well as the added driving head pressure.
"Total Change" is the difference between the Effluent change from $t_0$ to $t_1$ and the Influent change from $t_0$ to $t_1$.

Notate temperature to the nearest half a degree. The correction calculation averages the two consecutive readings.
k is multiplied by the temperature correction, $R_T$, which is the ratio of the viscosity of water at test temperature to the viscosity of water at 20° C. Temperature range may be between 19° and 25° for formula calculation.
"Final Value" is the average of 4 consecutive readings of which none are less than or greater than 25% of their average. (50% of average if < 1 x $10^{-8}$)

# Appendix C

## Filter Design Calculations for TMA Drainage Layer

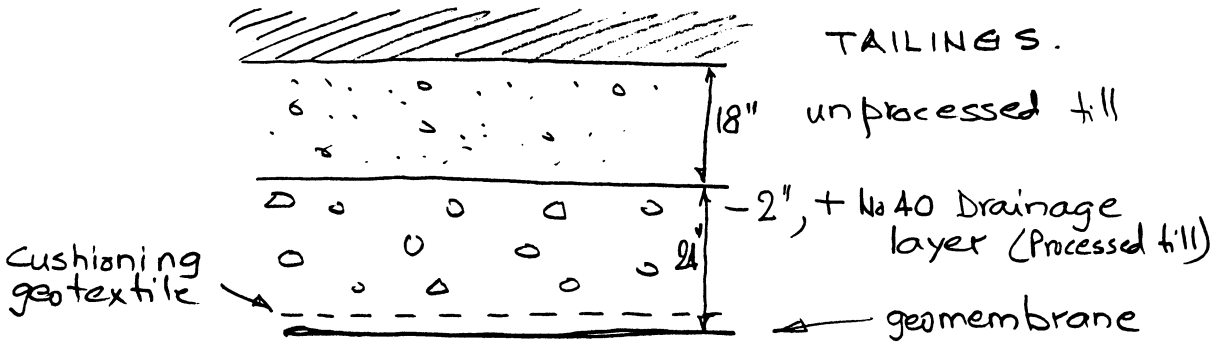
Foth & Van Dyke
consultants · engineers · scientists

Client: NMC Scope I.D.: 93C049
Project: TMA - Add 5 Page: 1/5
Prepared By: N × P Date: 11-9-98
Checked By: MRS Date: 11-10-98

# Filter Design For TMA Drainage Layer

Purpose: Evaluate the TMA Drainage collection system for potential for clogging by tailings.

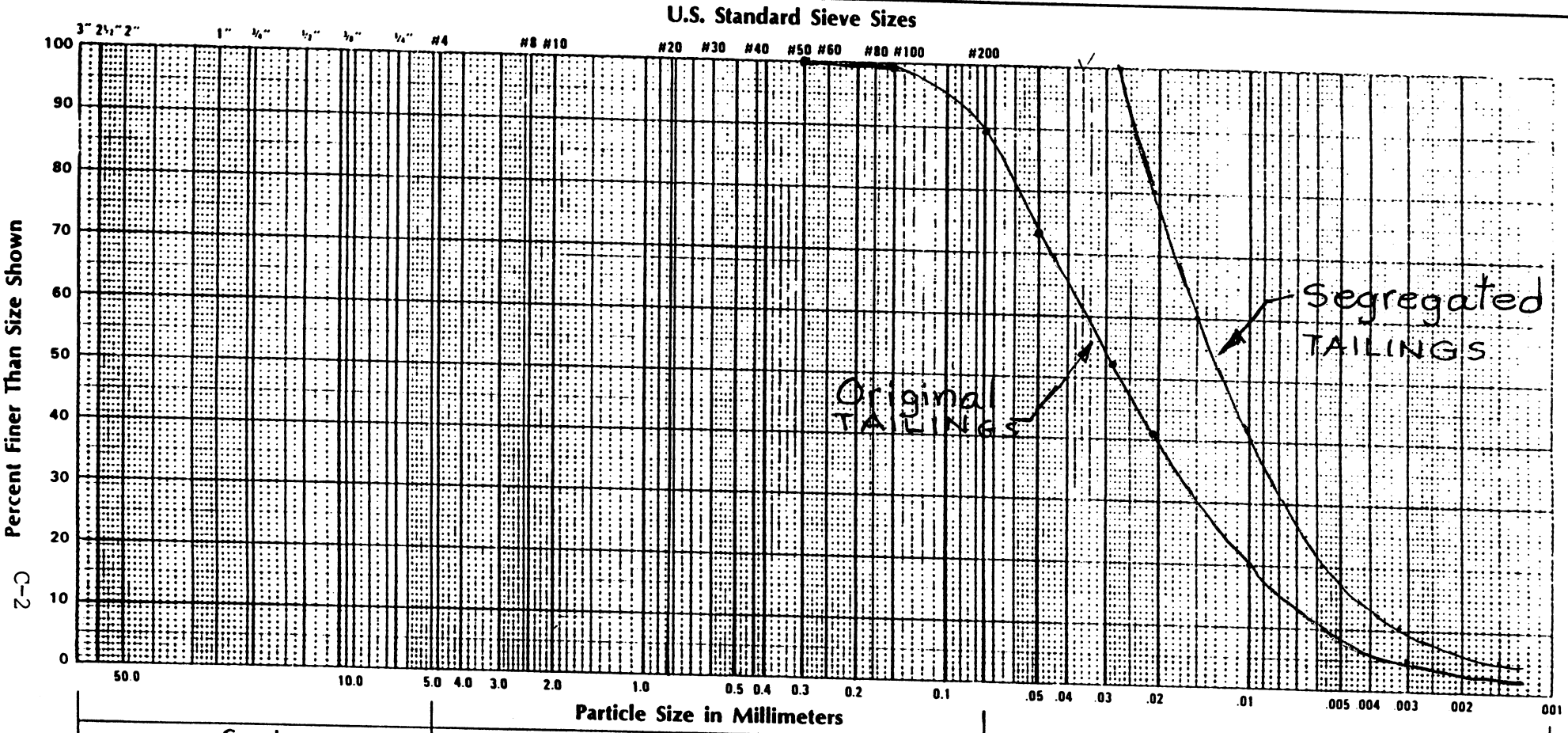
scope: As presented in the conceptual design, the drainage collection system consists of the following above the geomembrane liner




Filter calculations will be completed between tailings and unprocessed till and between the unprocessed till and the drainage layer.

As shown in Fig. 1 Two gradations for the tailings will be used, one, from tests by SRK on the depyritized tailings and two, a hypothetical gradation developed for a segregated tailings assuming that the maximum grain size of the segregated tailings will be equal to $D_{50}$ of original tailings.

# GRAIN SIZE DISTRIBUTION CURVE




| Gravel | | Sand | | | Silt | Clay |
|---|---|---|---|---|---|---|
| Coarse | Fine | Coarse | Medium | Fine | | |
| % = | % = | % = | % = | % = | % = | % = |

C-2

Location Sampled: _____ Elev. or Depth: _____ Date Sampled: _____

Sample Source: _____ Sampled Moisture Content (%): _____ Report No.: _____

Soil Classification (ASTM: D2487): _____

Atterberg Limits: LL_____ PL_____ PI _____

Munsell Color Code: _____

Date Received: _____

Coefficients: C[redacted] Cu= _____

**Foth & Van Dyke**

Figure 1. TAILINGS

Client: _____ Scope I.D.: _____

Project: _____ Page: _____

Prepared by: _____ Da[redacted]

Checked by: _____ Date: _____

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One gradation for the unprocessed till will be used, this being the average of many gradation curves for till shown in Exxon (1985 b). See the distributions of all tills used and design gradation curve in attached Figure 2.

As shown on Figure 3, a range of gradation is used for the drainage layer (−2"; + No 40). The range of gradations is obtained from the till test data shown on Figure 2

Use the following Design criteria (NAVFAC DM 7.1)

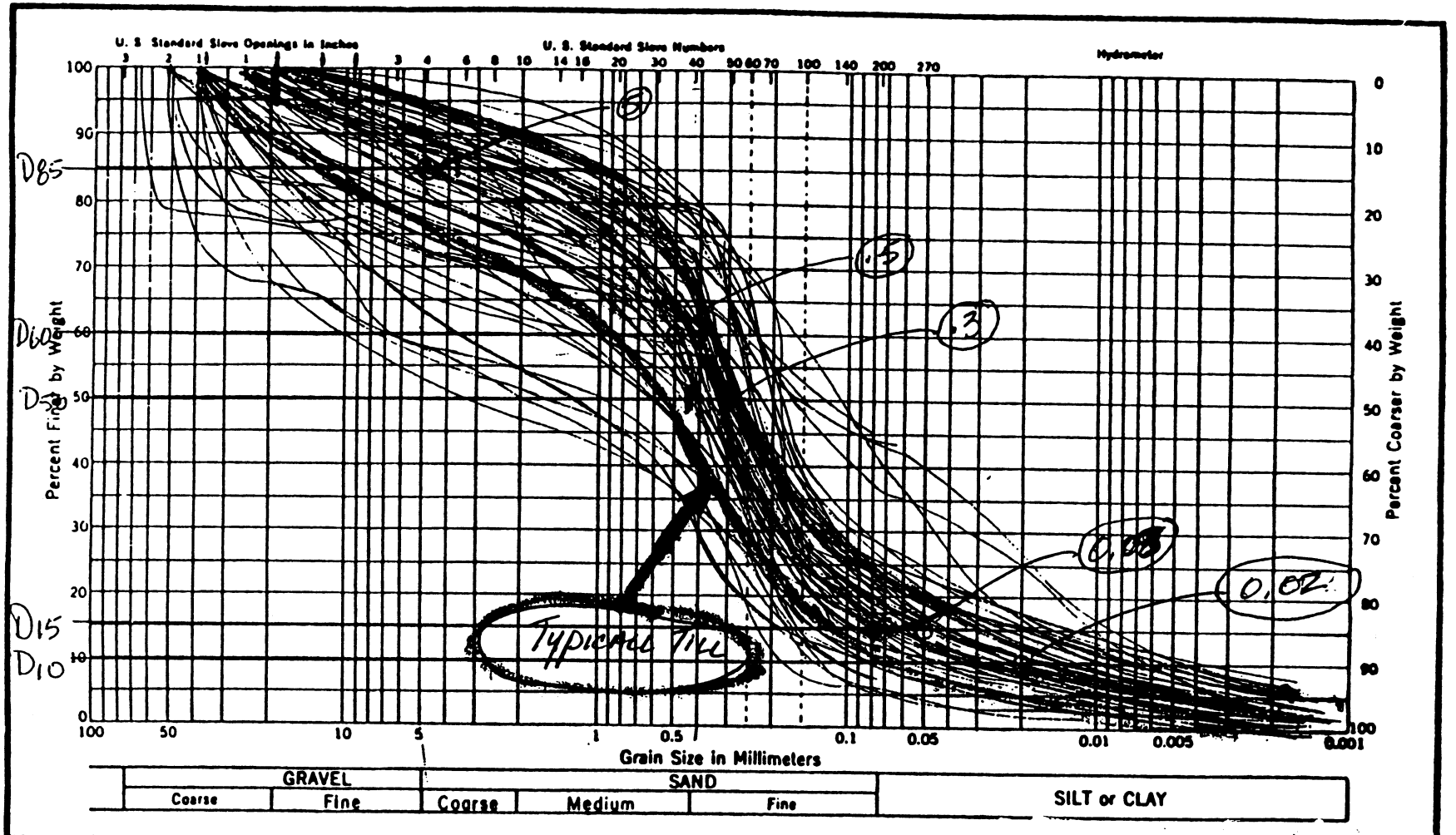
$$\frac{D_{15}\ \text{FILTER}}{D_{85}\ \text{BASE}} \leq 5$$

$$\frac{D_{50}\ \text{FILTER}}{D_{50}\ \text{BASE}} < 25$$

$$4 < \frac{D_{15}\ \text{FILTER}}{D_{15}\ \text{BASE}} < 20$$

Filter should have no size $> 3"$

# UNIFIED CLAS、ICATION SYSTEM




| SAMPLE NO. | W.C. | LL | PL | PI | CLASSIFICATION |
|---|---|---|---|---|---|
| | | | | | Glacial Till SM-SP, SM |

FIGURE - 2
COMPOSITE GRADATION CURVES

Ref: Exxon (1985)

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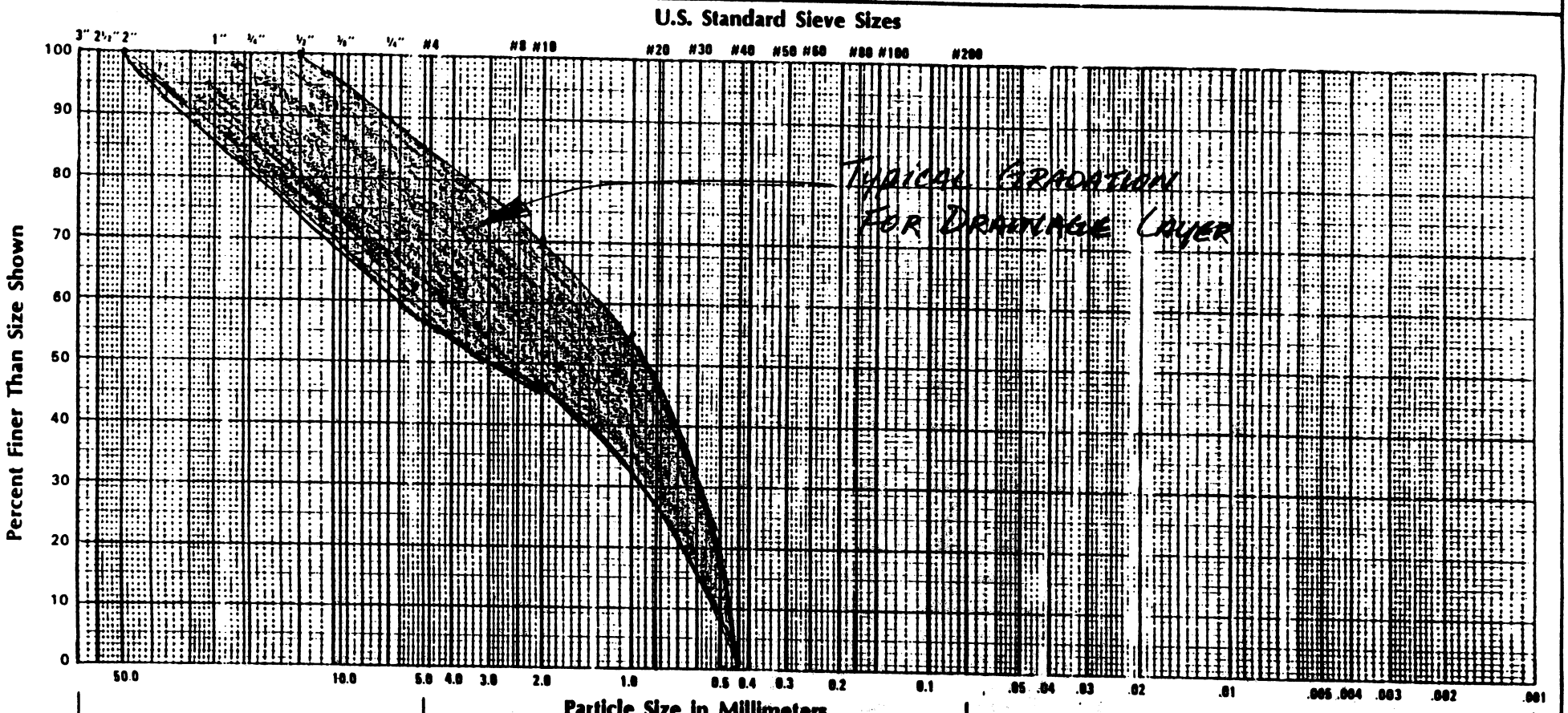
# GRAIN SIZE DISTRIBUTION CURVE




| Gravel | | Sand | | | Silt | Clay |
|---|---|---|---|---|---|---|
| Coarse | Fine | Coarse | Medium | Fine | | |
| % = | % = | % = | % = | % = | % = | % = |

Location Sampled: _____ Elev. or Depth: _____ Date Sampled: _____

Sample Source: _____ Sampled Moisture Content (%): _____ Report No.: _____

Soil Classification (ASTM: D2487): _____

Atterberg Limits: LL____ PL____ PI ____

Munsell Color Code: _____

Date Received: _____

Coefficients: Cc = _____ Cu= _____

**Foth & Van Dyke**

FIGURE 3

DRAINAGE LAYER

Client: _____ Scope I.D.: _____

Project: _____ Page: _____

Prepared by: _____ Date: _____

Checked by: _____ Date: _____

C-5

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## CALCULATIONS

| Material. | Grain sizes $D_{15}$ mm | $D_{50}$ mm | $D_{85}$ mm | Cu |
|---|---|---|---|---|
| TAILINGS | 0.0074 | 0.027 | 0.069 | 6.0 |
| SEGREGATED TAILINGS | 0.004 | 0.012 | 0.021 | 4.7 |
| UNPROCESSED TILL | 0.08 | 0.3 | 5.0 | 25 |
| DRAINAGE LAYER | 0.48-0.6 | 0.9 - 3.0 | 5.0 - 25.0 | 2.9 - 11.5. |

## TAILINGS AND UNPROCESSED TILL

$$\frac{D_{15}\,F}{D_{85}\,B} = \frac{0.08}{0.069} = 1.2 < 5 \quad \text{ok}$$

$$\frac{D_{50}\,F}{D_{50}\,B} = \frac{0.3}{0.027} = 11.1 < 25 \quad \text{ok}$$

$$\frac{D_{15}\,F}{D_{15}\,B} = \frac{0.08}{0.0074} = 10.8 \quad > 4 \quad < 20 \quad \text{ok}$$

∴ Unprocessed till will act as good filter for whole Tails.

## SEGREGATED TAILINGS AND UNPROCESSED TILL

$$\frac{D_{15}\,F}{D_{85}\,B} = \frac{0.08}{0.021} = 3.8 < 5 \quad \text{ok}$$

$$\frac{D_{50}\,F}{D_{50}\,B} = \frac{0.3}{0.012} = 25 \quad \text{ok}$$

$$\frac{D_{15}\,F}{D_{15}\,B} = \frac{0.08}{0.004} = 20 \quad \text{ok}$$

∴ Unprocessed till will act as good filter for segregated tails.

## UNPROCESSED TILL AND DRAINAGE LAYER

$$\frac{D_{15}\,F}{D_{85}\,B} = \frac{0.48-0.6}{5.0} = 0.096-0.12 < 5 \quad \text{ok}$$

$$\frac{D_{50}\,F}{D_{50}\,B} = \frac{0.9-3.0}{0.3} = 3-10 < 25 \quad \text{ok}$$

$$\frac{D_{15}\,F}{D_{15}\,B} = \frac{0.48-0.6}{0.08} = 6-7.5 < 20 \quad \text{ok}$$

The drainage layer will act as good filter for unprocessed till

## CONCLUSION

The proposed TMA Drainage collection system will perform without clogging of the drainage layer by the tailings.

# Appendix D

## Geosynthetic Material Decision Matrices for Crandon Project Containment Facilities

# Geosynthetic Material Decision Matrices for Crandon Project Containment Facilities

Scope ID: 93C049

Prepared for

**Nicolet Minerals Company**

7 North Brown Street, 3rd Floor

Rhinelander, WI 54501-3161

Prepared by

**Foth & Van Dyke and Associates Inc.**

Originally Issued April 1997

Updated December 1998



**Foth & Van Dyke, 1998**

2737 S. Ridge Road, P.O. Box 19012, Green Bay, Wisconsin 54304, 920/497-2500, FAX: 920/497-8516

# Geosynthetic Material Decision Matrices for Crandon Project Containment Facilities

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# 1 Introduction

The proposed design for the Crandon Project tailings management area (TMA) and other project containment facilities includes several geosynthetic components. These include geomembranes, geotextiles, geocomposites and geosynthetic clay liners(GCL). The use of geosynthetics in containment applications has progressively evolved as new products and new applications have become available. The pace of this evolution is such that it is very likely some geosynthetic materials will be phased out and new materials phased in prior to the end of a long operating life of a facility such as 28 years for the proposed TMA. To address these potential changes, applicants, designers and many regulators desire designs that have the flexibility to incorporate improved materials in the future.

NMC proposes that decision matrices be used for future evaluation of alternative geosynthetics after the Crandon Project permitting process specifying certain geosynthetics has been completed. Alternative geosynthetics would only be allowed if they are shown to be equivalent to or superior to the originally specified products. The decision matrices include material property requirements arrived at on the basis of the facility design (for details refer to the Feasibility Report, Foth and Van Dyke, 1995 and subsequent addenda, Foth and Van Dyke, 1996a and b, 1997, and 1998a and b, hereafter collectively referred to as the Feasibility Report ); methods of evaluating material properties of the candidate geosynthetic material including specific standard tests; and the actions to be taken regarding the decision process based on those evaluations. Geosynthetics used for the Crandon Project in containment applications include the TMA, reclaim pond, wastewater storage basins, treated water discharge lagoons, tailings transport pipeline ditch, etc. The discussion of decision matrices that follow in this report is directed specifically at the project's TMA. However, the logic presented relative to their development and use is directly applicable to the other project containment facilities as well.

Due to the specific considerations involved in evaluating and selecting geosynthetics for different applications, individual decision matrices for each geosynthetic material proposed for use in a containment facility (i.e., geomembrane for the liners; geomembrane for TMA cap barrier; geotextiles for cushioning and separation, geocomposites for sidewall drainage; and geosynthetic clay liner in the composite barriers of both liners and the TMA cap) are needed. Descriptions of the proposed decision matrix for each material and a discussion of how each matrix would be applied is presented in Sections 2 through 7.

It should be noted that the discussion that follows references numerous standard methods and procedures that are currently used to test and evaluate materials of construction. Should testing methods change, the new methodology would be substituted for evaluations to be completed in accordance with the procedures outlined in the appropriate decision matrix.

## 2 Use of Decision Matrices

The sole purpose of the decision matrices presented in this document is to identify suitable alternative geosynthetic materials in case the presently identified materials are no longer available or become obsolete due to developments in the industry. As such, they do not include the specifications for geosynthetics nor the required installation quality assurance procedures. They do include discussion of the principles on which the material selection and CQA requirements were based so that if in the future non-availability of the currently specified material or availability of a better material makes it necessary to revise the product specifications, these can be accomplished without violating the permit conditions. For example, HDPE is proposed in the permit documents for use as a liner and TMA cap geomembrane material. The technical specifications and CQA requirements for HDPE ( and other geosynthetics) are given in the CQA manual prepared for the project. If HDPE (or any of the other proposed geosynthetics) is approved by the regulators, the basis for the approval is understood to be not only the absolute values of certain physical properties of the geomembrane, but all the intangible attributes of HDPE that make it the best material for containment of most materials including the tailings and expected leachates from the TMA. Therefore, substitution of HDPE in the future should not be based solely on the physical properties of HDPE, but also on the attributes which will make the substitute an equivalent or better material from the aspects of installation and performance. Similarly, certain physical properties of HDPE will have to be met by the substitute geomembrane even if the substitute is touted as the "best" material based on industry experience. This is because the permitting process evaluates the performance of the proposed system in quantitative terms. Changes in material properties which adversely affect those quantitative evaluations cannot be accepted within the bounds of the permit.

During the evaluation of an alternate material using the decision matrix, any conflicts that arise should be resolved using the physical properties included in the CQA manual rather than those in the decision matrices because the CQA manual is likely to be updated more often. If there is any variations between the properties listed in the two documents, the ones in the CQA manual will invariably be more stringent and hence appropriate. The conflicts referred to here are expected to be limited to those between the contractors and construction contract administrators. Also, in the event that two or more materials under evaluation are deemed acceptable, NMC expects to make the final selection based on relative economics.

While selection of the manufacturer of a specific geosynthetic is not considered to be a design issue, it is an important consideration and should be addressed during the bidding phase of the project and monitored through the manufacturing quality assurance (MQA) program just prior to the construction phase. Crandon Project specifications will typically include a list of acceptable manufacturers of the geosynthetics selected by the professional design engineer, who will be the engineer of record, taking into account the manufacturer's ability to produce the materials, the conditions for acceptability of which are laid out in this document, and cost.

# 3 Liner Geomembrane

The May 1995 Crandon Project TMA Feasibility Report and subsequent addenda discuss both design principles and methods, and identifies high density polyethylene (HDPE) as the best suited material for use in the TMA base liner. HDPE has also been identified as the best suited material for lining of the reclaim pond, wastewater storage basins, treated water discharge lagoons, tailings transport pipeline ditch, etc. The discussion which follows has been specifically directed towards the base liner of the TMA. However, the discussions are applicable equally to each of the other containment applications listed above. Therefore, the decision matrix which is presented here has applicability to each of the other cases as well.

Figure 1 presents a decision matrix that can be employed at any future date to evaluate and select an alternative geomembrane for use in the base liner.

The matrix has four columns. The extreme left column contains the design/performance requirements which are based on the design computations presented in the Feasibility Report. The second column describes the methods for evaluating the alternative material. The third column illustrates the decision process. The fourth column indicates the action to be taken based on the material evaluations and subsequent decision process. A detailed discussion describing how the matrix is applied to a material for each design/performance requirement follows.

## 3.1 Chemical Composition

The geomembrane base liner decision matrix (Figure 1) includes two design/performance requirements with regard to chemical composition of the material. The first relates to geomembrane compatibility with tailings and leachate. The second relates to the longevity of the geomembrane. Each is discussed below.

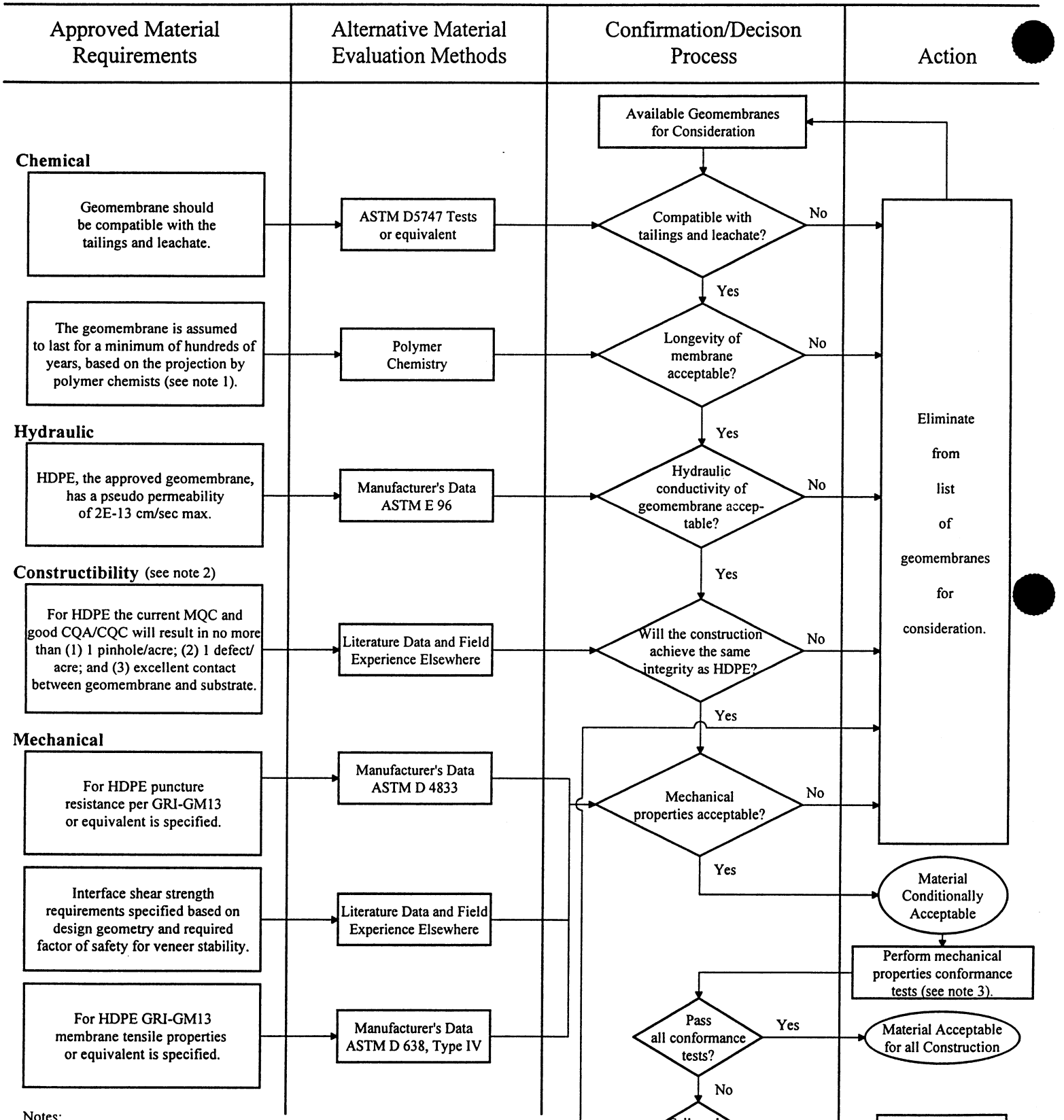
### 3.1.1 Compatibility

One of the primary requirements for geomembranes in liner applications is chemical compatibility with the materials they come in contact with. In the case of the Crandon Project TMA, the liner will be in contact with the geosynthetic clay liner (GCL) below and the drainage medium (processed till or a geocomposite) above.

The liner will also come in contact with mine water before the start of tailings deposition, and afterwards with process water and/or leachate as the process water and the tailings react. The leachate could include lower pH conditions. In view of the above, compatibility needs to be established between the geomembrane and the liquids described.

ASTM D5747, Practice for Tests to Evaluate the Chemical Resistance of Geomembranes to Liquids, is the current standard compatibility test for geomembranes. To assess compatibility, the evaluation of an alternative geomembrane would be accomplished by the ASTM D5747 tests, or equivalent standards, using both process water and a manufactured leachate with

# Figure 1
# Crandon Project
# Decision Matrix for Geomembrane Application for Base Liners




Notes:

1. Methods used to estimate geomembrane life are evolving over time. It is expected that the predicted minimum lifetime will increase significantly in the coming years.
2. Defects will be located using a leak location survey and repaired/remediated prior to the use of each cell. The quantitative data represents the capability of QA programs to quantify HDPE constructibility issues.
3. These tests are not required for preliminary acceptance but are to be performed just prior to construction to verify that the material meets the design requirements.

characteristics as defined by the TMA source term characterization work. If the ASTM D5747 tests show that statistically significant changes in tensile yield stress (or stress at a predetermined strain such as 100 percent) and density do not exceed 10 percent, the material will be considered to be compatible with the tailings and leachate, and the analysis will continue to the next step. If the material is determined to be incompatible, it will be eliminated from further consideration.

### 3.1.2 Longevity

When disposed of as a waste material in landfills, plastics are considered indestructible and permanent without the possibility of deterioration. When plastics are used as liners for containment purposes, their longevity is at times questioned. Based on the December 1996 report prepared by GeoSyntec Consultants of Boca Raton, Florida, titled *Assessment of Long-Term Performance of the Proposed HDPE Geomembrane Liner and Cap at the Crandon Project TMA Facility* (GeoSyntec, 1996), ". . . the HDPE geomembrane liner and cap at the TMA facility should function as designed for a very long time (e.g., hundreds of years) without deterioration in performance."

If an alternative geomembrane is considered in the future as a substitute for the currently specified material (HDPE) and polymer chemists estimate its lifespan will meet the lifespans for materials available at the time of evaluation, it will be deemed to meet the longevity design/performance requirements.

## 3.2 Hydraulic Conductivity

Water balance computations for the TMA facility are discussed in the Feasibility Report. Percolation through the liner will consist of two components, one through the intact membrane due to the permeability characteristics of the material itself and the other through the defects in the membrane caused during manufacture and installation. Only the permeability characteristics of the material are considered under this section. The other component of percolation due to defects will be considered under the constructibility aspects discussed later.

In the Feasibility Report, the geomembrane hydraulic conductivity used corresponds to that of HDPE. Even though minor changes in the hydraulic conductivity of the geomembrane, normally estimated from water vapor transmission tests (ASTM E96), will not change the computed percolation from the site significantly, the decision matrix specifies that the maximum allowable hydraulic conductivity for alternative geomembranes will be 2E-13 cm/sec as estimated based on the ASTM E96 water vapor transmission test, or equivalent.

## 3.3 Constructibility

Constructibility issues are important to geomembrane performance, but are critical only if the construction practices impact the quantitative results used in the design and evaluation of the system containing the geomembranes. Based on the state-of-practice, the Feasibility Report

assumed that the integrity of HDPE, if installed with current standards of MQC and good CQA/CQC, can be quantified as one manufacturing defect, one installation defect and excellent contact between the geomembrane and the substrate. Therefore a substitute geomembrane would be acceptable from a constructibility standpoint if it can be installed to the same degree of integrity as HDPE, quantified using qualitative comparison based largely on experience in the field elsewhere. Other issues to be considered in this regard are ease of installation and ability to weld, including to the geomembrane placed during the previous installation, in a timely fashion.

## 3.4 Mechanical Properties

### 3.4.1 Required Properties for an Alternative Geomembrane

The relevant geomembrane mechanical properties when considering an alternative material are tensile properties, puncture resistance, and interface shear strength characteristics. The tensile properties and puncture resistance described in the GRI - GM13 specifications (Hsuan and Koerner, 1997) for HDPE 60 mil smooth and textured liners have been specified in the TMA design presented in the Feasibility Report and will be the minimum acceptable values for smooth or textured alternative geomembranes.

Interface shear strength is an important parameter to verify stability of the cover soils (soil veneer) during the operation period of the TMA. The friction angle value specified (a minimum 21.2°) in Appendix C of Addendum No. 3 to the Feasibility Report (Foth & Van Dyke, 1997) is for the loading conditions anticipated in the field without any excess pore water pressure considered (i.e., total stress strength parameter). Interface shear strength values for an alternative geomembrane that are less than that specified will result in a factor of safety smaller than the design factor of safety and will not be considered as acceptable.

### 3.4.2 Verification of Properties for an Alternative Geomembrane

The acceptability of an alternative geomembrane will be evaluated as follows. For tensile properties and puncture resistance, manufacturers' data will be compared to GRI-GM13 specifications (Hsuan and Koerner, 1997) to determine preliminary acceptability of the alternative material. Standardization of testing methods and the awareness of the strict QA/QC procedures which occur during construction, plus efforts by geosynthetic societies and trade organizations have established the credibility of material properties published by manufacturers. Therefore, manufacturers' data are sufficient and appropriate for preliminary acceptance of an alternative geomembrane. However, during the construction stage, the QA/QC procedures outlined in Appendix A of Addendum No. 3 to the Feasibility Report (Foth & Van Dyke, 1997) require that manufacturers' QC test data be obtained for each roll of material. In addition, the procedures outlined in Appendix A also require conformance testing (ASTM D 638, Type IV for tensile properties and ASTM D4833 for puncture resistance) on a specified number of rolls. These procedures will assist in verifying that the material in the field meets the design requirements.

In the case of interface strength, there is a slight difference in the proposed procedure. The required strength properties for the HDPE liner and GCL interface specified in the Feasibility Report were arrived at based on facility geometry, the required factor of safety, and a total stress analysis. The interface strength, then, must be obtained as a total stress strength parameter, i.e., using a test which simulates the most critical loading condition in the field. For the soil veneer stability over the base liner of the TMA along the lower interface between the geomembrane and the GCL, the most critical loading condition is a slow rate of shear with drainage permitted after the GCL is saturated. Therefore, the test performed should be a direct shear box test at a very low rate of displacement and under saturated conditions.

For evaluating failure potential along the upper interface, i.e., between the geomembrane and the cushioning geotextile or the geomembrane and the geocomposite, a similar test can be performed with the GCL being replaced by the geocomposite or geotextile. Since excess pore water pressures are not likely to develop (except when flow parallel to the slope is caused during extremely heavy rainfall occurrences) the total and effective stress strength parameters and analyses will be the same for the upper interface. The stability of the soil veneer under extreme conditions of rainfall which could lead to erosion will be addressed through repairs of the erosion rills and washouts.

During the placement of cover soils on the sideslope, very little movement will occur along the interfaces, if at all. This is because the construction specifications will require oversight of soil placement, prevention of pushing more than 1 ft of soil ahead of the low ground pressure machinery that will be used, and avoiding large braking forces. Thus, the peak strength (along the interface) will be the appropriate total stress strength. However, to be conservative, especially for the lower interface, the residual strength available in published literature/field experience will be used for preliminary selection.

Before construction starts, it is anticipated that a pre-construction report will be prepared. By that time, the availability and acceptability of the materials would have been finally evaluated and a final selection made, not only of the geomembrane, but also of the materials which form the critical interfaces. Therefore, interface shear tests (ASTM D 5321, or equivalent) will be performed prior to installation at the rate of one test per 400,000 square feet of geomembrane expected to be installed on the sideslopes. The tests will be conducted on the interfaces (both above and below the membrane) under saturated conditions with drainage permitted (low rates of displacement). These tests will be run to large strains to obtain residual strengths. If the interface strength values from these tests (residual strengths) do not meet the design requirements, the alternative geomembrane will be rejected. If they meet the requirements along with the tensile properties and puncture resistance requirements, the material will be accepted for use in TMA construction.

## 3.5 Summary

In summary, the decision matrix in Figure 1 illustrates how NMC would proceed to evaluate a material other than HDPE as an alternative geomembrane liner. Chemical, hydraulic, and

mechanical requirements of the geomembrane design will be evaluated for the proposed alternative material against the criteria established above. Installation requirements the alternative material will need to meet include compatibility with the previously installed geomembrane to which the alternative material may have to be welded, potential installation defects, etc. Unquantifiable features which facilitate an easier installation may be considered based on engineering judgement, but only if the other requirements as shown on the decision matrix are met first.

# 4 Final Cover Geomembrane

The Feasibility Report discusses both design principles and methods, and identifies high density polyethylene (HDPE) as best suited for use in the TMA final cover. The features of the final cover, specifically the shallow slopes, low probability of differential settlement, and absence of tensile stresses make low vapor transmission and durability the two critical attributes for the cover geomembrane. HDPE therefore becomes the material of choice for this application.

Figure 2 presents a decision matrix that can be employed at any future date to evaluate and select an alternative geomembrane for use in the final cover. The matrix has four columns. The extreme left column contains the design/performance requirements which are based on the design computations presented in the Feasibility Report. The second column describes the methods for evaluating the alternative material. The third column illustrates the decision process. The fourth column indicates the action to be taken based on the material evaluations and subsequent decision process. A detailed discussion describing how the matrix is applied to a material for each design/performance requirement follows.

## 4.1 Environmental Factors

For the TMA, the shallow final cover slopes eliminate design concerns associated with the stability against failure along the interface of the geomembrane and the adjacent layers above and below. However, the following three environmental factors need to be considered qualitatively while selecting a suitable geomembrane for final cover applications.

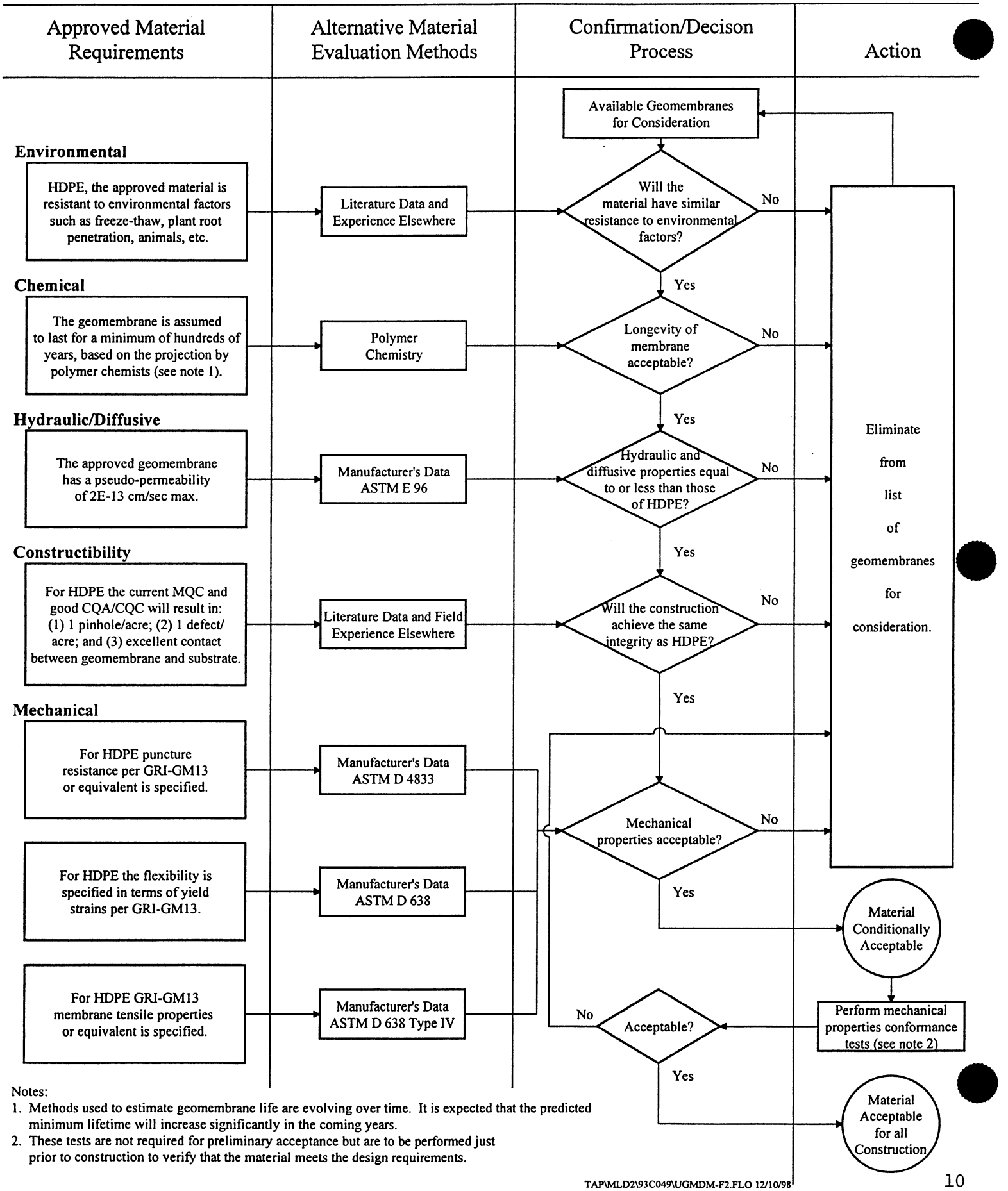
- Temperature variations;
- Penetration by plant roots;
- Burrowing animals.

These factors have been accounted for in the TMA design by providing a thick soil cover with a biotic barrier layer over the geomembrane. Since HDPE is the selected membrane for the cover, any alternative geomembrane should have equal or better performance under the environmental conditions cited.

## 4.2 Chemical Compatibility

When disposed of as a waste material in landfills, plastics are considered indestructible and permanent without the possibility of deterioration. When plastics are used as liners for containment purposes, their longevity is at times questioned. Based on the December 1996 report prepared by GeoSyntec Consultants of Boca Raton, Florida, titled *Assessment of Long-Term Performance of the Proposed HDPE Geomembrane Liner and Cap at the Crandon Project TMA Facility* (GeoSyntec, 1996), ". . . the HDPE geomembrane liner and cap at the TMA facility should function as designed for a very long time (e.g., hundreds of years) without deterioration in performance."

# Figure 2
# Crandon Project
# Decision Matrix for Geomembrane Application for Final Covers




Notes:

1. Methods used to estimate geomembrane life are evolving over time. It is expected that the predicted minimum lifetime will increase significantly in the coming years.
2. These tests are not required for preliminary acceptance but are to be performed just prior to construction to verify that the material meets the design requirements.

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If an alternative geomembrane is considered in the future as a substitute for the currently specified material (HDPE) and polymer chemists estimate its lifespan will meet the lifespans for materials available at the time of evaluation, it will be deemed to meet the longevity design/performance requirements.

## 4.3 Hydraulic Conductivity and Diffusion Coefficient

In the water balance computations discussed in the TMA Feasibility Report, the geomembrane pseudo-permeability used corresponds to that of HDPE. Even though minor changes in the pseudo-permeability of the geomembrane, normally estimated from water vapor transmission tests (ASTM E 96), will not change the computed percolation from the site significantly, the decision matrix specifies that the maximum allowable pseudo-permeability for alternative geomembranes be 2E-13 cm/sec as estimated based on the ASTM E 96 water vapor transmission test, or equivalent.

An oxygen transport model (SRK, 1997) was used to evaluate the potential for oxygen movement through the final cover and into the tailings. In this study, a diffusion coefficient corresponding to that of HDPE was used. Therefore, any alternative material being considered should have a diffusion coefficient equal to or less than that of HDPE.

## 4.4 Constructibility

Constructibility issues are important to geomembrane performance, but are critical only if the construction practices impact the quantitative results used in the design and evaluation of the system containing the geomembranes. Based on the state-of-practice, the Feasibility Report assumed that the integrity of HDPE if installed with current standards of MQC and CQA/CQC, can be quantified as one manufacturing defect, one installation defect and excellent contact between the geomembrane and the substrate. Therefore a substitute geomembrane would be acceptable from a constructibility standpoint if it can be installed to the same degree of integrity as HDPE, quantified using qualitative comparison based largely on experience in the field elsewhere. Other issues to be considered in this regard are ease of installation and ability to weld, including to the geomembrane placed during the previous installation, in a timely fashion.

## 4.5 Mechanical Properties

### 4.5.1 Required Properties for an Alternative Geomembrane

Even though the mechanical properties of the geomembrane in the final cover system are not required to resist any anticipated mechanical stresses or strains, NMC has specified the same puncture resistance as the HDPE geomembrane currently proposed. The same logic has been used for the tensile properties. Therefore, the alternative material must meet the mechanical properties listed in the GRI-GM13 specifications (Hsuan and Koerner, 1997) corresponding to HDPE.

### 4.5.2 Verification of Properties for an Alternative Geomembrane

The acceptability of an alternative geomembrane will be evaluated as follows. For tensile properties and puncture resistance, manufacturers' data will be used to determine preliminary acceptance of the alternative material. Standardization of testing methods and the awareness of the strict QA/QC procedures which occur during construction, plus efforts by geosynthetic societies and trade organizations have established the credibility of material properties published by manufacturers. Therefore, manufacturers' data are sufficient and appropriate for preliminary acceptance of an alternative geomembrane. However, during the construction stage, the QA/QC procedures outlined in Appendix A of Addendum No. 3 to the Feasibility Report (Foth & Van Dyke, 1997) require that manufacturers' QC test data be obtained for each roll of material. In addition, the procedures outlined in Appendix A also require conformance testing (ASTM D 638, Type IV for tensile properties and ASTM D4833 for puncture resistance) on a specified number of rolls. These procedures will assist in verifying that the material in the field meets the design requirements. Normally, geomembranes which are more flexible than HDPE are characterized by lower break strength. Since flexibility is more important for the final cover, the break strength of an alternative material may be less than that of HDPE by up to 20 percent.

## 4.6 Summary

In summary, the decision matrix in Figure 2 illustrates how NMC would proceed to evaluate a material other than HDPE as an alternative geomembrane for the final cover application. Environmental, chemical, hydraulic/diffusive, and mechanical requirements of the geomembrane design will be evaluated for the proposed alternative material against the criteria established above. Installation requirements the alternative material will need to meet include compatibility with the previously installed geomembrane to which the alternative material may have to be welded, potential installation defects, etc. Unquantifiable features which facilitate an easier installation may be considered acceptable based on engineering judgement, but only if the other requirements as shown on the decision matrix are met first.

# 5 Geotextiles for Cushioning and Separation

The Feasibility Report discusses both design principles and methods for geotextiles used for cushioning. Geotextiles for cushioning are proposed for the base of all TMA cells, and the final cover. Geotextiles are proposed for cushioning on the base and sideslopes of the reclaim and other containment ponds. Geotextiles are also proposed for separation between the fill and riprap on the sideslopes of the reclaim and other containment ponds.

For cushioning geotextiles, a 12 oz/sy non-woven needle punched geotextile will be used. Field testing to document the adequacy of this cushioning geotextile has been planned (see Section 5.3). The scope of this test may also include use of 8 oz/sy and 10 oz/sy geotextiles. Based on the results of the field tests to be completed prior to actual construction, a single layer of a 12 oz/sy or two layers of 12 oz/sy geotextile will most likely be used. A class 2 geotextile per AASHTO M 288-96 (AASHTO, 1995) is considered appropriate. For separation, a class 2 geotextile meeting the requirements of Table 3 of AASHTO M 288-96 is specified.

Figure 3 presents a decision matrix that can be employed at any future date to evaluate and select an alternative geotextile(s) for use as a cushioning geotextile or for separation.

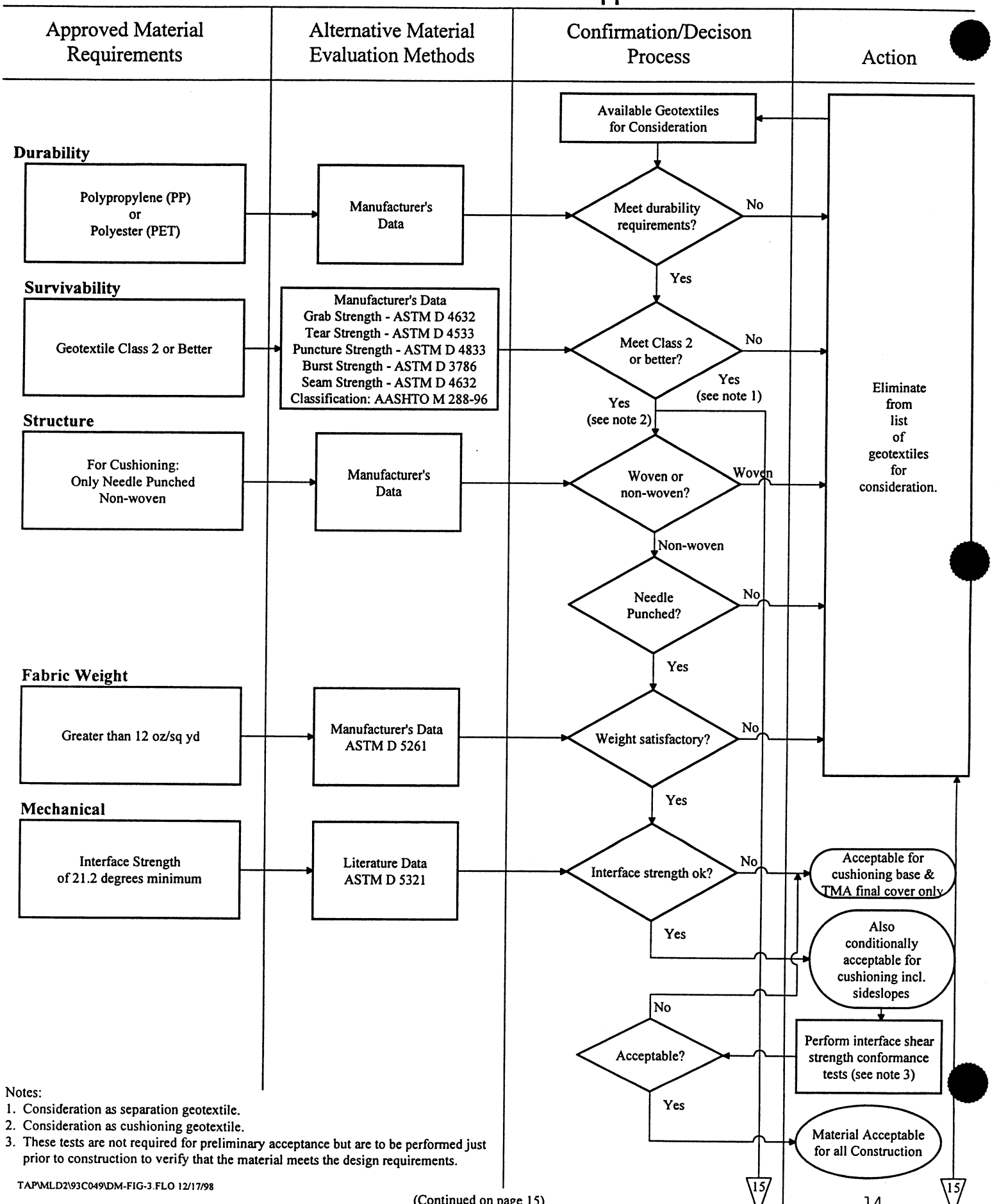
## 5.1 Durability of Polymers

Polypropylene geotextiles are considered as the primary geotextile for application at the TMA site although polyester is also acceptable provided chemical compatibility with the liquids in the TMA and the ponds can be established. The durability of the geotextile in the TMA liner system is a desirable feature at least until the time when the percolation from the TMA becomes insignificant and equal to that through the cap. This is not a critical issue because the presence of the GCL and the P-40 layer below the geomembrane will provide very high puncture resistance. The primary purpose of the geotextile therefore becomes to effect a blunt (larger radius) contact if angular stones within the drainage layer come in contact with the geotextile. Drainage of the tailings under the force of gravity is likely to be completed in about 100 years after closure of any cell. The reclaim pond and other containment ponds will have a much shorter design life. Because geotextiles are expected to last longer than 100 years, no quantitative estimates are deemed necessary. However, any alternative material will be acceptable only if the durability of the geotextile is comparable to that of polypropylene or polyester.

## 5.2 Survivability

All geotextiles, regardless of their application need to be specified with survivability requirements. AASHTO M 288-96 (1995) provides geotextile classes depending on the severity of installation conditions. For TMA applications, the installation conditions are not considered harsh and a Class 2 classification is considered appropriate. Any alternative geotextile used for cushioning or separation at the TMA will have to meet AASHTO 288-96, Class 2 requirements or equivalent.

# Figure 3
# Crandon Project
# Decision Matrix for Geotextile Applications




Notes:
1. Consideration as separation geotextile.
2. Consideration as cushioning geotextile.
3. These tests are not required for preliminary acceptance but are to be performed just prior to construction to verify that the material meets the design requirements.

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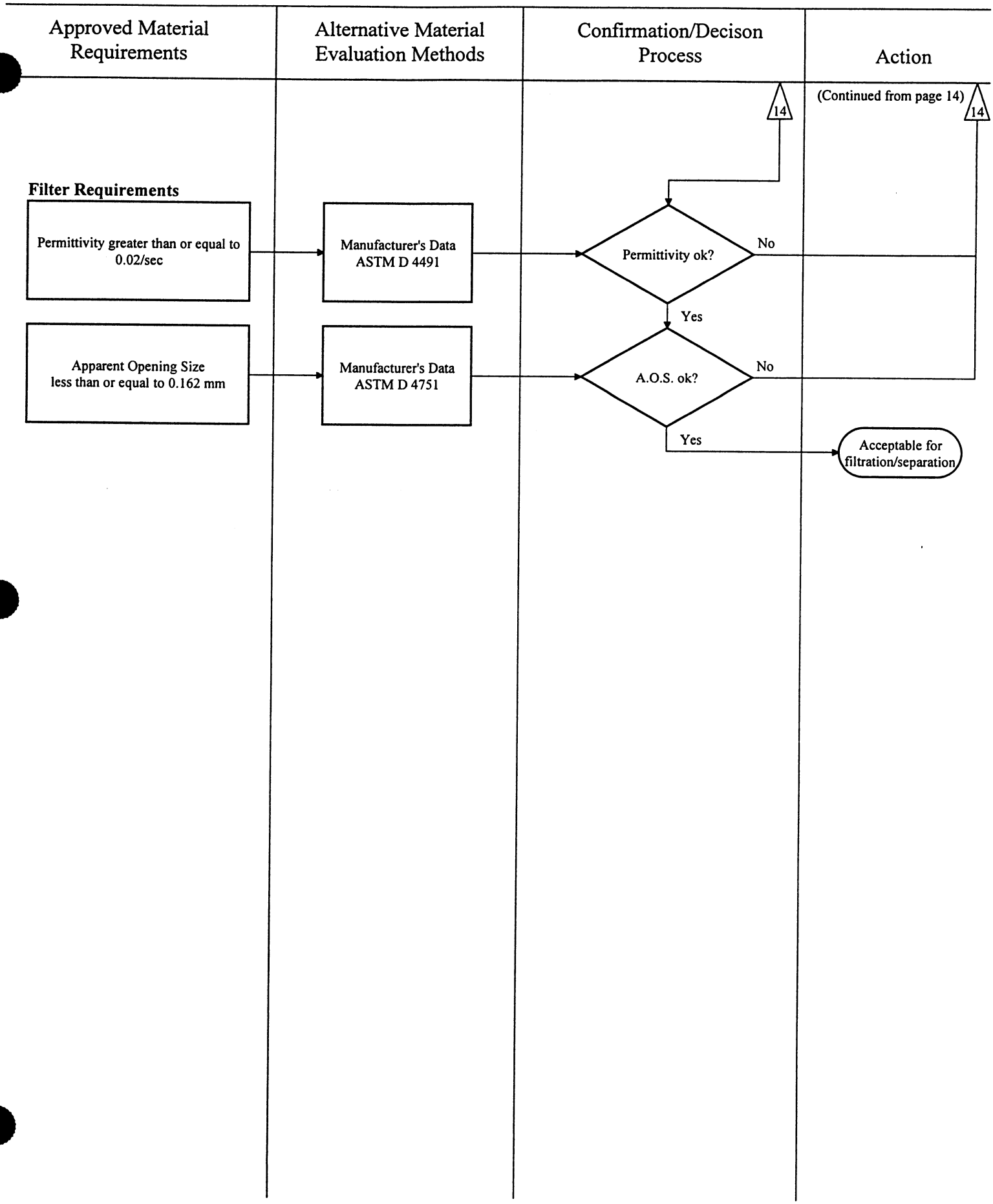
(Continued on page 15)

**Figure 3** *(Continued)*



## 5.3 Structure and Fabric Weight

Geotextiles are produced as either woven or non-woven products. For cushioning purposes only needle-punched, non-woven geotextiles will be acceptable. For separation, either woven or non-woven geotextiles will be acceptable.

For cushioning geotextiles a minimum mass per unit area of 12 oz/sy will be used. A field test to document the adequacy of this cushioning geotextile is planned. The test sample set up will be similar to the TMA base liner system, i.e., a 12-inch layer of P-40 material overlain by a GCL which in turn will be overlain by the geomembrane, 12 oz/sy geotextile and an 24-inch layer of the drainage layer. The field tests will be completed using actual construction equipment operating over the drainage layer to simulate construction stresses which will likely be the severest stress the geotextile will be subjected to during its design life. In order to assess the effectiveness of the protection provided by the geotextile, the geomembrane below the geotextile will be exhumed and evaluated to see if there is any damage to the geomembrane. Besides monitoring visual damage, laboratory tests will also be performed to ascertain whether unacceptable changes in the geomembrane properties have resulted. One such property is the break strength (ASTM D 638, Type IV, or equivalent). Other properties could include vapor transmission or the mode of rupture in a multiaxial test. If unacceptable change in properties has not resulted, a 12 oz/sy geotextile will be used in construction. If unacceptable change in properties is observed, two layers of 12 oz/sy geotextile will be employed. As an alternative, the design of the cushioning geotextile may be revised based on a more detailed field testing program using several geotextiles of differing weights per unit area. Separate field test programs to simulate the conditions of the pond liners are not planned, since the TMA base liner conditions represents the most stringent design condition. Results from the test proposed will also be used to determine the geotextile weight for the ponds.

## 5.4 Mechanical Properties

The cushioning geotextile used in the reclaim and other containment ponds will create potential planes of failure along the interfaces both above and below the geotextile. The interface below is with the geomembrane and that above is with the till layer. Since the stability of the protective cover soils on the sideslopes of the ponds is predicated upon the weakest plane and since the design of the components is based on a desired factor of safety, it is necessary that both interfaces discussed above have a minimum friction angle of 21.2°. If this value cannot be met by an alternate geotextile, the alternative material cannot be used for the sideslopes and its consideration will be limited to the base application.

## 5.5 Filter Requirements

Geotextiles used for separation must have permittivity greater than that of the till soil or a minimum value equal to a default value of 0.02 $sec^{-1}$. The permittivity of the till layer is equal to 2.7E-06 $sec^{-1}$. Therefore, the specification adopted from AASHTO M 288-96 (1995) is a minimum permittivity of 0.02 $sec^{-1}$. Any alternative material being considered should meet the

above criterion. If AASHTO M 288-96 is revised or an equivalent specification is made available, the revised or new specification will govern.

The required apparent opening size (AOS) for geotextiles used for separation is obtained based on filter criteria applied to the till. This value has been determined as 0.162 mm. AASHTO M 288-96 (1995) specifies AOS to be less than 0.60 mm. Therefore, 0.162 mm (maximum) will govern.

## 5.6 Verification of Properties

To verify the needed properties of the geotextiles, i.e., survivability, the interface shear strength characteristics and the filter requirements, the standard test methods and the minimum acceptable factors of safety to be used by the manufacturer, engineer, and CQA personnel are presented in Table 5-1.

## Table 5-1

## Geotextile Test Methods and Required Values

| | | Measured Elongation <50% | Measured Elongation ≥50% |
|---|---|---|---|
| Grab Strength | ASTM D 4632 | 1100 N (247 lb) | 700 N (158 lb) |
| Sewn Seam Strength | ASTM D 4632 | 990 N (223 lb) | 630 N (142 lb) |
| Tear Strength | ASTM D 4533 | 400 N (90 lb) | 250 N (56 lb) |
| Puncture Strength | ASTM D 4833 | 400 N (90 lb) | 250 N (56 lb) |
| Burst Strength | ASTM D 3786 | 2700 N (608 lb) | 1300 N (293 lb) |
| Cushioning Geotextile | | | |
| Mass per unit area | ASTM D 5261 | 12 oz/sy | |
| Interface shear strength | ASTM D 5321 | 21.2° minimum | |
| Separation Geotextile | | | |
| Permittivity | ASTM D 4491 | 0.02 $sec^{-1}$ minimum | |
| Apparent opening size | ASTM D 4751 | 0.162 mm maximum | |

Prepared by: NXP
Checked by: REM

# 6 Geocomposites

The Feasibility Report discusses both design principles and methods for the geocomposite to be used for sideslope drainage. The proposed geocomposite consists of a geonet with geotextiles laminated to it on both sides.

The geotextiles used for the geocomposite do not have to meet the survivability requirements for geotextiles as described in Section 5.2. But the geotextiles have to satisfy three design conditions, namely an interface shear strength of 21.2 degrees, minimum permittivity of 0.02/sec and an apparent opening size of 0.162 mm or less.. The permittivity and apparent opening size requirements are important for the upper geotextile only. The geonet in almost all available geocomposites is made of polyethylene polymer. The geocomposite must meet the allowable transmissivity (in-plane flow rate) requirements for the proposed design which is a minimum 0.97 gal/min/ft at a hydraulic gradient of 0.1 and a pressure of 14.5 psi.

Figure 4 presents a decision matrix that can be employed at any future date to evaluate the selection of an alternative geocomposite for sideslope drainage of the TMA.

## 6.1 Geocomposite Construction

The geonet of the geocomposite will be HDPE and the geotextiles laminated to it either polypropylene or polyester. These materials are believed to possess a design life far exceeding the design requirements of the sideslope drainage system of the TMA. HELP model analyses (Foth & Van Dyke, 1998b) show that the drainage in the geocomposite layer drops off to insignificant values within approximately 66 years after TMA cell closure. Any alternative geocomposite being considered for use should have similar life expectancy.

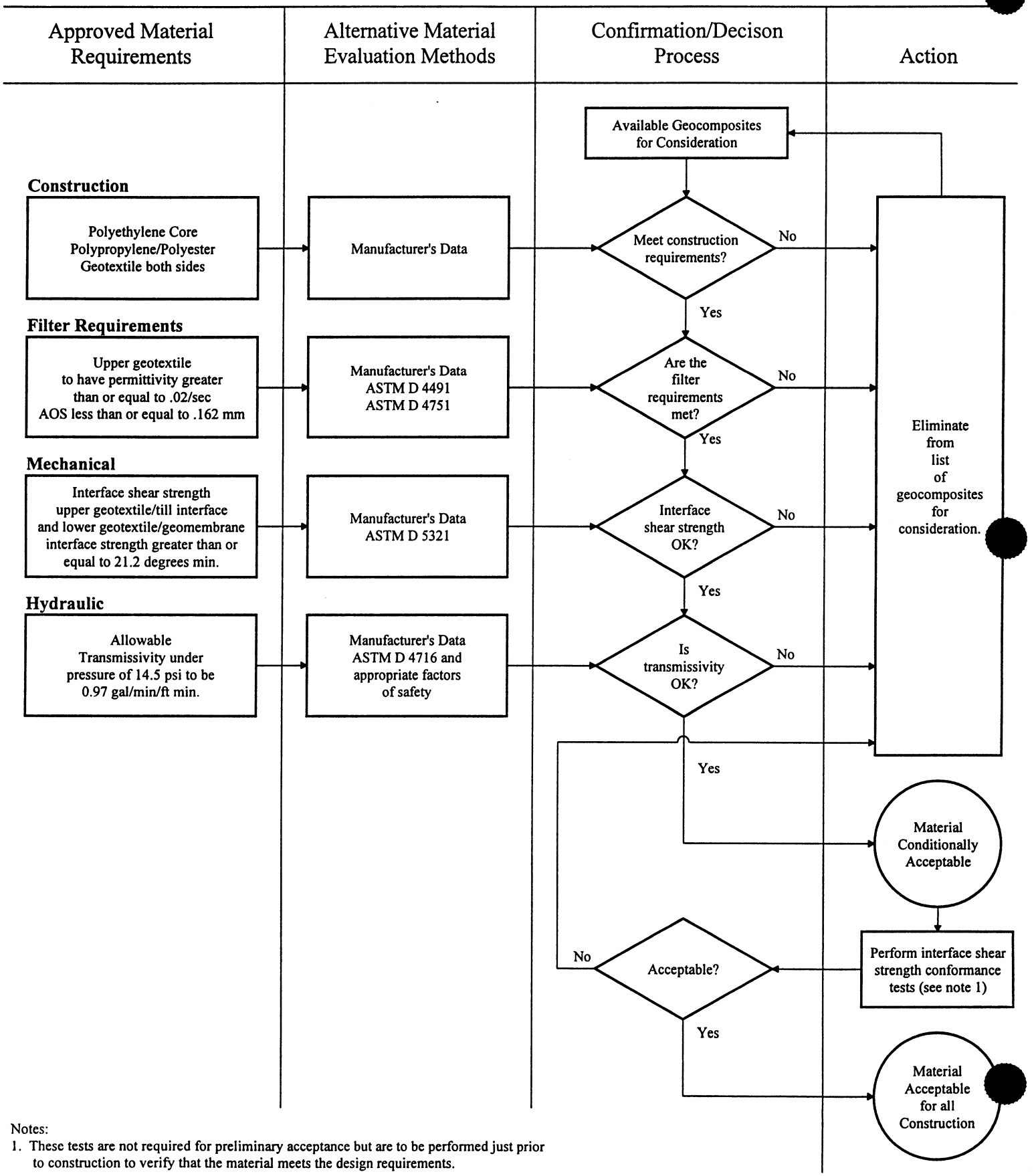
## 6.2 Filter Requirements

Since the upper geotextile of the geocomposite will act as a separation layer between the till and the geonet, the required properties and the methods of verification for any alternative material being considered should meet the following conditions

Geotextiles used for separation must have permittivity greater than that of the soil or a minimum value equal to a default value of 0.02/sec. The permittivity of the protective layer above the geocomposite is much less than 0.02/sec and therefore the default value will be used.

The required apparent opening size (AOS) for geotextiles used for separation is based on filter criteria applied to the base soil (the till overlying the geocomposite). The value has been preliminarily determined as 0.162 mm. AASHTO M 288-96 (1995) specifies AOS to be less than 0.60 mm. Therefore 0.162 mm (maximum) will govern.

# Figure 4
# Crandon Project
# Decision Matrix for Geocomposite Applications




Notes:

1. These tests are not required for preliminary acceptance but are to be performed just prior to construction to verify that the material meets the design requirements.

TAP\MLD2\93C049\UGMDM-F4.FLO 11/16/98

## 6.3 Mechanical Properties

The geocomposite which will be used on the sideslopes of the TMA will create potential planes of failure along the interfaces both above and below the geocomposite. The interface below will be with the geomembrane and that above is with the till layer. Since the stability of the cover soils on the sideslopes is predicated on the weakest plane and since the design of the TMA components is based on a desired factor of safety, it is necessary that both interfaces discussed above possess a minimum friction angle of 21.2°.

## 6.4 Hydraulic Properties

The in-plane flow rate or transmissivity of the geocomposite as proposed for the TMA is an allowable minimum 0.97 gal/min/ft at a hydraulic gradient of 0.1 and a pressure of 14.5 psi obtained from test values and appropriate factors of safety to account for creep, clogging, geosynthetic intrusion, etc. Any alternative geocomposite under consideration must possess similar or larger allowable transmissivity.

## 6.5 Verification of Properties

To verify the needed properties of the geocomposite (i.e., permittivity and apparent opening size of the upper geotextile, the interface shear strength characteristics and the transmissivity of the geocomposite), the standard test methods and the minimum acceptable factors of safety to be used by the manufacturer, engineer, and CQA personnel are presented in Table 6-1.

## Table 6-1

## Geocomposite Test Methods and Required Values

| | | |
|---|---|---|
| Upper Geotextile | | |
| Permittivity | ASTM D 4491 | 0.02 $sec^{-1}$ minimum |
| Apparent Opening Size | ASTM D 4751 | 0.162 mm maximum |
| Interface Shear Strength with Till | ASTM D 5321 | 21.2° minimum |
| Lower Geotextile | | |
| Interface Shear Strength with Geomembrane | ASTM D 5321 | 21.2° minimum |
| Transmissivity of Geocomposite | ASTM D 4716 | minimum of FOS multiplied by 0.97 gal/min/ft at a hydraulic gradient of 0.1 and at a pressure of 14.5 psi |

FOS - Factor of Safety

Prepared by: NXP
Checked by: REM

# 7 Geosynthetic Clay Liner

The Feasibility Report discusses both design principles and methods and identifies a geosynthetic clay liner (GCL) as the soil component of the composite hydraulic barriers of both the liner and final cover systems of the TMA. The GCL identified will have sodium bentonite sandwiched between a woven or non-woven lower geotextile and non-woven upper geotextile and needle punched such that the internal shear strengths are high. As a natural mineral, bentonite is considered to have unlimited durability if it is chemically compatible with the leachate expected to be produced in the TMA. The geotextiles will not play a role in the performance of the GCL after the TMA cells are filled with tailings.

Figure 5 presents a decision matrix that can be employed at any future date to evaluate and select an alternative geosynthetic clay liner for use at the site.

## 7.1 Structure

The GCL chosen consists of bentonite sandwiched between non-woven geotextiles and subsequently needle punched. Needle punching increases the internal shear strength of the GCL. Any alternative GCLs considered should also have the same structure.

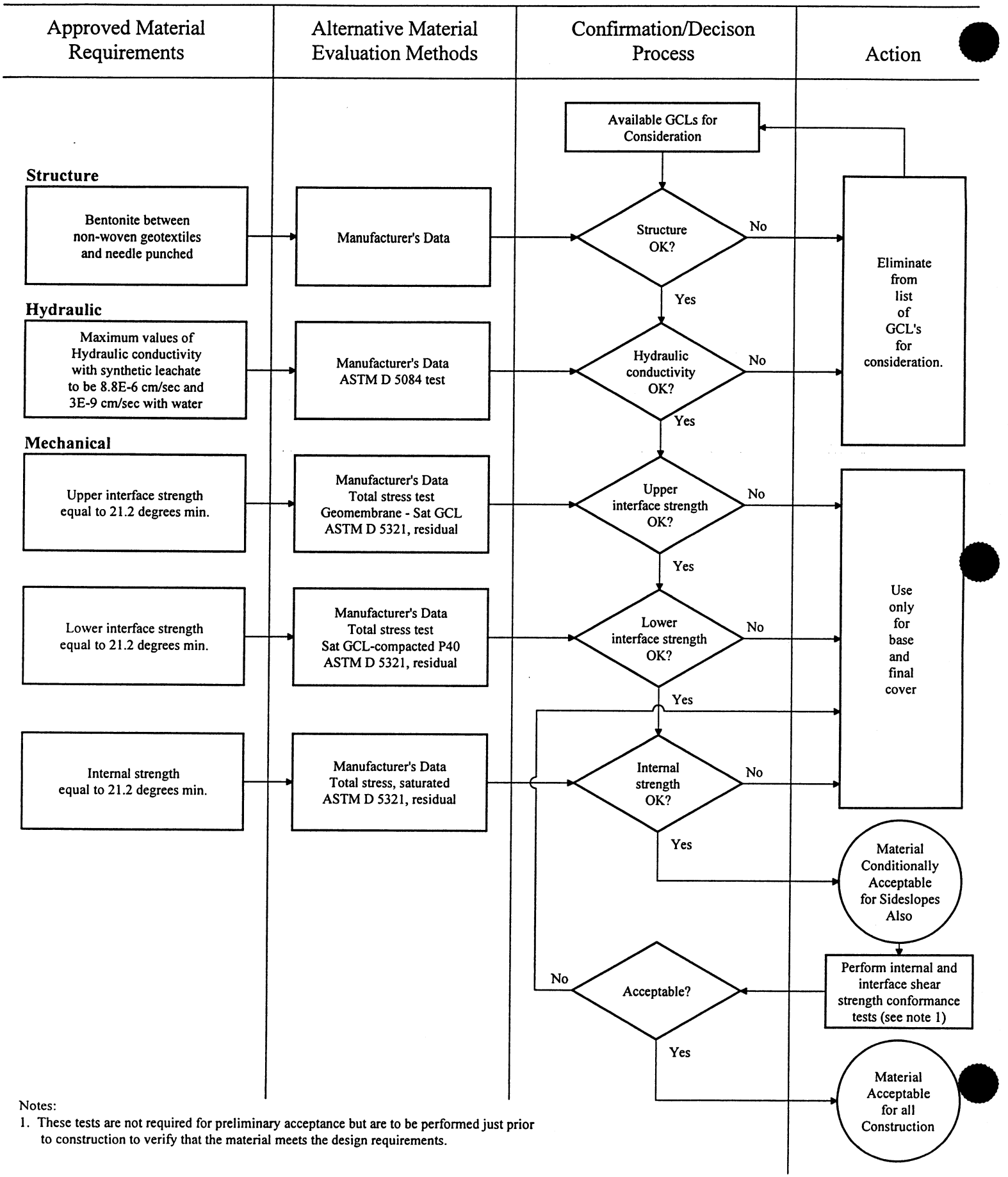
## 7.2 Hydraulic Conductivity

The most important property of the GCL for the TMA application is its low hydraulic conductivity. A GCL with a maximum design hydraulic conductivity of 3E-09 cm/sec was specified in the Feasibility Report. As tested using methods in ASTM D 5084, using water as permeant, the resulting hydraulic conductivity of an alternate GCL should not be more than 3E-09 cm/sec at a confining stress of 5 psi and a head pressure of 2 psi. The hydraulic conductivity with a leachate expected to be generated at the TMA should not be more than 8.8E-06 cm/sec. The permeant used in such a test should be a synthetic leachate specifically prepared to represent the leachate likely to be produced at the site. Characteristics of the site's anticipated leachate are provided in the Feasibility Report.

## 7.3 Mechanical Properties

The GCL creates two interfaces, one between the lower geotextile of the GCL and the underlying P40 till layer, and the second between the upper geotextile and the geomembrane overlying it. These interfaces need to have shear strengths (residual) equal to or higher than 21.2°, the value determined to be required to obtain the design factor of safety of the cover soils over the sideslopes of the TMA. For the interface between the lower geotextile of the GCL and the underlying P40 till material, the total stress strength parameter is to be obtained from a direct shear test (ASTM D 5321) with the P40 till material compacted wet of optimum but not saturated prior to the slow rate of shear displacement. The second interface, i.e., between the GCL and the geomembrane, is discussed in Section 3.4.2 for the base liner geomembrane decision matrix.

# Figure 5
# Crandon Project
# Decision Matrix for GCL Applications




Notes:

1. These tests are not required for preliminary acceptance but are to be performed just prior to construction to verify that the material meets the design requirements.

The internal shear strength of the GCL is also an important parameter. Since the GCL will be forming a plane surface, a potential failure plane could be created. Currently available research data appear to show that prior to placement of tailings, when concern for slope stability is maximum, the total stress strength parameter can be represented by a friction parameter for the expected range of normal stresses along the potential failure plane.. Therefore, the internal shear strength (residual) of the GCL has also been specified as a minimum of 21.2°.

## 7.4 Verification of Properties

The hydraulic conductivity of an alternative GCL should be determined using the hydraulic conductivity test specified in ASTM D 5084 using both water and a synthetic leachate representing the site leachate as permeants. The site interface shear characteristics must be determined using a slow direct shear test machine. Details relating to the tests for the GCL geomembrane interface are discussed in Section 3.4.2 for the base liner geomembrane decision matrix.

For the interface between the P40 till soil and the lower geotextile of the GCL, the till should be compacted to the field density specifications (wettest permissible moisture content and lowest permissible densities) and the test run at a very slow rate of displacement to represent field conditions. The total strength should be represented as a friction parameter since the failure surface is pre-determined in the field. If a GCL does not pass the interface shear test, but passes all others, its application will be limited to the base and final cover of the TMA.

## 8 References


AASHTO M 288-96, 1995. Draft "Standard Specification for Geotextiles". February 2, 1995.

Foth & Van Dyke, 1995. *Tailings Management Area Feasibility Report/Plan of Operation.*

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Hsuan, Y. (Grace) and Koerner, R.M., 1997. "GRI Finalizes Its First Specification". Geotechnical Fabrics Report, September 1997, Volume 15, Number 7.

Steffen Robertson and Kirsten, Inc., April 1997. *Crandon Project TMA Oxygen Transport Modeling.*

# Appendix E

## Leachate Sump Size Determination and Pump Sizing

Foth & Van Dyke
consultants · engineers · scientists

Client: NMC | Scope I.D.: 93C049
Project: TMA - Add 5 | Page: 1/3
Prepared By: Nx P | Date: 11-10-98
Checked By: MRS | Date: 11-10-98

# SUMP SIZE DETERMINATION

Purpose: To determine the required size of sump to store monthly average leachate generation with 6 pumping cycles per day.

Scope: Determine the largest required sump size using leachate generation rates from HELP model runs for operation conditions - second stage. TMA-1 will have 4 sumps and TMA 2 + 3 2 sumps each. Use monthly generation rates from HELP model as opposed to average annual or peak daily

Data:

| | Area | | | |
|---|---|---|---|---|
| Cell Name | Upper s/s $ft^2$ | Lower s/s $ft^2$ | Base $ft^2$ | Source |
| TMA 1 | 797,600 | 1,212,600 | 731,900 | CAD file |
| TMA 2, TMA 3 | 623,400 | 621,300 | 709,700 | CAD file |

| | Drainage in/day | | | |
|---|---|---|---|---|
| BASIS | upper s/s | Lower s/s | Base | Source |
| Av. Annual | 0.064 | 0.0796 | 0.086 | HELP |
| Monthly (max) | 0.133 (Mar) | 0.111 (Feb) | 0.108 (Jul) | HELP |
| Peak Daily | 0.30724 | 0.30214 | 0.28 | HELP |

CALCULATION

TMA 1

$$\text{Volume/sump/day} = \frac{1}{4}\left[(797{,}600)\left(\frac{.133}{12}\right) + (1{,}212{,}600)\left(\frac{.111}{12}\right) + (731{,}900)\left(\frac{.108}{12}\right)\right]$$

$$= \frac{1}{4}(8840.1 + 11216.6 + 6587.1)$$

$$= \underline{6660.9} \text{ cft}$$

TMA 2, 3

$$\text{Volume/sump/day} = \frac{1}{2}\left[(623{,}400)\left(\frac{.133}{12}\right) + (621{,}300)\left(\frac{.111}{12}\right) + (709{,}700)\left(\frac{.108}{12}\right)\right]$$

$$\frac{1}{2}(6909.4 + 5747 + 6387.3)$$

$$= \underline{9521.85}$$

With 6 pumping cycles per day, size of sump required $= \frac{9521.85}{6(n)} = \frac{1587.0}{n}$ cft

Assuming porosity of stones in the sump = 0.3

size of sump $= \frac{1587.0}{.3} = \underline{5{,}290.0}$ cft

Assume the shape of the sump to be a truncated square pyramid

Using 3' lowering of leachate per cycle, i.e, difference in elevation between and ON and OFF relays being 3', required area at ON elevation is

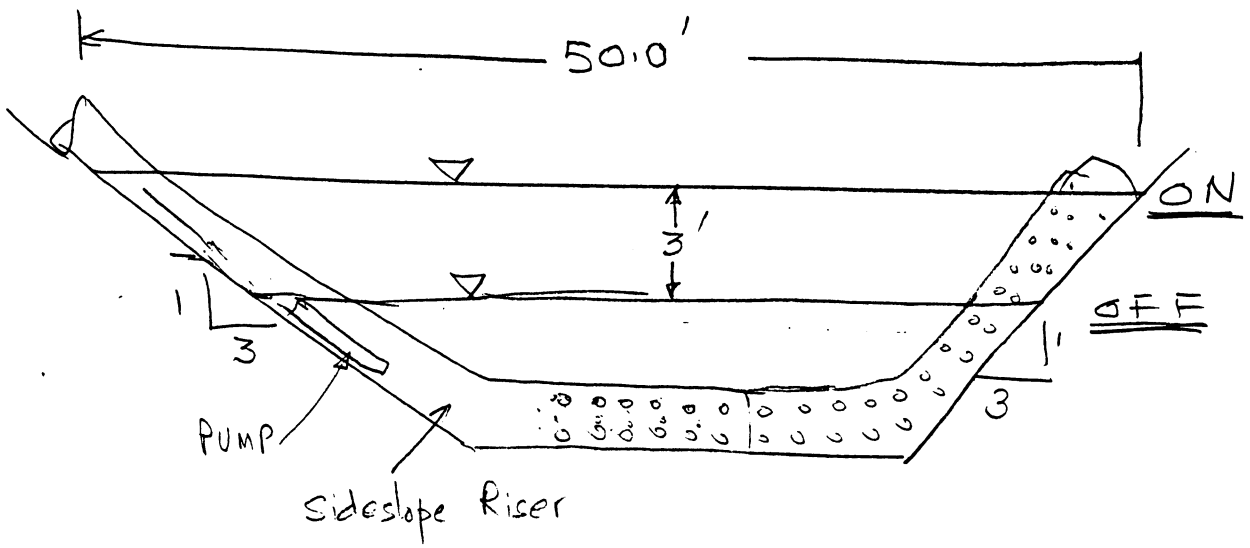
$$\left[B^2 + (B-18)^2\right]\frac{3}{2} = 5290.0$$

$$B^2 + B^2 - 36B + 324 - 3526.7 = 0$$

$$B^2 - 18B - 1601.3 = 0$$

$$B = \frac{18 \pm \sqrt{324 + 6405.2}}{2}$$

$$= \frac{18 + 82.0}{2} = \underline{\underline{50.0'}}$$




Note: 6 pumping cycles was an assumption to size the sump. Actual pumping cycles will depend on the capacity of pump used.

**NMC - TMA SIDE SLOPE RISER PUMP CALCULATIONS**
**STAGE II CONDITIONS**
**TMA CELL 1A - SIDE SLOPE RISER SSR-1 (NORTHWEST CORNOR)**

**PROJECT SCOPE I.D. : 93C049**

**PREPARED BY:** HJA 12/2

**CHECKED BY:** PAK 12/23/98

**ESTIMATED SYSTEM HEAD CONDITIONS:**

**A) STATIC HEAD:**

| | |
|---|---|
| Elevation at Discharge to Gravity Pipeline | 1730.00 |
| Low Pumping Elevation at Pump Shut-off | 1632.00 |
| Total Static Head (feet) | 98.00 |

**B) FITTINGS AND VALVES (Side Slope Riser Pump Forcemain)**

Nominal Pipe Diameter (in) 4

| Type Minor Loss | Number | K-Value | Total |
|---|---|---|---|
| 90 DEGREE ELBOW | 2 | 0.54 | 1.08 |
| 45 DEGREE ELBOW | 4 | 0.29 | 1.16 |
| TEE (THRU) | 1 | 0.36 | 0.36 |
| TEE (BRANCH) | 0 | 1.08 | 0.00 |
| SWING CHECK | 1 | 1.80 | 1.80 |
| PLUG VALVE | 1 | 0.32 | 0.32 |
| ENTRANCE | 1 | 0.50 | 0.50 |
| EXIT | 1 | 1.00 | 1.00 |
| | | Sum of K-Value | 6.22 |

**C) HEADLOSS CALCULATIONS**

| | |
|---|---|
| Sum of K-Values (4") | 6.22 |
| Sum of K-Values (12") | 2.4 |
| Pipe Length (ft) (4") | 352 |
| Pipe Length (ft) (12") | 270 |
| Pipe C-Value | 140 |
| Static Head (ft) | 98 |
| Type Pipe | HDPE, DR 17, 100 psi |
| Nominal Pipe Dia. (in) | 4 |
| Inside Pipe Dia. (in) | 3.94 |
| Nominal Pipe Dia. (in) | 12 |
| Inside Pipe Dia. (in) | 11.16 |

| Flow Rate (gpm) | Diameter (in) | Velocity (ft/sec) | K-Value | Minor Losses (ft) | Pipe Length (ft) | Friction Head (ft) | Static Head (feet) | Total Head (feet) |
|---|---|---|---|---|---|---|---|---|
| **4 " FORCEMAIN** | | | | | | | | |
| 120 | 3.94 | 3.16 | 6.22 | 1.0 | 352 | 3.5 | 98.00 | 102.5 |
| 140 | 3.94 | 3.68 | 6.22 | 1.3 | 352 | 4.7 | 98.00 | 104.0 |
| 160 | 3.94 | 4.21 | 6.22 | 1.7 | 352 | 6.0 | 98.00 | 105.7 |
| 180 | 3.94 | 4.74 | 6.22 | 2.2 | 352 | 7.4 | 98.00 | 107.6 |
| **12" FORCEMAIN** | | | | | | | | |
| 120 | 11.16 | 0.39 | 2.4 | 0.01 | 270 | 0.02 | 0.00 | 0.0 |
| 140 | 11.16 | 0.46 | 2.4 | 0.01 | 270 | 0.02 | 0.00 | 0.0 |
| 160 | 11.16 | 0.52 | 2.4 | 0.01 | 270 | 0.03 | 0.00 | 0.0 |
| 180 | 11.16 | 0.59 | 2.4 | 0.01 | 270 | 0.04 | 0.00 | 0.0 |
| **TOTAL HEAD** | | | | | | | | |
| 120 | | | | | | | | 102.5 |
| 140 | | | | | | | | 104.0 |
| 160 | | | | | | | | 105.7 |
| 180 | | | | | | | | 107.6 |

# NMC - TMA SIDE SLOPE RISER PUMP CALCULATIONS
## STAGE II CONDITIONS
## TMA CELL 1A - SIDE SLOPE RISER SSR-2 (SOUTHEAST CORNOR)

PROJECT SCOPE I.D. : 93C049

PREPARED BY: HJA 12/23/94

CHECKED BY: PHK 12/23/94

**ESTIMATED SYSTEM HEAD CONDITIONS:**

**A) STATIC HEAD:**

| | |
|---|---|
| Elevation at Discharge to Gravity Pipeline | 1730.00 |
| Low Pumping Elevation at Pump Shut-off | 1632.00 |
| Total Static Head (feet) | 98.00 |

**B) FITTINGS AND VALVES (Side Slope Riser Pump Forcemain)**

Nominal Pipe Diameter (in) 4

| Type Minor Loss | Number | K-Value | Total |
|---|---|---|---|
| 90 DEGREE ELBOW | 2 | 0.54 | 1.08 |
| 45 DEGREE ELBOW | 4 | 0.29 | 1.16 |
| TEE (THRU) | 1 | 0.36 | 0.36 |
| TEE (BRANCH) | 0 | 1.08 | 0.00 |
| SWING CHECK | 1 | 1.80 | 1.80 |
| PLUG VALVE | 1 | 0.32 | 0.32 |
| ENTRANCE | 1 | 0.50 | 0.50 |
| EXIT | 1 | 1.00 | 1.00 |
| | | Sum of K-Value | 6.22 |

**C) HEADLOSS CALCULATIONS**

| | |
|---|---|
| Sum of K-Values (4") | 6.22 |
| Sum of K-Values (12") | 3.4 |
| Pipe Length (ft), (4") | 509 |
| Pipe Length (ft), (12") | 2250 |
| Pipe C-Value | 140 |
| Static Head (ft) | 98 |
| Type Pipe | HDPE, DR 17, 100 psi |
| Nominal Pipe Dia. (in) | 4 |
| Inside Pipe Dia. (in) | 3.94 |
| Nominal Pipe Dia. (in) | 12 |
| Inside Pipe Dia. (in) | 11.16 |

| Flow Rate (gpm) | Diameter (in) | Velocity (ft/sec) | K-Value | Minor Losses (ft) | Pipe Length (ft) | Friction Head (ft) | Static Head (feet) | Total Head (feet) |
|---|---|---|---|---|---|---|---|---|
| **4" FORCEMAIN** | | | | | | | | |
| 120 | 3.94 | 3.16 | 6.22 | 1.0 | 509 | 5.1 | 98.00 | 104.0 |
| 140 | 3.94 | 3.68 | 6.22 | 1.3 | 509 | 6.7 | 98.00 | 106.0 |
| 160 | 3.94 | 4.21 | 6.22 | 1.7 | 509 | 8.6 | 98.00 | 108.3 |
| 180 | 3.94 | 4.74 | 6.22 | 2.2 | 509 | 10.7 | 98.00 | 110.9 |
| **12" FORCEMAIN** | | | | | | | | |
| 120 | 11.16 | 0.39 | 3.4 | 0.01 | 2,250 | 0.14 | 0.00 | 0.1 |
| 140 | 11.16 | 0.46 | 3.4 | 0.01 | 2,250 | 0.19 | 0.00 | 0.2 |
| 160 | 11.16 | 0.52 | 3.4 | 0.01 | 2,250 | 0.24 | 0.00 | 0.3 |
| 180 | 11.16 | 0.59 | 3.4 | 0.02 | 2,250 | 0.30 | 0.00 | 0.3 |
| **TOTAL HEAD** | | | | | | | | |
| 120 | | | | | | | | 104.2 |
| 140 | | | | | | | | 106.2 |
| 160 | | | | | | | | 108.6 |
| 180 | | | | | | | | 111.2 |

**NMC - TMA SIDE SLOPE RISER PUMP CALCULATIONS**
**STAGE II CONDITIONS**
**TMA CELL 1B - SIDE SLOPE RISER SSR-3 (NORTHEAST CORNOR)**

**PROJECT SCOPE I.D. : 93C049**

**PREPARED BY:** HJA 12/

**CHECKED BY:** PAH 12/23/98

**ESTIMATED SYSTEM HEAD CONDITIONS:**

**A) STATIC HEAD:**

| | |
|---|---|
| Elevation at Discharge to Gravity Pipeline | 1730.00 |
| Low Pumping Elevation at Pump Shut-off | 1622.00 |
| Total Static Head (feet) | 108.00 |

**B) FITTINGS AND VALVES (Side Slope Riser Pump Forcemain)**

Nominal Pipe Diameter (in) 4

| Type Minor Loss | Number | K-Value | Total |
|---|---|---|---|
| 90 DEGREE ELBOW | 2 | 0.54 | 1.08 |
| 45 DEGREE ELBOW | 4 | 0.29 | 1.16 |
| TEE (THRU) | 1 | 0.36 | 0.36 |
| TEE (BRANCH) | 0 | 1.08 | 0.00 |
| SWING CHECK | 1 | 1.80 | 1.80 |
| PLUG VALVE | 2 | 0.32 | 0.64 |
| ENTRANCE | 1 | 0.50 | 0.50 |
| EXIT | 1 | 1.00 | 1.00 |
| | | Sum of K-Value | 6.54 |

**C) HEADLOSS CALCULATIONS**

| | |
|---|---|
| Sum of K-Values (4") | 6.54 |
| Sum of K-Values (12") | 5.4 |
| Pipe Length (ft), (4") | 1211 |
| Pipe Length (ft), (12") | 4150 |
| Pipe C-Value | 140 |
| Static Head (ft) | 108 |
| Type Pipe | HDPE, DR 17, 100 psi |
| Nominal Pipe Dia. (in) | 4 |
| Inside Pipe Dia. (in) | 3.94 |
| Nominal Pipe Dia. (in) | 12 |
| Inside Pipe Dia. (in) | 11.16 |

| Flow Rate (gpm) | Diameter (in) | Velocity (ft/sec) | K-Value | Minor Losses (ft) | Pipe Length (ft) | Friction Head (ft) | Static Head (feet) | Total Head (feet) |
|---|---|---|---|---|---|---|---|---|
| **4" FORCEMAIN** | | | | | | | | |
| 120 | 3.94 | 3.16 | 6.54 | 1.0 | 1,211 | 12.0 | 108.00 | 121.1 |
| 140 | 3.94 | 3.68 | 6.54 | 1.4 | 1,211 | 16.0 | 108.00 | 125.4 |
| 160 | 3.94 | 4.21 | 6.54 | 1.8 | 1,211 | 20.5 | 108.00 | 130.3 |
| 180 | 3.94 | 4.74 | 6.54 | 2.3 | 1,211 | 25.5 | 108.00 | 135.8 |
| **12" FORCEMAIN** | | | | | | | | |
| 120 | 11.16 | 0.39 | 5.4 | 0.01 | 4,150 | 0.3 | 0.00 | 0.3 |
| 140 | 11.16 | 0.46 | 5.4 | 0.02 | 4,150 | 0.3 | 0.00 | 0.4 |
| 160 | 11.16 | 0.52 | 5.4 | 0.02 | 4,150 | 0.4 | 0.00 | 0.5 |
| 180 | 11.16 | 0.59 | 5.4 | 0.03 | 4,150 | 0.6 | 0.00 | 0.6 |
| **TOTAL HEAD** | | | | | | | | |
| 120 | | | | | | | | 121.3 |
| 140 | | | | | | | | 125.8 |
| 160 | | | | | | | | 130.8 |
| 180 | | | | | | | | 136.4 |

# NMC - TMA SIDE SLOPE RISER PUMP CALCULATIONS
## STAGE II CONDITIONS
## TMA CELL 1B - SIDE SLOPE RISER SSR-4 (SOUTHWEST CORNOR)

PROJECT SCOPE I.D. : 93C049

PREPARED BY: HJA 12/23/98

CHECKED BY: PAH 12/23/98

**ESTIMATED SYSTEM HEAD CONDITIONS:**

**A) STATIC HEAD:**

| | |
|---|---|
| Elevation at Discharge to Gravity Pipeline | 1730.00 |
| Low Pumping Elevation at Pump Shut-off | 1622.00 |
| Total Static Head (feet) | 108.00 |

**B) FITTINGS AND VALVES (Side Slope Riser Pump Forcemain)**

Nominal Pipe Diameter (in) 4

| Type Minor Loss | Number | K-Value | Total |
|---|---|---|---|
| 90 DEGREE ELBOW | 2 | 0.54 | 1.08 |
| 45 DEGREE ELBOW | 4 | 0.29 | 1.16 |
| TEE (THRU) | 1 | 0.36 | 0.36 |
| TEE (BRANCH) | 0 | 1.08 | 0.00 |
| SWING CHECK | 1 | 1.80 | 1.80 |
| PLUG VALVE | 2 | 0.32 | 0.64 |
| ENTRANCE | 1 | 0.50 | 0.50 |
| EXIT | 1 | 1.00 | 1.00 |
| | | Sum of K-Value | 6.54 |

**C) HEADLOSS CALCULATIONS**

| | |
|---|---|
| Sum of K-Values (4") | 6.54 |
| Sum of K-Values (12") | 2.4 |
| Pipe Length (ft), (4") | 618 |
| Pipe Length (ft), (12") | 60 |
| Pipe C-Value | 140 |
| Static Head (ft) | 108 |
| Type Pipe | HDPE, DR 17, 100 psi |
| Nominal Pipe Dia. (in) | 4 |
| Inside Pipe Dia. (in) | 3.94 |
| Nominal Pipe Dia. (in) | 12 |
| Inside Pipe Dia. (in) | 11.16 |

| Flow Rate (gpm) | Diameter (in) | Velocity (ft/sec) | K-Value | Minor Losses (ft) | Pipe Length (ft) | Friction Head (ft) | Static Head (feet) | Total Head (feet) |
|---|---|---|---|---|---|---|---|---|
| **4" FORCEMAIN** | | | | | | | | |
| 120 | 3.94 | 3.16 | 6.54 | 1.0 | 618 | 6.1 | 108.00 | 115.2 |
| 140 | 3.94 | 3.68 | 6.54 | 1.4 | 618 | 8.2 | 108.00 | 117.6 |
| 160 | 3.94 | 4.21 | 6.54 | 1.8 | 618 | 10.5 | 108.00 | 120.3 |
| 180 | 3.94 | 4.74 | 6.54 | 2.3 | 618 | 13.0 | 108.00 | 123.3 |
| **12" FORCEMAIN** | | | | | | | | |
| 120 | 11.16 | 0.39 | 2.4 | 0.01 | 60 | 0.00 | 0.00 | 0.0 |
| 140 | 11.16 | 0.46 | 2.4 | 0.01 | 60 | 0.01 | 0.00 | 0.0 |
| 160 | 11.16 | 0.52 | 2.4 | 0.01 | 60 | 0.01 | 0.00 | 0.0 |
| 180 | 11.16 | 0.59 | 2.4 | 0.01 | 60 | 0.01 | 0.00 | 0.0 |
| **TOTAL HEAD** | | | | | | | | |
| 120 | | | | | | | | 115.2 |
| 140 | | | | | | | | 117.6 |
| 160 | | | | | | | | 120.3 |
| 180 | | | | | | | | 123.3 |

**NMC - TMA SIDE SLOPE RISER PUMP CALCULATIONS -**
**STAGE II CONDITIONS**
**TMA CELL 2 - SIDE SLOPE RISER SSR-5 (SOUTHWEST CORNOR)**

**PROJECT SCOPE I.D. : 93C049**

**PREPARED BY:** HJA 12/23/94

**CHECKED BY:** PAH 12/23/

**ESTIMATED SYSTEM HEAD CONDITIONS:**

**A) STATIC HEAD:**

| | |
|---|---|
| Elevation at Discharge to Gravity Pipeline | 1730.00 |
| Low Pumping Elevation at Pump Shut-off | 1637.00 |
| Total Static Head (feet) | 93.00 |

**B) FITTINGS AND VALVES (Side Slope Riser Pump Forcemain)**

Nominal Pipe Diameter (in) 4

| Type Minor Loss | Number | K-Value | Total |
|---|---|---|---|
| 90 DEGREE ELBOW | 2 | 0.54 | 1.08 |
| 45 DEGREE ELBOW | 4 | 0.29 | 1.16 |
| TEE (THRU) | 1 | 0.36 | 0.36 |
| TEE (BRANCH) | 0 | 1.08 | 0.00 |
| SWING CHECK | 1 | 1.80 | 1.80 |
| PLUG VALVE | 1 | 0.32 | 0.32 |
| ENTRANCE | 1 | 0.50 | 0.50 |
| EXIT | 1 | 1.00 | 1.00 |
| | | Sum of K-Value | 6.22 |

**C) HEADLOSS CALCULATIONS**

| | |
|---|---|
| Sum of K-Values (4") | 6.22 |
| Sum of K-Values (12") | 4.9 |
| Pipe Length (ft), (4") | 483 |
| Pipe Length (ft), (12") | 2250 |
| Pipe C-Value | 140 |
| Static Head (ft) | 93 |
| Type Pipe | HDPE, DR 17, 100 psi |
| Nominal Pipe Dia. (in) | 4 |
| Inside Pipe Dia. (in) | 3.94 |
| Nominal Pipe Dia. (in) | 12 |
| Inside Pipe Dia. (in) | 11.16 |

| Flow Rate (gpm) | Diameter (in) | Velocity (ft/sec) | K-Value | Minor Losses (ft) | Pipe Length (ft) | Friction Head (ft) | Static Head (feet) | Total Head (feet) |
|---|---|---|---|---|---|---|---|---|
| **4" FORCEMAIN** | | | | | | | | |
| 120 | 3.94 | 3.16 | 6.22 | 1.0 | 483 | 4.8 | 93.00 | 98.8 |
| 140 | 3.94 | 3.68 | 6.22 | 1.3 | 483 | 6.4 | 93.00 | 100.7 |
| 160 | 3.94 | 4.21 | 6.22 | 1.7 | 483 | 8.2 | 93.00 | 102.9 |
| 180 | 3.94 | 4.74 | 6.22 | 2.2 | 483 | 10.2 | 93.00 | 105.3 |
| **12" FORCEMAIN** | | | | | | | | |
| 120 | 11.16 | 0.39 | 4.9 | 0.01 | 2,250 | 0.1 | 0.00 | 0.2 |
| 140 | 11.16 | 0.46 | 4.9 | 0.02 | 2,250 | 0.2 | 0.00 | 0.2 |
| 160 | 11.16 | 0.52 | 4.9 | 0.02 | 2,250 | 0.2 | 0.00 | 0.3 |
| 180 | 11.16 | 0.59 | 4.9 | 0.03 | 2,250 | 0.3 | 0.00 | 0.3 |
| **TOTAL HEAD** | | | | | | | | |
| 120 | | | | | | | | 98.9 |
| 140 | | | | | | | | 100.9 |
| 160 | | | | | | | | 103.2 |
| 180 | | | | | | | | 105.7 |

6/8

**NMC - TMA SIDE SLOPE RISER PUMP CALCULATIONS**
**STAGE II CONDITIONS**
**TMA CELL 2 - SIDE SLOPE RISER SSR-6 (NORTHEAST CORNOR)**

**PROJECT SCOPE I.D. : 93C049**

**PREPARED BY:** HJA 12/23/98

**CHECKED BY:** PAK 12/23/98

**ESTIMATED SYSTEM HEAD CONDITIONS:**

**A) STATIC HEAD:**

| | |
|---|---|
| Elevation at Discharge to Gravity Pipeline | 1730.00 |
| Low Pumping Elevation at Pump Shut-off | 1637.00 |
| Total Static Head (feet) | 93.00 |

**B) FITTINGS AND VALVES (Side Slope Riser Pump Forcemain)**

Nominal Pipe Diameter (in) 4

| Type Minor Loss | Number | K-Value | Total |
|---|---|---|---|
| 90 DEGREE ELBOW | 2 | 0.54 | 1.08 |
| 45 DEGREE ELBOW | 4 | 0.29 | 1.16 |
| TEE (THRU) | 1 | 0.36 | 0.36 |
| TEE (BRANCH) | 0 | 1.08 | 0.00 |
| SWING CHECK | 1 | 1.80 | 1.80 |
| PLUG VALVE | 2 | 0.32 | 0.64 |
| ENTRANCE | 1 | 0.50 | 0.50 |
| EXIT | 1 | 1.00 | 1.00 |
| | | Sum of K-Value | 6.54 |

**C) HEADLOSS CALCULATIONS**

| | |
|---|---|
| Sum of K-Values (4") | 6.54 |
| Sum of K-Values (12") | 4.9 |
| Pipe Length (ft), (4") | 2133 |
| Pipe Length (ft), (12") | 3550 |
| Pipe C-Value | 140 |
| Static Head (ft) | 93 |
| Type Pipe | HDPE, DR 17, 100 psi |
| Nominal Pipe Dia. (in) | 4 |
| Inside Pipe Dia. (in) | 3.94 |
| Nominal Pipe Dia. (in) | 12 |
| Inside Pipe Dia. (in) | 11.16 |

| Flow Rate (gpm) | Diameter (in) | Velocity (ft/sec) | K-Value | Minor Losses (ft) | Pipe Length (ft) | Friction Head (ft) | Static Head (feet) | Total Head (feet) |
|---|---|---|---|---|---|---|---|---|
| **4" FORCEMAIN** | | | | | | | | |
| 120 | 3.94 | 3.16 | 6.54 | 1.0 | 2,133 | 21.2 | 93.00 | 115.2 |
| 140 | 3.94 | 3.68 | 6.54 | 1.4 | 2,133 | 28.2 | 93.00 | 122.6 |
| 160 | 3.94 | 4.21 | 6.54 | 1.8 | 2,133 | 36.1 | 93.00 | 130.9 |
| 180 | 3.94 | 4.74 | 6.54 | 2.3 | 2,133 | 44.9 | 93.00 | 140.2 |
| **12" FORCEMAIN** | | | | | | | | |
| 120 | 11.16 | 0.39 | 4.9 | 0.01 | 3,550 | 0.2 | 0.00 | 0.2 |
| 140 | 11.16 | 0.46 | 4.9 | 0.02 | 3,550 | 0.3 | 0.00 | 0.3 |
| 160 | 11.16 | 0.52 | 4.9 | 0.02 | 3,550 | 0.4 | 0.00 | 0.4 |
| 180 | 11.16 | 0.59 | 4.9 | 0.03 | 3,550 | 0.5 | 0.00 | 0.5 |
| **TOTAL HEAD** | | | | | | | | |
| 120 | | | | | | | | 115.5 |
| 140 | | | | | | | | 122.9 |
| 160 | | | | | | | | 131.3 |
| 180 | | | | | | | | 140.7 |

**NMC - TMA SIDE SLOPE RISER PUMP CALCULATIONS**
**STAGE II CONDITIONS**
**TMA CELL 3 - SIDE SLOPE RISER SSR-7 (NORTHWEST CORNOR)**

**PROJECT SCOPE I.D. : 93C049**

**PREPARED BY:** 12/23/98

**CHECKED BY:** 12/23/98

**ESTIMATED SYSTEM HEAD CONDITIONS:**

**A) STATIC HEAD:**

| | |
|---|---|
| Elevation at Discharge to Gravity Pipeline | 1730.00 |
| Low Pumping Elevation at Pump Shut-off | 1637.00 |
| Total Static Head (feet) | 93.00 |

**B) FITTINGS AND VALVES (Side Slope Riser Pump Forcemain)**

Nominal Pipe Diameter (in) 4

| Type Minor Loss | Number | K-Value | Total |
|---|---|---|---|
| 90 DEGREE ELBOW | 2 | 0.54 | 1.08 |
| 45 DEGREE ELBOW | 4 | 0.29 | 1.16 |
| TEE (THRU) | 1 | 0.36 | 0.36 |
| TEE (BRANCH) | 0 | 1.08 | 0.00 |
| SWING CHECK | 1 | 1.80 | 1.80 |
| PLUG VALVE | 2 | 0.32 | 0.64 |
| ENTRANCE | 1 | 0.50 | 0.50 |
| EXIT | 1 | 1.00 | 1.00 |
| | | Sum of K-Value | 6.54 |

**C) HEADLOSS CALCULATIONS**

| | |
|---|---|
| Sum of K-Values (4") | 6.54 |
| Sum of K-Values (12") | 5.4 |
| Pipe Length (ft), (4") | 1133 |
| Pipe Length (ft), (12") | 4150 |
| Pipe C-Value | 140 |
| Static Head (ft) | 93 |
| Type Pipe | HDPE, DR 17, 100 psi |
| Nominal Pipe Dia. (in) | 4 |
| Inside Pipe Dia. (in) | 3.94 |
| Nominal Pipe Dia. (in) | 12 |
| Inside Pipe Dia. (in) | 11.16 |

| Flow Rate (gpm) | Diameter (in) | Velocity (ft/sec) | K-Value | Minor Losses (ft) | Pipe Length (ft) | Friction Head (ft) | Static Head (feet) | Total Head (feet) |
|---|---|---|---|---|---|---|---|---|
| **4" FORCEMAIN** | | | | | | | | |
| 120 | 3.94 | 3.16 | 6.54 | 1.0 | 1,133 | 11.3 | 93.00 | 105.3 |
| 140 | 3.94 | 3.68 | 6.54 | 1.4 | 1,133 | 15.0 | 93.00 | 109.4 |
| 160 | 3.94 | 4.21 | 6.54 | 1.8 | 1,133 | 19.2 | 93.00 | 114.0 |
| 180 | 3.94 | 4.74 | 6.54 | 2.3 | 1,133 | 23.8 | 93.00 | 119.1 |
| **12" FORCEMAIN** | | | | | | | | |
| 120 | 11.16 | 0.39 | 5.4 | 0.01 | 4,150 | 0.3 | 0.00 | 0.3 |
| 140 | 11.16 | 0.46 | 5.4 | 0.02 | 4,150 | 0.3 | 0.00 | 0.4 |
| 160 | 11.16 | 0.52 | 5.4 | 0.02 | 4,150 | 0.4 | 0.00 | 0.5 |
| 180 | 11.16 | 0.59 | 5.4 | 0.03 | 4,150 | 0.6 | 0.00 | 0.6 |
| **TOTAL HEAD** | | | | | | | | |
| 120 | | | | | | | | 105.6 |
| 140 | | | | | | | | 109.7 |
| 160 | | | | | | | | 114.4 |
| 180 | | | | | | | | 119.7 |

NMC - TMA SIDE SLOPE RISER PUMP CALCULATIONS
STAGE II CONDITIONS
TMA CELL 3 - SIDE SLOPE RISER SSR-8 (SOUTHEAST CORNOR)

PROJECT SCOPE I.D. : 93C049

PREPARED BY: 12/23/98 HJA

CHECKED BY: 12/23/98 PAH

**ESTIMATED SYSTEM HEAD CONDITIONS:**

**A) STATIC HEAD:**

| | |
|---|---|
| Elevation at Discharge to Gravity Pipeline | 1730.00 |
| Low Pumping Elevation at Pump Shut-off | 1637.00 |
| Total Static Head (feet) | 93.00 |

**B) FITTINGS AND VALVES (Side Slope Riser Pump Forcemain)**

Nominal Pipe Diameter (in) 4

| Type Minor Loss | Number | K-Value | Total |
|---|---|---|---|
| 90 DEGREE ELBOW | 2 | 0.54 | 1.08 |
| 45 DEGREE ELBOW | 4 | 0.29 | 1.16 |
| TEE (THRU) | 1 | 0.36 | 0.36 |
| TEE (BRANCH) | 0 | 1.08 | 0.00 |
| SWING CHECK | 1 | 1.80 | 1.80 |
| PLUG VALVE | 2 | 0.32 | 0.64 |
| ENTRANCE | 1 | 0.50 | 0.50 |
| EXIT | 1 | 1.00 | 1.00 |
| | | Sum of K-Value | 6.54 |

**C) HEADLOSS CALCULATIONS**

| | |
|---|---|
| Sum of K-Values (4") | 6.54 |
| Sum of K-Values (12") | 4.9 |
| Pipe Length (ft), (4") | 2133 |
| Pipe Length (ft), (12") | 3550 |
| Pipe C-Value | 140 |
| Static Head (ft) | 93 |
| Type Pipe | HDPE, DR 17, 100 psi |
| Nominal Pipe Dia. (in) | 4 |
| Inside Pipe Dia. (in) | 3.94 |
| Nominal Pipe Dia. (in) | 12 |
| Inside Pipe Dia. (in) | 11.16 |

| Flow Rate (gpm) | Diameter (in) | Velocity (ft/sec) | K-Value | Minor Losses (ft) | Pipe Length (ft) | Friction Head (ft) | Static Head (feet) | Total Head (feet) |
|---|---|---|---|---|---|---|---|---|
| **4" FORCEMAIN** | | | | | | | | |
| 120 | 3.94 | 3.16 | 6.54 | 1.0 | 2,133 | 21.2 | 93.00 | 115.2 |
| 140 | 3.94 | 3.68 | 6.54 | 1.4 | 2,133 | 28.2 | 93.00 | 122.6 |
| 160 | 3.94 | 4.21 | 6.54 | 1.8 | 2,133 | 36.1 | 93.00 | 130.9 |
| 180 | 3.94 | 4.74 | 6.54 | 2.3 | 2,133 | 44.9 | 93.00 | 140.2 |
| **12" FORCEMAIN** | | | | | | | | |
| 120 | 11.16 | 0.39 | 4.9 | 0.01 | 3,550 | 0.2 | 0.00 | 0.2 |
| 140 | 11.16 | 0.46 | 4.9 | 0.02 | 3,550 | 0.3 | 0.00 | 0.3 |
| 160 | 11.16 | 0.52 | 4.9 | 0.02 | 3,550 | 0.4 | 0.00 | 0.4 |
| 180 | 11.16 | 0.59 | 4.9 | 0.03 | 3,550 | 0.5 | 0.00 | 0.5 |
| **TOTAL HEAD** | | | | | | | | |
| 120 | | | | | | | | 115.5 |
| 140 | | | | | | | | 122.9 |
| 160 | | | | | | | | 131.3 |
| 180 | | | | | | | | 140.7 |

# Appendix F

# Comments on GCL Compatibility With Depyritized Tailings Process Water

*Charles D. Shackelford, Ph.D., P.E.*
*Civil Engineer*

2836 Claremont Drive, Fort Collins, Colorado 80526
(970)226-1922

September 3, 1998

Mr. Jerry W. Sevick, P.E., Vice President
Foth & Van Dyke
2737 South Ridge Road
P. O. Box 19012
Green Bay, WI 54307-9012

Dear Jerry:

As per your request, I have reviewed the attached Table 3-5 entitled "Estimated Average Reclaim Pond Effluent Water Characteristics" in the context of assessing the potential effects of the use of this water on the analyses and conclusions contained in my April 22, 1998, report entitled, "GCL Compatibility Testing for Base Liner at the Tailings Management Area for the Proposed Nicolet Minerals Company Zinc/Copper Mine, Near Crandon, Wisconsin."

Based on the data in Table 3-5, the sum of the calcium and magnesium concentrations of 327 mg/L (=300 + 27) is less than the measured calcium concentration of 360 mg/L originally reported for the process water, and the sum of the sodium and potassium concentrations of 53 mg/L (=26 + 27) for the reclaimed water is less than the sum of the target sodium and potassium concentrations of 120 mg/L (=110 + 10) for the process water. Also, aside from manganese, which has a concentration of 1.2 mg/L in the reclaimed water, the concentrations for the other major metals in the reclaimed water are all less than 0.1 mg/L. As a result, the reclaimed water has characteristics that are very close to those originally reported for the process water. Therefore, I do not expect that the use of the reclaimed water would result in any significant differences in the analyses and conclusions contained in my April 22, 1998, that are based on the use of the process water.

Sincerely,

Charles D. Shackelford

Charles D. Shackelford

# Table 3-5

## Estimated Average Reclaim Pond Effluent Water Characteristics

| Parameter | Concentration[1] | Parameter | Concentration[1] |
|---|---|---|---|
| Aluminum[2] | <0.022 | Molybdenum[3] | <0.040 |
| Antimony[2] | 0.0061 | Nickel[2] | 0.016 |
| Arsenic[2] | 0.0025 | Potassium[2] | 27 |
| Barium[2] | 0.028 | Selenium[2] | 0.024 |
| Beryllium[2] | <0.00033 | Silver[2] | 0.00028 |
| Cadmium[2] | 0.0018 | Sodium[2] | 26 |
| Calcium[2] | 300 | Thallium[3] | <0.003 |
| Chromium[2] | <0.00053 | Zinc[2] | 1.3 |
| Cobalt[2] | 0.030 | pH[2] | 7.6 ← neutral |
| Copper[2] | 0.0017 | Chloride[2] | 33 |
| Iron[2] | <0.0023 | Cyanide, Total[2] | <0.0034 |
| Fluoride[2] | 1.0 | Alkalinity as $CaCO_3$[2] | 66 |
| Lead[2] | 0.0044 | Ammonia (as N)[4] | 0.03 |
| Magnesium[2] | 27 | Nitrate (as N)[4] | 0.08 |
| Manganese[2] | 1.2 | Sulfate[2] | 901 |
| Mercury[2] | 0.0000238 | TOC as NPOC[2] | 37 |

[1] All concentrations are mg/L with the exception of pH which is reported in standard units, and conductivity which is reported as µS/cm. Metal concentration are expressed as the "dissolved" form.

[2] Values from the EnChem Inc. analysis of a May 20, 1998 water sample from Lakefield locked cycle analyses of the Crandon Project master ore composite performed in February and March, 1998.

[3] Values from the Wisconsin State Laboratory of Hygiene analysis of a June 16, 1994 sample from Lakefield locked cycle analyses of the Crandon Project master ore composite.

[4] Estimated value based on expected average mine drainage concentrations for ammonia and nitrate of 3.3 and 8.2 mg/L (as N), respectively, and mine drainage providing approximately 1 percent of the total flow to the process water tank. For nitrate, the value represents the incremental increase above the background of approximately 0.75 mg/L (as N).

Prepared by: JWS
Checked by: CJB1

A.W. $Ca^{++}$ 40.08 g/mole

$$300 \frac{mg}{L} \cdot \frac{g}{1000\,mg} \cdot \frac{mole}{40.08\,g} = 0.0075\,M$$

$$= 0.0150\,N$$

Note: Hand markings on this table are by Charles D. Shackelford, Ph.D., P.E.

# Appendix G

## TMA Runoff Basin Sizing Calculations

# Foth & Van Dyke
# Memorandum

December 18, 1998

TO: Paul Egelhoff, Foth & Van Dyke

CC: Master File

FR: Michael D. Liebman MDL
Steve Birr SRB

RE: TMA Runoff Basin Sizing Calculations

## Background

At the Tailings Management Area (TMA), site grading plans were developed to manage all stormwater runoff and convey that runoff to a detention facility/runoff basin. In sizing these runoff basins, the largest drainage area was used. In all watersheds, this happened to be the final grade or reclamation phase. Drawing No. 18 illustrates runoff basin locations for the TMA for the post reclamation condition.

## Hydrology and Hydraulics

The hydrologic analyses were based on a combination of several factors. Methods used include the SCS TR-55 software to determine stormwater runoff flows from the reclaimed and existing drainage area resulting from a 100-year, 24-hour storm event. This software, along with Haestad Methods POND2 software, was then used for sizing of the runoff basin. Drawing No. 31, Detail 4, illustrates the type and size of the runoff basin outlet structure needed, and the resulting hydraulic factors, including discharge flow and "peak" basin water elevation. Attachments A and B present the analysis results for the TR-55 flow analysis and the POND2 runoff basin sizing, respectively.

## Summary

Using the information obtained from the modeling software, the sediment removal efficiencies were estimated. The table below presents the micron size of particles that will be settled in each basin using the particulate size removal table shown in Attachment C. The particle size removal is in direct relation to the surface area of the pond and the outflow at "peak" basin water elevation.

## Particle Size Removal

| Basin | Outflow (cfs) | Peak Elevation | Surface Area (acres) | Micron Size |
|---|---|---|---|---|
| 9 | 9.5 | 1635.25 | 1.90 | 7 |
| 10 | 8.09 | 1694.59 | 1.74 | 6 |
| 11 | 3.47 | 1703.07 | 0.37 | 9 |
| 12 | 1.53 | 1624.52 | 0.79 | 4 |
| 13 | 2.24 | 1694.58 | 0.34 | 8 |
| 14 | 7.34 | 1713.73 | 0.95 | 8 |

Prepared by: SRB
Checked by: PAE

# Attachment A

# TR-55 Hydrology Analysis

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 12-10-1998 08:01:09
Watershed file: --> NMC9 .WSD
Hydrograph file: --> NMC9 .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
BASIN 9 12/98
100 YEAR STORM EVENT

>>>> Input Parameters Used to Compute Hydrograph <<<<

| Subarea Description | AREA (acres) | CN | Tc (hrs) | * Tt (hrs) | Precip. (in) | Runoff (in) | Ia/p input/used | |
|---|---|---|---|---|---|---|---|---|
| 9A | 8.00 | 60.0 | 0.50 | 0.75 | 5.00 | 1.30 | .27 | .30 |
| 9B | 11.70 | 60.0 | 0.50 | 0.75 | 5.00 | 1.30 | .27 | .30 |
| 9C | 13.00 | 60.0 | 0.75 | 0.30 | 5.00 | 1.30 | .27 | .30 |
| 9D | 16.50 | 60.0 | 0.75 | 0.30 | 5.00 | 1.30 | .27 | .30 |
| 9E | 3.50 | 60.0 | 0.50 | 0.30 | 5.00 | 1.30 | .27 | .30 |
| 9F | 0.70 | 60.0 | 0.10 | 0.10 | 5.00 | 1.30 | .27 | .30 |
| 9G | 1.70 | 60.0 | 0.10 | 0.00 | 5.00 | 1.30 | .27 | .30 |
| 9H | 1.40 | 60.0 | 0.10 | 0.00 | 5.00 | 1.30 | .27 | .30 |
| 9I | 8.00 | 60.0 | 0.50 | 0.20 | 5.00 | 1.30 | .27 | .30 |
| 9J | 10.30 | 60.0 | 0.75 | 0.10 | 5.00 | 1.30 | .27 | .30 |
| 9K | 12.40 | 60.0 | 0.50 | 0.00 | 5.00 | 1.30 | .27 | .30 |
| 9L | 16.40 | 60.0 | 0.50 | 0.00 | 5.00 | 1.30 | .27 | .30 |
| 9M | 7.20 | 60.0 | 0.50 | 0.00 | 5.00 | 1.30 | .27 | .30 |

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 110.80 acres or 0.1731 sq.mi
Peak discharge = 55 cfs

WARNING: Drainage areas of two or more subareas
differ by a factor of 5 or greater.

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 12-10-1998 08:01:09
Watershed file: --> NMC9 .WSD
Hydrograph file: --> NMC9 .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
BASIN 9 12/98
100 YEAR STORM EVENT

>>>> Computer Modifications of Input Parameters <<<<<

| Subarea Description | Input Values Tc (hr) | * Tt (hr) | Rounded Values Tc (hr) | * Tt (hr) | Ia/p Interpolated (Yes/No) | Ia/p Messages |
|---|---|---|---|---|---|---|
| 9A | 0.57 | 0.59 | 0.50 | 0.75 | No | -- |
| 9B | 0.57 | 0.59 | 0.50 | 0.75 | No | -- |
| 9C | 0.67 | 0.35 | 0.75 | 0.30 | No | -- |
| 9D | 0.72 | 0.30 | 0.75 | 0.30 | No | -- |
| 9E | 0.58 | 0.30 | 0.50 | 0.30 | No | -- |
| 9F | 0.10 | 0.10 | ** | ** | No | -- |
| 9G | 0.10 | 0.00 | ** | ** | No | -- |
| 9H | 0.10 | 0.00 | ** | ** | No | -- |
| 9I | 0.57 | 0.17 | 0.50 | 0.20 | No | -- |
| 9J | 0.62 | 0.17 | 0.75 | 0.10 | No | -- |
| 9K | 0.62 | 0.00 | 0.50 | 0.00 | No | -- |
| 9L | 0.59 | 0.00 | 0.50 | 0.00 | No | -- |
| 9M | 0.61 | 0.00 | 0.50 | 0.00 | No | -- |

* Travel time from subarea outfall to composite watershed outfall point.
** Tc & Tt are available in the hydrograph tables.

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 12-10-1998 08:01:09
Watershed file: --> NMC9 .WSD
Hydrograph file: --> NMC9 .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
BASIN 9 12/98
100 YEAR STORM EVENT

>>>> Summary of Subarea Times to Peak <<<<

| Subarea | Peak Discharge at Composite Outfall (cfs) | Time to Peak at Composite Outfall (hrs) |
|---|---|---|
| 9A | 5 | 13.2 |
| 9B | 7 | 13.2 |
| 9C | 8 | 13.0 |
| 9D | 10 | 13.0 |
| 9E | 3 | 12.8 |
| 9F | 1 | 12.1 |
| 9G | 3 | 12.1 |
| 9H | 3 | 12.1 |
| 9I | 6 | 12.6 |
| 9J | 7 | 12.8 |
| 9K | 11 | 12.4 |
| 9L | 15 | 12.5 |
| 9M | 6 | 12.4 |
| Composite Watershed | 55 | 12.8 |

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 12-10-1998 08:01:09
Watershed file: --> NMC9 .WSD
Hydrograph file: --> NMC9 .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
BASIN 9 12/98
100 YEAR STORM EVENT

Composite Hydrograph Summary (cfs)

| Subarea Description | 11.0 hr | 11.3 hr | 11.6 hr | 11.9 hr | 12.0 hr | 12.1 hr | 12.2 hr | 12.3 hr | 12.4 hr |
|---|---|---|---|---|---|---|---|---|---|
| 9A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 9D | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 9E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9F | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| 9G | 0 | 0 | 0 | 1 | 2 | 3 | 2 | 1 | 1 |
| 9H | 0 | 0 | 0 | 0 | 2 | 3 | 1 | 1 | 0 |
| 9I | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 |
| 9J | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 9K | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 8 | 11 |
| 9L | 0 | 0 | 0 | 0 | 0 | 2 | 5 | 10 | 14 |
| 9M | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 5 | 6 |
| Total (cfs) | 0 | 0 | 0 | 1 | 4 | 11 | 15 | 27 | 38 |

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 12-10-1998 08:01:09
Watershed file: --> NMC9 .WSD
Hydrograph file: --> NMC9 .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049

BASIN 9 12/98

100 YEAR STORM EVENT

Composite Hydrograph Summary (cfs)

| Subarea Description | 12.5 hr | 12.6 hr | 12.7 hr | 12.8 hr | 13.0 hr | 13.2 hr | 13.4 hr | 13.6 hr | 13.8 hr |
|---|---|---|---|---|---|---|---|---|---|
| 9A | 0 | 1 | 1 | 2 | 4 | 5 | 4 | 3 | 3 |
| 9B | 0 | 1 | 2 | 4 | 6 | 7 | 6 | 5 | 4 |
| 9C | 2 | 4 | 6 | 7 | 8 | 7 | 5 | 4 | 3 |
| 9D | 3 | 5 | 7 | 9 | 10 | 9 | 7 | 5 | 4 |
| 9E | 1 | 2 | 2 | 3 | 2 | 2 | 1 | 1 | 1 |
| 9F | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9G | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9H | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9I | 5 | 6 | 6 | 6 | 4 | 3 | 2 | 2 | 1 |
| 9J | 3 | 5 | 6 | 7 | 6 | 5 | 4 | 3 | 2 |
| 9K | 11 | 10 | 8 | 6 | 4 | 3 | 2 | 2 | 2 |
| 9L | 15 | 13 | 10 | 8 | 5 | 4 | 3 | 3 | 2 |
| 9M | 6 | 6 | 4 | 3 | 2 | 2 | 1 | 1 | 1 |
| Total (cfs) | 47 | 53 | 52 | 55 | 51 | 47 | 35 | 29 | 23 |

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 12-10-1998 08:01:09
Watershed file: --> NMC9 .WSD
Hydrograph file: --> NMC9 .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049

BASIN 9 12/98

100 YEAR STORM EVENT

Composite Hydrograph Summary (cfs)

| Subarea Description | 14.0 hr | 14.3 hr | 14.6 hr | 15.0 hr | 15.5 hr | 16.0 hr | 16.5 hr | 17.0 hr | 17.5 hr |
|---|---|---|---|---|---|---|---|---|---|
| 9A | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 9B | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| 9C | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| 9D | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 1 | 1 |
| 9E | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9F | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9G | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9H | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9I | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 9J | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 9K | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 9L | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 |
| 9M | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| Total (cfs) | 20 | 15 | 13 | 11 | 10 | 9 | 8 | 8 | 7 |

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 12-10-1998 08:01:09
Watershed file: --> NMC9 .WSD
Hydrograph file: --> NMC9 .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049

BASIN 9 12/98

100 YEAR STORM EVENT

Composite Hydrograph Summary (cfs)

| Subarea Description | 18.0 hr | 19.0 hr | 20.0 hr | 22.0 hr | 26.0 hr |
|---|---|---|---|---|---|
| 9A | 0 | 0 | 0 | 0 | 0 |
| 9B | 1 | 1 | 1 | 0 | 0 |
| 9C | 1 | 1 | 1 | 1 | 0 |
| 9D | 1 | 1 | 1 | 1 | 0 |
| 9E | 0 | 0 | 0 | 0 | 0 |
| 9F | 0 | 0 | 0 | 0 | 0 |
| 9G | 0 | 0 | 0 | 0 | 0 |
| 9H | 0 | 0 | 0 | 0 | 0 |
| 9I | 0 | 0 | 0 | 0 | 0 |
| 9J | 1 | 1 | 0 | 0 | 0 |
| 9K | 1 | 1 | 1 | 0 | 0 |
| 9L | 1 | 1 | 1 | 1 | 0 |
| 9M | 0 | 0 | 0 | 0 | 0 |
| Total (cfs) | 6 | 6 | 5 | 3 | 0 |

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 12-10-1998 08:01:09
Watershed file: --> NMC9 .WSD
Hydrograph file: --> NMC9 .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049

BASIN 9 12/98

100 YEAR STORM EVENT

| Time (hrs) | Flow (cfs) | Time (hrs) | Flow (cfs) |
|---|---|---|---|
| 11.0 | 0 | 14.8 | 12 |
| 11.1 | 0 | 14.9 | 12 |
| 11.2 | 0 | 15.0 | 11 |
| 11.3 | 0 | 15.1 | 11 |
| 11.4 | 0 | 15.2 | 11 |
| 11.5 | 0 | 15.3 | 10 |
| 11.6 | 0 | 15.4 | 10 |
| 11.7 | 0 | 15.5 | 10 |
| 11.8 | 1 | 15.6 | 10 |
| 11.9 | 1 | 15.7 | 10 |
| 12.0 | 4 | 15.8 | 9 |
| 12.1 | 11 | 15.9 | 9 |
| 12.2 | 15 | 16.0 | 9 |
| 12.3 | 27 | 16.1 | 9 |
| 12.4 | 38 | 16.2 | 9 |
| 12.5 | 47 | 16.3 | 8 |
| 12.6 | 53 | 16.4 | 8 |
| 12.7 | 52 | 16.5 | 8 |
| 12.8 | 55 | 16.6 | 8 |
| 12.9 | 53 | 16.7 | 8 |
| 13.0 | 51 | 16.8 | 8 |
| 13.1 | 49 | 16.9 | 8 |
| 13.2 | 47 | 17.0 | 8 |
| 13.3 | 41 | 17.1 | 8 |
| 13.4 | 35 | 17.2 | 8 |
| 13.5 | 32 | 17.3 | 7 |
| 13.6 | 29 | 17.4 | 7 |
| 13.7 | 26 | 17.5 | 7 |
| 13.8 | 23 | 17.6 | 7 |
| 13.9 | 22 | 17.7 | 7 |
| 14.0 | 20 | 17.8 | 6 |
| 14.1 | 18 | 17.9 | 6 |
| 14.2 | 17 | 18.0 | 6 |
| 14.3 | 15 | 18.1 | 6 |
| 14.4 | 14 | 18.2 | 6 |
| 14.5 | 14 | 18.3 | 6 |
| 14.6 | 13 | 18.4 | 6 |
| 14.7 | 12 | 18.5 | 6 |

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 12-10-1998 08:01:09
Watershed file: --> NMC9 .WSD
Hydrograph file: --> NMC9 .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
BASIN 9 12/98
100 YEAR STORM EVENT

| Time (hrs) | Flow (cfs) | Time (hrs) | Flow (cfs) |
|---|---|---|---|
| 18.6 | 6 | 22.4 | 3 |
| 18.7 | 6 | 22.5 | 3 |
| 18.8 | 6 | 22.6 | 3 |
| 18.9 | 6 | 22.7 | 2 |
| 19.0 | 6 | 22.8 | 2 |
| 19.1 | 6 | 22.9 | 2 |
| 19.2 | 6 | 23.0 | 2 |
| 19.3 | 6 | 23.1 | 2 |
| 19.4 | 6 | 23.2 | 2 |
| 19.5 | 6 | 23.3 | 2 |
| 19.6 | 5 | 23.4 | 2 |
| 19.7 | 5 | 23.5 | 2 |
| 19.8 | 5 | 23.6 | 2 |
| 19.9 | 5 | 23.7 | 2 |
| 20.0 | 5 | 23.8 | 2 |
| 20.1 | 5 | 23.9 | 2 |
| 20.2 | 5 | 24.0 | 2 |
| 20.3 | 5 | 24.1 | 1 |
| 20.4 | 5 | 24.2 | 1 |
| 20.5 | 4 | 24.3 | 1 |
| 20.6 | 4 | 24.4 | 1 |
| 20.7 | 4 | 24.5 | 1 |
| 20.8 | 4 | 24.6 | 1 |
| 20.9 | 4 | 24.7 | 1 |
| 21.0 | 4 | 24.8 | 1 |
| 21.1 | 4 | 24.9 | 1 |
| 21.2 | 4 | 25.0 | 1 |
| 21.3 | 4 | 25.1 | 1 |
| 21.4 | 4 | 25.2 | 1 |
| 21.5 | 4 | 25.3 | 1 |
| 21.6 | 3 | 25.4 | 0 |
| 21.7 | 3 | 25.5 | 0 |
| 21.8 | 3 | 25.6 | 0 |
| 21.9 | 3 | 25.7 | 0 |
| 22.0 | 3 | 25.8 | 0 |
| 22.1 | 3 | 25.9 | 0 |
| 22.2 | 3 | | |
| 22.3 | 3 | | |

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 11-11-1998 18:19:50
Watershed file: --> NMC10 .WSD
Hydrograph file: --> NMC10 .HYD

nicolet MINING COMPANY
FOTH AND VAN DYKE 93C049
BASIN 10 11/98
100 YEAR STORM EVENT

>>>> Input Parameters Used to Compute Hydrograph <<<<

| Subarea Description | AREA (acres) | CN | Tc (hrs) | * Tt (hrs) | Precip. (in) | Runoff (in) | Ia/p input | Ia/p used |
|---|---|---|---|---|---|---|---|---|
| 10A | 13.30 | 60.0 | 0.50 | 0.40 | 5.00 | 1.30 | .27 | .30 |
| 10B | 13.30 | 60.0 | 0.50 | 0.40 | 5.00 | 1.30 | .27 | .30 |
| 10C | 12.00 | 60.0 | 0.75 | 0.10 | 5.00 | 1.30 | .27 | .30 |
| 10D | 22.90 | 60.0 | 0.50 | 0.00 | 5.00 | 1.30 | .27 | .30 |

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 61.50 acres or 0.09609 sq.mi
Peak discharge = 39 cfs

>>>> Computer Modifications of Input Parameters <<<<<

| Subarea Description | Input Values Tc (hr) | Input Values * Tt (hr) | Rounded Values Tc (hr) | Rounded Values * Tt (hr) | Ia/p Interpolated (Yes/No) | Ia/p Messages |
|---|---|---|---|---|---|---|
| 10A | 0.60 | 0.31 | 0.50 | 0.40 | No | -- |
| 10B | 0.60 | 0.31 | 0.50 | 0.40 | No | -- |
| 10C | 0.66 | 0.17 | 0.75 | 0.10 | No | -- |
| 10D | 0.58 | 0.00 | 0.50 | 0.00 | No | -- |

* Travel time from subarea outfall to composite watershed outfall point.

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 11-11-1998 18:19:50
Watershed file: --> NMC10 .WSD
Hydrograph file: --> NMC10 .HYD

nicolet MINING COMPANY
FOTH AND VAN DYKE 93C049
BASIN 10 11/98
100 YEAR STORM EVENT

>>>> Summary of Subarea Times to Peak <<<<

| Subarea | Peak Discharge at Composite Outfall (cfs) | Time to Peak at Composite Outfall (hrs) |
|---|---|---|
| 10A | 10 | 12.8 |
| 10B | 10 | 12.8 |
| 10C | 8 | 12.8 |
| 10D | 20 | 12.4 |
| Composite Watershed | 39 | 12.8 |

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 11-11-1998 18:19:50
Watershed file: --> NMC10 .WSD
Hydrograph file: --> NMC10 .HYD

nicolet MINING COMPANY
FOTH AND VAN DYKE 93C049
BASIN 10 11/98
100 YEAR STORM EVENT

Composite Hydrograph Summary (cfs)

| Subarea Description | 11.0 hr | 11.3 hr | 11.6 hr | 11.9 hr | 12.0 hr | 12.1 hr | 12.2 hr | 12.3 hr | 12.4 hr |
|---|---|---|---|---|---|---|---|---|---|
| 10A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 10B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 10C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 |
| 10D | 0 | 0 | 0 | 0 | 0 | 2 | 7 | 15 | 20 |
| Total (cfs) | 0 | 0 | 0 | 0 | 0 | 2 | 7 | 16 | 24 |

| Subarea Description | 12.5 hr | 12.6 hr | 12.7 hr | 12.8 hr | 13.0 hr | 13.2 hr | 13.4 hr | 13.6 hr | 13.8 hr |
|---|---|---|---|---|---|---|---|---|---|
| 10A | 3 | 6 | 8 | 10 | 9 | 7 | 5 | 3 | 3 |
| 10B | 3 | 6 | 8 | 10 | 9 | 7 | 5 | 3 | 3 |
| 10C | 3 | 5 | 7 | 8 | 7 | 6 | 4 | 3 | 3 |
| 10D | 20 | 18 | 14 | 11 | 7 | 5 | 4 | 4 | 3 |
| Total (cfs) | 29 | 35 | 37 | 39 | 32 | 25 | 18 | 13 | 12 |

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 11-11-1998 18:19:50
Watershed file: --> NMC10 .WSD
Hydrograph file: --> NMC10 .HYD

nicolet MINING COMPANY
FOTH AND VAN DYKE 93C049
BASIN 10 11/98
100 YEAR STORM EVENT

Composite Hydrograph Summary (cfs)

| Subarea Description | 14.0 hr | 14.3 hr | 14.6 hr | 15.0 hr | 15.5 hr | 16.0 hr | 16.5 hr | 17.0 hr | 17.5 hr |
|---|---|---|---|---|---|---|---|---|---|
| 10A | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| 10B | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| 10C | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 10D | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 |
| Total (cfs) | 9 | 9 | 7 | 5 | 5 | 5 | 5 | 4 | 4 |

| Subarea Description | 18.0 hr | 19.0 hr | 20.0 hr | 22.0 hr | 26.0 hr |
|---|---|---|---|---|---|
| 10A | 1 | 1 | 1 | 1 | 0 |
| 10B | 1 | 1 | 1 | 1 | 0 |
| 10C | 1 | 1 | 1 | 0 | 0 |
| 10D | 1 | 1 | 1 | 1 | 0 |
| Total (cfs) | 4 | 4 | 4 | 3 | 0 |

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 11-11-1998 18:19:50
Watershed file: --> NMC10 .WSD
Hydrograph file: --> NMC10 .HYD

nicolet MINING COMPANY
FOTH AND VAN DYKE 93C049

BASIN 10 11/98

100 YEAR STORM EVENT

| Time (hrs) | Flow (cfs) | Time (hrs) | Flow (cfs) |
|---|---|---|---|
| 11.0 | 0 | 14.8 | 6 |
| 11.1 | 0 | 14.9 | 5 |
| 11.2 | 0 | 15.0 | 5 |
| 11.3 | 0 | 15.1 | 5 |
| 11.4 | 0 | 15.2 | 5 |
| 11.5 | 0 | 15.3 | 5 |
| 11.6 | 0 | 15.4 | 5 |
| 11.7 | 0 | 15.5 | 5 |
| 11.8 | 0 | 15.6 | 5 |
| 11.9 | 0 | 15.7 | 5 |
| 12.0 | 0 | 15.8 | 5 |
| 12.1 | 2 | 15.9 | 5 |
| 12.2 | 7 | 16.0 | 5 |
| 12.3 | 16 | 16.1 | 5 |
| 12.4 | 24 | 16.2 | 5 |
| 12.5 | 29 | 16.3 | 5 |
| 12.6 | 35 | 16.4 | 5 |
| 12.7 | 37 | 16.5 | 5 |
| 12.8 | 39 | 16.6 | 5 |
| 12.9 | 36 | 16.7 | 5 |
| 13.0 | 32 | 16.8 | 4 |
| 13.1 | 28 | 16.9 | 4 |
| 13.2 | 25 | 17.0 | 4 |
| 13.3 | 22 | 17.1 | 4 |
| 13.4 | 18 | 17.2 | 4 |
| 13.5 | 16 | 17.3 | 4 |
| 13.6 | 13 | 17.4 | 4 |
| 13.7 | 12 | 17.5 | 4 |
| 13.8 | 12 | 17.6 | 4 |
| 13.9 | 10 | 17.7 | 4 |
| 14.0 | 9 | 17.8 | 4 |
| 14.1 | 9 | 17.9 | 4 |
| 14.2 | 9 | 18.0 | 4 |
| 14.3 | 9 | 18.1 | 4 |
| 14.4 | 8 | 18.2 | 4 |
| 14.5 | 8 | 18.3 | 4 |
| 14.6 | 7 | 18.4 | 4 |
| 14.7 | 6 | 18.5 | 4 |

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 11-11-1998 18:19:50
Watershed file: --> NMC10 .WSD
Hydrograph file: --> NMC10 .HYD

nicolet MINING COMPANY
FOTH AND VAN DYKE 93C049
BASIN 10 11/98
100 YEAR STORM EVENT

| Time (hrs) | Flow (cfs) | Time (hrs) | Flow (cfs) |
|---|---|---|---|
| 18.6 | 4 | 22.4 | 3 |
| 18.7 | 4 | 22.5 | 3 |
| 18.8 | 4 | 22.6 | 3 |
| 18.9 | 4 | 22.7 | 2 |
| 19.0 | 4 | 22.8 | 2 |
| 19.1 | 4 | 22.9 | 2 |
| 19.2 | 4 | 23.0 | 2 |
| 19.3 | 4 | 23.1 | 2 |
| 19.4 | 4 | 23.2 | 2 |
| 19.5 | 4 | 23.3 | 2 |
| 19.6 | 4 | 23.4 | 2 |
| 19.7 | 4 | 23.5 | 2 |
| 19.8 | 4 | 23.6 | 2 |
| 19.9 | 4 | 23.7 | 2 |
| 20.0 | 4 | 23.8 | 2 |
| 20.1 | 4 | 23.9 | 2 |
| 20.2 | 4 | 24.0 | 2 |
| 20.3 | 4 | 24.1 | 1 |
| 20.4 | 4 | 24.2 | 1 |
| 20.5 | 4 | 24.3 | 1 |
| 20.6 | 4 | 24.4 | 1 |
| 20.7 | 4 | 24.5 | 1 |
| 20.8 | 4 | 24.6 | 1 |
| 20.9 | 4 | 24.7 | 1 |
| 21.0 | 4 | 24.8 | 1 |
| 21.1 | 3 | 24.9 | 1 |
| 21.2 | 3 | 25.0 | 1 |
| 21.3 | 3 | 25.1 | 1 |
| 21.4 | 3 | 25.2 | 1 |
| 21.5 | 3 | 25.3 | 1 |
| 21.6 | 3 | 25.4 | 0 |
| 21.7 | 3 | 25.5 | 0 |
| 21.8 | 3 | 25.6 | 0 |
| 21.9 | 3 | 25.7 | 0 |
| 22.0 | 3 | 25.8 | 0 |
| 22.1 | 3 | 25.9 | 0 |
| 22.2 | 3 | | |
| 22.3 | 3 | | |

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 11-11-1998 18:23:24
Watershed file: --> NMC11 .WSD
Hydrograph file: --> NMC11 .HYD

nicolet MINING COMPANY
FOTH AND VAN DYKE 93C049
BASIN 11 11/98
100 YEAR STORM EVENT

>>>> Input Parameters Used to Compute Hydrograph <<<<

| Subarea Description | AREA (acres) | CN | Tc (hrs) | * Tt (hrs) | Precip. (in) | Runoff (in) | Ia/p input/used |
|---|---|---|---|---|---|---|---|
| 11A | 14.70 | 60.0 | 0.50 | 0.00 | 5.00 | 1.30 | .27 .30 |

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 14.70 acres or 0.02297 sq.mi
Peak discharge = 13 cfs

>>>> Computer Modifications of Input Parameters <<<<<

| Subarea Description | Input Values Tc (hr) | * Tt (hr) | Rounded Values Tc (hr) | * Tt (hr) | Ia/p Interpolated (Yes/No) | Ia/p Messages |
|---|---|---|---|---|---|---|
| 11A | 0.51 | 0.00 | 0.50 | 0.00 | No | -- |

* Travel time from subarea outfall to composite watershed outfall point.

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 11-11-1998 18:23:24
Watershed file: --> NMC11 .WSD
Hydrograph file: --> NMC11 .HYD

nicolet MINING COMPANY
FOTH AND VAN DYKE 93C049
BASIN 11 11/98
100 YEAR STORM EVENT

>>>> Summary of Subarea Times to Peak <<<<

| Subarea | Peak Discharge at Composite Outfall (cfs) | Time to Peak at Composite Outfall (hrs) |
|---|---|---|
| 11A | 13 | 12.4 |
| Composite Watershed | 13 | 12.4 |

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 11-11-1998 18:23:24
Watershed file: --> NMC11 .WSD
Hydrograph file: --> NMC11 .HYD

nicolet MINING COMPANY
FOTH AND VAN DYKE 93C049

BASIN 11 11/98

100 YEAR STORM EVENT

Composite Hydrograph Summary (cfs)

| Subarea Description | 11.0 hr | 11.3 hr | 11.6 hr | 11.9 hr | 12.0 hr | 12.1 hr | 12.2 hr | 12.3 hr | 12.4 hr |
|---|---|---|---|---|---|---|---|---|---|
| 11A | 0 | 0 | 0 | 0 | 0 | 2 | 5 | 9 | 13 |
| Total (cfs) | 0 | 0 | 0 | 0 | 0 | 2 | 5 | 9 | 13 |

| Subarea Description | 12.5 hr | 12.6 hr | 12.7 hr | 12.8 hr | 13.0 hr | 13.2 hr | 13.4 hr | 13.6 hr | 13.8 hr |
|---|---|---|---|---|---|---|---|---|---|
| 11A | 13 | 11 | 9 | 7 | 5 | 4 | 3 | 2 | 2 |
| Total (cfs) | 13 | 11 | 9 | 7 | 5 | 4 | 3 | 2 | 2 |

| Subarea Description | 14.0 hr | 14.3 hr | 14.6 hr | 15.0 hr | 15.5 hr | 16.0 hr | 16.5 hr | 17.0 hr | 17.5 hr |
|---|---|---|---|---|---|---|---|---|---|
| 11A | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Total (cfs) | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

| Subarea Description | 18.0 hr | 19.0 hr | 20.0 hr | 22.0 hr | 26.0 hr |
|---|---|---|---|---|---|
| 11A | 1 | 1 | 1 | 1 | 0 |
| Total (cfs) | 1 | 1 | 1 | 1 | 0 |

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 11-11-1998 18:23:24
Watershed file: --> NMC11 .WSD
Hydrograph file: --> NMC11 .HYD

nicolet MINING COMPANY
FOTH AND VAN DYKE 93C049
BASIN 11 11/98
100 YEAR STORM EVENT

| Time (hrs) | Flow (cfs) | Time (hrs) | Flow (cfs) |
|---|---|---|---|
| 11.0 | 0 | 14.8 | 1 |
| 11.1 | 0 | 14.9 | 1 |
| 11.2 | 0 | 15.0 | 1 |
| 11.3 | 0 | 15.1 | 1 |
| 11.4 | 0 | 15.2 | 1 |
| 11.5 | 0 | 15.3 | 1 |
| 11.6 | 0 | 15.4 | 1 |
| 11.7 | 0 | 15.5 | 1 |
| 11.8 | 0 | 15.6 | 1 |
| 11.9 | 0 | 15.7 | 1 |
| 12.0 | 0 | 15.8 | 1 |
| 12.1 | 2 | 15.9 | 1 |
| 12.2 | 5 | 16.0 | 1 |
| 12.3 | 9 | 16.1 | 1 |
| 12.4 | 13 | 16.2 | 1 |
| 12.5 | 13 | 16.3 | 1 |
| 12.6 | 11 | 16.4 | 1 |
| 12.7 | 9 | 16.5 | 1 |
| 12.8 | 7 | 16.6 | 1 |
| 12.9 | 6 | 16.7 | 1 |
| 13.0 | 5 | 16.8 | 1 |
| 13.1 | 4 | 16.9 | 1 |
| 13.2 | 4 | 17.0 | 1 |
| 13.3 | 4 | 17.1 | 1 |
| 13.4 | 3 | 17.2 | 1 |
| 13.5 | 3 | 17.3 | 1 |
| 13.6 | 2 | 17.4 | 1 |
| 13.7 | 2 | 17.5 | 1 |
| 13.8 | 2 | 17.6 | 1 |
| 13.9 | 2 | 17.7 | 1 |
| 14.0 | 2 | 17.8 | 1 |
| 14.1 | 2 | 17.9 | 1 |
| 14.2 | 2 | 18.0 | 1 |
| 14.3 | 2 | 18.1 | 1 |
| 14.4 | 2 | 18.2 | 1 |
| 14.5 | 1 | 18.3 | 1 |
| 14.6 | 1 | 18.4 | 1 |
| 14.7 | 1 | 18.5 | 1 |

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 11-11-1998 18:23:24
Watershed file: --> NMC11 .WSD
Hydrograph file: --> NMC11 .HYD

nicolet MINING COMPANY
FOTH AND VAN DYKE 93C049
BASIN 11 11/98
100 YEAR STORM EVENT

| Time (hrs) | Flow (cfs) | Time (hrs) | Flow (cfs) |
|---|---|---|---|
| 18.6 | 1 | 22.4 | 1 |
| 18.7 | 1 | 22.5 | 1 |
| 18.8 | 1 | 22.6 | 1 |
| 18.9 | 1 | 22.7 | 1 |
| 19.0 | 1 | 22.8 | 1 |
| 19.1 | 1 | 22.9 | 1 |
| 19.2 | 1 | 23.0 | 1 |
| 19.3 | 1 | 23.1 | 1 |
| 19.4 | 1 | 23.2 | 1 |
| 19.5 | 1 | 23.3 | 1 |
| 19.6 | 1 | 23.4 | 1 |
| 19.7 | 1 | 23.5 | 1 |
| 19.8 | 1 | 23.6 | 1 |
| 19.9 | 1 | 23.7 | 1 |
| 20.0 | 1 | 23.8 | 1 |
| 20.1 | 1 | 23.9 | 1 |
| 20.2 | 1 | 24.0 | 0 |
| 20.3 | 1 | 24.1 | 0 |
| 20.4 | 1 | 24.2 | 0 |
| 20.5 | 1 | 24.3 | 0 |
| 20.6 | 1 | 24.4 | 0 |
| 20.7 | 1 | 24.5 | 0 |
| 20.8 | 1 | 24.6 | 0 |
| 20.9 | 1 | 24.7 | 0 |
| 21.0 | 1 | 24.8 | 0 |
| 21.1 | 1 | 24.9 | 0 |
| 21.2 | 1 | 25.0 | 0 |
| 21.3 | 1 | 25.1 | 0 |
| 21.4 | 1 | 25.2 | 0 |
| 21.5 | 1 | 25.3 | 0 |
| 21.6 | 1 | 25.4 | 0 |
| 21.7 | 1 | 25.5 | 0 |
| 21.8 | 1 | 25.6 | 0 |
| 21.9 | 1 | 25.7 | 0 |
| 22.0 | 1 | 25.8 | 0 |
| 22.1 | 1 | 25.9 | 0 |
| 22.2 | 1 | | |
| 22.3 | 1 | | |

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 11-11-1998 18:24:08
Watershed file: --> NMC12 .WSD
Hydrograph file: --> NMC12 .HYD

nicolet MINING COMPANY
FOTH AND VAN DYKE 93C049
BASIN 12 11/98
100 YEAR STORM EVENT

>>>> Input Parameters Used to Compute Hydrograph <<<<

| Subarea Description | AREA (acres) | CN | Tc (hrs) | * Tt (hrs) | Precip. (in) | Runoff (in) | Ia/p input/used |
|---|---|---|---|---|---|---|---|
| 12A | 26.20 | 60.0 | 0.75 | 0.00 | 5.00 | 1.30 | .27 .30 |

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 26.20 acres or 0.04094 sq.mi
Peak discharge = 19 cfs

>>>> Computer Modifications of Input Parameters <<<<<

| Subarea Description | Input Values Tc (hr) | * Tt (hr) | Rounded Values Tc (hr) | * Tt (hr) | Ia/p Interpolated (Yes/No) | Ia/p Messages |
|---|---|---|---|---|---|---|
| 12A | 0.66 | 0.00 | 0.75 | 0.00 | No | -- |

* Travel time from subarea outfall to composite watershed outfall point.

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 11-11-1998 18:24:08
Watershed file: --> NMC12 .WSD
Hydrograph file: --> NMC12 .HYD

nicolet MINING COMPANY
FOTH AND VAN DYKE 93C049
BASIN 12 11/98
100 YEAR STORM EVENT

>>>> Summary of Subarea Times to Peak <<<<

| Subarea | Peak Discharge at Composite Outfall (cfs) | Time to Peak at Composite Outfall (hrs) |
|---|---|---|
| 12A | 19 | 12.7 |
| Composite Watershed | 19 | 12.7 |

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 11-11-1998 18:24:08
Watershed file: --> NMC12 .WSD
Hydrograph file: --> NMC12 .HYD

nicolet MINING COMPANY
FOTH AND VAN DYKE 93C049

BASIN 12 11/98

100 YEAR STORM EVENT

Composite Hydrograph Summary (cfs)

| Subarea Description | 11.0 hr | 11.3 hr | 11.6 hr | 11.9 hr | 12.0 hr | 12.1 hr | 12.2 hr | 12.3 hr | 12.4 hr |
|---|---|---|---|---|---|---|---|---|---|
| 12A | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 5 | 9 |
| Total (cfs) | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 5 | 9 |

| Subarea Description | 12.5 hr | 12.6 hr | 12.7 hr | 12.8 hr | 13.0 hr | 13.2 hr | 13.4 hr | 13.6 hr | 13.8 hr |
|---|---|---|---|---|---|---|---|---|---|
| 12A | 14 | 17 | 19 | 17 | 13 | 10 | 7 | 6 | 5 |
| Total (cfs) | 14 | 17 | 19 | 17 | 13 | 10 | 7 | 6 | 5 |

| Subarea Description | 14.0 hr | 14.3 hr | 14.6 hr | 15.0 hr | 15.5 hr | 16.0 hr | 16.5 hr | 17.0 hr | 17.5 hr |
|---|---|---|---|---|---|---|---|---|---|
| 12A | 4 | 4 | 3 | 3 | 2 | 2 | 2 | 2 | 2 |
| Total (cfs) | 4 | 4 | 3 | 3 | 2 | 2 | 2 | 2 | 2 |

| Subarea Description | 18.0 hr | 19.0 hr | 20.0 hr | 22.0 hr | 26.0 hr |
|---|---|---|---|---|---|
| 12A | 2 | 1 | 1 | 1 | 0 |
| Total (cfs) | 2 | 1 | 1 | 1 | 0 |

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 11-11-1998 18:24:08
Watershed file: --> NMC12 .WSD
Hydrograph file: --> NMC12 .HYD

nicolet MINING COMPANY
FOTH AND VAN DYKE 93C049

BASIN 12 11/98

100 YEAR STORM EVENT

| Time (hrs) | Flow (cfs) | Time (hrs) | Flow (cfs) |
|---|---|---|---|
| 11.0 | 0 | 14.8 | 3 |
| 11.1 | 0 | 14.9 | 3 |
| 11.2 | 0 | 15.0 | 3 |
| 11.3 | 0 | 15.1 | 3 |
| 11.4 | 0 | 15.2 | 3 |
| 11.5 | 0 | 15.3 | 2 |
| 11.6 | 0 | 15.4 | 2 |
| 11.7 | 0 | 15.5 | 2 |
| 11.8 | 0 | 15.6 | 2 |
| 11.9 | 0 | 15.7 | 2 |
| 12.0 | 0 | 15.8 | 2 |
| 12.1 | 0 | 15.9 | 2 |
| 12.2 | 2 | 16.0 | 2 |
| 12.3 | 5 | 16.1 | 2 |
| 12.4 | 9 | 16.2 | 2 |
| 12.5 | 14 | 16.3 | 2 |
| 12.6 | 17 | 16.4 | 2 |
| 12.7 | 19 | 16.5 | 2 |
| 12.8 | 17 | 16.6 | 2 |
| 12.9 | 15 | 16.7 | 2 |
| 13.0 | 13 | 16.8 | 2 |
| 13.1 | 12 | 16.9 | 2 |
| 13.2 | 10 | 17.0 | 2 |
| 13.3 | 8 | 17.1 | 2 |
| 13.4 | 7 | 17.2 | 2 |
| 13.5 | 7 | 17.3 | 2 |
| 13.6 | 6 | 17.4 | 2 |
| 13.7 | 6 | 17.5 | 2 |
| 13.8 | 5 | 17.6 | 2 |
| 13.9 | 4 | 17.7 | 2 |
| 14.0 | 4 | 17.8 | 2 |
| 14.1 | 4 | 17.9 | 2 |
| 14.2 | 4 | 18.0 | 2 |
| 14.3 | 4 | 18.1 | 2 |
| 14.4 | 4 | 18.2 | 2 |
| 14.5 | 3 | 18.3 | 2 |
| 14.6 | 3 | 18.4 | 2 |
| 14.7 | 3 | 18.5 | 2 |

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 11-11-1998 18:24:08
Watershed file: --> NMC12 .WSD
Hydrograph file: --> NMC12 .HYD

nicolet MINING COMPANY
FOTH AND VAN DYKE 93C049
BASIN 12 11/98
100 YEAR STORM EVENT

| Time (hrs) | Flow (cfs) | Time (hrs) | Flow (cfs) |
|---|---|---|---|
| 18.6 | 1 | 22.4 | 1 |
| 18.7 | 1 | 22.5 | 1 |
| 18.8 | 1 | 22.6 | 1 |
| 18.9 | 1 | 22.7 | 1 |
| 19.0 | 1 | 22.8 | 1 |
| 19.1 | 1 | 22.9 | 1 |
| 19.2 | 1 | 23.0 | 1 |
| 19.3 | 1 | 23.1 | 1 |
| 19.4 | 1 | 23.2 | 1 |
| 19.5 | 1 | 23.3 | 1 |
| 19.6 | 1 | 23.4 | 1 |
| 19.7 | 1 | 23.5 | 1 |
| 19.8 | 1 | 23.6 | 1 |
| 19.9 | 1 | 23.7 | 1 |
| 20.0 | 1 | 23.8 | 1 |
| 20.1 | 1 | 23.9 | 1 |
| 20.2 | 1 | 24.0 | 0 |
| 20.3 | 1 | 24.1 | 0 |
| 20.4 | 1 | 24.2 | 0 |
| 20.5 | 1 | 24.3 | 0 |
| 20.6 | 1 | 24.4 | 0 |
| 20.7 | 1 | 24.5 | 0 |
| 20.8 | 1 | 24.6 | 0 |
| 20.9 | 1 | 24.7 | 0 |
| 21.0 | 1 | 24.8 | 0 |
| 21.1 | 1 | 24.9 | 0 |
| 21.2 | 1 | 25.0 | 0 |
| 21.3 | 1 | 25.1 | 0 |
| 21.4 | 1 | 25.2 | 0 |
| 21.5 | 1 | 25.3 | 0 |
| 21.6 | 1 | 25.4 | 0 |
| 21.7 | 1 | 25.5 | 0 |
| 21.8 | 1 | 25.6 | 0 |
| 21.9 | 1 | 25.7 | 0 |
| 22.0 | 1 | 25.8 | 0 |
| 22.1 | 1 | 25.9 | 0 |
| 22.2 | 1 | | |
| 22.3 | 1 | | |

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 11-11-1998 18:24:48
Watershed file: --> NMC13 .WSD
Hydrograph file: --> NMC13 .HYD

nicolet MINING COMPANY
FOTH AND VAN DYKE 93C049
BASIN 13 11/98
100 YEAR STORM EVENT

>>>> Input Parameters Used to Compute Hydrograph <<<<

| Subarea Description | AREA (acres) | CN | Tc (hrs) | * Tt (hrs) | Precip. (in) | Runoff (in) | Ia/p input | Ia/p used |
|---|---|---|---|---|---|---|---|---|
| 13A | 11.60 | 60.0 | 0.50 | 0.00 | 5.00 | 1.30 | .27 | .30 |

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 11.60 acres or 0.01813 sq.mi
Peak discharge = 10 cfs

>>>> Computer Modifications of Input Parameters <<<<<

| Subarea Description | Input Values Tc (hr) | Input Values * Tt (hr) | Rounded Values Tc (hr) | Rounded Values * Tt (hr) | Ia/p Interpolated (Yes/No) | Ia/p Messages |
|---|---|---|---|---|---|---|
| 13A | 0.55 | 0.00 | 0.50 | 0.00 | No | -- |

* Travel time from subarea outfall to composite watershed outfall point.

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 11-11-1998 18:24:48
Watershed file: --> NMC13 .WSD
Hydrograph file: --> NMC13 .HYD

nicolet MINING COMPANY
FOTH AND VAN DYKE 93C049
BASIN 13 11/98
100 YEAR STORM EVENT

>>>> Summary of Subarea Times to Peak <<<<

| Subarea | Peak Discharge at Composite Outfall (cfs) | Time to Peak at Composite Outfall (hrs) |
|---|---|---|
| 13A | 10 | 12.4 |
| Composite Watershed | 10 | 12.4 |

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 11-11-1998 18:24:48
Watershed file: --> NMC13 .WSD
Hydrograph file: --> NMC13 .HYD

nicolet MINING COMPANY
FOTH AND VAN DYKE 93C049
BASIN 13 11/98
100 YEAR STORM EVENT

Composite Hydrograph Summary (cfs)

| Subarea Description | 11.0 hr | 11.3 hr | 11.6 hr | 11.9 hr | 12.0 hr | 12.1 hr | 12.2 hr | 12.3 hr | 12.4 hr |
|---|---|---|---|---|---|---|---|---|---|
| 13A | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 7 | 10 |
| Total (cfs) | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 7 | 10 |

| Subarea Description | 12.5 hr | 12.6 hr | 12.7 hr | 12.8 hr | 13.0 hr | 13.2 hr | 13.4 hr | 13.6 hr | 13.8 hr |
|---|---|---|---|---|---|---|---|---|---|
| 13A | 10 | 9 | 7 | 6 | 4 | 3 | 2 | 2 | 2 |
| Total (cfs) | 10 | 9 | 7 | 6 | 4 | 3 | 2 | 2 | 2 |

| Subarea Description | 14.0 hr | 14.3 hr | 14.6 hr | 15.0 hr | 15.5 hr | 16.0 hr | 16.5 hr | 17.0 hr | 17.5 hr |
|---|---|---|---|---|---|---|---|---|---|
| 13A | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Total (cfs) | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

| Subarea Description | 18.0 hr | 19.0 hr | 20.0 hr | 22.0 hr | 26.0 hr |
|---|---|---|---|---|---|
| 13A | 1 | 1 | 1 | 0 | 0 |
| Total (cfs) | 1 | 1 | 1 | 0 | 0 |

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 11-11-1998 18:24:48
Watershed file: --> NMC13 .WSD
Hydrograph file: --> NMC13 .HYD

nicolet MINING COMPANY
FOTH AND VAN DYKE 93C049
BASIN 13 11/98
100 YEAR STORM EVENT

| Time (hrs) | Flow (cfs) | Time (hrs) | Flow (cfs) |
|---|---|---|---|
| 11.0 | 0 | 14.8 | 1 |
| 11.1 | 0 | 14.9 | 1 |
| 11.2 | 0 | 15.0 | 1 |
| 11.3 | 0 | 15.1 | 1 |
| 11.4 | 0 | 15.2 | 1 |
| 11.5 | 0 | 15.3 | 1 |
| 11.6 | 0 | 15.4 | 1 |
| 11.7 | 0 | 15.5 | 1 |
| 11.8 | 0 | 15.6 | 1 |
| 11.9 | 0 | 15.7 | 1 |
| 12.0 | 0 | 15.8 | 1 |
| 12.1 | 1 | 15.9 | 1 |
| 12.2 | 4 | 16.0 | 1 |
| 12.3 | 7 | 16.1 | 1 |
| 12.4 | 10 | 16.2 | 1 |
| 12.5 | 10 | 16.3 | 1 |
| 12.6 | 9 | 16.4 | 1 |
| 12.7 | 7 | 16.5 | 1 |
| 12.8 | 6 | 16.6 | 1 |
| 12.9 | 5 | 16.7 | 1 |
| 13.0 | 4 | 16.8 | 1 |
| 13.1 | 4 | 16.9 | 1 |
| 13.2 | 3 | 17.0 | 1 |
| 13.3 | 2 | 17.1 | 1 |
| 13.4 | 2 | 17.2 | 1 |
| 13.5 | 2 | 17.3 | 1 |
| 13.6 | 2 | 17.4 | 1 |
| 13.7 | 2 | 17.5 | 1 |
| 13.8 | 2 | 17.6 | 1 |
| 13.9 | 2 | 17.7 | 1 |
| 14.0 | 2 | 17.8 | 1 |
| 14.1 | 2 | 17.9 | 1 |
| 14.2 | 1 | 18.0 | 1 |
| 14.3 | 1 | 18.1 | 1 |
| 14.4 | 1 | 18.2 | 1 |
| 14.5 | 1 | 18.3 | 1 |
| 14.6 | 1 | 18.4 | 1 |
| 14.7 | 1 | 18.5 | 1 |

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 11-11-1998 18:24:48
Watershed file: --> NMC13 .WSD
Hydrograph file: --> NMC13 .HYD

nicolet MINING COMPANY
FOTH AND VAN DYKE 93C049
BASIN 13 11/98
100 YEAR STORM EVENT

| Time (hrs) | Flow (cfs) | Time (hrs) | Flow (cfs) |
|---|---|---|---|
| 18.6 | 1 | 22.4 | 0 |
| 18.7 | 1 | 22.5 | 0 |
| 18.8 | 1 | 22.6 | 0 |
| 18.9 | 1 | 22.7 | 0 |
| 19.0 | 1 | 22.8 | 0 |
| 19.1 | 1 | 22.9 | 0 |
| 19.2 | 1 | 23.0 | 0 |
| 19.3 | 1 | 23.1 | 0 |
| 19.4 | 1 | 23.2 | 0 |
| 19.5 | 1 | 23.3 | 0 |
| 19.6 | 1 | 23.4 | 0 |
| 19.7 | 1 | 23.5 | 0 |
| 19.8 | 1 | 23.6 | 0 |
| 19.9 | 1 | 23.7 | 0 |
| 20.0 | 1 | 23.8 | 0 |
| 20.1 | 1 | 23.9 | 0 |
| 20.2 | 1 | 24.0 | 0 |
| 20.3 | 1 | 24.1 | 0 |
| 20.4 | 1 | 24.2 | 0 |
| 20.5 | 1 | 24.3 | 0 |
| 20.6 | 1 | 24.4 | 0 |
| 20.7 | 1 | 24.5 | 0 |
| 20.8 | 1 | 24.6 | 0 |
| 20.9 | 1 | 24.7 | 0 |
| 21.0 | 0 | 24.8 | 0 |
| 21.1 | 0 | 24.9 | 0 |
| 21.2 | 0 | 25.0 | 0 |
| 21.3 | 0 | 25.1 | 0 |
| 21.4 | 0 | 25.2 | 0 |
| 21.5 | 0 | 25.3 | 0 |
| 21.6 | 0 | 25.4 | 0 |
| 21.7 | 0 | 25.5 | 0 |
| 21.8 | 0 | 25.6 | 0 |
| 21.9 | 0 | 25.7 | 0 |
| 22.0 | 0 | 25.8 | 0 |
| 22.1 | 0 | 25.9 | 0 |
| 22.2 | 0 | | |
| 22.3 | 0 | | |

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 11-12-1998 08:14:30
Watershed file: --> NMC14 .WSD
Hydrograph file: --> NMC14 .HYD

nicolet MINING COMPANY
FOTH AND VAN DYKE 93C049
BASIN 14 11/98
100 YEAR STORM EVENT

>>>> Input Parameters Used to Compute Hydrograph <<<<

| Subarea Description | AREA (acres) | CN | Tc (hrs) | * Tt (hrs) | Precip. (in) | Runoff (in) | Ia/p input/used |
|---|---|---|---|---|---|---|---|
| 14A | 29.00 | 60.0 | 0.75 | 0.00 | 5.00 | 1.30 | .27 .30 |

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 29.00 acres or 0.04531 sq.mi
Peak discharge = 20 cfs

>>>> Computer Modifications of Input Parameters <<<<<

| Subarea Description | Input Values Tc (hr) | Input Values * Tt (hr) | Rounded Values Tc (hr) | Rounded Values * Tt (hr) | Ia/p Interpolated (Yes/No) | Ia/p Messages |
|---|---|---|---|---|---|---|
| 14A | 0.68 | 0.00 | 0.75 | 0.00 | No | -- |

* Travel time from subarea outfall to composite watershed outfall point.

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 11-12-1998 08:14:30
Watershed file: --> NMC14 .WSD
Hydrograph file: --> NMC14 .HYD

nicolet MINING COMPANY
FOTH AND VAN DYKE 93C049
BASIN 14 11/98
100 YEAR STORM EVENT

>>>> Summary of Subarea Times to Peak <<<<

| Subarea | Peak Discharge at Composite Outfall (cfs) | Time to Peak at Composite Outfall (hrs) |
|---|---|---|
| 14A | 20 | 12.7 |
| Composite Watershed | 20 | 12.7 |

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 11-12-1998 08:14:30
Watershed file: --> NMC14 .WSD
Hydrograph file: --> NMC14 .HYD

nicolet MINING COMPANY
FOTH AND VAN DYKE 93C049
BASIN 14 11/98
100 YEAR STORM EVENT

Composite Hydrograph Summary (cfs)

| Subarea Description | 11.0 hr | 11.3 hr | 11.6 hr | 11.9 hr | 12.0 hr | 12.1 hr | 12.2 hr | 12.3 hr | 12.4 hr |
|---|---|---|---|---|---|---|---|---|---|
| 14A | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 5 | 10 |
| Total (cfs) | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 5 | 10 |

| Subarea Description | 12.5 hr | 12.6 hr | 12.7 hr | 12.8 hr | 13.0 hr | 13.2 hr | 13.4 hr | 13.6 hr | 13.8 hr |
|---|---|---|---|---|---|---|---|---|---|
| 14A | 16 | 19 | 20 | 19 | 14 | 11 | 8 | 6 | 5 |
| Total (cfs) | 16 | 19 | 20 | 19 | 14 | 11 | 8 | 6 | 5 |

| Subarea Description | 14.0 hr | 14.3 hr | 14.6 hr | 15.0 hr | 15.5 hr | 16.0 hr | 16.5 hr | 17.0 hr | 17.5 hr |
|---|---|---|---|---|---|---|---|---|---|
| 14A | 5 | 4 | 3 | 3 | 3 | 2 | 2 | 2 | 2 |
| Total (cfs) | 5 | 4 | 3 | 3 | 3 | 2 | 2 | 2 | 2 |

| Subarea Description | 18.0 hr | 19.0 hr | 20.0 hr | 22.0 hr | 26.0 hr |
|---|---|---|---|---|---|
| 14A | 2 | 2 | 1 | 1 | 0 |
| Total (cfs) | 2 | 2 | 1 | 1 | 0 |

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 11-12-1998 08:14:30
Watershed file: --> NMC14 .WSD
Hydrograph file: --> NMC14 .HYD

nicolet MINING COMPANY
FOTH AND VAN DYKE 93C049
BASIN 14 11/98
100 YEAR STORM EVENT

| Time (hrs) | Flow (cfs) | Time (hrs) | Flow (cfs) |
|---|---|---|---|
| 11.0 | 0 | 14.8 | 3 |
| 11.1 | 0 | 14.9 | 3 |
| 11.2 | 0 | 15.0 | 3 |
| 11.3 | 0 | 15.1 | 3 |
| 11.4 | 0 | 15.2 | 3 |
| 11.5 | 0 | 15.3 | 3 |
| 11.6 | 0 | 15.4 | 3 |
| 11.7 | 0 | 15.5 | 3 |
| 11.8 | 0 | 15.6 | 3 |
| 11.9 | 0 | 15.7 | 3 |
| 12.0 | 0 | 15.8 | 2 |
| 12.1 | 0 | 15.9 | 2 |
| 12.2 | 2 | 16.0 | 2 |
| 12.3 | 5 | 16.1 | 2 |
| 12.4 | 10 | 16.2 | 2 |
| 12.5 | 16 | 16.3 | 2 |
| 12.6 | 19 | 16.4 | 2 |
| 12.7 | 20 | 16.5 | 2 |
| 12.8 | 19 | 16.6 | 2 |
| 12.9 | 16 | 16.7 | 2 |
| 13.0 | 14 | 16.8 | 2 |
| 13.1 | 12 | 16.9 | 2 |
| 13.2 | 11 | 17.0 | 2 |
| 13.3 | 9 | 17.1 | 2 |
| 13.4 | 8 | 17.2 | 2 |
| 13.5 | 7 | 17.3 | 2 |
| 13.6 | 6 | 17.4 | 2 |
| 13.7 | 6 | 17.5 | 2 |
| 13.8 | 5 | 17.6 | 2 |
| 13.9 | 5 | 17.7 | 2 |
| 14.0 | 5 | 17.8 | 2 |
| 14.1 | 5 | 17.9 | 2 |
| 14.2 | 4 | 18.0 | 2 |
| 14.3 | 4 | 18.1 | 2 |
| 14.4 | 4 | 18.2 | 2 |
| 14.5 | 3 | 18.3 | 2 |
| 14.6 | 3 | 18.4 | 2 |
| 14.7 | 3 | 18.5 | 2 |

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 11-12-1998 08:14:30
Watershed file: --> NMC14 .WSD
Hydrograph file: --> NMC14 .HYD

nicolet MINING COMPANY
FOTH AND VAN DYKE 93C049
BASIN 14 11/98
100 YEAR STORM EVENT

| Time (hrs) | Flow (cfs) | Time (hrs) | Flow (cfs) |
|---|---|---|---|
| 18.6 | 2 | 22.4 | 1 |
| 18.7 | 2 | 22.5 | 1 |
| 18.8 | 2 | 22.6 | 1 |
| 18.9 | 2 | 22.7 | 1 |
| 19.0 | 2 | 22.8 | 1 |
| 19.1 | 2 | 22.9 | 1 |
| 19.2 | 2 | 23.0 | 1 |
| 19.3 | 2 | 23.1 | 1 |
| 19.4 | 2 | 23.2 | 1 |
| 19.5 | 2 | 23.3 | 1 |
| 19.6 | 1 | 23.4 | 1 |
| 19.7 | 1 | 23.5 | 1 |
| 19.8 | 1 | 23.6 | 1 |
| 19.9 | 1 | 23.7 | 1 |
| 20.0 | 1 | 23.8 | 1 |
| 20.1 | 1 | 23.9 | 1 |
| 20.2 | 1 | 24.0 | 0 |
| 20.3 | 1 | 24.1 | 0 |
| 20.4 | 1 | 24.2 | 0 |
| 20.5 | 1 | 24.3 | 0 |
| 20.6 | 1 | 24.4 | 0 |
| 20.7 | 1 | 24.5 | 0 |
| 20.8 | 1 | 24.6 | 0 |
| 20.9 | 1 | 24.7 | 0 |
| 21.0 | 1 | 24.8 | 0 |
| 21.1 | 1 | 24.9 | 0 |
| 21.2 | 1 | 25.0 | 0 |
| 21.3 | 1 | 25.1 | 0 |
| 21.4 | 1 | 25.2 | 0 |
| 21.5 | 1 | 25.3 | 0 |
| 21.6 | 1 | 25.4 | 0 |
| 21.7 | 1 | 25.5 | 0 |
| 21.8 | 1 | 25.6 | 0 |
| 21.9 | 1 | 25.7 | 0 |
| 22.0 | 1 | 25.8 | 0 |
| 22.1 | 1 | 25.9 | 0 |
| 22.2 | 1 | | |
| 22.3 | 1 | | |

# Attachment B

# Pond-2 Hydraulic Analysis

```
**************************************************************************
*                                                                        *
* NICOLET MINING COMPANY          93C049          FOTH & VAN DYKE        *
*       TMA RUNOFF BASIN 9                              12/98            *
*                                                                        *
*                                                                        *
*                                                                        *
**************************************************************************
```

Inflow Hydrograph: NMC9 .HYD
Rating Table file: NMC9 .PND

----INITIAL CONDITIONS----
Elevation = 1628.99 ft
Outflow = 0.00 cfs
Storage = 0.00 ac-ft

| GIVEN POND DATA | | | INTERMEDIATE ROUTING COMPUTATIONS | |
|---|---|---|---|---|
| ELEVATION (ft) | OUTFLOW (cfs) | STORAGE (ac-ft) | 2S/t (cfs) | 2S/t + O (cfs) |
| 1628.99 | 0.0 | 0.000 | 0.0 | 0.0 |
| 1629.49 | 0.0 | 0.006 | 1.4 | 1.4 |
| 1629.99 | 0.0 | 0.013 | 3.3 | 3.3 |
| 1630.49 | 0.0 | 0.024 | 5.8 | 5.8 |
| 1630.99 | 0.0 | 0.038 | 9.1 | 9.1 |
| 1631.49 | 0.0 | 0.055 | 13.2 | 13.2 |
| 1631.99 | 0.0 | 0.076 | 18.3 | 18.3 |
| 1632.49 | 0.0 | 0.897 | 217.0 | 217.0 |
| 1632.99 | 0.0 | 1.746 | 422.6 | 422.6 |
| 1633.49 | 0.0 | 2.615 | 632.8 | 632.8 |
| 1633.99 | 0.0 | 3.503 | 847.7 | 847.7 |
| 1634.49 | 8.9 | 4.410 | 1067.3 | 1076.2 |
| 1634.99 | 9.3 | 5.337 | 1291.6 | 1300.9 |
| 1635.49 | 9.6 | 6.284 | 1520.8 | 1530.4 |
| 1635.99 | 22.4 | 7.251 | 1754.8 | 1777.2 |

Time increment (t) = 0.100 hrs.

Pond File: NMC9 .PND
Inflow Hydrograph: NMC9 .HYD
Outflow Hydrograph: OUT .HYD

| INFLOW HYDROGRAPH | | ROUTING COMPUTATIONS | | | | |
|---|---|---|---|---|---|---|
| TIME (hrs) | INFLOW (cfs) | I1+I2 (cfs) | 2S/t - O (cfs) | 2S/t + O (cfs) | OUTFLOW (cfs) | ELEVATION (ft) |
| 11.000 | 0.00 | ----- | 0.0 | 0.0 | 0.00 | 1628.99 |
| 11.100 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1628.99 |
| 11.200 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1628.99 |
| 11.300 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1628.99 |
| 11.400 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1628.99 |
| 11.500 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1628.99 |
| 11.600 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1628.99 |
| 11.700 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1628.99 |
| 11.800 | 1.00 | 1.0 | 1.0 | 1.0 | 0.00 | 1629.36 |
| 11.900 | 1.00 | 2.0 | 3.0 | 3.0 | 0.00 | 1629.92 |
| 12.000 | 4.00 | 5.0 | 8.0 | 8.0 | 0.00 | 1630.82 |
| 12.100 | 11.00 | 15.0 | 23.0 | 23.0 | 0.00 | 1632.00 |
| 12.200 | 15.00 | 26.0 | 49.0 | 49.0 | 0.00 | 1632.07 |
| 12.300 | 27.00 | 42.0 | 91.0 | 91.0 | 0.00 | 1632.17 |
| 12.400 | 38.00 | 65.0 | 156.0 | 156.0 | 0.00 | 1632.34 |
| 12.500 | 47.00 | 85.0 | 241.0 | 241.0 | 0.00 | 1632.55 |
| 12.600 | 53.00 | 100.0 | 341.0 | 341.0 | 0.00 | 1632.79 |
| 12.700 | 52.00 | 105.0 | 446.0 | 446.0 | 0.00 | 1633.05 |
| 12.800 | 55.00 | 107.0 | 553.0 | 553.0 | 0.00 | 1633.30 |
| 12.900 | 53.00 | 108.0 | 661.0 | 661.0 | 0.00 | 1633.56 |
| 13.000 | 51.00 | 104.0 | 765.0 | 765.0 | 0.00 | 1633.80 |
| 13.100 | 49.00 | 100.0 | 863.7 | 865.0 | 0.67 | 1634.03 |
| 13.200 | 47.00 | 96.0 | 950.9 | 959.7 | 4.36 | 1634.24 |
| 13.300 | 41.00 | 88.0 | 1024.0 | 1038.9 | 7.45 | 1634.41 |
| 13.400 | 35.00 | 76.0 | 1082.1 | 1100.0 | 8.94 | 1634.54 |
| 13.500 | 32.00 | 67.0 | 1131.1 | 1149.1 | 9.03 | 1634.65 |
| 13.600 | 29.00 | 61.0 | 1173.9 | 1192.1 | 9.11 | 1634.75 |
| 13.700 | 26.00 | 55.0 | 1210.5 | 1228.9 | 9.17 | 1634.83 |
| 13.800 | 23.00 | 49.0 | 1241.1 | 1259.5 | 9.23 | 1634.90 |
| 13.900 | 22.00 | 45.0 | 1267.5 | 1286.1 | 9.27 | 1634.96 |
| 14.000 | 20.00 | 42.0 | 1290.9 | 1309.5 | 9.31 | 1635.01 |
| 14.100 | 18.00 | 38.0 | 1310.2 | 1328.9 | 9.34 | 1635.05 |
| 14.200 | 17.00 | 35.0 | 1326.5 | 1345.2 | 9.36 | 1635.09 |
| 14.300 | 15.00 | 32.0 | 1339.8 | 1358.5 | 9.38 | 1635.12 |
| 14.400 | 14.00 | 29.0 | 1350.0 | 1368.8 | 9.39 | 1635.14 |
| 14.500 | 14.00 | 28.0 | 1359.2 | 1378.0 | 9.40 | 1635.16 |
| 14.600 | 13.00 | 27.0 | 1367.4 | 1386.2 | 9.41 | 1635.18 |
| 14.700 | 12.00 | 25.0 | 1373.5 | 1392.4 | 9.42 | 1635.19 |
| 14.800 | 12.00 | 24.0 | 1378.7 | 1397.5 | 9.43 | 1635.20 |
| 14.900 | 12.00 | 24.0 | 1383.8 | 1402.7 | 9.43 | 1635.21 |
| 15.000 | 11.00 | 23.0 | 1387.9 | 1406.8 | 9.44 | 1635.22 |
| 15.100 | 11.00 | 22.0 | 1391.0 | 1409.9 | 9.44 | 1635.23 |
| 15.200 | 11.00 | 22.0 | 1394.2 | 1413.0 | 9.45 | 1635.23 |
| 15.300 | 10.00 | 21.0 | 1396.3 | 1415.2 | 9.45 | 1635.24 |
| 15.400 | 10.00 | 20.0 | 1397.4 | 1416.3 | 9.45 | 1635.24 |

Pond File: NMC9 .PND
Inflow Hydrograph: NMC9 .HYD
Outflow Hydrograph: OUT .HYD

| INFLOW HYDROGRAPH | | ROUTING COMPUTATIONS | | | | |
|---|---|---|---|---|---|---|
| TIME (hrs) | INFLOW (cfs) | I1+I2 (cfs) | 2S/t - O (cfs) | 2S/t + O (cfs) | OUTFLOW (cfs) | ELEVATION (ft) |
| 15.500 | 10.00 | 20.0 | 1398.4 | 1417.4 | 9.45 | 1635.24 |
| 15.600 | 10.00 | 20.0 | 1399.5 | 1418.4 | 9.45 | 1635.25 |
| 15.700 | 10.00 | 20.0 | 1400.6 | 1419.5 | 9.46 | 1635.25 |
| 15.800 | 9.00 | 19.0 | 1400.7 | 1419.6 | 9.46 | 1635.25 |
| 15.900 | 9.00 | 18.0 | 1399.8 | 1418.7 | 9.45 | 1635.25 |
| 16.000 | 9.00 | 18.0 | 1398.9 | 1417.8 | 9.45 | 1635.24 |
| 16.100 | 9.00 | 18.0 | 1398.0 | 1416.9 | 9.45 | 1635.24 |
| 16.200 | 9.00 | 18.0 | 1397.1 | 1416.0 | 9.45 | 1635.24 |
| 16.300 | 8.00 | 17.0 | 1395.2 | 1414.1 | 9.45 | 1635.24 |
| 16.400 | 8.00 | 16.0 | 1392.3 | 1411.2 | 9.44 | 1635.23 |
| 16.500 | 8.00 | 16.0 | 1389.4 | 1408.3 | 9.44 | 1635.22 |
| 16.600 | 8.00 | 16.0 | 1386.6 | 1405.4 | 9.44 | 1635.22 |
| 16.700 | 8.00 | 16.0 | 1383.7 | 1402.6 | 9.43 | 1635.21 |
| 16.800 | 8.00 | 16.0 | 1380.8 | 1399.7 | 9.43 | 1635.21 |
| 16.900 | 8.00 | 16.0 | 1378.0 | 1396.8 | 9.43 | 1635.20 |
| 17.000 | 8.00 | 16.0 | 1375.1 | 1394.0 | 9.42 | 1635.19 |
| 17.100 | 8.00 | 16.0 | 1372.3 | 1391.1 | 9.42 | 1635.19 |
| 17.200 | 8.00 | 16.0 | 1369.5 | 1388.3 | 9.41 | 1635.18 |
| 17.300 | 7.00 | 15.0 | 1365.7 | 1384.5 | 9.41 | 1635.17 |
| 17.400 | 7.00 | 14.0 | 1360.9 | 1379.7 | 9.40 | 1635.16 |
| 17.500 | 7.00 | 14.0 | 1356.1 | 1374.9 | 9.40 | 1635.15 |
| 17.600 | 7.00 | 14.0 | 1351.3 | 1370.1 | 9.39 | 1635.14 |
| 17.700 | 7.00 | 14.0 | 1346.5 | 1365.3 | 9.38 | 1635.13 |
| 17.800 | 6.00 | 13.0 | 1340.8 | 1359.5 | 9.38 | 1635.12 |
| 17.900 | 6.00 | 12.0 | 1334.0 | 1352.8 | 9.37 | 1635.10 |
| 18.000 | 6.00 | 12.0 | 1327.3 | 1346.0 | 9.36 | 1635.09 |
| 18.100 | 6.00 | 12.0 | 1320.6 | 1339.3 | 9.35 | 1635.07 |
| 18.200 | 6.00 | 12.0 | 1313.9 | 1332.6 | 9.34 | 1635.06 |
| 18.300 | 6.00 | 12.0 | 1307.3 | 1325.9 | 9.33 | 1635.04 |
| 18.400 | 6.00 | 12.0 | 1300.6 | 1319.3 | 9.32 | 1635.03 |
| 18.500 | 6.00 | 12.0 | 1294.0 | 1312.6 | 9.32 | 1635.02 |
| 18.600 | 6.00 | 12.0 | 1287.4 | 1306.0 | 9.31 | 1635.00 |
| 18.700 | 6.00 | 12.0 | 1280.8 | 1299.4 | 9.30 | 1634.99 |
| 18.800 | 6.00 | 12.0 | 1274.2 | 1292.8 | 9.29 | 1634.97 |
| 18.900 | 6.00 | 12.0 | 1267.7 | 1286.2 | 9.27 | 1634.96 |
| 19.000 | 6.00 | 12.0 | 1261.1 | 1279.7 | 9.26 | 1634.94 |
| 19.100 | 6.00 | 12.0 | 1254.6 | 1273.1 | 9.25 | 1634.93 |
| 19.200 | 6.00 | 12.0 | 1248.2 | 1266.6 | 9.24 | 1634.91 |
| 19.300 | 6.00 | 12.0 | 1241.7 | 1260.2 | 9.23 | 1634.90 |
| 19.400 | 6.00 | 12.0 | 1235.3 | 1253.7 | 9.22 | 1634.88 |
| 19.500 | 6.00 | 12.0 | 1228.9 | 1247.3 | 9.20 | 1634.87 |
| 19.600 | 5.00 | 11.0 | 1221.5 | 1239.9 | 9.19 | 1634.85 |
| 19.700 | 5.00 | 10.0 | 1213.1 | 1231.5 | 9.18 | 1634.84 |
| 19.800 | 5.00 | 10.0 | 1204.8 | 1223.1 | 9.16 | 1634.82 |
| 19.900 | 5.00 | 10.0 | 1196.5 | 1214.8 | 9.15 | 1634.80 |
| 20.000 | 5.00 | 10.0 | 1188.2 | 1206.5 | 9.13 | 1634.78 |

Pond File: NMC9 .PND
Inflow Hydrograph: NMC9 .HYD
Outflow Hydrograph: OUT .HYD

| INFLOW HYDROGRAPH | | ROUTING COMPUTATIONS | | | | |
|---|---|---|---|---|---|---|
| TIME (hrs) | INFLOW (cfs) | I1+I2 (cfs) | 2S/t - O (cfs) | 2S/t + O (cfs) | OUTFLOW (cfs) | ELEVATION (ft) |
| 20.100 | 5.00 | 10.0 | 1180.0 | 1198.2 | 9.12 | 1634.76 |
| 20.200 | 5.00 | 10.0 | 1171.8 | 1190.0 | 9.10 | 1634.74 |
| 20.300 | 5.00 | 10.0 | 1163.6 | 1181.8 | 9.09 | 1634.72 |
| 20.400 | 5.00 | 10.0 | 1155.5 | 1173.6 | 9.07 | 1634.71 |
| 20.500 | 4.00 | 9.0 | 1146.4 | 1164.5 | 9.06 | 1634.69 |
| 20.600 | 4.00 | 8.0 | 1136.3 | 1154.4 | 9.04 | 1634.66 |
| 20.700 | 4.00 | 8.0 | 1126.2 | 1144.3 | 9.02 | 1634.64 |
| 20.800 | 4.00 | 8.0 | 1116.2 | 1134.2 | 9.00 | 1634.62 |
| 20.900 | 4.00 | 8.0 | 1106.3 | 1124.2 | 8.99 | 1634.60 |
| 21.000 | 4.00 | 8.0 | 1096.3 | 1114.3 | 8.97 | 1634.57 |
| 21.100 | 4.00 | 8.0 | 1086.4 | 1104.3 | 8.95 | 1634.55 |
| 21.200 | 4.00 | 8.0 | 1076.6 | 1094.4 | 8.93 | 1634.53 |
| 21.300 | 4.00 | 8.0 | 1066.7 | 1084.6 | 8.91 | 1634.51 |
| 21.400 | 4.00 | 8.0 | 1057.0 | 1074.7 | 8.84 | 1634.49 |
| 21.500 | 4.00 | 8.0 | 1048.1 | 1065.0 | 8.47 | 1634.47 |
| 21.600 | 3.00 | 7.0 | 1039.0 | 1055.1 | 8.08 | 1634.44 |
| 21.700 | 3.00 | 6.0 | 1029.6 | 1045.0 | 7.68 | 1634.42 |
| 21.800 | 3.00 | 6.0 | 1020.9 | 1035.6 | 7.32 | 1634.40 |
| 21.900 | 3.00 | 6.0 | 1013.0 | 1026.9 | 6.98 | 1634.38 |
| 22.000 | 3.00 | 6.0 | 1005.6 | 1019.0 | 6.67 | 1634.36 |
| 22.100 | 3.00 | 6.0 | 998.9 | 1011.6 | 6.39 | 1634.35 |
| 22.200 | 3.00 | 6.0 | 992.6 | 1004.9 | 6.12 | 1634.33 |
| 22.300 | 3.00 | 6.0 | 986.9 | 998.6 | 5.88 | 1634.32 |
| 22.400 | 3.00 | 6.0 | 981.6 | 992.9 | 5.65 | 1634.31 |
| 22.500 | 3.00 | 6.0 | 976.7 | 987.6 | 5.45 | 1634.30 |
| 22.600 | 3.00 | 6.0 | 972.1 | 982.7 | 5.26 | 1634.29 |
| 22.700 | 2.00 | 5.0 | 967.1 | 977.1 | 5.04 | 1634.27 |
| 22.800 | 2.00 | 4.0 | 961.4 | 971.1 | 4.81 | 1634.26 |
| 22.900 | 2.00 | 4.0 | 956.3 | 965.4 | 4.59 | 1634.25 |
| 23.000 | 2.00 | 4.0 | 951.5 | 960.3 | 4.39 | 1634.24 |
| 23.100 | 2.00 | 4.0 | 947.1 | 955.5 | 4.20 | 1634.23 |
| 23.200 | 2.00 | 4.0 | 943.0 | 951.1 | 4.03 | 1634.22 |
| 23.300 | 2.00 | 4.0 | 939.3 | 947.0 | 3.87 | 1634.21 |
| 23.400 | 2.00 | 4.0 | 935.9 | 943.3 | 3.72 | 1634.20 |
| 23.500 | 2.00 | 4.0 | 932.7 | 939.9 | 3.59 | 1634.19 |
| 23.600 | 2.00 | 4.0 | 929.7 | 936.7 | 3.47 | 1634.18 |
| 23.700 | 2.00 | 4.0 | 927.0 | 933.7 | 3.35 | 1634.18 |
| 23.800 | 2.00 | 4.0 | 924.5 | 931.0 | 3.25 | 1634.17 |
| 23.900 | 2.00 | 4.0 | 922.2 | 928.5 | 3.15 | 1634.17 |
| 24.000 | 2.00 | 4.0 | 920.1 | 926.2 | 3.06 | 1634.16 |
| 24.100 | 1.00 | 3.0 | 917.2 | 923.1 | 2.94 | 1634.16 |
| 24.200 | 1.00 | 2.0 | 913.7 | 919.2 | 2.79 | 1634.15 |
| 24.300 | 1.00 | 2.0 | 910.4 | 915.7 | 2.65 | 1634.14 |
| 24.400 | 1.00 | 2.0 | 907.3 | 912.4 | 2.52 | 1634.13 |
| 24.500 | 1.00 | 2.0 | 904.5 | 909.3 | 2.40 | 1634.12 |
| 24.600 | 1.00 | 2.0 | 901.9 | 906.5 | 2.29 | 1634.12 |

Pond File: NMC9 .PND
Inflow Hydrograph: NMC9 .HYD
Outflow Hydrograph: OUT .HYD

| INFLOW HYDROGRAPH | | ROUTING COMPUTATIONS | | | | |
|---|---|---|---|---|---|---|
| TIME (hrs) | INFLOW (cfs) | I1+I2 (cfs) | 2S/t - O (cfs) | 2S/t + O (cfs) | OUTFLOW (cfs) | ELEVATION (ft) |
| 24.700 | 1.00 | 2.0 | 899.6 | 903.9 | 2.19 | 1634.11 |
| 24.800 | 1.00 | 2.0 | 897.4 | 901.6 | 2.10 | 1634.11 |
| 24.900 | 1.00 | 2.0 | 895.3 | 899.4 | 2.01 | 1634.10 |
| 25.000 | 1.00 | 2.0 | 893.5 | 897.3 | 1.93 | 1634.10 |
| 25.100 | 1.00 | 2.0 | 891.8 | 895.5 | 1.86 | 1634.09 |
| 25.200 | 1.00 | 2.0 | 890.2 | 893.8 | 1.79 | 1634.09 |
| 25.300 | 1.00 | 2.0 | 888.7 | 892.2 | 1.73 | 1634.09 |
| 25.400 | 0.00 | 1.0 | 886.4 | 889.7 | 1.64 | 1634.08 |
| 25.500 | 0.00 | 0.0 | 883.4 | 886.4 | 1.51 | 1634.07 |
| 25.600 | 0.00 | 0.0 | 880.6 | 883.4 | 1.39 | 1634.07 |
| 25.700 | 0.00 | 0.0 | 878.1 | 880.6 | 1.28 | 1634.06 |
| 25.800 | 0.00 | 0.0 | 875.7 | 878.1 | 1.18 | 1634.06 |
| 25.900 | 0.00 | 0.0 | 873.5 | 875.7 | 1.09 | 1634.05 |

********** SUMMARY OF ROUTING COMPUTATIONS **********

Pond File: NMC9 .PND
Inflow Hydrograph: NMC9 .HYD
Outflow Hydrograph: OUT .HYD

Starting Pond W.S. Elevation = 1628.99 ft

***** Summary of Peak Outflow and Peak Elevation *****

| | | |
|---|---|---|
| Peak Inflow | = | 55.00 cfs |
| Peak Outflow | = | 9.46 cfs |
| Peak Elevation | = | 1635.25 ft |

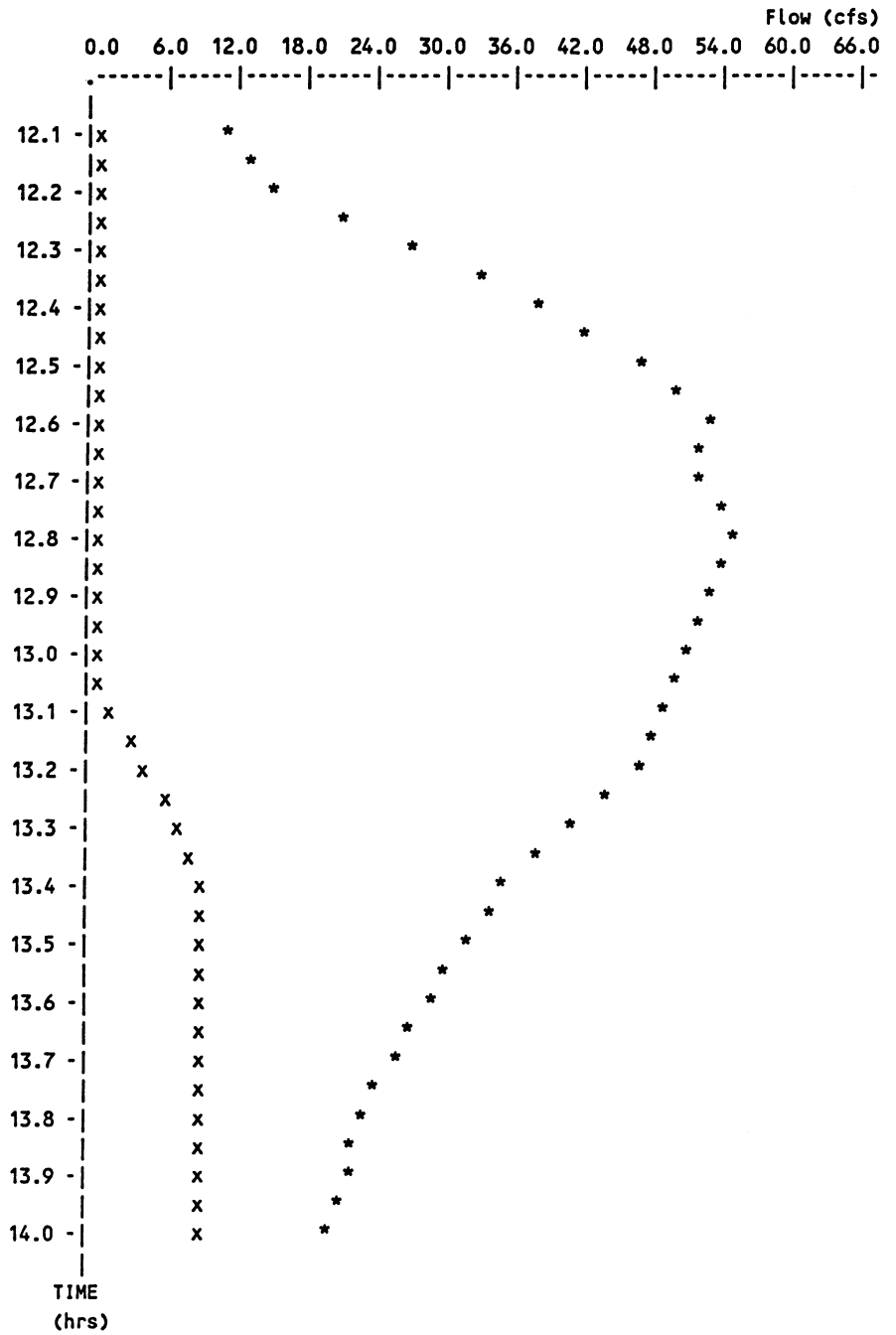
***** Summary of Approximate Peak Storage *****

| | | |
|---|---|---|
| Initial Storage | = | 0.00 ac-ft |
| Peak Storage From Storm | = | 5.83 ac-ft |
| Total Storage in Pond | = | 5.83 ac-ft |

Pond File: NMC9 .PND
Inflow Hydrograph: NMC9 .HYD
Outflow Hydrograph: OUT .HYD

EXECUTED: 12-10-1998
08:04:41

Peak Inflow = 55.00 cfs
Peak Outflow = 9.46 cfs
Peak Elevation = 1635.25 ft




* File: NMC9 .HYD Qmax = 55.0 cfs
x File: OUT .HYD Qmax = 9.5 cfs

```
**************************************************************************
*                                                                        *
* NICOLET MINING COMPANY          93C049          FOTH & VAN DYKE        *
*       TMA SED. BASIN 10                               12/98            *
*                                                                        *
*                                                                        *
*                                                                        *
**************************************************************************
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Inflow Hydrograph: NMC10 .HYD
Rating Table file: NMC10 .PND

----INITIAL CONDITIONS----
Elevation = 1690.00 ft
Outflow = 0.00 cfs
Storage = 0.00 ac-ft

| GIVEN POND DATA | | | INTERMEDIATE ROUTING COMPUTATIONS | |
|---|---|---|---|---|
| ELEVATION (ft) | OUTFLOW (cfs) | STORAGE (ac-ft) | 2S/t (cfs) | 2S/t + O (cfs) |
| 1690.00 | 0.0 | 0.000 | 0.0 | 0.0 |
| 1690.20 | 0.0 | 0.002 | 0.5 | 0.5 |
| 1690.40 | 0.0 | 0.004 | 1.1 | 1.1 |
| 1690.60 | 0.0 | 0.007 | 1.7 | 1.7 |
| 1690.80 | 0.0 | 0.010 | 2.5 | 2.5 |
| 1691.00 | 0.0 | 0.014 | 3.3 | 3.3 |
| 1691.20 | 0.0 | 0.018 | 4.3 | 4.3 |
| 1691.40 | 0.0 | 0.022 | 5.3 | 5.3 |
| 1691.60 | 0.0 | 0.027 | 6.5 | 6.5 |
| 1691.80 | 0.0 | 0.032 | 7.8 | 7.8 |
| 1692.00 | 0.0 | 0.038 | 9.2 | 9.2 |
| 1692.20 | 0.0 | 0.044 | 10.7 | 10.7 |
| 1692.40 | 0.0 | 0.051 | 12.4 | 12.4 |
| 1692.60 | 0.0 | 0.059 | 14.3 | 14.3 |
| 1692.80 | 0.0 | 0.067 | 16.3 | 16.3 |
| 1693.00 | 0.0 | 0.082 | 19.8 | 19.8 |
| 1693.20 | 0.0 | 0.403 | 97.6 | 97.6 |
| 1693.40 | 0.0 | 0.728 | 176.1 | 176.1 |
| 1693.60 | 0.0 | 1.055 | 255.4 | 255.4 |
| 1693.80 | 0.0 | 1.386 | 335.5 | 335.5 |
| 1694.00 | 7.6 | 1.720 | 416.4 | 424.0 |
| 1694.20 | 7.8 | 2.058 | 498.0 | 505.8 |
| 1694.40 | 7.9 | 2.399 | 580.5 | 588.4 |
| 1694.60 | 8.1 | 2.743 | 663.8 | 671.9 |
| 1694.80 | 11.2 | 3.091 | 747.9 | 759.1 |

Time increment (t) = 0.100 hrs.

Pond File: NMC10 .PND
Inflow Hydrograph: NMC10 .HYD
Outflow Hydrograph: OUT .HYD

| INFLOW HYDROGRAPH | | ROUTING COMPUTATIONS | | | | |
|---|---|---|---|---|---|---|
| TIME (hrs) | INFLOW (cfs) | I1+I2 (cfs) | 2S/t - O (cfs) | 2S/t + O (cfs) | OUTFLOW (cfs) | ELEVATION (ft) |
| 11.000 | 0.00 | ----- | 0.0 | 0.0 | 0.00 | 1690.00 |
| 11.100 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1690.00 |
| 11.200 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1690.00 |
| 11.300 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1690.00 |
| 11.400 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1690.00 |
| 11.500 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1690.00 |
| 11.600 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1690.00 |
| 11.700 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1690.00 |
| 11.800 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1690.00 |
| 11.900 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1690.00 |
| 12.000 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1690.00 |
| 12.100 | 2.00 | 2.0 | 2.0 | 2.0 | 0.00 | 1690.68 |
| 12.200 | 7.00 | 9.0 | 11.0 | 11.0 | 0.00 | 1692.23 |
| 12.300 | 16.00 | 23.0 | 34.0 | 34.0 | 0.00 | 1693.04 |
| 12.400 | 24.00 | 40.0 | 74.0 | 74.0 | 0.00 | 1693.14 |
| 12.500 | 29.00 | 53.0 | 127.0 | 127.0 | 0.00 | 1693.28 |
| 12.600 | 35.00 | 64.0 | 191.0 | 191.0 | 0.00 | 1693.44 |
| 12.700 | 37.00 | 72.0 | 263.0 | 263.0 | 0.00 | 1693.62 |
| 12.800 | 39.00 | 76.0 | 338.4 | 339.0 | 0.30 | 1693.81 |
| 12.900 | 36.00 | 75.0 | 400.0 | 413.4 | 6.69 | 1693.98 |
| 13.000 | 32.00 | 68.0 | 452.6 | 468.0 | 7.71 | 1694.11 |
| 13.100 | 28.00 | 60.0 | 497.0 | 512.6 | 7.81 | 1694.22 |
| 13.200 | 25.00 | 53.0 | 534.3 | 550.0 | 7.85 | 1694.31 |
| 13.300 | 22.00 | 47.0 | 565.5 | 581.3 | 7.89 | 1694.38 |
| 13.400 | 18.00 | 40.0 | 589.6 | 605.5 | 7.94 | 1694.44 |
| 13.500 | 16.00 | 34.0 | 607.7 | 623.6 | 7.98 | 1694.48 |
| 13.600 | 13.00 | 29.0 | 620.6 | 636.7 | 8.02 | 1694.52 |
| 13.700 | 12.00 | 25.0 | 629.5 | 645.6 | 8.04 | 1694.54 |
| 13.800 | 12.00 | 24.0 | 637.4 | 653.5 | 8.06 | 1694.56 |
| 13.900 | 10.00 | 22.0 | 643.3 | 659.4 | 8.07 | 1694.57 |
| 14.000 | 9.00 | 19.0 | 646.1 | 662.3 | 8.08 | 1694.58 |
| 14.100 | 9.00 | 18.0 | 648.0 | 664.1 | 8.08 | 1694.58 |
| 14.200 | 9.00 | 18.0 | 649.8 | 666.0 | 8.09 | 1694.59 |
| 14.300 | 9.00 | 18.0 | 651.6 | 667.8 | 8.09 | 1694.59 |
| 14.400 | 8.00 | 17.0 | 652.4 | 668.6 | 8.09 | 1694.59 |
| 14.500 | 8.00 | 16.0 | 652.3 | 668.4 | 8.09 | 1694.59 |
| 14.600 | 7.00 | 15.0 | 651.1 | 667.3 | 8.09 | 1694.59 |
| 14.700 | 6.00 | 13.0 | 647.9 | 664.1 | 8.08 | 1694.58 |
| 14.800 | 6.00 | 12.0 | 643.8 | 659.9 | 8.07 | 1694.57 |
| 14.900 | 5.00 | 11.0 | 638.7 | 654.8 | 8.06 | 1694.56 |
| 15.000 | 5.00 | 10.0 | 632.6 | 648.7 | 8.04 | 1694.54 |
| 15.100 | 5.00 | 10.0 | 626.5 | 642.6 | 8.03 | 1694.53 |
| 15.200 | 5.00 | 10.0 | 620.5 | 636.5 | 8.02 | 1694.52 |
| 15.300 | 5.00 | 10.0 | 614.5 | 630.5 | 8.00 | 1694.50 |
| 15.400 | 5.00 | 10.0 | 608.5 | 624.5 | 7.99 | 1694.49 |

Pond File: NMC10 .PND
Inflow Hydrograph: NMC10 .HYD
Outflow Hydrograph: OUT .HYD

| INFLOW HYDROGRAPH | | ROUTING COMPUTATIONS | | | | |
|---|---|---|---|---|---|---|
| TIME (hrs) | INFLOW (cfs) | I1+I2 (cfs) | 2S/t - O (cfs) | 2S/t + O (cfs) | OUTFLOW (cfs) | ELEVATION (ft) |
| 15.500 | 5.00 | 10.0 | 602.6 | 618.5 | 7.97 | 1694.47 |
| 15.600 | 5.00 | 10.0 | 596.6 | 612.6 | 7.96 | 1694.46 |
| 15.700 | 5.00 | 10.0 | 590.8 | 606.6 | 7.94 | 1694.44 |
| 15.800 | 5.00 | 10.0 | 584.9 | 600.8 | 7.93 | 1694.43 |
| 15.900 | 5.00 | 10.0 | 579.1 | 594.9 | 7.92 | 1694.42 |
| 16.000 | 5.00 | 10.0 | 573.3 | 589.1 | 7.90 | 1694.40 |
| 16.100 | 5.00 | 10.0 | 567.5 | 583.3 | 7.89 | 1694.39 |
| 16.200 | 5.00 | 10.0 | 561.7 | 577.5 | 7.89 | 1694.37 |
| 16.300 | 5.00 | 10.0 | 555.9 | 571.7 | 7.88 | 1694.36 |
| 16.400 | 5.00 | 10.0 | 550.2 | 565.9 | 7.87 | 1694.35 |
| 16.500 | 5.00 | 10.0 | 544.5 | 560.2 | 7.87 | 1694.33 |
| 16.600 | 5.00 | 10.0 | 538.8 | 554.5 | 7.86 | 1694.32 |
| 16.700 | 5.00 | 10.0 | 533.0 | 548.8 | 7.85 | 1694.30 |
| 16.800 | 4.00 | 9.0 | 526.4 | 542.0 | 7.84 | 1694.29 |
| 16.900 | 4.00 | 8.0 | 518.7 | 534.4 | 7.83 | 1694.27 |
| 17.000 | 4.00 | 8.0 | 511.0 | 526.7 | 7.83 | 1694.25 |
| 17.100 | 4.00 | 8.0 | 503.4 | 519.0 | 7.82 | 1694.23 |
| 17.200 | 4.00 | 8.0 | 495.8 | 511.4 | 7.81 | 1694.21 |
| 17.300 | 4.00 | 8.0 | 488.2 | 503.8 | 7.80 | 1694.20 |
| 17.400 | 4.00 | 8.0 | 480.7 | 496.2 | 7.78 | 1694.18 |
| 17.500 | 4.00 | 8.0 | 473.1 | 488.7 | 7.76 | 1694.16 |
| 17.600 | 4.00 | 8.0 | 465.7 | 481.1 | 7.74 | 1694.14 |
| 17.700 | 4.00 | 8.0 | 458.2 | 473.7 | 7.72 | 1694.12 |
| 17.800 | 4.00 | 8.0 | 450.8 | 466.2 | 7.70 | 1694.10 |
| 17.900 | 4.00 | 8.0 | 443.4 | 458.8 | 7.69 | 1694.09 |
| 18.000 | 4.00 | 8.0 | 436.1 | 451.4 | 7.67 | 1694.07 |
| 18.100 | 4.00 | 8.0 | 428.8 | 444.1 | 7.65 | 1694.05 |
| 18.200 | 4.00 | 8.0 | 421.5 | 436.8 | 7.63 | 1694.03 |
| 18.300 | 4.00 | 8.0 | 414.3 | 429.5 | 7.61 | 1694.01 |
| 18.400 | 4.00 | 8.0 | 407.4 | 422.3 | 7.46 | 1694.00 |
| 18.500 | 4.00 | 8.0 | 401.7 | 415.4 | 6.86 | 1693.98 |
| 18.600 | 4.00 | 8.0 | 396.9 | 409.7 | 6.37 | 1693.97 |
| 18.700 | 4.00 | 8.0 | 393.0 | 404.9 | 5.96 | 1693.96 |
| 18.800 | 4.00 | 8.0 | 389.7 | 401.0 | 5.63 | 1693.95 |
| 18.900 | 4.00 | 8.0 | 387.0 | 397.7 | 5.35 | 1693.94 |
| 19.000 | 4.00 | 8.0 | 384.8 | 395.0 | 5.12 | 1693.93 |
| 19.100 | 4.00 | 8.0 | 383.0 | 392.8 | 4.92 | 1693.93 |
| 19.200 | 4.00 | 8.0 | 381.4 | 391.0 | 4.77 | 1693.93 |
| 19.300 | 4.00 | 8.0 | 380.2 | 389.4 | 4.63 | 1693.92 |
| 19.400 | 4.00 | 8.0 | 379.1 | 388.2 | 4.53 | 1693.92 |
| 19.500 | 4.00 | 8.0 | 378.2 | 387.1 | 4.43 | 1693.92 |
| 19.600 | 4.00 | 8.0 | 377.5 | 386.2 | 4.36 | 1693.91 |
| 19.700 | 4.00 | 8.0 | 376.9 | 385.5 | 4.30 | 1693.91 |
| 19.800 | 4.00 | 8.0 | 376.4 | 384.9 | 4.25 | 1693.91 |
| 19.900 | 4.00 | 8.0 | 376.0 | 384.4 | 4.20 | 1693.91 |
| 20.000 | 4.00 | 8.0 | 375.7 | 384.0 | 4.17 | 1693.91 |

Pond File: NMC10 .PND
Inflow Hydrograph: NMC10 .HYD
Outflow Hydrograph: OUT .HYD

| INFLOW HYDROGRAPH | | ROUTING COMPUTATIONS | | | | |
|---|---|---|---|---|---|---|
| TIME (hrs) | INFLOW (cfs) | I1+I2 (cfs) | 2S/t - O (cfs) | 2S/t + O (cfs) | OUTFLOW (cfs) | ELEVATION (ft) |
| 20.100 | 4.00 | 8.0 | 375.4 | 383.7 | 4.14 | 1693.91 |
| 20.200 | 4.00 | 8.0 | 375.2 | 383.4 | 4.12 | 1693.91 |
| 20.300 | 4.00 | 8.0 | 375.0 | 383.2 | 4.10 | 1693.91 |
| 20.400 | 4.00 | 8.0 | 374.8 | 383.0 | 4.08 | 1693.91 |
| 20.500 | 4.00 | 8.0 | 374.7 | 382.8 | 4.07 | 1693.91 |
| 20.600 | 4.00 | 8.0 | 374.6 | 382.7 | 4.05 | 1693.91 |
| 20.700 | 4.00 | 8.0 | 374.5 | 382.6 | 4.05 | 1693.91 |
| 20.800 | 4.00 | 8.0 | 374.4 | 382.5 | 4.04 | 1693.91 |
| 20.900 | 4.00 | 8.0 | 374.3 | 382.4 | 4.03 | 1693.91 |
| 21.000 | 4.00 | 8.0 | 374.3 | 382.3 | 4.03 | 1693.91 |
| 21.100 | 3.00 | 7.0 | 373.4 | 381.3 | 3.94 | 1693.90 |
| 21.200 | 3.00 | 6.0 | 371.9 | 379.4 | 3.77 | 1693.90 |
| 21.300 | 3.00 | 6.0 | 370.6 | 377.9 | 3.64 | 1693.90 |
| 21.400 | 3.00 | 6.0 | 369.5 | 376.6 | 3.53 | 1693.89 |
| 21.500 | 3.00 | 6.0 | 368.6 | 375.5 | 3.44 | 1693.89 |
| 21.600 | 3.00 | 6.0 | 367.9 | 374.6 | 3.36 | 1693.89 |
| 21.700 | 3.00 | 6.0 | 367.3 | 373.9 | 3.30 | 1693.89 |
| 21.800 | 3.00 | 6.0 | 366.8 | 373.3 | 3.25 | 1693.89 |
| 21.900 | 3.00 | 6.0 | 366.4 | 372.8 | 3.21 | 1693.88 |
| 22.000 | 3.00 | 6.0 | 366.1 | 372.4 | 3.17 | 1693.88 |
| 22.100 | 3.00 | 6.0 | 365.8 | 372.1 | 3.14 | 1693.88 |
| 22.200 | 3.00 | 6.0 | 365.5 | 371.8 | 3.12 | 1693.88 |
| 22.300 | 3.00 | 6.0 | 365.3 | 371.5 | 3.10 | 1693.88 |
| 22.400 | 3.00 | 6.0 | 365.2 | 371.3 | 3.08 | 1693.88 |
| 22.500 | 3.00 | 6.0 | 365.0 | 371.2 | 3.07 | 1693.88 |
| 22.600 | 3.00 | 6.0 | 364.9 | 371.0 | 3.06 | 1693.88 |
| 22.700 | 2.00 | 5.0 | 364.0 | 369.9 | 2.96 | 1693.88 |
| 22.800 | 2.00 | 4.0 | 362.4 | 368.0 | 2.79 | 1693.87 |
| 22.900 | 2.00 | 4.0 | 361.1 | 366.4 | 2.66 | 1693.87 |
| 23.000 | 2.00 | 4.0 | 360.0 | 365.1 | 2.55 | 1693.87 |
| 23.100 | 2.00 | 4.0 | 359.1 | 364.0 | 2.45 | 1693.86 |
| 23.200 | 2.00 | 4.0 | 358.4 | 363.1 | 2.37 | 1693.86 |
| 23.300 | 2.00 | 4.0 | 357.8 | 362.4 | 2.31 | 1693.86 |
| 23.400 | 2.00 | 4.0 | 357.2 | 361.8 | 2.26 | 1693.86 |
| 23.500 | 2.00 | 4.0 | 356.8 | 361.2 | 2.21 | 1693.86 |
| 23.600 | 2.00 | 4.0 | 356.5 | 360.8 | 2.18 | 1693.86 |
| 23.700 | 2.00 | 4.0 | 356.2 | 360.5 | 2.15 | 1693.86 |
| 23.800 | 2.00 | 4.0 | 355.9 | 360.2 | 2.12 | 1693.86 |
| 23.900 | 2.00 | 4.0 | 355.7 | 359.9 | 2.10 | 1693.86 |
| 24.000 | 2.00 | 4.0 | 355.6 | 359.7 | 2.08 | 1693.85 |
| 24.100 | 1.00 | 3.0 | 354.6 | 358.6 | 1.98 | 1693.85 |
| 24.200 | 1.00 | 2.0 | 353.0 | 356.6 | 1.81 | 1693.85 |
| 24.300 | 1.00 | 2.0 | 351.6 | 355.0 | 1.67 | 1693.84 |
| 24.400 | 1.00 | 2.0 | 350.5 | 353.6 | 1.56 | 1693.84 |
| 24.500 | 1.00 | 2.0 | 349.6 | 352.5 | 1.46 | 1693.84 |
| 24.600 | 1.00 | 2.0 | 348.8 | 351.6 | 1.38 | 1693.84 |

Pond File: NMC10 .PND
Inflow Hydrograph: NMC10 .HYD
Outflow Hydrograph: OUT .HYD

| INFLOW HYDROGRAPH | | ROUTING COMPUTATIONS | | | | |
|---|---|---|---|---|---|---|
| TIME (hrs) | INFLOW (cfs) | I1+I2 (cfs) | 2S/t - O (cfs) | 2S/t + O (cfs) | OUTFLOW (cfs) | ELEVATION (ft) |
| 24.700 | 1.00 | 2.0 | 348.2 | 350.8 | 1.32 | 1693.83 |
| 24.800 | 1.00 | 2.0 | 347.7 | 350.2 | 1.26 | 1693.83 |
| 24.900 | 1.00 | 2.0 | 347.2 | 349.7 | 1.22 | 1693.83 |
| 25.000 | 1.00 | 2.0 | 346.9 | 349.2 | 1.18 | 1693.83 |
| 25.100 | 1.00 | 2.0 | 346.6 | 348.9 | 1.15 | 1693.83 |
| 25.200 | 1.00 | 2.0 | 346.3 | 348.6 | 1.12 | 1693.83 |
| 25.300 | 1.00 | 2.0 | 346.1 | 348.3 | 1.10 | 1693.83 |
| 25.400 | 0.00 | 1.0 | 345.1 | 347.1 | 1.00 | 1693.83 |
| 25.500 | 0.00 | 0.0 | 343.5 | 345.1 | 0.83 | 1693.82 |
| 25.600 | 0.00 | 0.0 | 342.1 | 343.5 | 0.69 | 1693.82 |
| 25.700 | 0.00 | 0.0 | 341.0 | 342.1 | 0.57 | 1693.81 |
| 25.800 | 0.00 | 0.0 | 340.0 | 341.0 | 0.47 | 1693.81 |
| 25.900 | 0.00 | 0.0 | 339.2 | 340.0 | 0.39 | 1693.81 |

********** SUMMARY OF ROUTING COMPUTATIONS **********

Pond File: NMC10 .PND
Inflow Hydrograph: NMC10 .HYD
Outflow Hydrograph: OUT .HYD

Starting Pond W.S. Elevation = 1690.00 ft

***** Summary of Peak Outflow and Peak Elevation *****

| | | |
|---|---|---|
| Peak Inflow | = | 39.00 cfs |
| Peak Outflow | = | 8.09 cfs |
| Peak Elevation | = | 1694.59 ft |

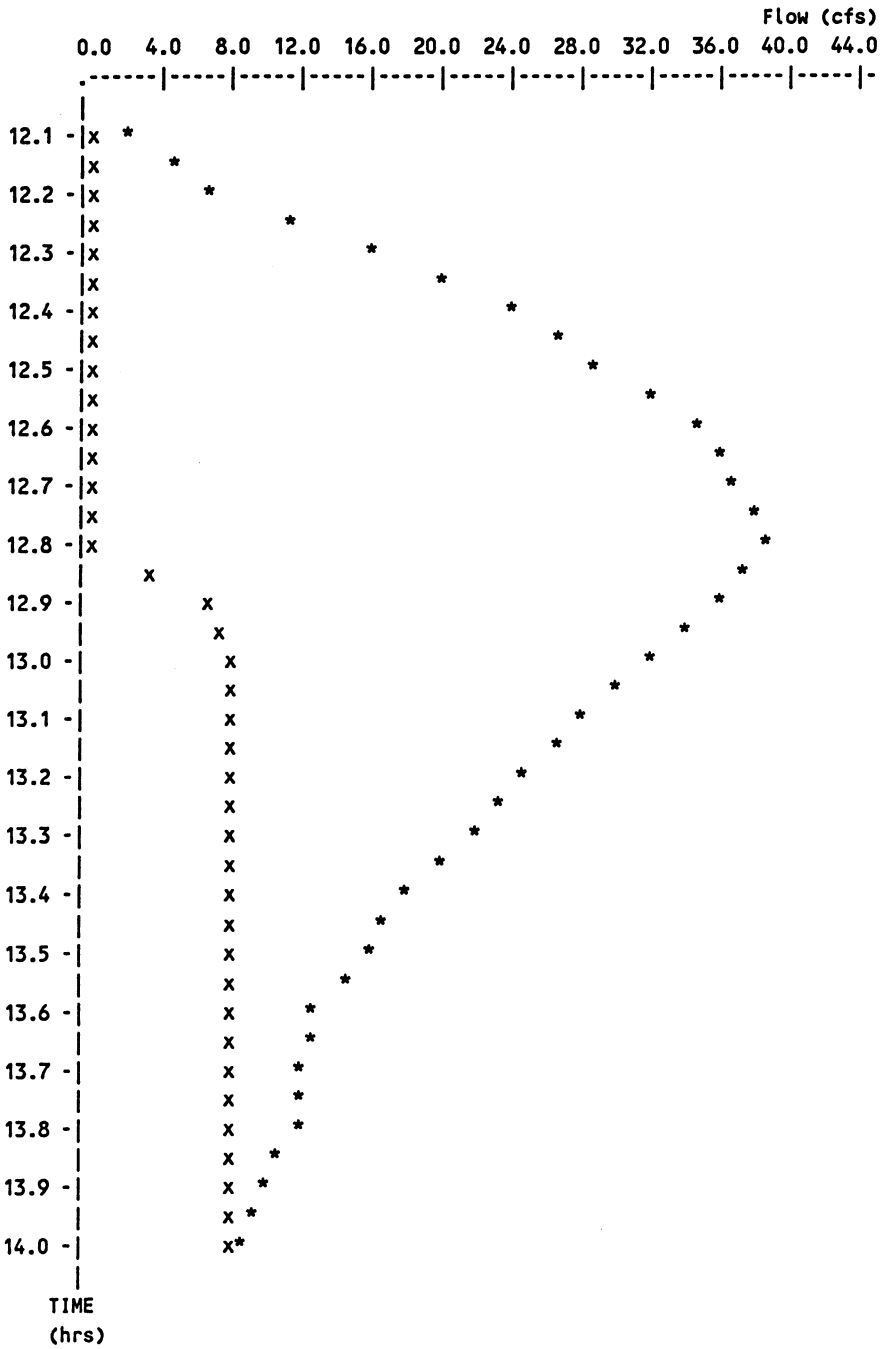
***** Summary of Approximate Peak Storage *****

| | | |
|---|---|---|
| Initial Storage | = | 0.00 ac-ft |
| Peak Storage From Storm | = | 2.73 ac-ft |
| Total Storage in Pond | = | 2.73 ac-ft |

Pond File: NMC10 .PND
Inflow Hydrograph: NMC10 .HYD
Outflow Hydrograph: OUT .HYD

EXECUTED: 12-07-1998
09:04:27

Peak Inflow = 39.00 cfs
Peak Outflow = 8.09 cfs
Peak Elevation = 1694.59 ft




* File: NMC10 .HYD Qmax = 39.0 cfs
x File: OUT .HYD Qmax = 8.1 cfs

```
**************************************************************************
*                                                                        *
* NICOLET MINING COMPANY          93C049          FOTH & VAN DYKE        *
*       TMA SED. BASIN 11                               12/98            *
*                                                                        *
*                                                                        *
*                                                                        *
**************************************************************************
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Inflow Hydrograph: NMC11 .HYD
Rating Table file: NMC11 .PND

----INITIAL CONDITIONS----
Elevation = 1697.99 ft
Outflow = 0.00 cfs
Storage = 0.00 ac-ft

| GIVEN POND DATA | | | INTERMEDIATE ROUTING COMPUTATIONS | |
|---|---|---|---|---|
| ELEVATION (ft) | OUTFLOW (cfs) | STORAGE (ac-ft) | 2S/t (cfs) | 2S/t + O (cfs) |
| 1697.99 | 0.0 | 0.000 | 0.0 | 0.0 |
| 1698.19 | 0.0 | 0.002 | 0.5 | 0.5 |
| 1698.39 | 0.0 | 0.004 | 1.0 | 1.0 |
| 1698.59 | 0.0 | 0.007 | 1.7 | 1.7 |
| 1698.79 | 0.0 | 0.010 | 2.4 | 2.4 |
| 1698.99 | 0.0 | 0.013 | 3.3 | 3.3 |
| 1699.19 | 0.0 | 0.017 | 4.2 | 4.2 |
| 1699.39 | 0.0 | 0.022 | 5.3 | 5.3 |
| 1699.59 | 0.0 | 0.027 | 6.4 | 6.4 |
| 1699.79 | 0.0 | 0.032 | 7.7 | 7.7 |
| 1699.99 | 0.0 | 0.038 | 9.1 | 9.1 |
| 1700.19 | 0.0 | 0.044 | 10.7 | 10.7 |
| 1700.39 | 0.0 | 0.051 | 12.3 | 12.3 |
| 1700.59 | 0.0 | 0.059 | 14.2 | 14.2 |
| 1700.79 | 0.0 | 0.067 | 16.2 | 16.2 |
| 1700.99 | 0.0 | 0.076 | 18.3 | 18.3 |
| 1701.19 | 0.0 | 0.127 | 30.6 | 30.6 |
| 1701.39 | 0.0 | 0.181 | 43.7 | 43.7 |
| 1701.59 | 0.0 | 0.237 | 57.3 | 57.3 |
| 1701.79 | 0.0 | 0.294 | 71.3 | 71.3 |
| 1701.99 | 0.0 | 0.354 | 85.7 | 85.7 |
| 1702.19 | 0.0 | 0.416 | 100.6 | 100.6 |
| 1702.39 | 0.0 | 0.479 | 116.0 | 116.0 |
| 1702.59 | 0.0 | 0.545 | 131.9 | 131.9 |
| 1702.79 | 0.0 | 0.613 | 148.3 | 148.3 |
| 1702.99 | 0.0 | 0.683 | 165.2 | 165.2 |
| 1703.19 | 8.6 | 0.754 | 182.6 | 191.2 |
| 1703.39 | 8.8 | 0.828 | 200.5 | 209.3 |
| 1703.59 | 8.9 | 0.905 | 218.9 | 227.8 |
| 1703.79 | 9.1 | 0.983 | 237.9 | 247.0 |
| 1703.99 | 9.3 | 1.064 | 257.4 | 266.7 |

GIVEN POND DATA

| ELEVATION (ft) | OUTFLOW (cfs) | STORAGE (ac-ft) |
|---|---|---|
| 1704.19 | 9.4 | 1.146 |
| 1704.39 | 9.6 | 1.232 |
| 1704.59 | 10.5 | 1.319 |
| 1704.79 | 14.9 | 1.409 |
| 1704.99 | 21.7 | 1.501 |

INTERMEDIATE ROUTING COMPUTATIONS

| 2S/t (cfs) | 2S/t + O (cfs) |
|---|---|
| 277.4 | 286.8 |
| 298.1 | 307.7 |
| 319.2 | 329.7 |
| 341.0 | 355.9 |
| 363.3 | 385.0 |

Time increment (t) = 0.100 hrs.

Pond File: NMC11 .PND
Inflow Hydrograph: NMC11 .HYD
Outflow Hydrograph: OUT .HYD

| INFLOW HYDROGRAPH | | ROUTING COMPUTATIONS | | | | |
|---|---|---|---|---|---|---|
| TIME (hrs) | INFLOW (cfs) | I1+I2 (cfs) | 2S/t - O (cfs) | 2S/t + O (cfs) | OUTFLOW (cfs) | ELEVATION (ft) |
| 11.000 | 0.00 | ----- | 0.0 | 0.0 | 0.00 | 1697.99 |
| 11.100 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1697.99 |
| 11.200 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1697.99 |
| 11.300 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1697.99 |
| 11.400 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1697.99 |
| 11.500 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1697.99 |
| 11.600 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1697.99 |
| 11.700 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1697.99 |
| 11.800 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1697.99 |
| 11.900 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1697.99 |
| 12.000 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1697.99 |
| 12.100 | 2.00 | 2.0 | 2.0 | 2.0 | 0.00 | 1698.67 |
| 12.200 | 5.00 | 7.0 | 9.0 | 9.0 | 0.00 | 1699.97 |
| 12.300 | 9.00 | 14.0 | 23.0 | 23.0 | 0.00 | 1701.07 |
| 12.400 | 13.00 | 22.0 | 45.0 | 45.0 | 0.00 | 1701.41 |
| 12.500 | 13.00 | 26.0 | 71.0 | 71.0 | 0.00 | 1701.79 |
| 12.600 | 11.00 | 24.0 | 95.0 | 95.0 | 0.00 | 1702.11 |
| 12.700 | 9.00 | 20.0 | 115.0 | 115.0 | 0.00 | 1702.38 |
| 12.800 | 7.00 | 16.0 | 131.0 | 131.0 | 0.00 | 1702.58 |
| 12.900 | 6.00 | 13.0 | 144.0 | 144.0 | 0.00 | 1702.74 |
| 13.000 | 5.00 | 11.0 | 155.0 | 155.0 | 0.00 | 1702.87 |
| 13.100 | 4.00 | 9.0 | 164.0 | 164.0 | 0.00 | 1702.98 |
| 13.200 | 4.00 | 8.0 | 167.5 | 172.0 | 2.26 | 1703.04 |
| 13.300 | 4.00 | 8.0 | 168.7 | 175.5 | 3.41 | 1703.07 |
| 13.400 | 3.00 | 7.0 | 168.7 | 175.7 | 3.47 | 1703.07 |
| 13.500 | 3.00 | 6.0 | 168.4 | 174.7 | 3.16 | 1703.06 |
| 13.600 | 2.00 | 5.0 | 168.0 | 173.4 | 2.72 | 1703.05 |
| 13.700 | 2.00 | 4.0 | 167.5 | 172.0 | 2.24 | 1703.04 |
| 13.800 | 2.00 | 4.0 | 167.3 | 171.5 | 2.08 | 1703.04 |
| 13.900 | 2.00 | 4.0 | 167.3 | 171.3 | 2.03 | 1703.04 |
| 14.000 | 2.00 | 4.0 | 167.2 | 171.3 | 2.01 | 1703.04 |
| 14.100 | 2.00 | 4.0 | 167.2 | 171.2 | 2.00 | 1703.04 |
| 14.200 | 2.00 | 4.0 | 167.2 | 171.2 | 2.00 | 1703.04 |
| 14.300 | 2.00 | 4.0 | 167.2 | 171.2 | 2.00 | 1703.04 |
| 14.400 | 2.00 | 4.0 | 167.2 | 171.2 | 2.00 | 1703.04 |
| 14.500 | 1.00 | 3.0 | 166.9 | 170.2 | 1.67 | 1703.03 |
| 14.600 | 1.00 | 2.0 | 166.4 | 168.9 | 1.23 | 1703.02 |
| 14.700 | 1.00 | 2.0 | 166.3 | 168.4 | 1.08 | 1703.02 |
| 14.800 | 1.00 | 2.0 | 166.2 | 168.3 | 1.03 | 1703.01 |
| 14.900 | 1.00 | 2.0 | 166.2 | 168.2 | 1.01 | 1703.01 |
| 15.000 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 15.100 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 15.200 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 15.300 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 15.400 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |

Pond File: NMC11 .PND
Inflow Hydrograph: NMC11 .HYD
Outflow Hydrograph: OUT .HYD

| INFLOW HYDROGRAPH | | ROUTING COMPUTATIONS | | | | |
|---|---|---|---|---|---|---|
| TIME (hrs) | INFLOW (cfs) | I1+I2 (cfs) | 2S/t - O (cfs) | 2S/t + O (cfs) | OUTFLOW (cfs) | ELEVATION (ft) |
| 15.500 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 15.600 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 15.700 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 15.800 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 15.900 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 16.000 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 16.100 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 16.200 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 16.300 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 16.400 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 16.500 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 16.600 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 16.700 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 16.800 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 16.900 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 17.000 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 17.100 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 17.200 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 17.300 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 17.400 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 17.500 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 17.600 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 17.700 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 17.800 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 17.900 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 18.000 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 18.100 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 18.200 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 18.300 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 18.400 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 18.500 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 18.600 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 18.700 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 18.800 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 18.900 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 19.000 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 19.100 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 19.200 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 19.300 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 19.400 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 19.500 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 19.600 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 19.700 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 19.800 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 19.900 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 20.000 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |

Pond File: NMC11 .PND
Inflow Hydrograph: NMC11 .HYD
Outflow Hydrograph: OUT .HYD

| INFLOW HYDROGRAPH | | ROUTING COMPUTATIONS | | | | |
|---|---|---|---|---|---|---|
| TIME (hrs) | INFLOW (cfs) | I1+I2 (cfs) | 2S/t - O (cfs) | 2S/t + O (cfs) | OUTFLOW (cfs) | ELEVATION (ft) |
| 20.100 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 20.200 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 20.300 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 20.400 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 20.500 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 20.600 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 20.700 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 20.800 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 20.900 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 21.000 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 21.100 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 21.200 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 21.300 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 21.400 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 21.500 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 21.600 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 21.700 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 21.800 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 21.900 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 22.000 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 22.100 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 22.200 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 22.300 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 22.400 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 22.500 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 22.600 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 22.700 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 22.800 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 22.900 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 23.000 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 23.100 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 23.200 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 23.300 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 23.400 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 23.500 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 23.600 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 23.700 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 23.800 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 23.900 | 1.00 | 2.0 | 166.2 | 168.2 | 1.00 | 1703.01 |
| 24.000 | 0.00 | 1.0 | 165.9 | 167.2 | 0.67 | 1703.01 |
| 24.100 | 0.00 | 0.0 | 165.4 | 165.9 | 0.23 | 1703.00 |
| 24.200 | 0.00 | 0.0 | 165.3 | 165.4 | 0.08 | 1702.99 |
| 24.300 | 0.00 | 0.0 | 165.2 | 165.3 | 0.03 | 1702.99 |
| 24.400 | 0.00 | 0.0 | 165.2 | 165.2 | 0.01 | 1702.99 |
| 24.500 | 0.00 | 0.0 | 165.2 | 165.2 | 0.00 | 1702.99 |
| 24.600 | 0.00 | 0.0 | 165.2 | 165.2 | 0.00 | 1702.99 |

Pond File: NMC11 .PND
Inflow Hydrograph: NMC11 .HYD
Outflow Hydrograph: OUT .HYD

| INFLOW HYDROGRAPH | | ROUTING COMPUTATIONS | | | | |
|---|---|---|---|---|---|---|
| TIME (hrs) | INFLOW (cfs) | I1+I2 (cfs) | 2S/t - O (cfs) | 2S/t + O (cfs) | OUTFLOW (cfs) | ELEVATION (ft) |
| 24.700 | 0.00 | 0.0 | 165.2 | 165.2 | 0.00 | 1702.99 |
| 24.800 | 0.00 | 0.0 | 165.2 | 165.2 | 0.00 | 1702.99 |
| 24.900 | 0.00 | 0.0 | 165.2 | 165.2 | 0.00 | 1702.99 |
| 25.000 | 0.00 | 0.0 | 165.2 | 165.2 | 0.00 | 1702.99 |
| 25.100 | 0.00 | 0.0 | 165.2 | 165.2 | 0.00 | 1702.99 |
| 25.200 | 0.00 | 0.0 | 165.2 | 165.2 | 0.00 | 1702.99 |
| 25.300 | 0.00 | 0.0 | 165.2 | 165.2 | 0.00 | 1702.99 |
| 25.400 | 0.00 | 0.0 | 165.2 | 165.2 | 0.00 | 1702.99 |
| 25.500 | 0.00 | 0.0 | 165.2 | 165.2 | 0.00 | 1702.99 |
| 25.600 | 0.00 | 0.0 | 165.2 | 165.2 | 0.00 | 1702.99 |
| 25.700 | 0.00 | 0.0 | 165.2 | 165.2 | 0.00 | 1702.99 |
| 25.800 | 0.00 | 0.0 | 165.2 | 165.2 | 0.00 | 1702.99 |
| 25.900 | 0.00 | 0.0 | 165.2 | 165.2 | 0.00 | 1702.99 |

********** SUMMARY OF ROUTING COMPUTATIONS **********

Pond File: NMC11 .PND
Inflow Hydrograph: NMC11 .HYD
Outflow Hydrograph: OUT .HYD

Starting Pond W.S. Elevation = 1697.99 ft

***** Summary of Peak Outflow and Peak Elevation *****

Peak Inflow = 13.00 cfs
Peak Outflow = 3.47 cfs
Peak Elevation = 1703.07 ft

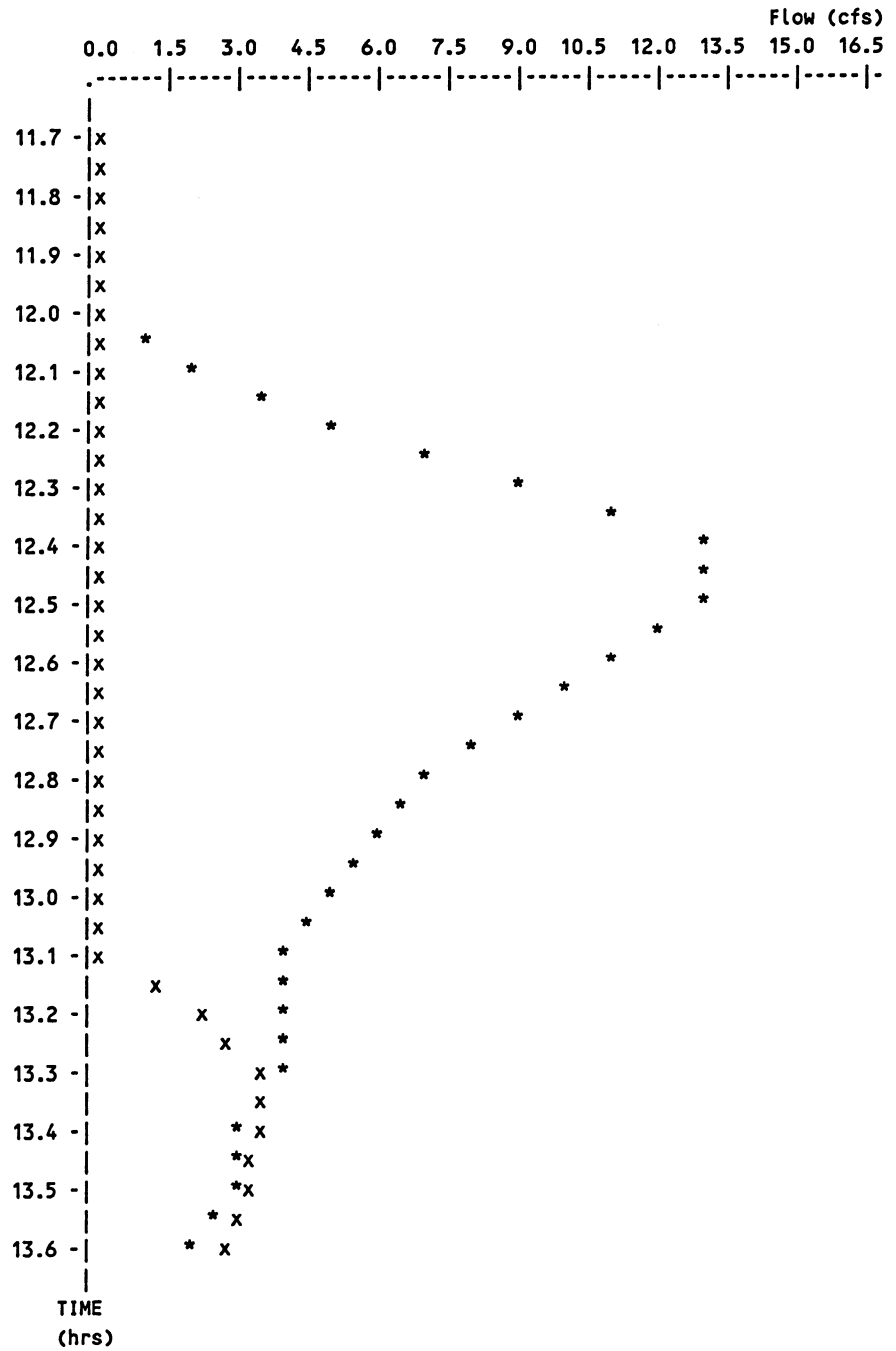
***** Summary of Approximate Peak Storage *****

| | | |
|---|---|---|
| Initial Storage | = | 0.00 ac-ft |
| Peak Storage From Storm | = | 0.71 ac-ft |
| Total Storage in Pond | = | 0.71 ac-ft |

Pond File: NMC11 .PND
Inflow Hydrograph: NMC11 .HYD
Outflow Hydrograph: OUT .HYD

EXECUTED: 12-07-1998
09:08:40

Peak Inflow = 13.00 cfs
Peak Outflow = 3.47 cfs
Peak Elevation = 1703.07 ft




* File: NMC11 .HYD Qmax = 13.0 cfs
x File: OUT .HYD Qmax = 3.5 cfs

```
*********************************************
*                                           *
*   NICOLET MINING COMPANY          12/98   *
*             TMA SED. BASIN 12             *
*  FOTH AND VAN DYKE                93C049  *
*                                           *
*                                           *
*********************************************
```

Inflow Hydrograph: NMC12 .HYD
Rating Table file: NMC12 .PND

----INITIAL CONDITIONS----
Elevation = 1617.99 ft
Outflow = 0.00 cfs
Storage = 0.00 ac-ft

| GIVEN POND DATA | | | INTERMEDIATE ROUTING COMPUTATIONS | |
|---|---|---|---|---|
| ELEVATION (ft) | OUTFLOW (cfs) | STORAGE (ac-ft) | 2S/t (cfs) | 2S/t + O (cfs) |
| 1617.99 | 0.0 | 0.000 | 0.0 | 0.0 |
| 1618.19 | 0.0 | 0.002 | 0.5 | 0.5 |
| 1618.39 | 0.0 | 0.004 | 1.0 | 1.0 |
| 1618.59 | 0.0 | 0.007 | 1.7 | 1.7 |
| 1618.79 | 0.0 | 0.010 | 2.4 | 2.4 |
| 1618.99 | 0.0 | 0.013 | 3.3 | 3.3 |
| 1619.19 | 0.0 | 0.017 | 4.2 | 4.2 |
| 1619.39 | 0.0 | 0.022 | 5.3 | 5.3 |
| 1619.59 | 0.0 | 0.027 | 6.4 | 6.4 |
| 1619.79 | 0.0 | 0.032 | 7.7 | 7.7 |
| 1619.99 | 0.0 | 0.038 | 9.1 | 9.1 |
| 1620.19 | 0.0 | 0.044 | 10.7 | 10.7 |
| 1620.39 | 0.0 | 0.051 | 12.3 | 12.3 |
| 1620.59 | 0.0 | 0.059 | 14.2 | 14.2 |
| 1620.79 | 0.0 | 0.067 | 16.2 | 16.2 |
| 1620.99 | 0.0 | 0.076 | 18.3 | 18.3 |
| 1621.19 | 0.0 | 0.170 | 41.1 | 41.1 |
| 1621.39 | 0.0 | 0.270 | 65.3 | 65.3 |
| 1621.59 | 0.0 | 0.373 | 90.2 | 90.2 |
| 1621.79 | 0.0 | 0.479 | 115.9 | 115.9 |
| 1621.99 | 0.0 | 0.588 | 142.4 | 142.4 |
| 1622.19 | 0.0 | 0.701 | 169.6 | 169.6 |
| 1622.39 | 0.0 | 0.817 | 197.7 | 197.7 |
| 1622.59 | 0.0 | 0.936 | 226.5 | 226.5 |
| 1622.79 | 0.0 | 1.059 | 256.2 | 256.2 |
| 1622.99 | 0.0 | 1.185 | 286.7 | 286.7 |
| 1623.19 | 0.0 | 1.314 | 318.0 | 318.0 |
| 1623.39 | 0.0 | 1.447 | 350.2 | 350.2 |
| 1623.59 | 0.0 | 1.584 | 383.3 | 383.3 |
| 1623.79 | 0.0 | 1.724 | 417.2 | 417.2 |
| 1623.99 | 0.0 | 1.868 | 452.0 | 452.0 |

| GIVEN POND DATA | | | INTERMEDIATE ROUTING COMPUTATIONS | |
|---|---|---|---|---|
| ELEVATION (ft) | OUTFLOW (cfs) | STORAGE (ac-ft) | 2S/t (cfs) | 2S/t + O (cfs) |
| 1624.19 | 0.0 | 2.015 | 487.7 | 487.7 |
| 1624.39 | 0.0 | 2.167 | 524.4 | 524.4 |
| 1624.59 | 2.4 | 2.322 | 561.9 | 564.3 |
| 1624.79 | 14.4 | 2.481 | 600.4 | 614.8 |
| 1624.99 | 32.3 | 2.644 | 639.8 | 672.1 |

Time increment (t) = 0.100 hrs.

Pond File: NMC12 .PND
Inflow Hydrograph: NMC12 .HYD
Outflow Hydrograph: OUT .HYD

| INFLOW HYDROGRAPH | | ROUTING COMPUTATIONS | | | | |
|---|---|---|---|---|---|---|
| TIME (hrs) | INFLOW (cfs) | I1+I2 (cfs) | 2S/t - O (cfs) | 2S/t + O (cfs) | OUTFLOW (cfs) | ELEVATION (ft) |
| 11.000 | 0.00 | ----- | 0.0 | 0.0 | 0.00 | 1617.99 |
| 11.100 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1617.99 |
| 11.200 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1617.99 |
| 11.300 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1617.99 |
| 11.400 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1617.99 |
| 11.500 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1617.99 |
| 11.600 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1617.99 |
| 11.700 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1617.99 |
| 11.800 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1617.99 |
| 11.900 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1617.99 |
| 12.000 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1617.99 |
| 12.100 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1617.99 |
| 12.200 | 2.00 | 2.0 | 2.0 | 2.0 | 0.00 | 1618.67 |
| 12.300 | 5.00 | 7.0 | 9.0 | 9.0 | 0.00 | 1619.97 |
| 12.400 | 9.00 | 14.0 | 23.0 | 23.0 | 0.00 | 1621.03 |
| 12.500 | 14.00 | 23.0 | 46.0 | 46.0 | 0.00 | 1621.23 |
| 12.600 | 17.00 | 31.0 | 77.0 | 77.0 | 0.00 | 1621.48 |
| 12.700 | 19.00 | 36.0 | 113.0 | 113.0 | 0.00 | 1621.77 |
| 12.800 | 17.00 | 36.0 | 149.0 | 149.0 | 0.00 | 1622.04 |
| 12.900 | 15.00 | 32.0 | 181.0 | 181.0 | 0.00 | 1622.27 |
| 13.000 | 13.00 | 28.0 | 209.0 | 209.0 | 0.00 | 1622.47 |
| 13.100 | 12.00 | 25.0 | 234.0 | 234.0 | 0.00 | 1622.64 |
| 13.200 | 10.00 | 22.0 | 256.0 | 256.0 | 0.00 | 1622.79 |
| 13.300 | 8.00 | 18.0 | 274.0 | 274.0 | 0.00 | 1622.91 |
| 13.400 | 7.00 | 15.0 | 289.0 | 289.0 | 0.00 | 1623.00 |
| 13.500 | 7.00 | 14.0 | 303.0 | 303.0 | 0.00 | 1623.09 |
| 13.600 | 6.00 | 13.0 | 316.0 | 316.0 | 0.00 | 1623.18 |
| 13.700 | 6.00 | 12.0 | 328.0 | 328.0 | 0.00 | 1623.25 |
| 13.800 | 5.00 | 11.0 | 339.0 | 339.0 | 0.00 | 1623.32 |
| 13.900 | 4.00 | 9.0 | 348.0 | 348.0 | 0.00 | 1623.38 |
| 14.000 | 4.00 | 8.0 | 356.0 | 356.0 | 0.00 | 1623.42 |
| 14.100 | 4.00 | 8.0 | 364.0 | 364.0 | 0.00 | 1623.47 |
| 14.200 | 4.00 | 8.0 | 372.0 | 372.0 | 0.00 | 1623.52 |
| 14.300 | 4.00 | 8.0 | 380.0 | 380.0 | 0.00 | 1623.57 |
| 14.400 | 4.00 | 8.0 | 388.0 | 388.0 | 0.00 | 1623.62 |
| 14.500 | 3.00 | 7.0 | 395.0 | 395.0 | 0.00 | 1623.66 |
| 14.600 | 3.00 | 6.0 | 401.0 | 401.0 | 0.00 | 1623.69 |
| 14.700 | 3.00 | 6.0 | 407.0 | 407.0 | 0.00 | 1623.73 |
| 14.800 | 3.00 | 6.0 | 413.0 | 413.0 | 0.00 | 1623.77 |
| 14.900 | 3.00 | 6.0 | 419.0 | 419.0 | 0.00 | 1623.80 |
| 15.000 | 3.00 | 6.0 | 425.0 | 425.0 | 0.00 | 1623.83 |
| 15.100 | 3.00 | 6.0 | 431.0 | 431.0 | 0.00 | 1623.87 |
| 15.200 | 3.00 | 6.0 | 437.0 | 437.0 | 0.00 | 1623.90 |
| 15.300 | 2.00 | 5.0 | 442.0 | 442.0 | 0.00 | 1623.93 |
| 15.400 | 2.00 | 4.0 | 446.0 | 446.0 | 0.00 | 1623.96 |

Pond File: NMC12 .PND
Inflow Hydrograph: NMC12 .HYD
Outflow Hydrograph: OUT .HYD

| INFLOW HYDROGRAPH | | ROUTING COMPUTATIONS | | | | |
|---|---|---|---|---|---|---|
| TIME (hrs) | INFLOW (cfs) | I1+I2 (cfs) | 2S/t - O (cfs) | 2S/t + O (cfs) | OUTFLOW (cfs) | ELEVATION (ft) |
| 15.500 | 2.00 | 4.0 | 450.0 | 450.0 | 0.00 | 1623.98 |
| 15.600 | 2.00 | 4.0 | 454.0 | 454.0 | 0.00 | 1624.00 |
| 15.700 | 2.00 | 4.0 | 458.0 | 458.0 | 0.00 | 1624.02 |
| 15.800 | 2.00 | 4.0 | 462.0 | 462.0 | 0.00 | 1624.05 |
| 15.900 | 2.00 | 4.0 | 466.0 | 466.0 | 0.00 | 1624.07 |
| 16.000 | 2.00 | 4.0 | 470.0 | 470.0 | 0.00 | 1624.09 |
| 16.100 | 2.00 | 4.0 | 474.0 | 474.0 | 0.00 | 1624.11 |
| 16.200 | 2.00 | 4.0 | 478.0 | 478.0 | 0.00 | 1624.14 |
| 16.300 | 2.00 | 4.0 | 482.0 | 482.0 | 0.00 | 1624.16 |
| 16.400 | 2.00 | 4.0 | 486.0 | 486.0 | 0.00 | 1624.18 |
| 16.500 | 2.00 | 4.0 | 490.0 | 490.0 | 0.00 | 1624.20 |
| 16.600 | 2.00 | 4.0 | 494.0 | 494.0 | 0.00 | 1624.22 |
| 16.700 | 2.00 | 4.0 | 498.0 | 498.0 | 0.00 | 1624.25 |
| 16.800 | 2.00 | 4.0 | 502.0 | 502.0 | 0.00 | 1624.27 |
| 16.900 | 2.00 | 4.0 | 506.0 | 506.0 | 0.00 | 1624.29 |
| 17.000 | 2.00 | 4.0 | 510.0 | 510.0 | 0.00 | 1624.31 |
| 17.100 | 2.00 | 4.0 | 514.0 | 514.0 | 0.00 | 1624.33 |
| 17.200 | 2.00 | 4.0 | 518.0 | 518.0 | 0.00 | 1624.36 |
| 17.300 | 2.00 | 4.0 | 522.0 | 522.0 | 0.00 | 1624.38 |
| 17.400 | 2.00 | 4.0 | 525.8 | 526.0 | 0.10 | 1624.40 |
| 17.500 | 2.00 | 4.0 | 529.2 | 529.8 | 0.33 | 1624.42 |
| 17.600 | 2.00 | 4.0 | 532.1 | 533.2 | 0.53 | 1624.43 |
| 17.700 | 2.00 | 4.0 | 534.7 | 536.1 | 0.70 | 1624.45 |
| 17.800 | 2.00 | 4.0 | 537.0 | 538.7 | 0.86 | 1624.46 |
| 17.900 | 2.00 | 4.0 | 539.0 | 541.0 | 1.00 | 1624.47 |
| 18.000 | 2.00 | 4.0 | 540.7 | 543.0 | 1.12 | 1624.48 |
| 18.100 | 2.00 | 4.0 | 542.3 | 544.7 | 1.22 | 1624.49 |
| 18.200 | 2.00 | 4.0 | 543.7 | 546.3 | 1.32 | 1624.50 |
| 18.300 | 2.00 | 4.0 | 544.9 | 547.7 | 1.40 | 1624.51 |
| 18.400 | 2.00 | 4.0 | 545.9 | 548.9 | 1.47 | 1624.51 |
| 18.500 | 2.00 | 4.0 | 546.9 | 549.9 | 1.53 | 1624.52 |
| 18.600 | 1.00 | 3.0 | 546.8 | 549.9 | 1.53 | 1624.52 |
| 18.700 | 1.00 | 2.0 | 545.9 | 548.8 | 1.47 | 1624.51 |
| 18.800 | 1.00 | 2.0 | 545.0 | 547.9 | 1.41 | 1624.51 |
| 18.900 | 1.00 | 2.0 | 544.3 | 547.0 | 1.36 | 1624.50 |
| 19.000 | 1.00 | 2.0 | 543.7 | 546.3 | 1.32 | 1624.50 |
| 19.100 | 1.00 | 2.0 | 543.1 | 545.7 | 1.28 | 1624.50 |
| 19.200 | 1.00 | 2.0 | 542.6 | 545.1 | 1.25 | 1624.49 |
| 19.300 | 1.00 | 2.0 | 542.2 | 544.6 | 1.22 | 1624.49 |
| 19.400 | 1.00 | 2.0 | 541.8 | 544.2 | 1.19 | 1624.49 |
| 19.500 | 1.00 | 2.0 | 541.5 | 543.8 | 1.17 | 1624.49 |
| 19.600 | 1.00 | 2.0 | 541.2 | 543.5 | 1.15 | 1624.49 |
| 19.700 | 1.00 | 2.0 | 540.9 | 543.2 | 1.13 | 1624.48 |
| 19.800 | 1.00 | 2.0 | 540.7 | 542.9 | 1.11 | 1624.48 |
| 19.900 | 1.00 | 2.0 | 540.5 | 542.7 | 1.10 | 1624.48 |
| 20.000 | 1.00 | 2.0 | 540.3 | 542.5 | 1.09 | 1624.48 |

Pond File: NMC12 .PND
Inflow Hydrograph: NMC12 .HYD
Outflow Hydrograph: OUT .HYD

| INFLOW HYDROGRAPH | | ROUTING COMPUTATIONS | | | | |
|---|---|---|---|---|---|---|
| TIME (hrs) | INFLOW (cfs) | I1+I2 (cfs) | 2S/t - O (cfs) | 2S/t + O (cfs) | OUTFLOW (cfs) | ELEVATION (ft) |
| 20.100 | 1.00 | 2.0 | 540.2 | 542.3 | 1.08 | 1624.48 |
| 20.200 | 1.00 | 2.0 | 540.0 | 542.2 | 1.07 | 1624.48 |
| 20.300 | 1.00 | 2.0 | 539.9 | 542.0 | 1.06 | 1624.48 |
| 20.400 | 1.00 | 2.0 | 539.8 | 541.9 | 1.05 | 1624.48 |
| 20.500 | 1.00 | 2.0 | 539.7 | 541.8 | 1.05 | 1624.48 |
| 20.600 | 1.00 | 2.0 | 539.6 | 541.7 | 1.04 | 1624.48 |
| 20.700 | 1.00 | 2.0 | 539.6 | 541.6 | 1.04 | 1624.48 |
| 20.800 | 1.00 | 2.0 | 539.5 | 541.6 | 1.03 | 1624.48 |
| 20.900 | 1.00 | 2.0 | 539.4 | 541.5 | 1.03 | 1624.48 |
| 21.000 | 1.00 | 2.0 | 539.4 | 541.4 | 1.02 | 1624.48 |
| 21.100 | 1.00 | 2.0 | 539.3 | 541.4 | 1.02 | 1624.48 |
| 21.200 | 1.00 | 2.0 | 539.3 | 541.3 | 1.02 | 1624.47 |
| 21.300 | 1.00 | 2.0 | 539.3 | 541.3 | 1.02 | 1624.47 |
| 21.400 | 1.00 | 2.0 | 539.2 | 541.3 | 1.01 | 1624.47 |
| 21.500 | 1.00 | 2.0 | 539.2 | 541.2 | 1.01 | 1624.47 |
| 21.600 | 1.00 | 2.0 | 539.2 | 541.2 | 1.01 | 1624.47 |
| 21.700 | 1.00 | 2.0 | 539.2 | 541.2 | 1.01 | 1624.47 |
| 21.800 | 1.00 | 2.0 | 539.2 | 541.2 | 1.01 | 1624.47 |
| 21.900 | 1.00 | 2.0 | 539.1 | 541.2 | 1.01 | 1624.47 |
| 22.000 | 1.00 | 2.0 | 539.1 | 541.1 | 1.01 | 1624.47 |
| 22.100 | 1.00 | 2.0 | 539.1 | 541.1 | 1.01 | 1624.47 |
| 22.200 | 1.00 | 2.0 | 539.1 | 541.1 | 1.01 | 1624.47 |
| 22.300 | 1.00 | 2.0 | 539.1 | 541.1 | 1.00 | 1624.47 |
| 22.400 | 1.00 | 2.0 | 539.1 | 541.1 | 1.00 | 1624.47 |
| 22.500 | 1.00 | 2.0 | 539.1 | 541.1 | 1.00 | 1624.47 |
| 22.600 | 1.00 | 2.0 | 539.1 | 541.1 | 1.00 | 1624.47 |
| 22.700 | 1.00 | 2.0 | 539.1 | 541.1 | 1.00 | 1624.47 |
| 22.800 | 1.00 | 2.0 | 539.1 | 541.1 | 1.00 | 1624.47 |
| 22.900 | 1.00 | 2.0 | 539.1 | 541.1 | 1.00 | 1624.47 |
| 23.000 | 1.00 | 2.0 | 539.1 | 541.1 | 1.00 | 1624.47 |
| 23.100 | 1.00 | 2.0 | 539.1 | 541.1 | 1.00 | 1624.47 |
| 23.200 | 1.00 | 2.0 | 539.1 | 541.1 | 1.00 | 1624.47 |
| 23.300 | 1.00 | 2.0 | 539.0 | 541.1 | 1.00 | 1624.47 |
| 23.400 | 1.00 | 2.0 | 539.0 | 541.0 | 1.00 | 1624.47 |
| 23.500 | 1.00 | 2.0 | 539.0 | 541.0 | 1.00 | 1624.47 |
| 23.600 | 1.00 | 2.0 | 539.0 | 541.0 | 1.00 | 1624.47 |
| 23.700 | 1.00 | 2.0 | 539.0 | 541.0 | 1.00 | 1624.47 |
| 23.800 | 1.00 | 2.0 | 539.0 | 541.0 | 1.00 | 1624.47 |
| 23.900 | 1.00 | 2.0 | 539.0 | 541.0 | 1.00 | 1624.47 |
| 24.000 | 0.00 | 1.0 | 538.2 | 540.0 | 0.94 | 1624.47 |
| 24.100 | 0.00 | 0.0 | 536.5 | 538.2 | 0.83 | 1624.46 |
| 24.200 | 0.00 | 0.0 | 535.0 | 536.5 | 0.73 | 1624.45 |
| 24.300 | 0.00 | 0.0 | 533.8 | 535.0 | 0.64 | 1624.44 |
| 24.400 | 0.00 | 0.0 | 532.6 | 533.8 | 0.56 | 1624.44 |
| 24.500 | 0.00 | 0.0 | 531.6 | 532.6 | 0.50 | 1624.43 |
| 24.600 | 0.00 | 0.0 | 530.8 | 531.6 | 0.44 | 1624.43 |

Pond File: NMC12 .PND
Inflow Hydrograph: NMC12 .HYD
Outflow Hydrograph: OUT .HYD

| INFLOW HYDROGRAPH | | ROUTING COMPUTATIONS | | | | |
|---|---|---|---|---|---|---|
| TIME (hrs) | INFLOW (cfs) | I1+I2 (cfs) | 2S/t - O (cfs) | 2S/t + O (cfs) | OUTFLOW (cfs) | ELEVATION (ft) |
| 24.700 | 0.00 | 0.0 | 530.0 | 530.8 | 0.38 | 1624.42 |
| 24.800 | 0.00 | 0.0 | 529.3 | 530.0 | 0.34 | 1624.42 |
| 24.900 | 0.00 | 0.0 | 528.7 | 529.3 | 0.30 | 1624.41 |
| 25.000 | 0.00 | 0.0 | 528.2 | 528.7 | 0.26 | 1624.41 |
| 25.100 | 0.00 | 0.0 | 527.8 | 528.2 | 0.23 | 1624.41 |
| 25.200 | 0.00 | 0.0 | 527.4 | 527.8 | 0.20 | 1624.41 |
| 25.300 | 0.00 | 0.0 | 527.0 | 527.4 | 0.18 | 1624.40 |
| 25.400 | 0.00 | 0.0 | 526.7 | 527.0 | 0.16 | 1624.40 |
| 25.500 | 0.00 | 0.0 | 526.4 | 526.7 | 0.14 | 1624.40 |
| 25.600 | 0.00 | 0.0 | 526.2 | 526.4 | 0.12 | 1624.40 |
| 25.700 | 0.00 | 0.0 | 525.9 | 526.2 | 0.11 | 1624.40 |
| 25.800 | 0.00 | 0.0 | 525.8 | 525.9 | 0.09 | 1624.40 |
| 25.900 | 0.00 | 0.0 | 525.6 | 525.8 | 0.08 | 1624.40 |

********** SUMMARY OF ROUTING COMPUTATIONS **********

Pond File: NMC12 .PND
Inflow Hydrograph: NMC12 .HYD
Outflow Hydrograph: OUT .HYD

Starting Pond W.S. Elevation = 1617.99 ft

***** Summary of Peak Outflow and Peak Elevation *****

| | | |
|---|---|---|
| Peak Inflow | = | 19.00 cfs |
| Peak Outflow | = | 1.53 cfs |
| Peak Elevation | = | 1624.52 ft |

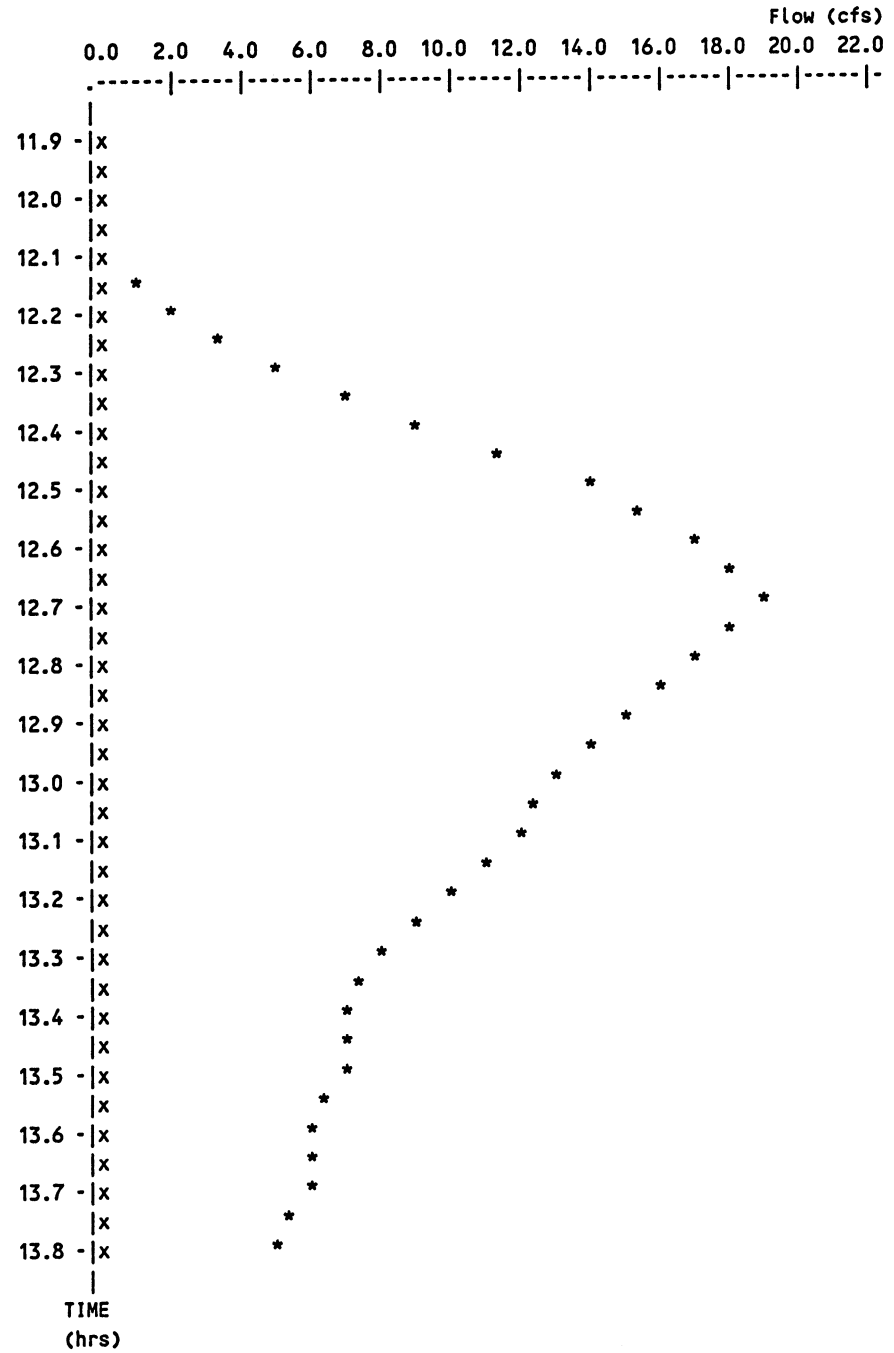
***** Summary of Approximate Peak Storage *****

| | | |
|---|---|---|
| Initial Storage | = | 0.00 ac-ft |
| Peak Storage From Storm | = | 2.27 ac-ft |
| Total Storage in Pond | = | 2.27 ac-ft |

Pond File: NMC12 .PND
Inflow Hydrograph: NMC12 .HYD
Outflow Hydrograph: OUT .HYD

EXECUTED: 12-07-1998
09:15:06

Peak Inflow = 19.00 cfs
Peak Outflow = 1.53 cfs
Peak Elevation = 1624.52 ft




* File: NMC12 .HYD Qmax = 19.0 cfs
x File: OUT .HYD Qmax = 1.5 cfs

```
**************************************************************************
*                                                                        *
* NICOLET MINING COMPANY          93C049          FOTH & VAN DYKE        *
*       TMA SED. BASIN 13                               12/98            *
*                                                                        *
*                                                                        *
*                                                                        *
**************************************************************************
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Inflow Hydrograph: NMC13 .HYD
Rating Table file: NMC13 .PND

----INITIAL CONDITIONS----
Elevation = 1689.99 ft
Outflow = 0.00 cfs
Storage = 0.00 ac-ft

| GIVEN POND DATA | | | INTERMEDIATE ROUTING COMPUTATIONS | |
|---|---|---|---|---|
| ELEVATION (ft) | OUTFLOW (cfs) | STORAGE (ac-ft) | 2S/t (cfs) | 2S/t + O (cfs) |
| 1689.99 | 0.0 | 0.000 | 0.0 | 0.0 |
| 1690.19 | 0.0 | 0.002 | 0.5 | 0.5 |
| 1690.39 | 0.0 | 0.004 | 1.0 | 1.0 |
| 1690.59 | 0.0 | 0.007 | 1.7 | 1.7 |
| 1690.79 | 0.0 | 0.010 | 2.4 | 2.4 |
| 1690.99 | 0.0 | 0.013 | 3.3 | 3.3 |
| 1691.19 | 0.0 | 0.017 | 4.2 | 4.2 |
| 1691.39 | 0.0 | 0.022 | 5.3 | 5.3 |
| 1691.59 | 0.0 | 0.027 | 6.4 | 6.4 |
| 1691.79 | 0.0 | 0.032 | 7.7 | 7.7 |
| 1691.99 | 0.0 | 0.038 | 9.1 | 9.1 |
| 1692.19 | 0.0 | 0.044 | 10.7 | 10.7 |
| 1692.39 | 0.0 | 0.051 | 12.3 | 12.3 |
| 1692.59 | 0.0 | 0.059 | 14.2 | 14.2 |
| 1692.79 | 0.0 | 0.067 | 16.2 | 16.2 |
| 1692.99 | 0.0 | 0.076 | 18.3 | 18.3 |
| 1693.19 | 0.0 | 0.125 | 30.3 | 30.3 |
| 1693.39 | 0.0 | 0.178 | 43.0 | 43.0 |
| 1693.59 | 0.0 | 0.233 | 56.3 | 56.3 |
| 1693.79 | 0.0 | 0.290 | 70.2 | 70.2 |
| 1693.99 | 0.0 | 0.350 | 84.6 | 84.6 |
| 1694.19 | 0.0 | 0.412 | 99.6 | 99.6 |
| 1694.39 | 0.0 | 0.476 | 115.2 | 115.2 |
| 1694.59 | 2.4 | 0.543 | 131.4 | 133.8 |
| 1694.79 | 14.4 | 0.612 | 148.1 | 162.5 |
| 1694.99 | 32.3 | 0.684 | 165.5 | 197.8 |

Time increment (t) = 0.100 hrs.

Pond File: NMC13 .PND
Inflow Hydrograph: NMC13 .HYD
Outflow Hydrograph: OUT .HYD

| INFLOW HYDROGRAPH | | ROUTING COMPUTATIONS | | | | |
|---|---|---|---|---|---|---|
| TIME (hrs) | INFLOW (cfs) | I1+I2 (cfs) | 2S/t - O (cfs) | 2S/t + O (cfs) | OUTFLOW (cfs) | ELEVATION (ft) |
| 11.000 | 0.00 | ----- | 0.0 | 0.0 | 0.00 | 1689.99 |
| 11.100 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1689.99 |
| 11.200 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1689.99 |
| 11.300 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1689.99 |
| 11.400 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1689.99 |
| 11.500 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1689.99 |
| 11.600 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1689.99 |
| 11.700 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1689.99 |
| 11.800 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1689.99 |
| 11.900 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1689.99 |
| 12.000 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1689.99 |
| 12.100 | 1.00 | 1.0 | 1.0 | 1.0 | 0.00 | 1690.37 |
| 12.200 | 4.00 | 5.0 | 6.0 | 6.0 | 0.00 | 1691.52 |
| 12.300 | 7.00 | 11.0 | 17.0 | 17.0 | 0.00 | 1692.87 |
| 12.400 | 10.00 | 17.0 | 34.0 | 34.0 | 0.00 | 1693.25 |
| 12.500 | 10.00 | 20.0 | 54.0 | 54.0 | 0.00 | 1693.55 |
| 12.600 | 9.00 | 19.0 | 73.0 | 73.0 | 0.00 | 1693.83 |
| 12.700 | 7.00 | 16.0 | 89.0 | 89.0 | 0.00 | 1694.05 |
| 12.800 | 6.00 | 13.0 | 102.0 | 102.0 | 0.00 | 1694.22 |
| 12.900 | 5.00 | 11.0 | 113.0 | 113.0 | 0.00 | 1694.36 |
| 13.000 | 4.00 | 9.0 | 120.2 | 122.0 | 0.88 | 1694.46 |
| 13.100 | 4.00 | 8.0 | 124.9 | 128.2 | 1.69 | 1694.53 |
| 13.200 | 3.00 | 7.0 | 127.5 | 131.9 | 2.16 | 1694.57 |
| 13.300 | 2.00 | 5.0 | 128.1 | 132.5 | 2.24 | 1694.58 |
| 13.400 | 2.00 | 4.0 | 127.7 | 132.1 | 2.18 | 1694.57 |
| 13.500 | 2.00 | 4.0 | 127.4 | 131.7 | 2.13 | 1694.57 |
| 13.600 | 2.00 | 4.0 | 127.2 | 131.4 | 2.10 | 1694.56 |
| 13.700 | 2.00 | 4.0 | 127.1 | 131.2 | 2.07 | 1694.56 |
| 13.800 | 2.00 | 4.0 | 127.0 | 131.1 | 2.05 | 1694.56 |
| 13.900 | 2.00 | 4.0 | 126.9 | 131.0 | 2.04 | 1694.56 |
| 14.000 | 2.00 | 4.0 | 126.8 | 130.9 | 2.03 | 1694.56 |
| 14.100 | 2.00 | 4.0 | 126.8 | 130.8 | 2.02 | 1694.56 |
| 14.200 | 1.00 | 3.0 | 126.0 | 129.8 | 1.89 | 1694.55 |
| 14.300 | 1.00 | 2.0 | 124.7 | 128.0 | 1.66 | 1694.53 |
| 14.400 | 1.00 | 2.0 | 123.7 | 126.7 | 1.49 | 1694.51 |
| 14.500 | 1.00 | 2.0 | 123.0 | 125.7 | 1.36 | 1694.50 |
| 14.600 | 1.00 | 2.0 | 122.5 | 125.0 | 1.27 | 1694.50 |
| 14.700 | 1.00 | 2.0 | 122.1 | 124.5 | 1.20 | 1694.49 |
| 14.800 | 1.00 | 2.0 | 121.8 | 124.1 | 1.15 | 1694.49 |
| 14.900 | 1.00 | 2.0 | 121.5 | 123.8 | 1.11 | 1694.48 |
| 15.000 | 1.00 | 2.0 | 121.4 | 123.5 | 1.08 | 1694.48 |
| 15.100 | 1.00 | 2.0 | 121.3 | 123.4 | 1.06 | 1694.48 |
| 15.200 | 1.00 | 2.0 | 121.2 | 123.3 | 1.04 | 1694.48 |
| 15.300 | 1.00 | 2.0 | 121.1 | 123.2 | 1.03 | 1694.48 |
| 15.400 | 1.00 | 2.0 | 121.1 | 123.1 | 1.02 | 1694.48 |

Pond File: NMC13 .PND
Inflow Hydrograph: NMC13 .HYD
Outflow Hydrograph: OUT .HYD

| INFLOW HYDROGRAPH | | ROUTING COMPUTATIONS | | | | |
|---|---|---|---|---|---|---|
| TIME (hrs) | INFLOW (cfs) | I1+I2 (cfs) | 2S/t - O (cfs) | 2S/t + O (cfs) | OUTFLOW (cfs) | ELEVATION (ft) |
| 15.500 | 1.00 | 2.0 | 121.0 | 123.1 | 1.02 | 1694.47 |
| 15.600 | 1.00 | 2.0 | 121.0 | 123.0 | 1.01 | 1694.47 |
| 15.700 | 1.00 | 2.0 | 121.0 | 123.0 | 1.01 | 1694.47 |
| 15.800 | 1.00 | 2.0 | 121.0 | 123.0 | 1.01 | 1694.47 |
| 15.900 | 1.00 | 2.0 | 120.9 | 123.0 | 1.01 | 1694.47 |
| 16.000 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 16.100 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 16.200 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 16.300 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 16.400 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 16.500 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 16.600 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 16.700 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 16.800 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 16.900 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 17.000 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 17.100 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 17.200 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 17.300 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 17.400 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 17.500 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 17.600 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 17.700 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 17.800 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 17.900 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 18.000 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 18.100 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 18.200 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 18.300 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 18.400 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 18.500 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 18.600 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 18.700 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 18.800 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 18.900 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 19.000 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 19.100 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 19.200 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 19.300 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 19.400 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 19.500 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 19.600 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 19.700 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 19.800 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 19.900 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 20.000 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |

Pond File: NMC13 .PND
Inflow Hydrograph: NMC13 .HYD
Outflow Hydrograph: OUT .HYD

| INFLOW HYDROGRAPH | | ROUTING COMPUTATIONS | | | | |
|---|---|---|---|---|---|---|
| TIME (hrs) | INFLOW (cfs) | I1+I2 (cfs) | 2S/t - O (cfs) | 2S/t + O (cfs) | OUTFLOW (cfs) | ELEVATION (ft) |
| 20.100 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 20.200 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 20.300 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 20.400 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 20.500 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 20.600 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 20.700 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 20.800 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 20.900 | 1.00 | 2.0 | 120.9 | 122.9 | 1.00 | 1694.47 |
| 21.000 | 0.00 | 1.0 | 120.2 | 121.9 | 0.87 | 1694.46 |
| 21.100 | 0.00 | 0.0 | 118.9 | 120.2 | 0.65 | 1694.44 |
| 21.200 | 0.00 | 0.0 | 117.9 | 118.9 | 0.48 | 1694.43 |
| 21.300 | 0.00 | 0.0 | 117.2 | 117.9 | 0.36 | 1694.42 |
| 21.400 | 0.00 | 0.0 | 116.7 | 117.2 | 0.26 | 1694.41 |
| 21.500 | 0.00 | 0.0 | 116.3 | 116.7 | 0.20 | 1694.41 |
| 21.600 | 0.00 | 0.0 | 116.0 | 116.3 | 0.14 | 1694.40 |
| 21.700 | 0.00 | 0.0 | 115.8 | 116.0 | 0.11 | 1694.40 |
| 21.800 | 0.00 | 0.0 | 115.6 | 115.8 | 0.08 | 1694.40 |
| 21.900 | 0.00 | 0.0 | 115.5 | 115.6 | 0.06 | 1694.39 |
| 22.000 | 0.00 | 0.0 | 115.4 | 115.5 | 0.04 | 1694.39 |
| 22.100 | 0.00 | 0.0 | 115.4 | 115.4 | 0.03 | 1694.39 |
| 22.200 | 0.00 | 0.0 | 115.3 | 115.4 | 0.02 | 1694.39 |
| 22.300 | 0.00 | 0.0 | 115.3 | 115.3 | 0.02 | 1694.39 |
| 22.400 | 0.00 | 0.0 | 115.3 | 115.3 | 0.01 | 1694.39 |
| 22.500 | 0.00 | 0.0 | 115.2 | 115.3 | 0.01 | 1694.39 |
| 22.600 | 0.00 | 0.0 | 115.2 | 115.2 | 0.01 | 1694.39 |
| 22.700 | 0.00 | 0.0 | 115.2 | 115.2 | 0.01 | 1694.39 |
| 22.800 | 0.00 | 0.0 | 115.2 | 115.2 | 0.00 | 1694.39 |
| 22.900 | 0.00 | 0.0 | 115.2 | 115.2 | 0.00 | 1694.39 |
| 23.000 | 0.00 | 0.0 | 115.2 | 115.2 | 0.00 | 1694.39 |
| 23.100 | 0.00 | 0.0 | 115.2 | 115.2 | 0.00 | 1694.39 |
| 23.200 | 0.00 | 0.0 | 115.2 | 115.2 | 0.00 | 1694.39 |
| 23.300 | 0.00 | 0.0 | 115.2 | 115.2 | 0.00 | 1694.39 |
| 23.400 | 0.00 | 0.0 | 115.2 | 115.2 | 0.00 | 1694.39 |
| 23.500 | 0.00 | 0.0 | 115.2 | 115.2 | 0.00 | 1694.39 |
| 23.600 | 0.00 | 0.0 | 115.2 | 115.2 | 0.00 | 1694.39 |
| 23.700 | 0.00 | 0.0 | 115.2 | 115.2 | 0.00 | 1694.39 |
| 23.800 | 0.00 | 0.0 | 115.2 | 115.2 | 0.00 | 1694.39 |
| 23.900 | 0.00 | 0.0 | 115.2 | 115.2 | 0.00 | 1694.39 |
| 24.000 | 0.00 | 0.0 | 115.2 | 115.2 | 0.00 | 1694.39 |
| 24.100 | 0.00 | 0.0 | 115.2 | 115.2 | 0.00 | 1694.39 |
| 24.200 | 0.00 | 0.0 | 115.2 | 115.2 | 0.00 | 1694.39 |
| 24.300 | 0.00 | 0.0 | 115.2 | 115.2 | 0.00 | 1694.39 |
| 24.400 | 0.00 | 0.0 | 115.2 | 115.2 | 0.00 | 1694.39 |
| 24.500 | 0.00 | 0.0 | 115.2 | 115.2 | 0.00 | 1694.39 |
| 24.600 | 0.00 | 0.0 | 115.2 | 115.2 | 0.00 | 1694.39 |

Pond File: NMC13 .PND
Inflow Hydrograph: NMC13 .HYD
Outflow Hydrograph: OUT .HYD

| INFLOW HYDROGRAPH | | ROUTING COMPUTATIONS | | | | |
|---|---|---|---|---|---|---|
| TIME (hrs) | INFLOW (cfs) | I1+I2 (cfs) | 2S/t - O (cfs) | 2S/t + O (cfs) | OUTFLOW (cfs) | ELEVATION (ft) |
| 24.700 | 0.00 | 0.0 | 115.2 | 115.2 | 0.00 | 1694.39 |
| 24.800 | 0.00 | 0.0 | 115.2 | 115.2 | 0.00 | 1694.39 |
| 24.900 | 0.00 | 0.0 | 115.2 | 115.2 | 0.00 | 1694.39 |
| 25.000 | 0.00 | 0.0 | 115.2 | 115.2 | 0.00 | 1694.39 |
| 25.100 | 0.00 | 0.0 | 115.2 | 115.2 | 0.00 | 1694.39 |
| 25.200 | 0.00 | 0.0 | 115.2 | 115.2 | 0.00 | 1694.39 |
| 25.300 | 0.00 | 0.0 | 115.2 | 115.2 | 0.00 | 1694.39 |
| 25.400 | 0.00 | 0.0 | 115.2 | 115.2 | 0.00 | 1694.39 |
| 25.500 | 0.00 | 0.0 | 115.2 | 115.2 | 0.00 | 1694.39 |
| 25.600 | 0.00 | 0.0 | 115.2 | 115.2 | 0.00 | 1694.39 |
| 25.700 | 0.00 | 0.0 | 115.2 | 115.2 | 0.00 | 1694.39 |
| 25.800 | 0.00 | 0.0 | 115.2 | 115.2 | 0.00 | 1694.39 |
| 25.900 | 0.00 | 0.0 | 115.2 | 115.2 | 0.00 | 1694.39 |

********** SUMMARY OF ROUTING COMPUTATIONS **********

Pond File: NMC13 .PND
Inflow Hydrograph: NMC13 .HYD
Outflow Hydrograph: OUT .HYD

Starting Pond W.S. Elevation = 1689.99 ft

***** Summary of Peak Outflow and Peak Elevation *****

| | | |
|---|---|---|
| Peak Inflow | = | 10.00 cfs |
| Peak Outflow | = | 2.24 cfs |
| Peak Elevation | = | 1694.58 ft |

***** Summary of Approximate Peak Storage *****

| | | |
|---|---|---|
| Initial Storage | = | 0.00 ac-ft |
| Peak Storage From Storm | = | 0.54 ac-ft |
| Total Storage in Pond | = | 0.54 ac-ft |

Pond File: NMC13 .PND
Inflow Hydrograph: NMC13 .HYD
Outflow Hydrograph: OUT .HYD

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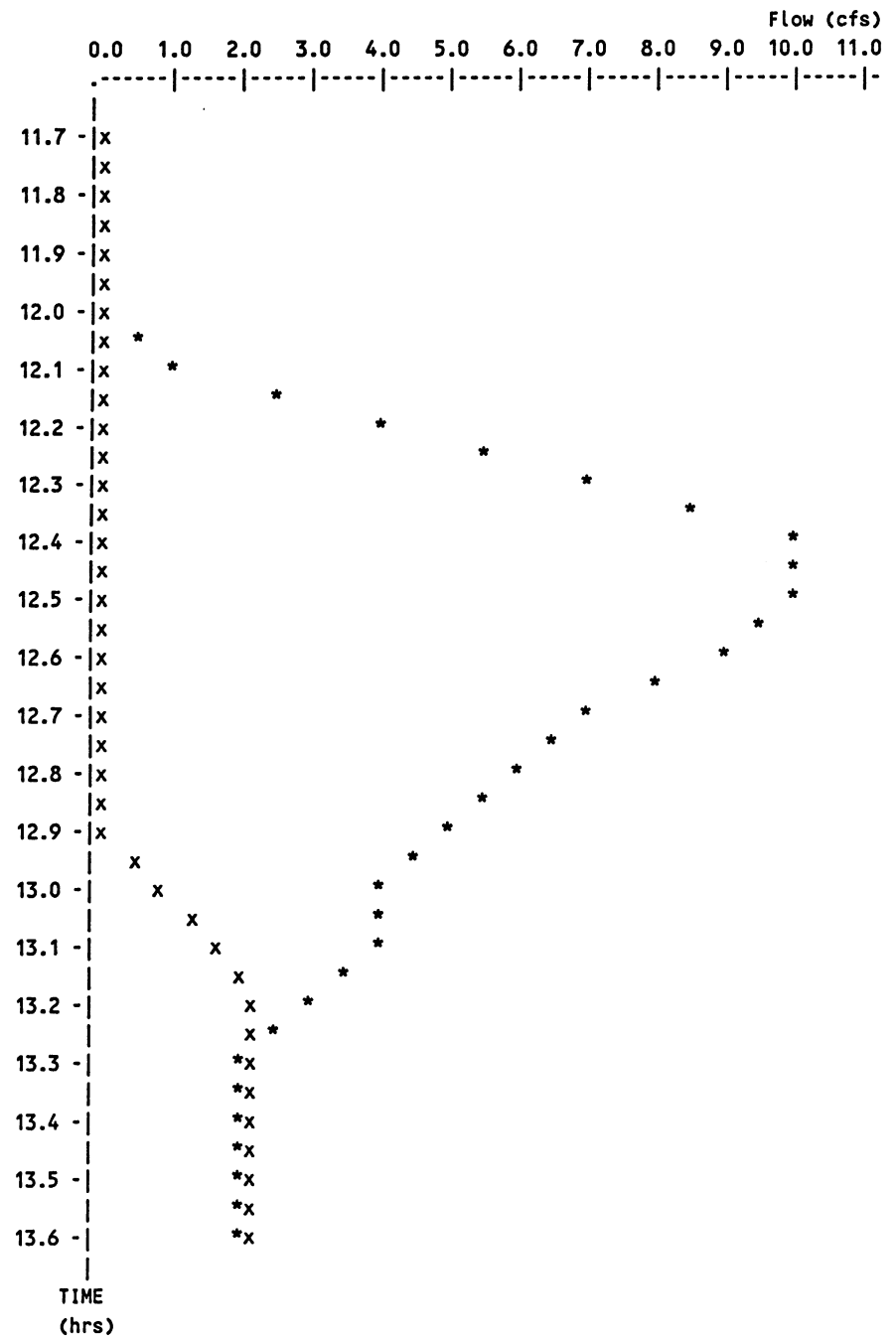
Peak Inflow = 10.00 cfs
Peak Outflow = 2.24 cfs
Peak Elevation = 1694.58 ft




* File: NMC13 .HYD Qmax = 10.0 cfs
x File: OUT .HYD Qmax = 2.2 cfs

```
**************************************************************************
*                                                                        *
* NICOLET MINING COMPANY          93C049          FOTH & VAN DYKE        *
*       TMA SED. BASIN 14                               12/98            *
*                                                                        *
*                                                                        *
*                                                                        *
**************************************************************************
```

Inflow Hydrograph: NMC14 .HYD
Rating Table file: NMC14 .PND

----INITIAL CONDITIONS----
Elevation = 1709.99 ft
Outflow = 0.00 cfs
Storage = 0.00 ac-ft

| GIVEN POND DATA | | | INTERMEDIATE ROUTING COMPUTATIONS | |
|---|---|---|---|---|
| ELEVATION (ft) | OUTFLOW (cfs) | STORAGE (ac-ft) | 2S/t (cfs) | 2S/t + O (cfs) |
| 1709.99 | 0.0 | 0.000 | 0.0 | 0.0 |
| 1710.19 | 0.0 | 0.002 | 0.5 | 0.5 |
| 1710.39 | 0.0 | 0.004 | 1.0 | 1.0 |
| 1710.59 | 0.0 | 0.007 | 1.7 | 1.7 |
| 1710.79 | 0.0 | 0.010 | 2.4 | 2.4 |
| 1710.99 | 0.0 | 0.013 | 3.3 | 3.3 |
| 1711.19 | 0.0 | 0.017 | 4.2 | 4.2 |
| 1711.39 | 0.0 | 0.022 | 5.3 | 5.3 |
| 1711.59 | 0.0 | 0.027 | 6.4 | 6.4 |
| 1711.79 | 0.0 | 0.032 | 7.7 | 7.7 |
| 1711.99 | 0.0 | 0.038 | 9.1 | 9.1 |
| 1712.19 | 0.0 | 0.044 | 10.7 | 10.7 |
| 1712.39 | 0.0 | 0.051 | 12.3 | 12.3 |
| 1712.59 | 0.0 | 0.059 | 14.2 | 14.2 |
| 1712.79 | 0.0 | 0.067 | 16.2 | 16.2 |
| 1712.99 | 0.0 | 0.076 | 18.3 | 18.3 |
| 1713.19 | 6.8 | 0.253 | 61.3 | 68.1 |
| 1713.39 | 7.0 | 0.438 | 106.0 | 113.0 |
| 1713.59 | 7.2 | 0.625 | 151.3 | 158.5 |
| 1713.79 | 7.4 | 0.814 | 197.1 | 204.5 |
| 1713.99 | 7.6 | 1.006 | 243.4 | 251.0 |
| 1714.19 | 7.8 | 1.199 | 290.3 | 298.1 |
| 1714.39 | 7.9 | 1.395 | 337.7 | 345.6 |
| 1714.59 | 8.9 | 1.593 | 385.6 | 394.5 |
| 1714.79 | 13.3 | 1.794 | 434.1 | 447.4 |
| 1714.99 | 20.1 | 1.996 | 483.0 | 503.1 |

Time increment (t) = 0.100 hrs.

Pond File: NMC14 .PND
Inflow Hydrograph: NMC14 .HYD
Outflow Hydrograph: OUT .HYD

| INFLOW HYDROGRAPH | | ROUTING COMPUTATIONS | | | | |
|---|---|---|---|---|---|---|
| TIME (hrs) | INFLOW (cfs) | I1+I2 (cfs) | 2S/t - O (cfs) | 2S/t + O (cfs) | OUTFLOW (cfs) | ELEVATION (ft) |
| 11.000 | 0.00 | ----- | 0.0 | 0.0 | 0.00 | 1709.99 |
| 11.100 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1709.99 |
| 11.200 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1709.99 |
| 11.300 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1709.99 |
| 11.400 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1709.99 |
| 11.500 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1709.99 |
| 11.600 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1709.99 |
| 11.700 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1709.99 |
| 11.800 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1709.99 |
| 11.900 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1709.99 |
| 12.000 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1709.99 |
| 12.100 | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 1709.99 |
| 12.200 | 2.00 | 2.0 | 2.0 | 2.0 | 0.00 | 1710.67 |
| 12.300 | 5.00 | 7.0 | 9.0 | 9.0 | 0.00 | 1711.97 |
| 12.400 | 10.00 | 15.0 | 22.4 | 24.0 | 0.78 | 1713.01 |
| 12.500 | 16.00 | 26.0 | 40.2 | 48.4 | 4.12 | 1713.11 |
| 12.600 | 19.00 | 35.0 | 61.5 | 75.2 | 6.83 | 1713.22 |
| 12.700 | 20.00 | 39.0 | 86.7 | 100.5 | 6.94 | 1713.33 |
| 12.800 | 19.00 | 39.0 | 111.5 | 125.7 | 7.06 | 1713.45 |
| 12.900 | 16.00 | 35.0 | 132.2 | 146.5 | 7.15 | 1713.54 |
| 13.000 | 14.00 | 30.0 | 147.8 | 162.2 | 7.22 | 1713.61 |
| 13.100 | 12.00 | 26.0 | 159.3 | 173.8 | 7.27 | 1713.66 |
| 13.200 | 11.00 | 23.0 | 167.7 | 182.3 | 7.30 | 1713.69 |
| 13.300 | 9.00 | 20.0 | 173.0 | 187.7 | 7.33 | 1713.72 |
| 13.400 | 8.00 | 17.0 | 175.3 | 190.0 | 7.34 | 1713.73 |
| 13.500 | 7.00 | 15.0 | 175.7 | 190.3 | 7.34 | 1713.73 |
| 13.600 | 6.00 | 13.0 | 174.0 | 188.7 | 7.33 | 1713.72 |
| 13.700 | 6.00 | 12.0 | 171.4 | 186.0 | 7.32 | 1713.71 |
| 13.800 | 5.00 | 11.0 | 167.8 | 182.4 | 7.30 | 1713.69 |
| 13.900 | 5.00 | 10.0 | 163.2 | 177.8 | 7.28 | 1713.67 |
| 14.000 | 5.00 | 10.0 | 158.7 | 173.2 | 7.26 | 1713.65 |
| 14.100 | 5.00 | 10.0 | 154.2 | 168.7 | 7.24 | 1713.63 |
| 14.200 | 4.00 | 9.0 | 148.7 | 163.2 | 7.22 | 1713.61 |
| 14.300 | 4.00 | 8.0 | 142.3 | 156.7 | 7.19 | 1713.58 |
| 14.400 | 4.00 | 8.0 | 136.0 | 150.3 | 7.16 | 1713.55 |
| 14.500 | 3.00 | 7.0 | 128.8 | 143.0 | 7.13 | 1713.52 |
| 14.600 | 3.00 | 6.0 | 120.6 | 134.8 | 7.10 | 1713.49 |
| 14.700 | 3.00 | 6.0 | 112.4 | 126.6 | 7.06 | 1713.45 |
| 14.800 | 3.00 | 6.0 | 104.4 | 118.4 | 7.02 | 1713.41 |
| 14.900 | 3.00 | 6.0 | 96.4 | 110.4 | 6.99 | 1713.38 |
| 15.000 | 3.00 | 6.0 | 88.5 | 102.4 | 6.95 | 1713.34 |
| 15.100 | 3.00 | 6.0 | 80.7 | 94.5 | 6.92 | 1713.31 |
| 15.200 | 3.00 | 6.0 | 72.9 | 86.7 | 6.88 | 1713.27 |
| 15.300 | 3.00 | 6.0 | 65.2 | 78.9 | 6.85 | 1713.24 |
| 15.400 | 3.00 | 6.0 | 57.6 | 71.2 | 6.81 | 1713.20 |

Pond File: NMC14 .PND
Inflow Hydrograph: NMC14 .HYD
Outflow Hydrograph: OUT .HYD

| INFLOW HYDROGRAPH | | ROUTING COMPUTATIONS | | | | |
|---|---|---|---|---|---|---|
| TIME (hrs) | INFLOW (cfs) | I1+I2 (cfs) | 2S/t - O (cfs) | 2S/t + O (cfs) | OUTFLOW (cfs) | ELEVATION (ft) |
| 15.500 | 3.00 | 6.0 | 51.2 | 63.6 | 6.19 | 1713.17 |
| 15.600 | 3.00 | 6.0 | 46.6 | 57.2 | 5.32 | 1713.15 |
| 15.700 | 3.00 | 6.0 | 43.2 | 52.6 | 4.68 | 1713.13 |
| 15.800 | 2.00 | 5.0 | 40.0 | 48.2 | 4.09 | 1713.11 |
| 15.900 | 2.00 | 4.0 | 37.0 | 44.0 | 3.52 | 1713.09 |
| 16.000 | 2.00 | 4.0 | 34.8 | 41.0 | 3.10 | 1713.08 |
| 16.100 | 2.00 | 4.0 | 33.2 | 38.8 | 2.80 | 1713.07 |
| 16.200 | 2.00 | 4.0 | 32.0 | 37.2 | 2.58 | 1713.07 |
| 16.300 | 2.00 | 4.0 | 31.2 | 36.0 | 2.42 | 1713.06 |
| 16.400 | 2.00 | 4.0 | 30.6 | 35.2 | 2.31 | 1713.06 |
| 16.500 | 2.00 | 4.0 | 30.1 | 34.6 | 2.22 | 1713.06 |
| 16.600 | 2.00 | 4.0 | 29.8 | 34.1 | 2.16 | 1713.05 |
| 16.700 | 2.00 | 4.0 | 29.6 | 33.8 | 2.12 | 1713.05 |
| 16.800 | 2.00 | 4.0 | 29.4 | 33.6 | 2.09 | 1713.05 |
| 16.900 | 2.00 | 4.0 | 29.3 | 33.4 | 2.06 | 1713.05 |
| 17.000 | 2.00 | 4.0 | 29.2 | 33.3 | 2.05 | 1713.05 |
| 17.100 | 2.00 | 4.0 | 29.1 | 33.2 | 2.03 | 1713.05 |
| 17.200 | 2.00 | 4.0 | 29.1 | 33.1 | 2.02 | 1713.05 |
| 17.300 | 2.00 | 4.0 | 29.0 | 33.1 | 2.02 | 1713.05 |
| 17.400 | 2.00 | 4.0 | 29.0 | 33.0 | 2.01 | 1713.05 |
| 17.500 | 2.00 | 4.0 | 29.0 | 33.0 | 2.01 | 1713.05 |
| 17.600 | 2.00 | 4.0 | 29.0 | 33.0 | 2.01 | 1713.05 |
| 17.700 | 2.00 | 4.0 | 29.0 | 33.0 | 2.00 | 1713.05 |
| 17.800 | 2.00 | 4.0 | 29.0 | 33.0 | 2.00 | 1713.05 |
| 17.900 | 2.00 | 4.0 | 28.9 | 33.0 | 2.00 | 1713.05 |
| 18.000 | 2.00 | 4.0 | 28.9 | 32.9 | 2.00 | 1713.05 |
| 18.100 | 2.00 | 4.0 | 28.9 | 32.9 | 2.00 | 1713.05 |
| 18.200 | 2.00 | 4.0 | 28.9 | 32.9 | 2.00 | 1713.05 |
| 18.300 | 2.00 | 4.0 | 28.9 | 32.9 | 2.00 | 1713.05 |
| 18.400 | 2.00 | 4.0 | 28.9 | 32.9 | 2.00 | 1713.05 |
| 18.500 | 2.00 | 4.0 | 28.9 | 32.9 | 2.00 | 1713.05 |
| 18.600 | 2.00 | 4.0 | 28.9 | 32.9 | 2.00 | 1713.05 |
| 18.700 | 2.00 | 4.0 | 28.9 | 32.9 | 2.00 | 1713.05 |
| 18.800 | 2.00 | 4.0 | 28.9 | 32.9 | 2.00 | 1713.05 |
| 18.900 | 2.00 | 4.0 | 28.9 | 32.9 | 2.00 | 1713.05 |
| 19.000 | 2.00 | 4.0 | 28.9 | 32.9 | 2.00 | 1713.05 |
| 19.100 | 2.00 | 4.0 | 28.9 | 32.9 | 2.00 | 1713.05 |
| 19.200 | 2.00 | 4.0 | 28.9 | 32.9 | 2.00 | 1713.05 |
| 19.300 | 2.00 | 4.0 | 28.9 | 32.9 | 2.00 | 1713.05 |
| 19.400 | 2.00 | 4.0 | 28.9 | 32.9 | 2.00 | 1713.05 |
| 19.500 | 2.00 | 4.0 | 28.9 | 32.9 | 2.00 | 1713.05 |
| 19.600 | 1.00 | 3.0 | 28.2 | 31.9 | 1.86 | 1713.04 |
| 19.700 | 1.00 | 2.0 | 27.0 | 30.2 | 1.63 | 1713.04 |
| 19.800 | 1.00 | 2.0 | 26.0 | 29.0 | 1.46 | 1713.03 |
| 19.900 | 1.00 | 2.0 | 25.4 | 28.0 | 1.33 | 1713.03 |
| 20.000 | 1.00 | 2.0 | 24.9 | 27.4 | 1.24 | 1713.03 |

Pond File: NMC14 .PND
Inflow Hydrograph: NMC14 .HYD
Outflow Hydrograph: OUT .HYD

| INFLOW HYDROGRAPH | | ROUTING COMPUTATIONS | | | | |
|---|---|---|---|---|---|---|
| TIME (hrs) | INFLOW (cfs) | I1+I2 (cfs) | 2S/t - O (cfs) | 2S/t + O (cfs) | OUTFLOW (cfs) | ELEVATION (ft) |
| 20.100 | 1.00 | 2.0 | 24.5 | 26.9 | 1.17 | 1713.02 |
| 20.200 | 1.00 | 2.0 | 24.3 | 26.5 | 1.13 | 1713.02 |
| 20.300 | 1.00 | 2.0 | 24.1 | 26.3 | 1.09 | 1713.02 |
| 20.400 | 1.00 | 2.0 | 24.0 | 26.1 | 1.07 | 1713.02 |
| 20.500 | 1.00 | 2.0 | 23.9 | 26.0 | 1.05 | 1713.02 |
| 20.600 | 1.00 | 2.0 | 23.8 | 25.9 | 1.04 | 1713.02 |
| 20.700 | 1.00 | 2.0 | 23.8 | 25.8 | 1.03 | 1713.02 |
| 20.800 | 1.00 | 2.0 | 23.7 | 25.8 | 1.02 | 1713.02 |
| 20.900 | 1.00 | 2.0 | 23.7 | 25.7 | 1.01 | 1713.02 |
| 21.000 | 1.00 | 2.0 | 23.7 | 25.7 | 1.01 | 1713.02 |
| 21.100 | 1.00 | 2.0 | 23.7 | 25.7 | 1.01 | 1713.02 |
| 21.200 | 1.00 | 2.0 | 23.6 | 25.7 | 1.01 | 1713.02 |
| 21.300 | 1.00 | 2.0 | 23.6 | 25.6 | 1.00 | 1713.02 |
| 21.400 | 1.00 | 2.0 | 23.6 | 25.6 | 1.00 | 1713.02 |
| 21.500 | 1.00 | 2.0 | 23.6 | 25.6 | 1.00 | 1713.02 |
| 21.600 | 1.00 | 2.0 | 23.6 | 25.6 | 1.00 | 1713.02 |
| 21.700 | 1.00 | 2.0 | 23.6 | 25.6 | 1.00 | 1713.02 |
| 21.800 | 1.00 | 2.0 | 23.6 | 25.6 | 1.00 | 1713.02 |
| 21.900 | 1.00 | 2.0 | 23.6 | 25.6 | 1.00 | 1713.02 |
| 22.000 | 1.00 | 2.0 | 23.6 | 25.6 | 1.00 | 1713.02 |
| 22.100 | 1.00 | 2.0 | 23.6 | 25.6 | 1.00 | 1713.02 |
| 22.200 | 1.00 | 2.0 | 23.6 | 25.6 | 1.00 | 1713.02 |
| 22.300 | 1.00 | 2.0 | 23.6 | 25.6 | 1.00 | 1713.02 |
| 22.400 | 1.00 | 2.0 | 23.6 | 25.6 | 1.00 | 1713.02 |
| 22.500 | 1.00 | 2.0 | 23.6 | 25.6 | 1.00 | 1713.02 |
| 22.600 | 1.00 | 2.0 | 23.6 | 25.6 | 1.00 | 1713.02 |
| 22.700 | 1.00 | 2.0 | 23.6 | 25.6 | 1.00 | 1713.02 |
| 22.800 | 1.00 | 2.0 | 23.6 | 25.6 | 1.00 | 1713.02 |
| 22.900 | 1.00 | 2.0 | 23.6 | 25.6 | 1.00 | 1713.02 |
| 23.000 | 1.00 | 2.0 | 23.6 | 25.6 | 1.00 | 1713.02 |
| 23.100 | 1.00 | 2.0 | 23.6 | 25.6 | 1.00 | 1713.02 |
| 23.200 | 1.00 | 2.0 | 23.6 | 25.6 | 1.00 | 1713.02 |
| 23.300 | 1.00 | 2.0 | 23.6 | 25.6 | 1.00 | 1713.02 |
| 23.400 | 1.00 | 2.0 | 23.6 | 25.6 | 1.00 | 1713.02 |
| 23.500 | 1.00 | 2.0 | 23.6 | 25.6 | 1.00 | 1713.02 |
| 23.600 | 1.00 | 2.0 | 23.6 | 25.6 | 1.00 | 1713.02 |
| 23.700 | 1.00 | 2.0 | 23.6 | 25.6 | 1.00 | 1713.02 |
| 23.800 | 1.00 | 2.0 | 23.6 | 25.6 | 1.00 | 1713.02 |
| 23.900 | 1.00 | 2.0 | 23.6 | 25.6 | 1.00 | 1713.02 |
| 24.000 | 0.00 | 1.0 | 22.9 | 24.6 | 0.86 | 1713.02 |
| 24.100 | 0.00 | 0.0 | 21.6 | 22.9 | 0.63 | 1713.01 |
| 24.200 | 0.00 | 0.0 | 20.7 | 21.6 | 0.46 | 1713.00 |
| 24.300 | 0.00 | 0.0 | 20.1 | 20.7 | 0.33 | 1713.00 |
| 24.400 | 0.00 | 0.0 | 19.6 | 20.1 | 0.24 | 1713.00 |
| 24.500 | 0.00 | 0.0 | 19.2 | 19.6 | 0.17 | 1713.00 |
| 24.600 | 0.00 | 0.0 | 19.0 | 19.2 | 0.13 | 1712.99 |

Pond File: NMC14 .PND
Inflow Hydrograph: NMC14 .HYD
Outflow Hydrograph: OUT .HYD

| INFLOW HYDROGRAPH | | ROUTING COMPUTATIONS | | | | |
|---|---|---|---|---|---|---|
| TIME (hrs) | INFLOW (cfs) | I1+I2 (cfs) | 2S/t - O (cfs) | 2S/t + O (cfs) | OUTFLOW (cfs) | ELEVATION (ft) |
| 24.700 | 0.00 | 0.0 | 18.8 | 19.0 | 0.09 | 1712.99 |
| 24.800 | 0.00 | 0.0 | 18.7 | 18.8 | 0.07 | 1712.99 |
| 24.900 | 0.00 | 0.0 | 18.6 | 18.7 | 0.05 | 1712.99 |
| 25.000 | 0.00 | 0.0 | 18.5 | 18.6 | 0.04 | 1712.99 |
| 25.100 | 0.00 | 0.0 | 18.4 | 18.5 | 0.03 | 1712.99 |
| 25.200 | 0.00 | 0.0 | 18.4 | 18.4 | 0.02 | 1712.99 |
| 25.300 | 0.00 | 0.0 | 18.4 | 18.4 | 0.01 | 1712.99 |
| 25.400 | 0.00 | 0.0 | 18.4 | 18.4 | 0.01 | 1712.99 |
| 25.500 | 0.00 | 0.0 | 18.3 | 18.4 | 0.01 | 1712.99 |
| 25.600 | 0.00 | 0.0 | 18.3 | 18.3 | 0.01 | 1712.99 |
| 25.700 | 0.00 | 0.0 | 18.3 | 18.3 | 0.00 | 1712.99 |
| 25.800 | 0.00 | 0.0 | 18.3 | 18.3 | 0.00 | 1712.99 |
| 25.900 | 0.00 | 0.0 | 18.3 | 18.3 | 0.00 | 1712.99 |

********** SUMMARY OF ROUTING COMPUTATIONS **********

Pond File: NMC14 .PND
Inflow Hydrograph: NMC14 .HYD
Outflow Hydrograph: OUT .HYD

Starting Pond W.S. Elevation = 1709.99 ft

***** Summary of Peak Outflow and Peak Elevation *****

| | | |
|---|---|---|
| Peak Inflow | = | 20.00 cfs |
| Peak Outflow | = | 7.34 cfs |
| Peak Elevation | = | 1713.73 ft |

***** Summary of Approximate Peak Storage *****

| | | |
|---|---|---|
| Initial Storage | = | 0.00 ac-ft |
| Peak Storage From Storm | = | 0.76 ac-ft |
| Total Storage in Pond | = | 0.76 ac-ft |

Pond File: NMC14 .PND
Inflow Hydrograph: NMC14 .HYD
Outflow Hydrograph: OUT .HYD

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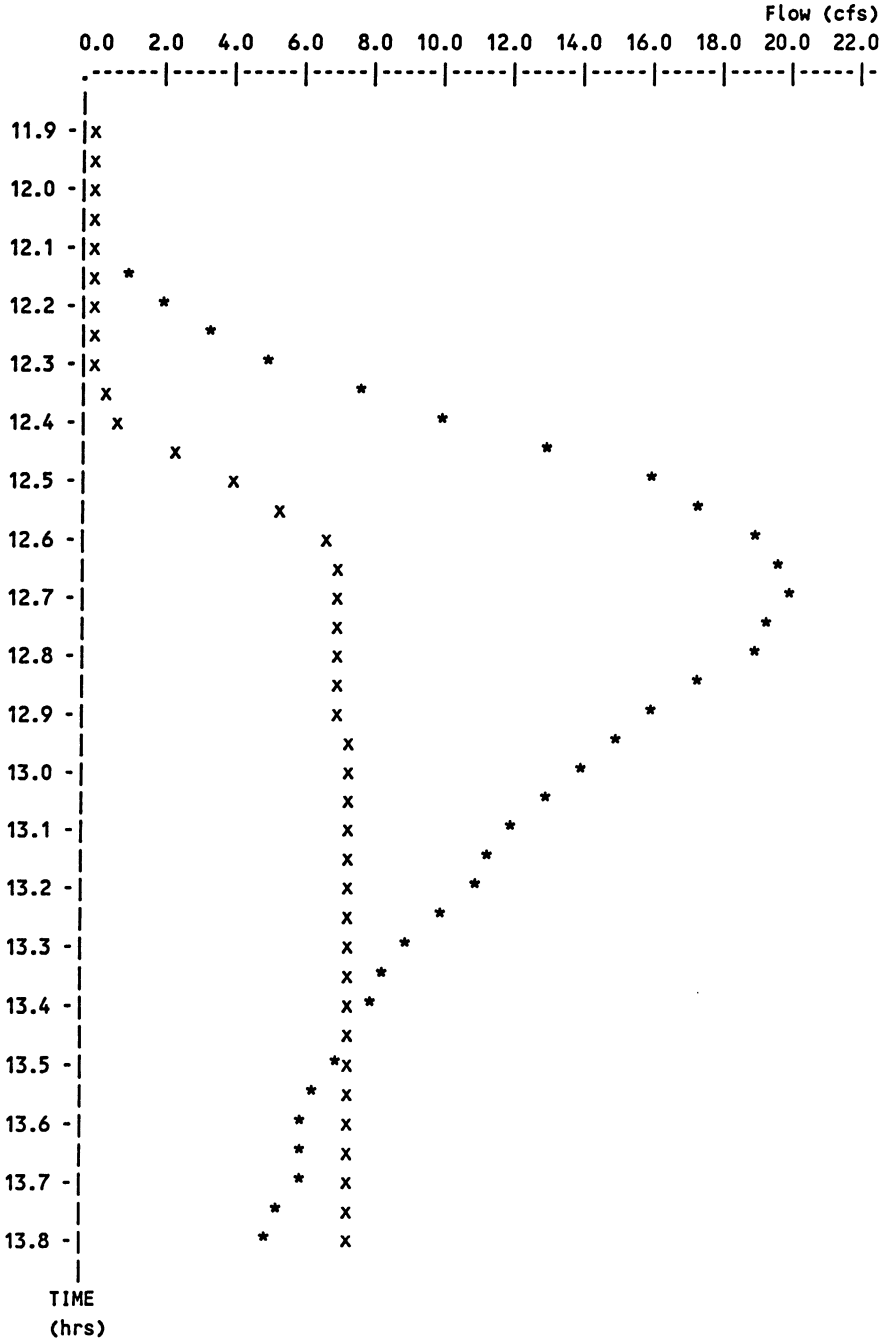
09:20:14

Peak Inflow = 20.00 cfs
Peak Outflow = 7.34 cfs
Peak Elevation = 1713.73 ft




* File: NMC14 .HYD Qmax = 20.0 cfs
x File: OUT .HYD Qmax = 7.3 cfs

# Attachment C

## Particle Size Removal Table

# Particle Size Removal Table

Goldman, et al., 1986. "Erosion & Sediment Control Handbook".

TABLE 8.1 Surface Area Requirements of Sediment Traps and Basins

| Particle size, mm | | Settling velocity, ft/sec (m/sec) | | Surface area requirements, ft² per ft³/sec discharge | (m² per m³/sec discharge) |
|---|---|---|---|---|---|
| 0.5 | (coarse sand) | 0.19 | (0.058) | 6.3 | (20.7) |
| 0.2 | (medium sand) | 0.067 | (0.020) | 17.9 | (58.7) |
| 0.1 | (fine sand) | 0.023 | (0.0070) | 52.2 | (171.0) |
| 0.05 | (coarse silt) | 0.0062 | (0.0019) | 193.6 | (635.0) |
| 0.02 | (medium silt) | 0.00096 | (0.00029) | 1,250.0 | (4,101.0) |
| 0.01 | (fine silt) | 0.00024 | (0.000073) | 5,000.0 | (16,404.0) |
| 0.005 | (clay) | 0.00006 | (0.000018) | 20,000.0 | (65,617.0) |

MICRONS
500
200
100
50
20
10
5

"Practices in Detention of Urban Stormwater Runoff".

| Kind of Material | Particle Diameter (micron) | Minimum Area Required (sq ft) |
|---|---|---|
| Coarse sand | 1,000 | 3.0 |
| Coarse sand | 200 | 14.5 |
| Fine sand | 100 | 38.2 |
| Fine sand | 60 | 80.0 |
| Fine sand | 40 | 145.0 |
| Silt | 10 | 2,030.0 |
| Coarse clay | 1 | 203,000.0 |
| Fine clay | 0.1 | 20,300,000.0 |

PARTICLE SIZE IN MICRONS

MINIMUM SURFACE AREA IN SQUARE FEET PER CFS OUTFLOW

# Appendix H

# TMA Sediment Load Analysis

# Foth & Van Dyke
# Memorandum

December 18, 1998

TO: Paul Egelhoff, Foth & Van Dyke

CC: Master File

FR: John Fassbender JJF/DMR

RE: Crandon Project - TMA Runoff Basin Sediment Load and Wetland F15 Calculations

## Background

The attached calculation estimates the amount of sediment to be discharged from runoff basins in the vicinity of the TMA. A separate calculation estimates the sediment load for wetland F15 for existing conditions. The wetland F15 calculation is similar to the 11/4/97 calculation transmitted with the 9/26/97 TMA response letter to the WDNR. The calculation has been revised for presentation in a format consistent with the runoff basin calculations.

## Calculation Procedure for Runoff Basin Sediment Loads

A universal soil loss equation (RUSLE) analysis for the final cover and exterior berm slopes was previously completed and included in Appendix L of Addendum No. 3 to the Crandon Project TMA Feasibility Report This calculation estimated the annual soil loss in tons/acre/year for the basins in the vicinity of the TMA. The "LS" variable used in this calculation was estimated for three different scenarios. The three scenarios are as follows:

- Convex slope in two sections for non-thawing soils.
- Convex slope in two sections for thawing soils.
- Calculation of LS using the average values of slope length.

The convex slope in two sections for thawing soils produced the highest LS value and was used in the sediment load calculation. A higher LS value also produces a higher estimate of the sediments to be discharged from the basins.

Two sediment loading conditions were analyzed: 1) the mulched condition which represents the year in which a reclaimed area is seeded and mulched; and 2) the grassed condition which represents the following year after vegetation is established.

The sediment loading evaluation was performed by establishing the minimum particle size each of the TMA runoff basins can remove for the design storm and then using the RUSLE and the soil types on site to estimate sediment loading for the proposed conditions.

## Soil Loss Calculation Procedure for Wetland F15 Using Existing Conditions

The soil loss from the existing forest land into wetland F15 has been estimated. The existing forest land is the land which drains into wetland F15. The existing conditions were separated into two land areas. The land areas were selected on the basis of their different slopes and therefore different soil loss rates.

The calculation was based on thawing soil conditions. This is consistent with the runoff basin calculations. A cover and management factor of 0.00055 was estimated by averaging the range of factors for a 75% to 100% undisturbed forest canopy.

## Results

The results of the runoff basin calculations are presented in the attached Table 1, Sediment Load Estimates for Runoff Basins. The results of the wetland F15 calculations are presented in the attached Table 2, Sediment Load Estimates from wetland F15, Existing Conditions.

JJF1:lxb

# Table 1

## Sediment Load Estimates for Runoff Basins

| Basin | R[1] | K[2] | LS[3] | C[4] | P[5] | SLF[6] (ton/ac/yr) | Drainage Acres[7] | Design Micron Size Removal[8] (microns) | % Soil <Micron Design[9] (%) | Sediment Load[10] (cy/yr) |
|---|---|---|---|---|---|---|---|---|---|---|
| **For mulched surfaces (C=.02):** | | | | | | | | | | |
| 9 | 95 | 0.24 | 6.71 | 0.02 | 1 | 3.06 | 110.8 | 7 | 7 | 18.76 |
| 10 | 95 | 0.24 | 6.71 | 0.02 | 1 | 3.06 | 61.5 | 6 | 6 | 8.93 |
| 11 | 95 | 0.24 | 6.71 | 0.02 | 1 | 3.06 | 14.7 | 9 | 9 | 3.20 |
| 12 | 95 | 0.24 | 6.71 | 0.02 | 1 | 3.06 | 26.2 | 4 | 3 | 1.90 |
| 13 | 95 | 0.24 | 6.71 | 0.02 | 1 | 3.06 | 11.6 | 8 | 8 | 2.24 |
| 14 | 95 | 0.24 | 6.71 | 0.02 | 1 | 3.06 | 29.0 | 8 | 8 | 5.61 |
| **For grass surfaces (C=0.012):** | | | | | | | | | | |
| 9 | 95 | 0.24 | 6.71 | 0.012 | 1 | 1.84 | 110.8 | 7 | 7 | 11.26 |
| 10 | 95 | 0.24 | 6.71 | 0.012 | 1 | 1.84 | 61.5 | 6 | 6 | 5.36 |
| 11 | 95 | 0.24 | 6.71 | 0.012 | 1 | 1.84 | 14.7 | 9 | 9 | 1.92 |
| 12 | 95 | 0.24 | 6.71 | 0.012 | 1 | 1.84 | 26.2 | 4 | 3 | 1.14 |
| 13 | 95 | 0.24 | 6.71 | 0.012 | 1 | 1.84 | 11.6 | 8 | 8 | 1.35 |
| 14 | 95 | 0.24 | 6.71 | 0.012 | 1 | 1.84 | 29.0 | 8 | 8 | 3.37 |

[1] See soil loss calculations, Appendix L, page 2/12 (Foth & Van Dyke, 1995).

[2] See soil loss calculations, Appendix L, page 10/12 (Foth & Van Dyke, 1995).

[3] See soil loss calculations, Appendix L, page 8/12, using a thawing soil loss scenario (Foth & Van Dyke, 1995). Note: Math correction for LS determination: LS=7.885 changed to LS=6.711.

[4] See soil loss calculations, Appendix L, page 11/12, C=0.02 for 4.0 tons straw/acre, C=0.012 for grass (Foth & Van Dyke, 1995).

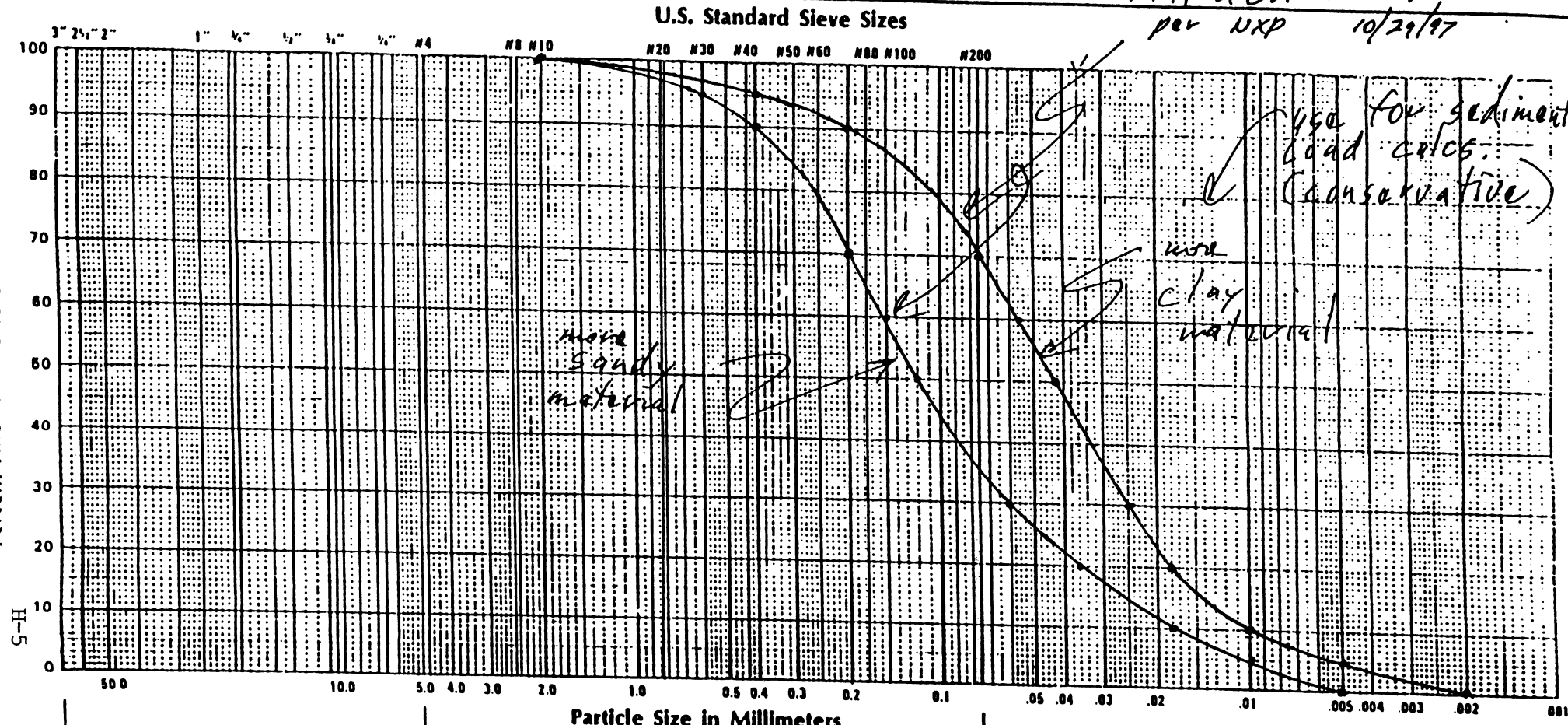
Prepared by: JJF1

Checked by: PAE

[5] See soil loss calculations, Appendix L, page 12/12, P=1 for no support practice (Foth & Van Dyke, 1995).
[6] See soil loss calculations, Appendix L, page 1/12, SLF is equal to RxKxLSxCxP (Foth & Van Dyke, 1995).
[7] See Appendix G, TMA Runoff Basin Sizing Calculations.
[8] See Table 9.3-1.
[9] See Attachment A.
[10] Sediment load is equal to SLF x Drainage Acres x (% soil < micron design) x (2000 lb/ton) x (c.y./2530 lbs).

# GRAIN SIZE DISTRIBUTION CURVE

Attach. 1
per UXP 10/29/97




H-5

| Gravel | | Sand | | | Silt | Clay |
|---|---|---|---|---|---|---|
| Coarse | Fine | Coarse | Medium | Fine | | |
| % = | % = | % = | % = | % = | % = | % = |

Location Sampled: _____ Elev. or Depth: _____ Date Sampled: _____

Sample Source: _____ Sampled Moisture Content (%): _____ Report No.: _____

Soil Classification (ASTM: D2487): _____

Atterberg Limits: LL _____ PL _____ PI _____

Munsell Color Code: _____

Date Received: _____

Coefficients: Cc = _____ Cu = _____

**Foth & Van Dyke**

Client: _____ Scope I.D.: _____

Project: _____ Page: _____

Prepared by: _____ Date: _____

Checked by: _____

# Table 2

## Sediment Load Estimates for Wetland F15, Existing Conditions

| Area | R[1] | K[2] | Horizontal Projection[3] (ft) | Slope[4] (%) | Slope[5] (deg.) | m[6] | L[7] | S[8] | LS[9] | C[10] | P[11] | SLF[12] (ton/ac/yr) | Drainage Acres[13] | Sediment Load[14] (cy/yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 95 | 0.24 | 998 | 7.0 | 4.00 | 0.5 | 3.71 | 0.78 | 2.91 | 0.00055 | 1 | 0.0365 | 76.35 | 2.20 |
| 2 | 95 | 0.24 | 350 | 2.5 | 1.43 | 0.5 | 2.20 | 0.30 | 0.66 | 0.00055 | 1 | 0.0083 | 42.35 | 0.28 |
| Total: | | | | | | | | | | | | | | 2.48 |

[1] See soil loss calculations, Appendix L, page 2/12 (Foth & Van Dyke, 1995).
[2] See soil loss calculations, Appendix L, page 10/12 (Foth & Van Dyke, 1995).
[3] Horizontal projection in feet of drainage area for basin (source p. 4 of Attachment 5 (NMC, 1997)).
[4] Average slope percentage of drainage area for basin (source p. 4 of Attachment 5 (NMC, 1997)).
[5] Average slope degree of drainage area for basin (= arc tangent of the slope percentage).
[6] See soil loss calculations, Appendix L, page 4/12, use 0.5 for thawing soils (Foth & Van Dyke, 1995).
[7] See soil loss calculations, Appendix L, page 5/12, L = (horizontal projection/72.6)^m (Foth & Van Dyke, 1995).
[8] See soil loss calculations, Appendix L, page 5/12, S = 10.8 sin (slope deg) + 0.03 for sin (slope deg) < 0.09.
[9] LS = L x S
[10] See soil loss calculations, Appendix L, page 11/12, C = 0.00055 is average for 100-75% undisturbed forest canopy (Foth & Van Dyke, 1995).
[11] See soil loss calculations, Appendix L, page 12/12, P = 1 for no support practice (Foth & Van Dyke, 1995).
[12] Sees soil loss calculations, Appendix L, page 1/12, SLF is equal to RxKxLSxCxP (Foth & Van Dyke, 1995).
[13] See Appendix G (TMA Runoff Basin Sizing Calculations).
[14] Sediment load is equal to SLF x Drainage Acres x (2,000 lb/ton) x (c.y./2,530 lbs).

Prepared by: JJF1
Checked by: PAE

# Appendix I

## Typical Limestone Chemical Characteristics

**Cutler-Magner Company**
12th Avenue West and Waterfront
P.O. Box 16807
Duluth, Minnesota 55816-0807
Phone: (218) 722-3981
FAX: (218) 722-2667

# Calcium Carbonate
## (Limestone)

## Average Chemical Analysis (%)

| | |
|---|---|
| $Fe_2O_3$ | 0.17 |
| $Al_2O_3$ | 0.15 |
| $SiO_2$ | 0.39 |
| S | 0.073 |
| CaO | 54.81 |
| MgO | 0.65 |
| L.O.I. | 43.83 |
| $CaCO_3$ | 97.83 |
| $MgCO_3$ | 1.37 |
| $P_2O_5$ | 0.003 |
| MnO | 0.014 |
| $TiO_2$ | 0.006 |

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GREAT LAKES CALCIUM CORPORATION

*Producers of Calcium Carbonate for Over 50 Years*

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UW-MADISON GEOLOGY LIBRARY

## Great Lakes Calcium Corporation
## Calcium Carbonate

| Chemical Compound | Percent of Sample |
|---|---|
| Calcium Carbonate | 98.18 |
| Elemental Calcium | 39.30 |
| Magnesium Carbonate | 1.36 |
| Elemental Magnesium | .40 |
| Silica | .23 |
| Aluminum | .08 |
| Iron | .13 |
| Sulfer | .059 |
| Total Available Carbonates | 99.54 |



*1400 Bylsby Avenue • P.O. Box 2236 • Green Bay, WI 54306-2236 • (414) 432-7731 or (800) 236-7737 • fax (414) 432-2782*

# Appendix J

# Assessment of TMA Drain Layer

SRK Consulting
Engineers and Scientists

Steffen Robertson and Kirsten (Canada.) Inc.
800, 580 Hornby Street
Vancouver, BC.
V6C 3B6

email: vancouver@srk.com
URL: http://www.srk.com
Tel: 604.681.4196
Fax: 604.687.5532

# MEMORANDUM

DATE: April 19, 2000

TO: Gerald Sevick, PE
Foth & Van Dyke, Green Bay, WI

FROM: John Chapman

**RE: 1UF004.01 - CRANDON PROJECT**
**ASSESSMENT OF TMA DRAIN LAYER**

## 1. INTRODUCTION

The objective of this memorandum is to provide the additional analysis requested by the Wisconsin Department of Natural Resources (WDNR, 1999) with respect to the potential for secondary minerals to accumulate within and reduce the permeability of the TMA drain layer. The analysis has been divided into two parts. The first is an initial assessment to illustrate that under upper bound conditions from the GWQPE, the risk of the drain layer plugging is extremely small. The second part of the assessment is a sensitivity analysis to illustrate the effects of:

- precipitation only within 1 meter of the drain pipes
- as above but with completely un-equilibrated water arriving from the oxidation zone.

In all cases, upper bound concentrations from the GWQPE are used and it is conservatively assumed that the drain would be at atmospheric $CO_2$ and oxidizing Eh conditions. These conditions would only arise if gas transfer in and out of the drain layer could take place. As discussed below, given the design of the TMA, it is highly unlikely that such a transfer will take place.

The drain layer design, as shown in Figure 5.3-1 of Addendum No. 5 to Crandon Project TMA Feasibility Report/Plan of Operation (FVD, 1998), comprises a series of drainage collection pipes placed in a 24 inch sand drainage layer at the base of the TMA. The sand layer is overlain by an 18 inch layer of till. Drainage net, surrounded by geofabric, will be used as the drainage layer on the side slopes of the TMA cells, which would allow leachate from the tailings to flow directly to the drain layer. Section 6.6 of Addendum 5 of the TMA Feasibility Report discusses the leachate

removal system. Leachate is expected to continuously pass through the sideslope drainage system, essentially resulting in near saturated conditions. The potential for air entry from the sideslopes to the drain layer is therefore expected to be low. The collection pipes in the drain layer at the base of each TMA cell will decant leachate to a sump. The sump pump will be actuated with a float device, which means that water will be pumped down as required, but the sump will not be pumped dry. The sump will act as an air-trap, preventing oxygen entry to the base drain layer and the leachate collection piping. Therefore, substantially no change in physico-chemical conditions is expected as leachate passes from the tailings into the drain layer.

# 2. INITIAL ASSESSMENT

## 2.1 Water Flux

Assessment of the total amount of precipitate that may accumulate in the drain layer requires an estimate of the total volume of flow that will pass through the drain layer. For the purpose of this assessment, representative calculations were completed based on the filling sequence for TMA Cell 2. TMA Cell 2 was used for the analysis because its filling sequence is simpler than that for TMA Cell 1. The conclusions of the analysis for TMA Cell 2 are also applicable to Cells 1 and 3.

Table 1 summarizes the TMA Cell 2 liner surface areas and predicted leachate collection rates. Table 2 summarizes the corresponding calculated leachate flow rates. Leachate collection rates shown in Table 1 for the operation and consolidation periods are the predicted HELP model average annual values (Table 8.3-1, FVD 1998). Post-capping rates are the actual predicted annual values from HELP model simulations for the lower sideslope, upper sideslope, and base. The leachate collection volumes for the lower and upper sideslope and base shown in Table 2 were calculated using the respective area and collection rates presented in Table 1. The annual flows for each area were then summed to arrive at the total cell annual and cumulative flows. Flow data in Table 2 is presented through year 27. The HELP model predicts that leachate collection will continue to decrease at a curvilinear rate until approximately year 134 when no additional collection is predicted. However, for the purposes of this assessment, the year 27 estimates are conservatively assumed to continue through to year 100.

Table 3 estimates the amount of leachate flow that originates in the oxidation zone. The percentages shown in bold in the middle column were estimated from a two-dimensional flow model of the TMA drainage, which was presented in SRK, 1999. The remaining values are interpolated.

## Table 1

## TMA2 – Summary of Filling Stage, Equivalent Liner Surface Areas Covered by Tailings and Leachate Collection Rates

| TMA 2 Stage | Time (Yr) | Surface Areas[1] (sq ft) | | | Collection Rate[2, 3] (in/yr) | | |
|---|---|---|---|---|---|---|---|
| | | Lower Sideslope | Upper Sideslope | Base | Lower Sideslope | Upper Sideslope | Base |
| Lower | 1 | 653,800 | 0 | 706,900 | 22.76 | N/A | 25.42 |
| | 2 | 653,800 | 0 | 706,900 | 22.76 | N/A | 25.42 |
| | 3 | 653,800 | 0 | 706,900 | 22.76 | N/A | 25.42 |
| Upper | 4 | 653,800 | 772,900 | 706,900 | 29.05 | 23.30 | 31.40 |
| | 5 | 653,800 | 772,900 | 706,900 | 29.05 | 23.30 | 31.40 |
| | 6 | 653,800 | 772,900 | 706,900 | 29.05 | 23.30 | 31.40 |
| | 7 | 653,800 | 772,900 | 706,900 | 29.05 | 23.30 | 31.40 |
| Consolidation | 8 | 653,800 | 772,900 | 706,900 | 29.05 | 23.30 | 31.40 |
| | 9 | 653,800 | 772,900 | 706,900 | 29.05 | 23.30 | 31.40 |
| Capped | 10 | 653,800 | 772,900 | 706,900 | 96.51 | 52.64 | 109.94 |
| | 11 | 653,800 | 772,900 | 706,900 | 30.37 | 6.02 | 51.38 |
| | 12 | 653,800 | 772,900 | 706,900 | 7.13 | 4.63 | 7.85 |
| | 13 | 653,800 | 772,900 | 706,900 | 6.35 | 3.75 | 6.98 |
| | 14 | 653,800 | 772,900 | 706,900 | 5.72 | 3.11 | 6.35 |
| | 15 | 653,800 | 772,900 | 706,900 | 5.19 | 2.63 | 5.85 |
| | 16 | 653,800 | 772,900 | 706,900 | 4.73 | 2.27 | 5.41 |
| | 17 | 653,800 | 772,900 | 706,900 | 4.36 | 1.92 | 5.03 |
| | 18 | 653,800 | 772,900 | 706,900 | 4.02 | 1.65 | 4.69 |
| | 19 | 653,800 | 772,900 | 706,900 | 3.73 | 1.44 | 4.41 |
| | 20 | 653,800 | 772,900 | 706,900 | 3.47 | 1.28 | 4.14 |
| | 21 | 653,800 | 772,900 | 706,900 | 3.19 | 1.15 | 3.90 |
| | 22 | 653,800 | 772,900 | 706,900 | 2.94 | 1.01 | 3.61 |
| | 23 | 653,800 | 772,900 | 706,900 | 2.72 | 0.92 | 3.36 |
| | 24 | 653,800 | 772,900 | 706,900 | 2.52 | 0.84 | 3.15 |
| | 25 | 653,800 | 772,900 | 706,900 | 2.37 | 0.78 | 2.96 |
| | 26 | 653,800 | 772,900 | 706,900 | 2.21 | 0.72 | 2.78 |
| | 27 | 653,800 | 772,900 | 706,900 | 2.08 | 0.67 | 2.63 |

Notes: 1 Source: Table 12 (NMC 1999).
2 Source: Average annual collection rates from Table 8.3-1 (FVD 1998) for operation and consolidation periods (Years 1 through 9).
3 Post capping annual collection rates from HELP model runs #6a - Base Closure, #7a - Upper Sideslope Closure, and #8a - Lower Sideslope Closure, file dated 10/20/98. (FVD, 1999)

Prepared by: NXP
Checked by: DMR

## Table 2
## TMA2 – Summary of Leachate Collection Volumes

| TMA 2 Stage | Time (Yr) | Flows, $m^3$ | | | | |
|---|---|---|---|---|---|---|
| | | Lower Sideslope | Upper Sideslope | Base | Total Annual | Total Cumulative, $m^3$ |
| Lower | 1 | 35,100 | 0 | 42,400 | 77,500 | 77,500 |
| | 2 | 35,100 | 0 | 42,400 | 77,500 | 155,000 |
| | 3 | 35,100 | 0 | 42,400 | 77,500 | 232,500 |
| Upper | 4 | 44,800 | 42,500 | 52,400 | 139,700 | 372,200 |
| | 5 | 44,800 | 42,500 | 52,400 | 139,700 | 511,900 |
| | 6 | 44,800 | 42,500 | 52,400 | 139,700 | 651,600 |
| | 7 | 44,800 | 42,500 | 52,400 | 139,700 | 791,300 |
| Consolidation | 8 | 44,800 | 42,500 | 52,400 | 139,700 | 931,000 |
| | 9 | 44,800 | 42,500 | 52,400 | 139,700 | 1,070,700 |
| Capped | 10 | 148,900 | 96,000 | 183,400 | 428,300 | 1,499,000 |
| | 11 | 46,800 | 11,000 | 85,700 | 143,500 | 1,642,500 |
| | 12 | 11,000 | 8,400 | 13,100 | 32,500 | 1,675,000 |
| | 13 | 9,800 | 6,800 | 11,700 | 28,300 | 1,703,300 |
| | 14 | 8,800 | 5,700 | 10,600 | 25,100 | 1,728,400 |
| | 15 | 8,000 | 4,800 | 9,800 | 22,600 | 1,751,000 |
| | 16 | 7,300 | 4,200 | 9,000 | 20,500 | 1,771,500 |
| | 17 | 6,700 | 3,500 | 8,400 | 18,600 | 1,790,100 |
| | 18 | 6,200 | 3,000 | 7,800 | 17,000 | 1,807,100 |
| | 19 | 5,800 | 2,600 | 7,400 | 15,800 | 1,822,900 |
| | 20 | 5,400 | 2,300 | 6,900 | 14,600 | 1,837,500 |
| | 21 | 4,900 | 2,100 | 6,500 | 13,500 | 1,851,000 |
| | 22 | 4,500 | 1,800 | 6,000 | 12,300 | 1,863,300 |
| | 23 | 4,200 | 1,700 | 5,600 | 11,500 | 1,874,800 |
| | 24 | 3,900 | 1,500 | 5,300 | 10,700 | 1,885,500 |
| | 25 | 3,700 | 1,400 | 4,900 | 10,000 | 1,895,500 |
| | 26 | 3,400 | 1,300 | 4,600 | 9,300 | 1,904,800 |
| | 27 | 3,200 | 1,200 | 4,400 | 8,800 | 1,913,600 |

Notes: Predicted annual flow values reduce to zero by year 134.

Prepared by: NXP
Checked by: DMR

## Table 3
## Annual Flows to Drain Layer from Process and Oxidation Zone Water

| Operations Stage | Year | Process Water Flow to Drain ($m^3$/year) | % Flow from Upper 3.5 Meter of sidewall[1] | Oxidation Zone Flow to Drain ($m^3$/year) |
|---|---|---|---|---|
| Lower | 1 | 77,500 | na | na |
| | 2 | 77,500 | na | na |
| | 3 | 77,500 | na | na |
| Upper | 4 | 139,700 | na | na |
| | 5 | 139,700 | na | na |
| | 6 | 139,700 | na | na |
| | 7 | 139,700 | na | na |
| Consolidation | 8 | 139,700 | **3.3%** | 0[2] |
| | 9 | 137,744 | **1.4%** | 1,956 |
| Capped | 10 | *140,005*[3] | **0.87%** | 1,595 |
| | 11 | 142,266 | 0.86% | 1,234 |
| | 12 | 32,224 | 0.85% | 276 |
| | 13 | 28,062 | 0.84% | 238 |
| | 14 | 24,892 | 0.83% | 208 |
| | 15 | 22,415 | 0.82% | 185 |
| | 16 | 20,334 | 0.81% | 166 |
| | 17 | 18,451 | 0.80% | 149 |
| | 18 | 16,864 | **0.80%** | 136 |
| | 19 | 15,686 | 0.72% | 114 |
| | 20 | 14,507 | 0.64% | 93 |
| | 21 | 13,424 | 0.56% | 76 |
| | 22 | 12,241 | 0.48% | 59 |
| | 23 | 11,454 | 0.40% | 46 |
| | 24 | 10,666 | 0.32% | 34 |
| | 25 | 9,976 | 0.24% | 24 |
| | 26 | 9,285 | 0.16% | 15 |
| | 27 | 8,791 | **0.10%** | 9 |

Notes: 1. Bold values are actual modeled values (SRK 1999), other values are interpolated.

2. Set to zero because this zone is still predominantly process water during the first year of consolidation.

3. Has been smoothed to reduce the effects of the flow variability in the HELP model.

"na" not applicable (no oxidation water at this time).

Prepared by: KSS
Checked by: DEH

## 2.2 Geochemical Modeling

Geochemical equilibrium modeling was carried out to estimate the amount of precipitate that could be formed from the process water and oxidation water entering the drain layer. Equilibrated process water and equilibrated oxidation zone water from Appendix B of the GWQPE (FVD, 1999/2000) were used as inputs for this initial set of simulations.

The equilibrated waters were subjected to atmospheric $CO_2$ and oxidizing conditions (Eh = 200 mV). The change in conditions was intended to simulate the effect of oxygen and $CO_2$ entering the drain layer via the collection pipes. Rather than including oxygen as a gas with a fixed partial pressure, (as was requested by the WDNR), Eh was used to define the redox. The reason for this is that the MINTEQA2 model calculations are very sensitive to oxygen partial pressure, and, any oxygen entered, even at a very low concentration, tends to drive the Eh to unrealistically high values.

### 2.2.1 Process Water

Equilibrated process water quality from the file TMA-PW6.out (Table 3 from Appendix B of the GWQPE) was used to provide input concentrations for the geochemical modeling of equilibrated process water entering the drain layer. The MINTEQA2 input and output files (UD-PW1.in/out) are provided in Attachment A.

The MINTEQA2 results indicate that ferrihydrite and gibbsite (C) would precipitate under atmospheric $CO_2$ and high redox (200 mV) conditions. Calcite and dolomite were below saturation, and gypsum was at equilibrium (SI = -0.001). The concentration of each precipitate is shown in Table 4 below.

The concentration of each precipitate was converted to a volume equivalent per unit volume of water by dividing by the density of the mineral phase.

**Table 4**
**Summary of Calculated Precipitate Volume from Process Water**

| Phase | Mineral Properties | | Precipitate Concentration | | Volume L/L |
|---|---|---|---|---|---|
| | Molar Weight | Density g/cm$^3$ | moles/l | g/l | |
| Gibbsite ($Al(OH)_3$) | 78 | 2.42 | 1.55E-07 | 1.21E-05 | 5.00E-09 |
| Ferrihydrite ($Fe(OH)_3$) | 107 | 3.12 | 5.12E-05 | 5.47E-03 | 1.75E-06 |
| Total | | | | | 1.76E-06 |

Prepared by: JTC
Checked by: KSS

### 2.2.2 Oxidation Zone Water

Equilibrated oxidation zone water quality from the file UB2c-12, sweep 4, (Table 8 from Appendix B of the GWQPE) was used as the input concentrations for the geochemical modeling of oxidation zone water entering the drain layer. The upper bound runs were selected as the input concentrations because they had the largest amount of dissolved solutes, and would therefore represent upper bound conditions with respect to precipitation within the drain layer. The equilibrated oxidation zone water was allowed to re-equilibrate within the drain layer under atmospheric $CO_2$ and high redox (200 mV) conditions. The MINTEQA2 input and output files (UD-ox1.in/out) are provided in Attachment A.

The results indicate that ferrihydrite, anglesite, gypsum, and $Sb(OH)_3$ would form under atmospheric $CO_2$ and high redox (200 mV) conditions. Ferrihydrite would be the most abundant phase. Calcite and dolomite were below saturation. The results are summarized in Table 5. As in the process water simulations, the results were converted to a volume equivalent per unit volume of water by dividing by the density of the mineral phase.

**Table 5**
**Summary of Precipitate Volume due to Solute Release from Oxidation Zone Water**

| Phase | Mineral Properties | | Precipitate Concentration | | Volume L/L |
|---|---|---|---|---|---|
| | Molar Weight | Density g/cm$^3$ | moles/L | g/L | |
| Ferrihydrite ($Fe(OH)_3$) | 106.9 | 3.12 | 7.56E-04 | 8.08E-02 | 2.59E-05 |
| Anglesite ($PbSO_4$) | 303.3 | 6.29 | 1.00E-05 | 3.04E-03 | 4.83E-07 |
| Gypsum ($CaSO_4 \cdot 2H_2O$) | 172.2 | 2.32 | 3.55E-05 | 6.10E-03 | 2.63E-06 |
| $Sb(OH)_3$ | 172.5 | 3.62 | 4.30E-05 | 7.41E-03 | 2.05E-06 |
| Net | | | | | 3.10E-05 |

Prepared by: JTC
Checked by: KSS

## 2.3 Precipitate Accumulation

The volume of precipitate that would accumulate within the TMA drain layer was calculated by multiplying the annual flows from each zone (Table 3) by the respective precipitate volumes in Tables 4 and 5. The results for the first 100 years of the TMA Cell 2 life are given in Table 6.

## 2.4 Change in Porosity and Hydraulic Conductivity

The effect of the precipitate on the drain layer porosity was estimated as summarized in Table 7. The results indicate that the precipitation will result in a negligible reduction of the drain layer porosity.

Several equations have been derived to describe the relationship between the hydraulic conductivity and porosity. The Kozeny-Carmen (Freeze and Cherry, 1979) is the most commonly used:

$$K = \left(\frac{\rho g}{\eta}\right)\frac{(n^3)}{(1-n)^2}\left(\frac{d_m^2}{180}\right) \qquad (1)$$

Where: $K$ = hydraulic conductivity (m/s),
$\rho$ = density of water (kg/m$^3$),
$g$ = 9.81 m/s$^2$
$\eta$ = viscosity (Ns/m$^2$)
n = porosity (vol/vol)
$d_m$ = representative grain size (m)

# Table 6
## Summary of Precipitate Accumulation in TMA 2 Drain Layer

| Operations Stage | Time | Process Water | | | | Oxidation Zone Water | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Flow | Volume Precipitate | Annual Volume Precipitate | Cumulative Volume Precipitate | Flow | Volume Precipitate | Annual Volume Precipitate | Cumulative Volume Precipitate |
| | | $m^3$ | $m^3/m^3$ | $m^3/yr$ | $m^3$ | $m^3$ | $m^3/m^3$ | $m^3/yr$ | $m^3$ |
| Lower | 1 | 77500 | 1.8E-06 | 0.14 | 0.14 | 0 | 0 | 0 | 0 |
| | 2 | 77500 | 1.8E-06 | 0.14 | 0.27 | 0 | 0 | 0 | 0 |
| | 3 | 77500 | 1.8E-06 | 0.14 | 0.41 | 0 | 0 | 0 | 0 |
| Upper | 4 | 139700 | 1.8E-06 | 0.25 | 0.65 | 0 | 0 | 0 | 0 |
| | 5 | 139700 | 1.8E-06 | 0.25 | 0.90 | 0 | 0 | 0 | 0 |
| | 6 | 139700 | 1.8E-06 | 0.25 | 1.1 | 0 | 0 | 0 | 0 |
| | 7 | 139700 | 1.8E-06 | 0.25 | 1.4 | 0 | 0 | 0 | 0 |
| Consolidation | 8 | 139700 | 1.8E-06 | 0.25 | 1.6 | 0 | 0 | 0 | 0 |
| | 9 | 137744 | 1.8E-06 | 0.24 | 1.9 | 1956 | 3.1E-05 | 0.061 | 0.061 |
| Capped | 10 | 140005 | 1.8E-06 | 0.25 | 2.1 | 1595 | 3.1E-05 | 0.050 | 0.11 |
| | 11 | 142266 | 1.8E-06 | 0.25 | 2.4 | 1234 | 3.1E-05 | 0.038 | 0.15 |
| | 12 | 32224 | 1.8E-06 | 0.057 | 2.4 | 276 | 3.1E-05 | 0.0086 | 0.16 |
| | 13 | 28062 | 1.8E-06 | 0.049 | 2.5 | 238 | 3.1E-05 | 0.0074 | 0.16 |
| | 14 | 24892 | 1.8E-06 | 0.044 | 2.5 | 208 | 3.1E-05 | 0.0065 | 0.17 |
| | 15 | 22415 | 1.8E-06 | 0.039 | 2.6 | 185 | 3.1E-05 | 0.0058 | 0.18 |
| | 16 | 20334 | 1.8E-06 | 0.036 | 2.6 | 166 | 3.1E-05 | 0.0052 | 0.18 |
| | 17 | 18451 | 1.8E-06 | 0.032 | 2.6 | 149 | 3.1E-05 | 0.0046 | 0.19 |
| | 18 | 16864 | 1.8E-06 | 0.030 | 2.7 | 136 | 3.1E-05 | 0.0042 | 0.19 |
| | 19 | 15686 | 1.8E-06 | 0.028 | 2.7 | 114 | 3.1E-05 | 0.0035 | 0.19 |
| | 20 | 14507 | 1.8E-06 | 0.025 | 2.7 | 93 | 3.1E-05 | 0.0029 | 0.20 |
| | 21 | 13424 | 1.8E-06 | 0.024 | 2.7 | 76 | 3.1E-05 | 0.0023 | 0.20 |
| | 22 | 12241 | 1.8E-06 | 0.022 | 2.8 | 59 | 3.1E-05 | 0.0018 | 0.20 |
| | 23 | 11454 | 1.8E-06 | 0.020 | 2.8 | 46 | 3.1E-05 | 0.0014 | 0.20 |
| | 24 | 10666 | 1.8E-06 | 0.019 | 2.8 | 34 | 3.1E-05 | 0.0011 | 0.20 |
| | 25 | 9976 | 1.8E-06 | 0.018 | 2.8 | 24 | 3.1E-05 | 0.00075 | 0.20 |
| | 26 | 9285 | 1.8E-06 | 0.016 | 2.8 | 15 | 3.1E-05 | 0.00046 | 0.21 |
| Assumed | 27 | 8791 | 1.8E-06 | 0.015 | 2.8 | 8.8 | 3.1E-05 | 0.00027 | 0.21 |
| Steady State | ↓ | | | | ↓ | | | | ↓ |
| | 100 | | | | 4.0 | | | | 0.22 |

Prepared by: KSS
Checked by: DEH

## Table 7
## Estimated Reduction in Pore Volume and Porosity of the Drainage Layer for 100 Year Period

| **Drain Layer Properties** | | | |
|---|---|---|---|
| Volume | 1413840 $ft^3$ | | |
| | 40035 $m^3$ | | |
| Porosity | 0.39 | | |
| Pore Volume | 15614 $m^3$ | | |
| **Precipitate Accumulation** | **Process Water** | **Oxidation Zone Water** | **Total** |
| Volume Precipitate ($m^3$) | 4.0 | 0.22 | 4.2 |
| Fraction of Pore Space (vol/vol) | 0.025% | 0.0014% | 0.027% |
| **Change in Porosity** | | | |
| Initial Porosity | | | 0.3900 |
| Final porosity | | | 0.3896 |
| **Change in Hydraulic Conductivity** | | | |
| Kozeny-Carmen Ratio | | | 1.001 |
| Initial Hydraulic Conductivity | | | 0.30 |
| Final Hydraulic Conductivity | | | 0.2997 |

Prepared by: JTC
Checked by: KSS

The Kozeny-Carmen equation can be rearranged to describe the change in hydraulic conductivity as a function of porosity:

$$\frac{K_1}{K_2} = \frac{(n_1^3)}{(1-n_1)^2} \times \frac{(1-n_2)^2}{(n_2^3)} \qquad (2)$$

Table 7 shows that the estimated reduction in porosity of the drain layer will have a negligible effect on the hydraulic conductivity (reduction from 0.30 to 0.2997 cm/s) of the drain layer.

# 3. SENSITIVITY ANALYSIS

As requested by the WDNR, the following additional cases were evaluated:

1) The total mass of precipitate estimated in the overall assessment was assumed to form within 1 meter distance from the drainage collection pipes, only within the drainage layer.

2) The geochemical modeling performed for the initial assessment above was revised to allow process water equilibrated with dolomite, smithsonite and siderite (C) at atmospheric conditions and un-equilibrated water from the oxidation zone, to equilibrate under atmospheric $CO_2$ and oxidizing conditions within the drain layer. As in case 1, all of the mass would form within 1 meter of the drainage collection pipes.

The results are summarized in the following sections.

## 3.1 Localized Accumulation of Precipitate – Sensitivity Case 1

To assess Case 1, it was assumed that all of the precipitates estimated in Table 6 would accumulate within one meter (3.3 ft) on either side of the collection pipes in the 0.61 m (2 ft) thick drainage layer, (i.e. within a space of 2 m by 0.61 m (2 sides x 3.3 ft by 2 ft)) for the entire length of the drainage pipe. The total length of drainage pipe that will be placed in the drainage layer of TMA cell 2 is approximately 5600 ft (Drawing 16, FVD 1998). The calculations are summarized in Table 8.

The calculations suggest that the pore space within the immediate vicinity of the leachate collection pipes could be reduced by only 0.52% under the assumptions of the evaluation. This represents a reduction in porosity from 0.39 to 0.388.

**Table 8**
**TMA 2 Localized Precipitation Calculations: Sensitivity Case 1**
**for 100 Year Period**

| | | | |
|---|---|---|---|
| **Drain Layer Properties** | | | |
| Length | 5600 ft | 1707 m | |
| Drain Layer Thickness | 2 ft | 0.610 m | |
| Distance within layer | 3.3 ft | 1 m | |
| Volume | 73491 $ft^3$ | 2081 $m^3$ | |
| Porosity | 0.39 | 0.39 | |
| Pore space | 28661 $ft^3$ | 812 $m^3$ | |
| **Precipitate Accumulation** | **Process Water** | **Oxidation Zone Water** | **Total** |
| Volume Precipitate ($m^3$) | 4.0 | 0.22 | 4.2 |
| Fraction of Pore Space (vol/vol) | 0.49% | 0.028% | 0.52% |
| **Change in Porosity** | | | |
| Initial Porosity | | | 0.390 |
| Final Porosity | | | 0.388 |
| **Change in Hydraulic Conductivity** | | | |
| Kozeny-Carmen Ratio | | | 1.02 |
| Initial Hydraulic Conductivity | | | 0.30 |
| Final Hydraulic Conductivity | | | 0.29 |

Prepared by: JTC
Checked by: KSS

## 3.2 Localized Accumulation of Precipitate – Sensitivity Case 2

### 3.2.1 Process Water

Process water from the last column of Table 2, Appendix B of the GWQPE (FVD, 2000) was equilibrated with dolomite, smithsonite and siderite (C) at Eh of 0 mV and atmospheric $CO_2$ conditions (MINTEQA2 File: UD-PW2ic.in). The output from this (UD-PW2ic.out) was then equilibrated at an Eh of 200 mV and atmospheric $CO_2$ conditions (UD-PW2fc.in/out) to simulate precipitation within the drain layer. The MINTEQA2 input and output files are provided in Attachment B.

The results indicate that gibbsite, barite, calcite, $Sb(OH)_3$ and ferrihydrite would precipitate under these conditions. Calcite would be the most significant phase. Gypsum and dolomite were undersaturated.

As shown in Table 9, the results were converted to a volume equivalent per unit volume of water by dividing by the density of the mineral phase.

**Table 9**
**Summary of Calculated Precipitate Volume from Process Water - Sensitivity Case 2**

| Phase | Mineral Properties | | Precipitate Concentration | | Volume L/L |
|---|---|---|---|---|---|
| | Molar Weight | Density g/cm$^3$ | moles/L | g/L | |
| Gibbsite ($Al(OH)_3$) | 78.0 | 2.42 | 3.5E-05 | 2.7E-03 | 1.12E-06 |
| Barite ($BaSO_4$) | 233.3 | 4.30 | 2.2E-07 | 5.0E-05 | 1.17E-08 |
| Calcite ($CaCO_3$) | 100.0 | 2.80 | 3.0E-04 | 3.0E-02 | 1.08E-05 |
| $Sb(OH)_3$ (s) | 172.5 | 3.62 | 4.8E-07 | 8.3E-05 | 2.28E-08 |
| Ferrihydrite ($Fe(OH)_3$) | 106.9 | 3.12 | 8.2E-06 | 8.7E-04 | 2.80E-07 |
| Total | | | | | 1.22E-05 |

Prepared by: JTC
Checked by: KSS

3.2.2 Oxidation Zone Water

Un-equilibrated oxidation zone water was allowed to equilibrate at atmospheric $CO_2$ and oxidizing conditions (Eh=200 mV) within the TMA drain layer. The input file was based on the un-equilibrated solution concentrations and solids in the upper bound MINTEQA2 runs (UB-2c12.in and UB-3c12.in), which includes all of the solute mass released into or present in the oxidation zone of the TMA. (Because the solute mass has not been equilibrated, the input files are not influenced by the $CO_2$ and redox conditions assumed in the GWQPE runs.)

The MINTEQA2 input and output files are provided in Attachment B. The results indicate that gibbsite, barite, ferrihydrite, rhodochrosite, anglesite, gypsum and $Sb(OH)_3$ would precipitate under these conditions. Gypsum and ferrihydrite would be the most significant phases. Calcite and dolomite were under-saturated.

As shown in Table 10, the results were converted to a volume equivalent per unit volume of water by dividing by the density of the mineral phase.

**Table 10**
**Summary of Calculated Precipitate Volume from Oxidation Zone Water Sensitivity Case 2**

| Phase | Mineral Properties | | Concentration of Precipitate | | Volume of Precipitate |
|---|---|---|---|---|---|
| | Molar Weight | Density g/cm$^3$ | moles/L | g/L | L/L |
| Gibbsite ($Al(OH)_3$) | 78 | 2.42 | 8.37E-04 | 6.53E-02 | 2.70E-05 |
| Barite ($BaSO_4$) | 233 | 4.30 | 9.87E-06 | 2.30E-03 | 5.36E-07 |
| Ferrihydrite ($Fe(OH)_3$) | 107 | 3.12 | 1.59E-01 | 1.70E+01 | 5.44E-03 |
| Rhodocrosite ($MnCO_3$) | 115 | 3.70 | 1.66E-03 | 1.91E-01 | 5.16E-05 |
| Anglesite ($PbSO_4$) | 303 | 6.29 | 1.49E-03 | 4.52E-01 | 7.18E-05 |
| Gypsum ($CaSO_4 \cdot H_2O$) | 172 | 2.32 | 1.29E-01 | 2.21E+01 | 9.54E-03 |
| Sb(OH)3 | 173 | 3.62 | 4.30E-05 | 7.41E-03 | 2.05E-06 |
| TOTAL | | | | | 1.51E-02 |

Prepared by: JTC
Checked by: KSS

As before, the rate of precipitate accumulation was estimated on an annual basis, as shown in Table 11. Table 12 summarizes the localized effect of the precipitation in the drain layer.

The porosity is estimated to decrease from 0.39 to about 0.32. The loss of pore space would cause a decrease in the hydraulic conductivity 0.30 cm/s to 0.14 cm/s.

## Table 11
## Summary of Precipitate Accumulation in TMA 2 Drain Layer – Sensitivity Case 2

| Operations Stage | Time | Process Water | | | | Oxidation Zone Water | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Flow $m^3$ | Volume Precipitate $m^3/m^3$ | Annual Volume Precipitate $m^3/yr$ | Cumulative Volume Precipitate $m^3$ | Flow $m^3$ | Volume Precipitate $m^3/m^3$ | Annual Volume Precipitate $m^3/yr$ | Cumulative Volume Precipitate $m^3$ |
| Lower | 1 | 77500 | 1.2E-05 | 0.95 | 1 | 0 | 0 | 0 | 0 |
| | 2 | 77500 | 1.2E-05 | 0.95 | 2 | 0 | 0 | 0 | 0 |
| | 3 | 77500 | 1.2E-05 | 0.95 | 3 | 0 | 0 | 0 | 0 |
| Upper | 4 | 139700 | 1.2E-05 | 1.7 | 5 | 0 | 0 | 0 | 0 |
| | 5 | 139700 | 1.2E-05 | 1.7 | 6 | 0 | 0 | 0 | 0 |
| | 6 | 139700 | 1.2E-05 | 1.7 | 8 | 0 | 0 | 0 | 0 |
| | 7 | 139700 | 1.2E-05 | 1.7 | 10 | 0 | 0 | 0 | 0 |
| Consolidation | 8 | 139700 | 1.2E-05 | 1.7 | 11 | 0 | 0 | 0 | 0 |
| | 9 | 137744 | 1.2E-05 | 1.7 | 13 | 1956 | 1.5E-02 | 30 | 30 |
| Capped | 10 | 140005 | 1.2E-05 | 1.7 | 15 | 1595 | 1.5E-02 | 24 | 54 |
| | 11 | 142266 | 1.2E-05 | 1.7 | 16 | 1234 | 1.5E-02 | 19 | 72 |
| | 12 | 32224 | 1.2E-05 | 0.39 | 17 | 276 | 1.5E-02 | 4.2 | 77 |
| | 13 | 28062 | 1.2E-05 | 0.34 | 17 | 238 | 1.5E-02 | 3.6 | 80 |
| | 14 | 24892 | 1.2E-05 | 0.30 | 18 | 208 | 1.5E-02 | 3.2 | 83 |
| | 15 | 22415 | 1.2E-05 | 0.27 | 18 | 185 | 1.5E-02 | 2.8 | 86 |
| | 16 | 20334 | 1.2E-05 | 0.25 | 18 | 166 | 1.5E-02 | 2.5 | 89 |
| | 17 | 18451 | 1.2E-05 | 0.23 | 18 | 149 | 1.5E-02 | 2.3 | 91 |
| | 18 | 16864 | 1.2E-05 | 0.21 | 18 | 136 | 1.5E-02 | 2.1 | 93 |
| | 19 | 15686 | 1.2E-05 | 0.19 | 19 | 114 | 1.5E-02 | 1.7 | 95 |
| | 20 | 14507 | 1.2E-05 | 0.18 | 19 | 93 | 1.5E-02 | 1.4 | 96 |
| | 21 | 13424 | 1.2E-05 | 0.16 | 19 | 76 | 1.5E-02 | 1.1 | 97 |
| | 22 | 12241 | 1.2E-05 | 0.15 | 19 | 59 | 1.5E-02 | 0.89 | 98 |
| | 23 | 11454 | 1.2E-05 | 0.14 | 19 | 46 | 1.5E-02 | 0.70 | 99 |
| | 24 | 10666 | 1.2E-05 | 0.13 | 19 | 34 | 1.5E-02 | 0.52 | 99 |
| | 25 | 9976 | 1.2E-05 | 0.12 | 20 | 24 | 1.5E-02 | 0.36 | 100 |
| | 26 | 9285 | 1.2E-05 | 0.11 | 20 | 15 | 1.5E-02 | 0.23 | 100 |
| Assumed | 27 | 8791 | 1.2E-05 | 0.11 | 20 | 9 | 1.5E-02 | 0.13 | 100 |
| Steady State | ↓ | | | | ↓ | | | | ↓ |
| | 100 | | | | 27 | | | | 110 |

Prepared by: KSS
Checked by: DEH

# Table 12
## TMA 2 Localized Precipitation Calculations: Sensitivity Case 2 for a 100 year Period

| **Drain Layer Properties** | | | |
|---|---|---|---|
| Length | 5600 ft | 1707 m | |
| Thickness | 2 ft | 0.61 m | |
| Distance within layer | 3.3 ft | 1 m | |
| Volume | 73491 $ft^3$ | 2081 $m^3$ | |
| Porosity | 0.39 | 0.39 | |
| Pore space | 28661 $ft^3$ | 812 $m^3$ | |
| **Precipitate Accumulation** | **Process Water** | **Oxidation Zone Water** | **Total** |
| Volume Precipitate ($m^3$) | 27 | 110 | 137 |
| Fraction of Pore Space (vol/vol) | 3.4% | 14% | 17% |
| **Change in Porosity** | | | |
| Initial Porosity | | | 0.39 |
| Final Porosity | | | 0.32 |
| **Change in Hydraulic Conductivity** | | | |
| Kozeny-Carmen Ratio | | | 2.1 |
| Initial Hydraulic Conductivity | | | 0.30 |
| Final Hydraulic Conductivity | | | 0.14 |

Prepared by: JTC
Checked by: KSS

# 4. SUMMARY

The results from the three evaluations are summarized in Table 13. The initial assessment suggests that the impact on the permeability of the drain layer will be negligible. This assessment is conservative in that a change in physico-chemical conditions is not expected as the leachate passes from the tailings to the drain layer. The design and operation of the leachate collection system will prevent oxygen entry to the drain layer. Therefore, there is no reason that a change in conditions would arise within the drain layer. As well, since there is no indication of a sudden change in conditions (Eh; $CO_2$) as the leachate passes through the drain layer, a relatively even distribution of precipitates would be expected, if any were to form.

Even if the precipitates estimated from the overall assessment or expected condition should occur within the relatively restricted zone around the leachate collection pipes, the impact on the hydraulic conductivity would be insignificant, as indicated by Case 1 of the sensitivity analysis.

Case 2 disregards the equilibration within the oxidation zone of the tailings and assumes that all oxidation products precipitate in the drain layer. Even under these conditions, the porosity of the drain layer would not be significantly reduced.

**Table 13**
**Summary of Estimated Reductions in Hydraulic Conductivity**

| Case | Precipitation Assumptions | $CO_2$ Concentration | Hydraulic Conductivity (cm/s) | |
|---|---|---|---|---|
| | | | 0 years | 100 years |
| Initial Assessment | Equilibrated process water and oxidation zone water. Precipitates form evenly throughout drain layer | 0.035% | 0.3 | 0.2997 |
| Sensitivity Case 1 | As above. Precipitates form locally within 1 m of collection pipes. | 0.035% | 0.3 | 0.29 |
| Sensitivity Case 2 | Equilibrated process water and un-equilibrated oxidation zone water. Precipitates form locally within 1 m of collection pipes. | 0.035% | 0.3 | 0.14 |

Prepared by: JTC
Checked by: KSS

# 5. REFERENCES

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# ATTACHMENT A

## Initial Assessment

**Assessment of effects of $CO_2$ partial pressure and Eh on potential for precipitation of secondary minerals from equilibrated process water and equilibrated oxidation zone water**

MINTEQA2 Files:

| | |
|---|---|
| ud_pw1b.in<br>ud_pw1b.out | Initial assessment, process water |
| ud_ox1b.in<br>ud_ox1b.out | Initial assessment, oxidation zone water |

(Files provided on compact disk to selected reviewers)

# ATTACHMENT B

## CASE 2

**Initial equilibration of process water within tailings at atmospheric $CO_2$ conditions and Eh = 0, then subsequent equilibration within the TMA drain layer at atmospheric $CO_2$ and oxidizing conditions (200 mV).**

**and**

**Equilibration of un-equilibrated oxidation zone water within the TMA drain under atmospheric $CO_2$ and oxidizing conditions (200 mV).**

MINTEQA2 Files:

| | |
|---|---|
| ud_pw2ic.in<br>ud_pw2ic.out | Case 2, initial equilibration of process water |
| ud_pw2fc.in<br>ud_pw2fc.out | Case 2, final equilibration of process water |
| ud_ox2.in<br>ud_ox2.out | Case 2, oxidation zone water |

(Files provided on compact disk to selected reviewers)