LAGOON AREA REMEDIATION
FINAL BASIS OF DESIGN REPORT

Pownal Tannery Superfund Site
Pownal, Vermont

December 2003

Prepared By:

Metcalf & Eddy, Inc.
30 Harvard Mill Square
Wakefield, MA 01880

Team Subcontractor:

TRC Environmental Corporation
100 Foot of John Street
Lowell, MA 01852

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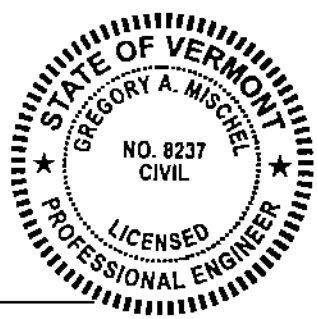

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1.0 INTRODUCTION

This report defines the technical parameters that will be used to design the remedy selected for implementation to reduce potential human health risks associated with the contaminated sludge found within the lagoons at the Pownal Tannery Superfund Site (Site) in Pownal, Vermont. The rational for the selected remedy is presented in the Record of Decision (ROD) Pownal Tannery Superfund Site (EPA, 2002).

1.1 Site Description

The Pownal Tannery Superfund Site consists of a 28-acre set of parcels located between Route 346 and the Hoosic River in the Village of North Pownal, Vermont which is in the south-western corner of the state. The location of the Site is shown on sheet C-2 and C-3 of the Design Drawings (Appendix A). The Site was a former hide tanning and finishing facility owned by the Pownal Tanning Company, Inc. The Site has been inactive since 1988, when the company declared bankruptcy. The Site originally consisted of three contamination sources: the former tannery building complex, a capped sludge landfill, and a lagoon system. The US Environmental Protection Agency (EPA), during a Non-Time Critical Removal Action that was completed in 2001 permanently capped the landfill and removed the building complex. Under a Memorandum of Agreement between EPA and the Vermont Department of Environmental Conservation (VTDEC), the State of Vermont is maintaining the sludge landfill. This report focuses on the cleanup planned for the lagoon system.

The area surrounding the Site is a rural and residential community with approximately 3,500 residents, with the nearest residences being approximately 200 feet from the lagoons. These residences rely upon ground water from private wells for their water supply. Currently, the lagoon area is fenced and locked, but is regularly broken into by the neighboring population for recreational purposes. The lagoon complex is partially covered with soil, over which disturbed wetlands vegetation are present. Three of the five lagoons on its western side border the Hoosic River, which is also used for recreational purposes during the warm months (Vermont Water Quality Standards, Class B for high quality habitat). On the eastern border of the Site there is an access road which is adjacent to railroad tracks owned and operated by the Guilford Transportation Rail Company. Drawings C-1, C-2 and C-3 in Appendix A show the Site location and the existing conditions of the Lagoon Area and access road. To the south of the lagoon complex is the former tannery building parcel and a hydroelectric facility and dam that were built in 1955 for use by the tannery. The remaining area (except the tannery landfill) was removed of all contamination to CERCLA residential standards, re-graded and seeded.

1.2 Selected Remedy

The selected remedy for the remaining lagoon area (as presented in the September 30, 2002 Record of Decision) includes the excavation of contaminated sludge materials from Lagoons 1 and 5, consolidation over Lagoon 3 and the southeast corner of Lagoon 4, and capping the consolidated sludge with a cover system. Development of a conceptual landfill design appropriate for the Site required evaluation of various factors including the volume of material to

be landfilled, impacts to the Hoosic River and the intended future use of the landfill area and other site-specific design considerations.

Implementation of the selected remedy identified in the ROD is anticipated to include the following components:

- Pre-construction activities;
- Erosion and sedimentation controls;
- Construct staging area over Lagoon 2;
- Clearing and grubbing of Lagoons 1, 2, 3, 4 (southeast portion only), and 5;
- Excavation of wastes from Lagoons 1 and 5;
- Consolidation of wastes over Lagoon 3 and the southeast portion of Lagoon 4;
- Construction of a solid waste cover system over the waste sludge;
- Institutional controls;
- Long-term ground water and river sediment monitoring;
- Operation and maintenance of the remedial action;
- Institutional control inspections; and
- Five-year Site reviews.

1.3 Objective

The objective of this report is to itemize and define the technical parameters on which the remedial design will be based and present the basis for the preliminary design.

1.4 Site Design Considerations

In addition to standard landfill design issues, there are two Site-specific factors that impact the overall design.

1.4.1 Hoosic River Floodplain Issues

The design of the remedial action, particularly the consolidation landfill, takes into account the potential impacts from the Hoosic River during the 100 year flood. In addition, a pre-design hydrologic modeling study was completed by TRC to evaluate the effect of the proposed facility on the Hoosic River flood stage. The results of the TRC hydrologic study are discussed in a separate document (Hoosic River Modeling Report) that is included in the FS.

The site land surface in the model included the landfill located on the east side of Lagoon 4 and Lagoon 3, and the removal of portions of the soil berm separating the river from the site. The soil berm in the model was lowered along the south side of Lagoons 1 and 5, and at the north end of Lagoon 4. The results of hydrologic modeling conducted by TRC showed that the construction of the facility would have minimal impact on the 100-year flood elevation presented in the FEMA study by eliminating the existing constrictions in the floodway (e.g. the soil berm). The TRC Hoosic River modeling study showed that the proposed facility would result in only a minor increase in the 100-year flood elevation in some locations and a decrease in the 100-year flood elevation in other locations adjacent to the proposed facility. Furthermore, the upper

elevation of the proposed facility (landfill) is projected to lie well above the 100-year flood elevation; therefore scour of the upper landfill surface is not a concern.

A separate river model was conducted by the VTDEC during design. The results of the VTDEC river model are presented in an October 14, 2003 Memorandum included as Appendix B. Based on the VTDEC river model, the VTDEC directed TRC to modify the design as follows:

- Maintain the soil berm height along the south side of Lagoons 1 and 5,
- Lower 125 linear feet of soil berm at the north end of Lagoon 4 to an elevation of between 495 and 500 feet above MSL to create an outlet for flood waters;
- Design erosion controls (riprap armor) for the Lagoon 4 berm outlet and the side slopes of the landfill for an overbank water flow velocity of 8.5 fps;
- Maintain a setback of 140 feet between the toe of the landside of the soil berm and the toe of the landfill;
- Backfill and re-grade the overbank area between the river and the landfill to a level that will not extend above a plane starting at elevation 500 at the north end of Lagoon 4 with a 0.4 percent slope up to the east end of Lagoon 1.

Appendix B also presents correspondence from the VTDEC regarding the design criteria developed from the river model. Given the potential for flood water to impact the landfill, the landfill slopes facing the Hoosic River will be armored with rock to prevent erosion during flood events.

1.4.2 Future Use of the Site

The Town of Pownal received funding from EPA to conduct a re-use assessment for the Pownal Tannery Superfund Site. As part of the re-use planning, the Town of Pownal and their consultant, Forcier Aldrich and Associates, Inc., conducted community interviews and forums that identified a desire and need for athletic and passive recreational facilities, including a soccer field, nature walk and a skating rink to be constructed after the lagoon system remediation is complete.

The re-use assessment also identified the lagoon area as a possible location for a municipal Waste Water Treatment Plant (WWTP). Currently, raw sewage is discharged directly to the Hoosic River from a number of area residences, and the Town is under an order from the state to mitigate this discharge. Construction of a WWTP and associated infrastructure would eliminate this discharge into the Hoosic River. The Town of Pownal is currently planning to construct a WWTP in the Lagoon 2 area.

The following summarizes how the future use and other site-specific considerations will be incorporated into the design.

Recreational Use: Several passive recreational uses of the site after remediation were identified including the construction of playing fields on the top of the landfill. Consistent with the future uses of the landfill area as a playing field, the cover should provide a relatively flat open surface to the extent practical. The State of Vermont Solid Waste Management Rules require minimum

5% landfill cap surface slopes for the closure of discrete disposal facilities. However, surface slopes on the order of 5% will be too steep to support the use of the field for athletic competition. Slightly flatter slopes of approximately 1 to 2% are more appropriate for an athletic playing area.

Minimum slope requirements for landfill covers are typically defined to ensure drainage of precipitation off of the landfill, minimizing percolation of water through the waste material and potential generation of leachate. This does not appear to be a concern at this Site for three reasons.

- According to the RI, Chemical analyses of ground water from four rounds of sampling at wells located in the lagoon system indicated no consistent exceedances of federal or state Maximum Contaminant Levels (MCLs).

- TCLP test results presented in the RI indicate that the Site waste materials are not actively generating leachate.

- The percolation of water will be limited by the low hydraulic conductivity of the consolidated sludge material that has been measured to be less than 2.54×10^{-6} cm/sec.

Therefore, the objective of minimizing percolation of water through the waste materials does not appear to be as critical as for typical municipal solid waste, which has high leaching potential. Nevertheless, the VTDEC cap requirements for an unlined discrete disposal facility will be adopted as the minimum requirements for the consolidation landfill cap, with the exception of the 5% slope requirement. The minimum Vermont cap includes a 24 inch thick soil barrier layer with a maximum hydraulic conductivity of 1 x 10-5 cm/sec and a six-inch layer of soil capable of sustaining vegetation. Alternatives and additional components to the minimum VTDEC cap have been evaluated including a gas vent layer, a geomembrane, a lateral drainage layer over the geomembrane, and a protective soil and erosion control layer. The HELP model has been used to analyze the alternatives and to design a cap with equivalent performance. The cap design is presented in Section 4.0 of this report.

An additional concern with shallow surface slopes is the effect of settlement on the final grades of the cover system. Excessive differential settlement could create flat slopes or depressions on the top of the landfill that promotes the infiltration of water into and through the cap. The consolidation parameters of the sludge and foundation soils will be determined and used to estimate settlement of the cover system. The final grades of the cover system will be designed to account for any significant differential settlement that may occur over the surface of the landfill.

Town WWTP: The design and construction of the remedial action will require coordination with the design and construction of the WWTP due to the close proximity and possible interaction of components. Design elements that may require coordination include the following:

- Consolidation landfill footprint in relation to the WWTP structures and discharge pipe;
- Preparation of the staging area in Lagoon 2 including preloading and consolidation of the underlying native clay layer;

- Widening of the Site access road to accommodate truck traffic;
- General Site grading in the area of the WWTP;
- Sequencing of construction; and
- Coordination of drainage patterns and general site grading.

The construction sequencing will be evaluated and discussed in more detail in the pre-final design.

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2.0 WASTE CHARACTERIZATION

2.1 Description of Materials to be Landfilled

Extent of Waste: The Remedial Investigation (RI) conducted at the Site by EPA identified the presence of contaminated sludge material in Lagoons 1, 3 and 5.

Contaminants: A site-specific human health and ecological risk assessment was performed as part of the RI to evaluate potential adverse impacts resulting from site-related contamination. As part of the risk assessment, site-specific clean-up criteria were developed, representing the maximum contaminant concentrations that do not pose unacceptable risks to human health. Materials containing contaminant concentrations in excess of these clean-up criteria are to be removed and incorporated into the consolidated landfill as part of the remedy proposed by EPA. The site-specific risk-based clean-up criteria specified in the ROD are summarized in Table 1.

Table 1: Soil Cleanup Levels
Pownal Tannery Superfund Site
Pownal, Vermont

Contaminant	Preliminary Remediation Goal (mg/kg)
Benzo(a)anthracene	1.7
Benzo(a)pyrene	0.17
Pentachlorophenol	7.7
N-Nitroso-di-n-propylamine	0.27
Arsenic	1.1
Chromium	733
Mercury	23
Lead	1,000
Dioxin TEQ	0.001

Saturated Waste: All of the sludge in Lagoon 5 and approximately 50 percent of the contaminated sludge encountered within Lagoons 1 and 3 is located below the ground water table. This is anticipated to be saturated upon removal and special handling procedures may be required.

Subsurface Gas: During the field investigation program portion of the RI, hydrogen sulfide gas and noxious odors were encountered emanating from boreholes advanced in Lagoon 3. These issues will require special consideration during the detailed design and construction phases of the implementation of selected remedy.

Demolition Debris: In addition to contaminated soils and sludge, there are several small wooden and concrete structures associated with the former tannery lagoon operation that will be

demolished and placed within the landfill. The design will establish the maximum dimension of, and placement procedure for the demolition debris to be placed in the landfill. The locations of structures to be demolished and other debris are shown on Drawing C-4 in Appendix A.

2.2 Volume of Materials to be Landfilled

2.2.1 Volume Calculations

Volume estimates of materials to be excavated were performed using the GISKey and Quicksurf software packages in conjunction with AutoCAD 2000. This method determines the volume between known surfaces, or stratigraphic features, in a defined area. Surfaces used in these calculations include the ground surface, the top of contaminated material surface, and the top of the underlying gravel layer. Drawing C-6 shows the limit of sludge in Lagoons1 and 5 and the elevation contours for the bottom of sludge/top of gravel layer. The final waste grades within the proposed landfill are shown on Drawing C-8 in Appendix A.

2.2.2 Lagoon Sludge and Clean Cover Soil Volumes

The outer boundary of sludge in Lagoon 1 and Lagoon 5 was established by overlying a 1974 aerial photograph of the active lagoons on top of the current surveyed topography in CAD. The sludge limit was supplemented with the geoprobe and test pit data to define the top surface of the sludge and the top of the underlying gravel layer. The volume of clean overlying soil was calculated using the existing ground surface contours and the top surface of the sludge layer. The volume of the sludge was calculated using the top surface of the sludge and the surface of the top of the gravel layer that underlies the sludge.

2.2.3 Soil Berm Volumes

A layer of black-stained soil was observed in test pits excavated in the berm separating Lagoons 1 and 5. The presence of the stained soil suggests that sludge and or contaminated soil was used to construct this berm. Therefore, this soil will be removed and placed within the landfill. The method used to calculate sludge volumes was also used to calculate the volume of clean and contaminated soil in the berm between Lagoon 1 and Lagoon 5. Contour surfaces were created for the ground, the top of black-stained soil, and the top of gravel. Depths to these units were determined from test pits on the top and the side of the berm. By subtracting the volumes under each surface, the total volumes of the black-stained soil and clean cover soil were calculated.

2.2.4 Design Volumes

The volume of the waste materials to be placed in the landfill was estimated to check that there was sufficient capacity in the proposed landfill. The volume of material in the completed landfill will depend on the degree of waste compaction, the ability of the contractor to precisely extract the targeted material, and the effect of any admixtures used to condition the sludge. The volumes of contaminated waste materials and clean overburden soils are presented in Table 2. Conditioning of the sludge material is needed to increase the strength of the material for placement and compaction. The conditioning process will likely reduce the volume of the sludge

in the landfill mainly through a reduction in water content and compaction. However the existing in-situ and final densities of the sludge material are unknown and the volume reduction cannot be accurately calculated at this time. Therefore, to be conservative, no volume reduction was assumed for the sludge.

For constructability reasons the existing clay cover over Lagoon 1 will be included in the design volume. A bulldozer would be the most efficient method for removing the clay. However, the lagoon sludge cannot support heavy equipment due to the low shear strength of the sludge. The removal of the thin layer of clay will therefore be difficult and time consuming. Also, there is no benefit to reusing the clay and there is sufficient capacity in the landfill. Therefore, the clay will be removed with the sludge and placed in the landfill.

The volumes presented in Table 2 assume the waste materials can be extracted without removing any of the overlying cover soils or underlying native soils. In reality this is not practical and some of the surrounding clean soils will undoubtedly be excavated with the sludge and placed in the landfill. In addition, there is some uncertainty regarding the exact limit of contaminated material. Consequently a contingency of 15 percent of the total volume has been included in the design volume to account for the uncertainty regarding the final extent of the excavation and the clean soil that will likely be excavated with the sludge.

Table 2: Design Volume of Sludge
Pownal Tannery Superfund Site

Location	Calculated Volume, cy
Lagoon 1 Sludge	26,962
Lagoon 1 Clay Cover	4,973
Lagoon 5 Sludge	5,351
Berms	3,276
15 % Contingency	6,084
15% Admixture Bulking Factor*	4,847
Total	**51,493**

* Applied to Lagoon 1 and 5 sludge only.

The use of an admixture to condition the sludge will likely increase the volume of the waste materials. Quick lime and Portland cement are currently being considered as admixtures. A bulking factor of 15% was included to account for the anticipated amount of admixtures required to stabilize the sludge in laboratory tests.

2.2.5 Landfill Capacity

The total waste capacity of the landfill was calculated at 55,464 cy using a CAD drawing showing the current ground contours and the proposed top of waste contours (sheet C-8, Appendix A). This volume takes into account the anticipated volume of demolition debris and cover that will be placed prior to constructing the landfill. There is sufficient capacity in the proposed landfill to contain the anticipated volume of sludge and other contaminated materials from Lagoons 1 and 5 plus approximately 3,971 cy of overlying "clean" soil that does not meet the clean up criteria when sampled.

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3.0 WASTE EXCAVATION AND CONSOLIDATION

The design must address the technical challenges associated with excavation and placement of the waste that will be encountered during the construction of the selected remedy. Some of the sludge in Lagoons 1 and 5 was found to be present below the ground water table. Also, noxious odors and hydrogen sulfide gas were found to emanate from some of the sludge materials in Lagoon 1. Remediation construction activities must take these issues into consideration to avoid the release of contaminants or an exposure risk to human health during implementation of the remedy. Therefore, the design will include provisions to address the following:

- Management of ground water during the excavation of the sludge material;
- Confirmatory sampling;
- Challenges associated with placement of the sludge due to the expected high water content and low shear strength; and
- Management of noxious gasses that may be released during the excavation and placement of the sludge materials.

The construction work will be conducted in two phases to expedite the project. Phase I will include the preparation of the Site including clearing and grubbing, establishment of sedimentation and erosion controls, installation of fencing, and filling Lagoon 2 to establish a staging area. Phase II will include the bulk of the RA work including excavation and consolidation of the lagoon sludge into the landfill and capping the landfill. Details regarding the construction phasing will be included in the pre-final design.

3.1 Site Preparation

Prior to the start of excavation the Site will be prepared by installing sedimentation and erosion controls, clearing and grubbing the landfill footprint and areas of excavation, establishing staging areas, and installing security fence. Sheet C-4 of the Design Drawings (Appendix A) show how the Site will be prepared for construction including areas to be cleared and grubbed, the location of erosion controls, staging areas and areas for temporary facilities. The Site gravel access road will be graded as needed to allow truck traffic during the RA. The WWTP contractor will complete final improvements to the access road including asphalt paving.

3.2 Excavation of Sludge

The sludge in Lagoons 1 and 5 will be removed and transported to the consolidation landfill. The most appropriate construction method for removal and transportation is governed primarily by the consistency and engineering properties of the sludge. A geotechnical investigation was conducted during which test pits were advanced within Lagoons 1 and 5 to collect samples for laboratory testing and to observe the behavior of the sludge during excavation. The results of the geotechnical investigation are presented in a Data Evaluation Report included in Appendix C.

Observations of sludge behavior during excavation of test pits during the geotechnical investigations in Lagoons 1 and 5 suggest that the sludge can be excavated using standard

equipment and suspension and dispersion of sludge in water is not likely. The sludge was observed to maintain its in-situ form under saturated conditions. Unconfined compression tests on sludge samples, however, show very low undrained shear strengths indicating the sludge would not support the weight of standard construction equipment. Therefore, excavation equipment will likely have to remain on stable ground surrounding the lagoons, or pads could be constructed as the lagoons are backfilled with soil. The contractor will be responsible for implementing the appropriate methods and means to safely and efficiently excavate the sludge.

Prior to excavation, the surface water will be pumped to a temporary on-site water treatment system before direct discharge to the Hoosic River. Discharge criteria were calculated assuming contaminant concentrations will be reduced when mixed with river water to levels at of below applicable EPA and/or VTDEC standards. The calculations were made assuming a treatment system flow rate of 400 gpm. Details of the calculation are presented in the Technical Memorandum dated May 9, 2003 included as Appendix D.

Uncontaminated granular soil that is currently located over the sludge layer around the perimeter of the Lagoons will be removed and set aside for re-use as common borrow fill. While the majority of the granular material will be removed, some uncontaminated soil will likely remain and become incorporated into the sludge. Limited amounts of the overlying granular soil could also be used as a bulking agent to improve the consistency and handling properties of excessively wet sludge. Uncontaminated overlying soils could also be used to construct berms within the excavation to contain loose sludge materials to the working face of the excavation and prevent the commingling of contaminated sludge and water with clean sidewall soils or backfill. Samples of the granular material will be collected and analyzed for contaminants of concern prior to re-use as clean backfill. The existing clay cover material over the Lagoon 1 will be removed with the sludge and transported directly to the landfill for consolidation under the cap.

The excavation and backfill of Lagoons 1 and 5 will be phased to:

a) Limit the generation of gasses (including hydrogen sulfide) and vapors that will likely be encountered while excavating Lagoon 1;

b) Minimize the accumulation of water within the excavation; and

c) Minimize contamination of clean backfill with potentially contaminated excavation water.

The sludge will be stabilized to improve shear strength prior to placement in the landfill. Sludge stabilization will be performed either in-situ (within the footprint of the Lagoon) or ex-situ (in an area outside the Lagoon footprint). In either case a standard or long-reach excavator will be used to remove sludge stabilized from the lagoon excavation. Sludge will be excavated down to the underlying gravel layer. Excavated sludge will be placed directly into dump trucks and transported to the landfill or an ex-situ stabilization area, depending on the stabilization method. The area of exposed sludge will be limited to minimize odors. Additional details regarding plans to mitigate off-site air emissions and other potential impacts resulting form the project are presented in the Final Plan for Minimizing Environmental and Public Impacts included in Appendix E. Excavated areas will be inspected to document sludge removal and backfilled as soon as possible to limit groundwater seepage into the excavation.

3.3 Excavation Dewatering

The need for excavation dewatering was evaluated in light of certain Site-specific factors. Excavation dewatering would be needed if the presence of standing water would significantly impair the ability of the contractor to excavate and remove the sludge. An initial concern about excavating "in the wet" was the possibility that the sludge would become suspended if agitated in the presence of water. In an extreme scenario, the sludge could become completely suspended resulting in a viscous fluid that will require settlement and consolidation of the solids in a settling basin to remove excess water prior to further dewatering. This type of settling process would be disproportionately expensive and time-consuming. Based on observations made during the geotechnical testing field program, however, the sludge was observed to be cohesive and did not liquefy or become suspended under saturated conditions when excavated. Based on these observations, excavating "in the wet" with standard construction equipment is considered feasible. The sludge excavation can therefore be conducted in the wet to limit the generation of potentially contaminated construction water. The contractor will have the choice to excavate in "in the wet" or to remove water from the excavation depending on the circumstances.

Another consideration is the rate at which groundwater would flow into the excavation. Some seepage from the sidewalls of the excavation is expected and is a function of the permeability of the sand and silty sand materials of the native soils and berm soils and the length of exposed sidewall. Analysis of slug test data performed during the RI indicates an average permeability of 3.3×10^{-4} cm/sec for the upper silty sand and sand layer. Based on the permeability, standard dewatering methods could be used to remove water that accumulates from sidewall seepage assuming the area of excavation is restricted and backfilling is performed as the excavation proceeds.

Dewatering below the sludge material does not appear to be feasible due to the anticipated high permeability of the underlying gravel layer. A five to ten foot thick layer of rounded gravel and cobbles was observed during the RI directly below the sludge. The gravel layer appears to be highly permeable former river bottom, and may be hydraulically connected to the Hoosic River. Dewatering of the gravel may not be possible using standard construction methods and would likely generate large volumes of water. Therefore, the contractor will not be required to dewater the gravel layer for any reason. The removal of excess water above the gravel layer may be required as the excavation is backfilled and water is displaced.

All water removed from the excavation will be treated to remove contaminants. The technical specifications for the RA requires the contractor to provide a water treatment system to remove contaminants of concern including PAH compounds, dioxins and metals. The treatment system is assumed at this time to consist of settling tanks to remove bulk solids and granular activated carbon (GAC) units in series. Additional methods to remove suspended solids may be required to remove the organic compounds that are likely adsorbed to the organic matter in the sludge materials. The Contractor will likely evaluate other treatment methods during mobilization for Phase II including the following:

- Metals precipitation (chemical precipitation, electrochemical precipitation, and iron co-precipitation).
- Metals precipitate and other suspended solids removal (coagulation, clarification, and filtration).

3.4 Confirming Limits of Excavation

The sludge materials in lagoons 1 and 5 and certain berm soils have been targeted for removal and consolidation within the on-site landfill. The RI identified the lagoon sludge as the only media containing contaminants of concern requiring remedial action. The distinctive color and consistency of the sludge makes the sludge easy to identify and distinguishable from the surrounding native soils. The lateral limits of the excavation will be easily identified using the color and consistency contrast between the sludge and soils. The bottom limit of the sludge is also well defined by the presence of a continuous layer of rounded gravel and cobbles located directly beneath the sludge materials in Lagoons 1 and 5. Sheets C-6 and C-7 of the Design Drawings (Appendix A) shows the approximate horizontal limit of sludge and the elevations of the sludge and gravel layers.

The lateral extent of the excavation will be determined by inspecting the sidewall of the excavation and confirming that the sludge has been removed. Because of the very coarse nature of the gravel, collection and analysis of a meaningful confirmatory sample is impractical. In addition, dewatering would be required to excavate the gravel layer and excessive amounts of potentially contaminated water would be generated. Therefore, the vertical extent of the sludge excavation will be based on a visual inspection to confirm that the sludge has been removed and the gravel layer encountered.

A layer of black-stained soil was observed in test pits excavated in the berm separating Lagoons 1 and 5. The presence of the stained soil suggests that sludge and or contaminated soil was used to construct this berm. Therefore, this soil will be removed and placed within the landfill.

3.5 Backfilling

Lagoons 1 and 5 will likely be backfilled continuously as the sludge is excavated. Backfilling may be conducted either in the dry or in the wet. Backfilling in the wet will be conducted using a granular soil that can be dumped into place and compacted by vibratory means once the fill reaches the groundwater elevation. Water would be completely removed from the excavation prior to backfilling in the dry with standard general fill soils. Water displaced by the backfill may become a nuisance and impede sludge excavation or backfilling operations. Removal and treatment of this excess water may be necessary with either method.

3.6 Sludge Conditioning

Geotechnical testing of the sludge from Lagoons 1 and 5 indicates that the material exhibits a high water content and low shear strength. Therefore, some degree of stabilization will be necessary to prepare the material for consolidation and compaction under the cap.

Several methods and materials were considered for stabilization of sludge. The method of air drying and mechanical tilling of the sludge in thin lifts was considered. However, the method was rejected because the required drying time is unknown and the weather is unpredictable and would certainly prolong the process if wet and cool conditions prevail.

The FS concluded that ex-situ stabilization of the lagoon sludge using a mixture of Portland cement and flyash would improve the strength of the material. However, the cost of material handling and equipment (screeners, crushers, pug mill, reagent silos, and air emission controls) may make this alternative cost prohibitive. Bulk addition of cement and/or flyash directly to sludge stockpiles or windrows will potentially create unacceptable releases of dust to the atmosphere. In situ mixing or the controlled application of stabilizing reagents in a mixing pit could be used to minimize the potential for generating dust by the addition of dry Portland cement. Both in-situ and ex-situ mixing methods may be acceptable based on the technical merits and constructability of the contractor's approach.

Lime in the form of quicklime was considered for stabilization due to its flexibility. Anhydrous quicklime is a more concentrated form of lime than the commonly-used hydrated form, containing 23-24 percent more "available" lime or oxide content, reducing the quantity needed for stabilization. Another advantage is that the heat of hydration accelerates the hardening of compacted lime-soil mixtures. This offers the possibility of extending its use further into the fall construction season or for emergency use in near freezing weather. Lime was used historically during the operation of the tannery to control odors in the lagoons and may help reduce odors during sludge conditioning.

Quicklime is available in granular form. This eliminates the concern of excessive dust emissions, which allows quicklime to be added in bulk and mixed using standard construction equipment with the sludge in windrows or mixing pits. Quicklime is available from a regional supplier.

Samples of lagoon sludge were mixed with various quantities of quick lime and/or Portland cement and tested in unconfined compression at a geotechnical laboratory to verify the effectiveness of the admixtures and to estimate the addition ratio. Details of the testing are presented in Appendix C. In summary, two possible reagent mixes were identified; 11 percent Portland cement, or a combination of 8 percent quicklime and 4 percent Portland cement. The Contractor will be required to conduct a "shake down" demonstration to evaluate the mix design and the Contractor-selected method for introducing the reagents.

3.7 Sludge Placement and Compaction

Conditioned sludge will be transported, placed, and compacted in the consolidation landfill. The material will be compacted to the maximum practicable dry density as determined during the "shake down" demonstration. No chemical testing of excavated sludge will be conducted since the goal did not include chemical stabilization and all sludge will be moved to the landfill and capped.

3.8 Worker Health, Safety and Air Emissions

Due to the potential issues associated with generation of hydrogen sulfide gas and odors, design and implementation of appropriate air monitoring procedures will be required for all activities involving the handling of contaminated materials. The potential for worker exposure must be addressed by implementing monitoring techniques suitable to ensure exposure limits set by the Occupational Safety and Health Agency (OSHA) are not exceeded. The requirements for appropriate PPE and location, frequency and parameters to be monitored during all aspects of the air monitoring program, will be evaluated by a Certified Industrial Hygienist (CIH) and incorporated into the construction procedures and methods required for remedy implementation. In addition to worker exposure issues, hydrogen sulfide gas also has the potential to pose an explosion hazard. As a result, mitigative measures will be incorporated to the remedy construction activities. Such measures may include continuous monitoring of the potential for explosive conditions in the work area, ventilation of excavations and use of non-sparking equipment. Appropriate requirements will be fully evaluated and identified in the specifications for construction of the remedy.

A specification will be prepared for the contractor of the RA to develop a detailed Health and Safety Plan. The requirements in the specification will be developed using the Health and Safety Plan that was developed for the RI and RD sampling and evaluation of the site. Past site evaluations generated significant data in relation to this project and will be incorporated into the specification. Remedial activities have the greatest risk for potential exposure and will require careful planning to maintain low risk of exposure during the remediation. A critical component of the specification will detail the appropriate level of training for site personnel with the intention of reducing the potential for exposure to the constituents of concern. The specification will require the contractor to develop an air monitoring program, exposure control procedures and other safety procedures associated with the potential hazards at the Site. The plan will be part of the comprehensive remedial plan for the site and will be designed to comply with OHSA and EPA standards.

The specification will provide minimum air monitoring requirements and action levels for use in the perimeter air monitoring program to be developed by the contractor. Measures to mitigate fugitive air emissions will be specified in the event that action levels are exceeded. Additional details regarding plans to mitigate off-site air emissions and other potential impacts resulting form the project are presented in the Final Plan for Minimizing Environmental and Public Impacts included in Appendix E.

4.0 CONSOLIDATION LANDFILL

The contaminated sludge will be excavated and consolidated into an on-site landfill. The landfill will be capped to prevent direct exposure to the sludge and prevent the release of contaminants by protecting the sludge from erosion.

Landfill Location: The proposed location for the landfill was identified in the ROD as the area of Lagoon 3 and the eastern portion of Lagoon 4. Limited options are available as to where an onsite consolidation landfill can be constructed. Specifically, two options were evaluated in detail during the River modeling effort. Landfill Option 2 was selected as the preferred alterative. Landfill Option 2 minimizes the encroachment into the river's floodway and for this reason is the preferred consolidation landfill configuration. In an August 23, 2002 letter on the proposed cleanup plan, the VTDEC identified Option 2 as the recommended alternative due to its limited encroachment within the floodway. Sheets C-8 and C-9 of the Design Drawings in Appendix A show the proposed grades of the sludge prior to cap construction, and final landfill grades.

Landfill Capacity: The capacity of the sludge consolidation landfill within the proposed sludge grades was calculated using the AutoCad software. A volume of 55,464 cubic yards was estimated between the existing grades and the proposed top of sludge grades prior to cap construction. The landfill capacity is sufficient to contain the anticipated volume of sludge.

Vermont Solid Waste Rules: The Vermont regulations specify certain requirements for possible landfill sites as well as design and performance standards for solid waste disposal facilities. A Feasibility Study Addendum dated June 2002 was prepared and appended to the FS to analyze how the selected remedy would achieve the substantive requirements of two ARARs, including the Vermont Solid Waste Management Rules. The analysis showed that the selected remedy would not meet some of the standards.

Recent amendments to the Vermont Solid Waste Rules (§301(d)) and Statutes (10 VSA §6605(d) & §6614) allow for the Secretary to waive certain statutory and rule requirements for solid waste facilities constructed as part of a state or federal environmental response action. The need for a waiver has been identified for some of the requirements. The State issued a waiver for these requirements dated August 13, 2003 (see Appendix B). The selected remedy will reduce risks associated with site contaminants and will not adversely affect public health, safety or the environment if the requirements are waived. In addition, the siting requirements will be complied with to the extent practical in light of the overall objectives of the remedy. Each regulatory requirement that will not be met is listed below followed by a discussion in **bold** text describing a justification for why the regulatory requirement could not be met and why a waiver is needed.

1) Construction of a disposal facility is prohibited in Class I and Class II wetlands and their associated buffer zones, as defined in the Vermont Wetlands Rules, unless a Conditional Use Determination has been issued by the Agency. Construction of a disposal facility in Class III wetlands, as defined by the Vermont Wetlands Rules, is prohibited unless a Water Quality Certification has been issued pursuant to 40 CFR Part 401, or has been

waived by the Agency. **Per an August 15, 2001 memorandum from Mr. Alan Quackenbush, District Wetland Ecologist, for the State of Vermont, the wetlands in the Lagoon area are classified as Class III and the State will not seek replacement of these man-made lagoon wetlands due to lack of significant function. Class II fringe wetlands along the Hoosic riverbank may be disturbed during excavation activities. These disturbed areas in the fringe wetland will be stabilized using native vegetation.**

2) Construction of a discrete disposal facility is prohibited, within the floodway or within the one hundred (100) year flood plain. **This requirement was waived by the VTDEC. The proposed landfill facility does lie within the current floodway and the 100-year floodplain of the Hoosic River. Based on the evaluations presented in the FS, there is no other practical on-site location to construct the landfill and off-site disposal was determined to be cost prohibitive.**

   A pre-design hydrologic modeling study was completed to evaluate the effect on the Hoosic River from the construction of the proposed facility as presented in the 30% design. The TRC Hoosic River modeling study showed that the proposed facility would result in a minor increase in the baseline FEMA 100-year flood elevation in some locations and a decrease in the 100-year flood elevation in other locations adjacent to the proposed facility. Furthermore, the upper elevation of the proposed facility (landfill) is projected to lie well above the 100-year flood elevation; therefore scour of the upper landfill surface is not a concern.

   A separate river model was conducted by the VTDEC during design. The results of the VTDEC river model are presented in a October 14, 2003 Memorandum included as Appendix B. The existing conditions were modeled by the VTDEC to replace the FEMA study as the baseline for comparison. The VTDEC model of the proposed facility included several modifications to the configuration of the landfill and soil berms, and input parameters originally used in the TRC model. Based on the VTDEC river model, the 100-year flood elevation will increase by 0.22 feet over the VTDEC baseline conditions as a result of the facility.

3) The Solid Waste management Rules require that the operator of a facility meet the following general performance standards of subsection (a) of Section 6-503:

   a. that the isolation distances to seasonal high groundwater, bedrock and surface waters are sufficient to assure that an emission or discharge from the facility will meet all applicable environmental quality and public health standards and rules. **Based on historical and recent ground water monitoring data, including five rounds of ground water sampling at 14 ground water monitoring wells in the Lagoon Area and ten private drinking water supply wells located nearby, the Remedial Investigation concluded that there is no active leachate source in the Lagoon Area. Furthermore, part of the proposed remedy would include a ground water monitoring well network and a long-term monitoring plan to provide an early warning of ground water impacts. Note also that the proposed facility will**

relocate the sludge material from the lagoons where much of the waste is currently below the water table, to a position above the water table in the landfill.

b. that the isolation distance to public and private drinking water supplies is sufficient to assure that an emission or discharge from the facility will not adversely affect drinking water. **Current ground water users in the area are located either across the Hoosic River from the Site or are located hydraulically upgradient from the proposed facility. Drinking water is withdrawn from both the overburden and bedrock aquifers. The bedrock aquifer underlies the Lagoon area by over 100 feet in some places and is protected from leachate infiltration by a thick (over 50 feet) layer of low permeability clay. As demonstrated in the RI, this clay not only prevents contaminated ground water from infiltrating to the bedrock, but also provides a confining layer above the bedrock aquifer that contributes to upward vertical hydraulic ground water pressure in the Lagoon Area. Since flow is directed upward from the bedrock, and private ground water users are located upgradient of the proposed facility, the proposed facility should not adversely affect private and public drinking water supplies.**

c. that the isolation distances to property lines, will be no less than fifty (50) feet or as determined by the Secretary,

In order to limit encroachment into the 100-year floodplain, the landfill will be located on the east side of the lagoon area adjacent to the property line. Alternative locations for the landfill were evaluated as part of the preliminary design. Maintaining the 50 foot setback from the property boundary was not possible without encroaching into the floodway or increasing the height to a level that is significantly above the floodplain and unacceptable from an aesthetic standpoint.

and that isolation distances to homes, public buildings (including schools, hospitals, and nursing homes), or places of public assembly are sufficient to assure that the facility will not:

i. result in objectionable odors off site of the facility. **The sludge is not expected to decompose significantly and produce emissions of gas. Therefore, the proposed facility should not cause any odor problems. Any potential air emissions during construction would be managed through monitoring and controls.**

ii result in an unreasonable visual impact for anyone off-site of the facility. **The Town plans to improve the visual aesthetics of the site using the remedial action as a basis for site improvements including hiking trails, a boat launch, skating rink and recreational fields. In addition, the height of the landfill will be limited to mitigate any adverse visual impacts.**

iii unreasonably increase the level of noise detectable by persons off-site of the facility. **Other than during construction, there will not be any noise associated with the facility.**

iv otherwise adversely affect pubic health **The proposed facility is needed to reduce risks to public health based on the results of the Remedial Investigation and the Human Health Risk Assessment. Based on these studies, in its present condition, the site poses unacceptable risks to trespassers, and the proposed remedial actions are designed to mitigate the adverse effects.**

d. that any facilities or activities meet the minimum numerical criteria in the following table. Diffuse disposal, or land application, applies to sludge and septage distributed over an area of land at a controlled rate to make efficient use of its nutrient and/or soil amendment value. Minimum criteria for discrete disposal (landfills) are based on underlying soils with a maximum permeability of 1×10^{-4} cm/sec. Discrete disposal sites with more permeable soils will be evaluated on a case-by-case basis, but are generally not acceptable. Discrete disposal sites with less permeable soils are acceptable and the minimum distances may be adjusted on a case-by-case basis, to reflect the lower permeability. **There are two layers of soils below the proposed facility. The uppermost layer is thin (less than 10 feet) and comprised of sand, silt and gravel. Hydraulic conductivity testing of this interval performed during the Remedial Investigation indicated a mean hydraulic conductivity of 5.3×10^{-3} cm/sec. The second soil layer that underlies the proposed facility is a very low permeability clay (estimated hydraulic conductivity of 1×10^{-6} cm/sec). This layer is over 50 feet thick beneath the proposed facility and will provide a very good low permeability lower boundary for any potential leachate from the proposed facility. However, as noted above, five rounds of ground water sampling at 14 ground water monitoring wells in the Lagoon Area and ten private drinking water supply wells located nearby, indicate that there is no active leachate source in the Lagoon Area and the potential for generating leachate will be severely limited by the construction of the landfill cap. Based on the site specific hydrogeology of the area, there is a reasonable basis to seek a waiver of these requirements.**

CATEGORY	Separation Distance	
	Required for Discrete Disposal	Proposed Facility
Minimum vertical separation from high seasonal water table	6'	0'
Minimum vertical separation to bedrock	10'	>14'
Minimum distance to waters of the state, including intermittent streams and all larger water bodies	300'	160'
Distance to drinking water source from waste management boundary	1000'	520'
Distance to property line	50'	20'

The proposed facility will meet the vertical separation criteria to bedrock. Since some waste in Lagoon 3 is currently in the saturated zone and is not proposed to be removed, the proposed facility will not meet the minimum vertical separation from the high seasonal water table requirement. However, as noted above, contaminants do not appear to be leaching to groundwater based on the results of five rounds of ground water sampling at 14 ground water monitoring wells in the Lagoon Area and ten private drinking water supply wells located nearby. The landfill is not expected to generate leachate since the waste is not currently generating leachate, and the proposed landfill cap will minimize the percolation of water through the waste. Therefore, there is a reasonable basis to request a waiver of this requirement.

The proposed facility will also not meet the 300 foot setback requirement from waters of the state. However, there is no other practical location alternative and no impacts to the adjacent surface water were identified during the Remedial Investigation.

4) The Vermont Solid Waste Management Rules require new discrete disposal facilities or new operational units at an existing facility, placed in operation after July 1, 1987, to have liner and leachate collection systems and appropriate provisions for leachate treatment, except as otherwise provided in Section 6-309(b) or in Section 6-606(b)(2)(B) of the rules. The Secretary may further waive the liner requirement for discrete disposal facilities or portions of discrete disposal facilities that are designated solely to receive particular waste components that are not the source of leachate harmful to public health and safety or the environment or the creation of nuisance conditions. **The Remedial Investigation sampling of the 14 ground water monitoring wells and adjacent surface water in the Hoosic River indicate that there are no existing leachate impacts to ground water or surface water, even though there is no engineered liner or leachate collection system below the lagoons. In addition, the majority of the contaminated sludge will be removed from the lagoons and placed above the groundwater table and covered by a landfill cap. Therefore, the potential for leachate generation will be significantly reduced relative to the existing condition, and it is reasonable to request that this requirement be waived. The VTDEC waived this requirement.**

4.1 Performance Standards

A human health and ecological risk assessment of the site identified direct human exposure to the contaminated sludge as the only pathway producing unacceptable elevated risks. The selected remedy for the site cost-effectively addresses this identified exposure scenario of concern by consolidating and capping the sludge materials and implementing appropriate administrative controls, such as deed restrictions, to mitigate the direct exposure pathway. The cover system will be designed to resist erosion that may expose contaminated sludge. Operation and maintenance will be required to detect and repair any erosion that may develop in the future.

4.2 Hydrologic Evaluation of Landfill Cover

The EPA Hydrologic Evaluation of Landfill Performance (HELP) model was used to evaluate the hydrologic performance of potential cover system configurations including the minimum cover required by the Vermont Solid Waste Management Rules, a "typical" Vermont landfill cover, and a custom cover system that utilizes barrier and drainage layers at a minimum slope of five percent and a surface slope of between one and two percent. The cover with the shallower one to two percent surface slope was evaluated to determine if the landfill can be used for playing fields. The hydrologic performance is one of the criteria used to select the cover system components.

The standard cover system required by the Vermont Solid Waste Management Rules for an unlined discrete disposal facility includes a minimum 2-foot thick layer of earthen material with a hydraulic conductivity of less than $1x10^{-5}$ cm/sec and less than the permeability of the base soils, and a minimum 6-inch thick layer of vegetative support material.

Based on discussions with the VTDEC, the typical landfill cover system used in the state includes a granular soil gas vent layer (12 inches), a geotextile, and soil barrier layer (24 inches), a root penetration layer (12 to 18 inches) and an erosion control layer (6 inches).

Alternatives and additional components to the standard or typical VTDEC cap were evaluated including a lateral drainage layer over the barrier layer. Although not a specific requirement of the VTDEC Solid Waste Rules, a lateral drainage layer would reduce the head of water over the barrier layer and would possibly produce an equivalent design as the standard solid waste cap even at shallow surface slopes. An evaluation was made using the HELP model to compare the hydrologic performance of the standard cap and the cap including a drainage layer with shallow slopes. In order to encourage internal drainage of the cap, the minimum slope of five percent will be maintained for the barrier and drainage layers while the thickness of the protection and erosion layers will be varied to achieve the shallower slopes of the landfill cap surface. Results of the HELP model study are presented in Appendix F. Tables 3 and 4 summarize the HELP model input parameters and the results of the modeling effort. Results of the model showed similar performance, and therefore the consolidation landfill cap will be designed with a drainage layer and shallow slopes.

4.3 Cover System Components

A consolidation landfill cover system has been designed to eliminate the direct exposure pathway to the sludge material. Sheets C-14 and C-15 of the Design Drawings in Appendix A includes a landfill cap sections and details for the landfill. The cap for the top of the landfill will have the following configuration from bottom to top:

- Six inch layer of granular foundation/gas vent sand layer;
- A 40-mil linear low density polyethylene (LLDPE) geomembrane barrier layer;
- Geocomposite drainage layer;
- Minimum 24 inches of vegetative support soil layer,
- Six inch layer of topsoil.

TABLE 3:
CAP DESCRIPTIONS AND HELP[1] MODEL INPUT PARAMETERS

General Cap Model Description						Cap Layer Properties and Related HELP Model Input Parameters[1]									
						Topsoil (Layer 1)		Root Penetration Layer (Layer 2)		Drainage Layer (Layer 3)		Barrier Layer (Layer 4)		Gas Vent Layer (Layer 5)	
Scenario	Cap Description	Basic Properties of Cap	Portion of Cap Modeled	Slope Cover	Slope Layers 3 to 5	Type and Thickness	HELP Parameters	Type and Thickness	HELP Parameters	Type and Thickness	HELP Parameters	Type and Thickness	HELP Parameters	Type and Thickness	HELP Parameters
1	Vermont Minimum Required Solid Waste Cover	5% surface slope, 2 layers over waste	Top	5%	NA	6-in. Loam	Soil Type 8	NA	NA	NA	NA	24-in. Silt	Soil Type 23	NA	NA
2	Vermont DEC Typical Required Cap (lined landfills)	5% surface slope, 4 layers over waste, (18-in. vegetative support layer)	Top	5%	5%	6-in. Loam	Soil Type 8	18-in. Silty Sand	Soil Type 7, 12-in. as lateral drainage	NA	NA	24-in. Silt	Soil Type 23	12-in. Silty Sand	Soil Type 5
3	1% TRC Cap, no geosynthetic layers	1% surface slope, 5 layers over waste	Top	1%	5%	6-in. Loam	Soil Type 8	12-In. Silty Sand	Soil Type 7	12-in. Coarse Sand	Soil Type 1	24-in. Silt	Soil Type 23	12-In. Silty Sand	Soil Type 5
4	2% TRC Cap, no geosynthetic layers	2% surface slope, 5 layers over waste	Top	2%	5%	6-in. Loam	Soil Type 8	12-in. Silty Sand	Soil Type 7	12-In. Coarse Sand	Soil Type 1	24-in. Silt	Soil Type 23	12-in. Silty Sand	Soil Type 5
5	1% TRC Cap, Geocomposite in place of drainage layer	1% surface slope, 5 layers over waste	Top	1%	5%	6-in. Loam	Soil Type 8	18-in. Fine Sandy Loam	Soil Type 7	0.5-cm Geo-composite	Material Type 20 (Drainage Net)	24-In. Silt	Soil Type 23	12-In. Silty Sand	Soil Type 5
6	1% TRC Cap, Geomembrane in place of barrier layer	1% surface slope, 5 layers over waste	Top	1%	5%	6-In. Loam	Soil Type 8	12-in. Silty Sand	Soil Type 7	12-in. Coarse Sand	Soil Type 1	40-mil LDPE Geo-membrane	Material Type 36[2]	12-in. Silty Sand	Soil Type 5
7	1% TRC Cap, Geocomposite and Geomembrane	1% surface slope, 5 layers over waste	Top	1%	5%	6-In. Loam	Soil Type 8	18-in. Silty Sand	Soil Type 7	0.5-cm Geo-composite	Material Type 20 (Drainage Net)	40-mil LDPE Geo-membrane	Material Type 36[2]	12-in. Silty Sand	Soil Type 5
8	2% TRC Cap, Geocomposite in place of drainage layer	2% surface slope, 5 layers over waste	Top	2%	5%	6-In. Loam	Soil Type 8	18-In. Silty Sand	Soil Type 7	0.5-cm Geo-composite	Material Type 20 (Drainage Net)	24-In. Silt	Soil Type 23	12-In. Silty Sand	Soil Type 5
9	2% TRC Cap, Geomembrane in place of barrier layer	2% surface slope, 5 layers over waste	Top	2%	5%	6-in. Loam	Soil Type 8	12-in. Silty Sand	Soil Type 7	12-in. Coarse Sand	Soil Type 1	40-mil LDPE Geo-membrane	Material Type 36[2]	12-in. Silty Sand	Soil Type 5
10	2% TRC Cap, Geocomposite and Geomembrane	2% surface slope, 5 layers over waste	Top	2%	5%	6-in. Loam	Soil Type 8	18-in. Silty Sand	Soil Type 7	0.5-cm Geo-composite	Material Type 20 (Drainage Net)	40-mil LDPE Geo-membrane	Material Type 36[2]	12-in. Silty Sand	Soil Type 5

[1] HELP Model Version 3.07 (11/1/97). Refer to Table 2 for descriptions of default soil and geosynthetic material model parameters.

[2] Additional HELP input parameters for Geomembrane: pinhole density = 1 holes/acre; installation defects = 7 holes/acre; and placement quality = 3 (good).

NA - Not Applicable.

Units -"in." = inches; "cm" = centimeters.

TABLE 4:
COMPARISON OF HELP[1] MODEL RESULTS

Scenario[2]	Cap Description	Average Annual Totals (Inches) Over 50-year Duration					Peak Daily Values (Inches) Over 50-year Duration				
		Precipitation	Runoff	Evapo-transpiration	Head over Barrier	Percolation Through Barrier	Precipitation	Runoff	Average Head Over Barrier	Maximum Head Over Barrier	Percolation Through Barrier
1	Vermont Minimum Required Solid Waste Cover	35.43	8.572	18.784	0.098	8.055	3.21	3.036	5.783	NA	0.379
2	Vermont DEC Typical Required Cap (lined landfills)	35.43	7.544	22.18	0.065	5.664	3.21	2.903	8.977	12.811	0.4206
3	1% TRC Cap, no geosynthetic layers	35.43	7.459	22.207	0.038	5.376	3.21	2.903	4.985	7.811	0.3697
4	2% TRC Cap, no geosynthetic layers	35.43	7.5	22.192	0.038	5.354	3.21	2.903	4.985	7.811	0.3697
5	1% TRC Cap, Geocomposite in place of drainage layer	35.43	7.533	22.268	0.000	4.2884	3.21	2.904	0.021	0.042	0.3062
6	1% TRC Cap, Geomembrane in place of barrier layer	35.43	7.459	22.207	0.507	0.5179	3.21	2.903	6.157	9.353	0.0131
7	1% TRC Cap, Geocomposite and Geomembrane	35.43	7.533	22.268	0.001	0.0025	3.21	2.904	0.03	0.06	0.0002
8	2% TRC Cap, Geocomposite in place of drainage layer	35.43	7.577	22.255	0.000	4.2735	3.21	2.904	0.021	0.042	0.3062
9	2% TRC Cap, Geomembrane in place of barrier layer	35.43	7.5	22.192	0.504	0.5107	3.21	2.903	6.137	9.328	0.013
10	2% TRC Cap, Geocomposite and Geomembrane	35.43	7.577	22.255	0.001	0.0025	3.21	2.904	0.03	0.06	0.0002

[1] HELP Model Version 3.07 (11/1/97).

[2] Refer to Tables 1 and 2 for further information on scenarios and cap layer properties.

The side slope of the landfill will have maximum slopes of 33.3 percent. Two configurations will be utilized for the side slopes of the cap. The side slope facing the Hoosic River will be constructed of the following layers:

- Six inch layer of granular foundation/gas vent sand layer;
- Textured 40-mil linear low density polyethylene (LLDPE) geomembrane barrier layer;
- A geotextile to protect the geomembrane from the overlying soil layers;
- Twelve inch layer of crushed gravel as a bedding material for riprap;
- A 24 inch layer of riprap.

The side slopes mainly on the east side of the landfill away from the River will be constructed of the following layers:

- Six inch layer of granular foundation/gas vent sand layer;
- A 40-mil linear low density polyethylene (LLDPE) geomembrane barrier layer;
- Geocomposite drainage layer;
- Minimum 24 inches of vegetative support soil layer,
- Six inch layer of topsoil.

The landfill has been designed to contain the anticipated volume of sludge with maximum slopes of 33.3%. The HELP model study showed that an alternative cap could provide equivalent performance. Therefore, the landfill cap was designed with a minimum five percent slope on the barrier and drainage layer and a maximum of two percent on the landfill surface.

4.3.1 Foundation/Gas Management Layer

Although VTDEC reports that the existing sludge does not generate measurable quantities of gas, the cover system will include a gas collection layer equipped with passive gas vents to provide a controlled outlet for any gas that might be generated. Hydrogen sulfide gas was detected in some of the borings that were advanced through the sludge during the RI. This was especially true where an existing layer of clay material had been placed over the sludge. The gas was trapped by the clay, which apparently prevented diffusion of the hydrogen sulfide gas out of the sludge. A gas venting layer is appropriate to minimize the potential for the development of gas pressure under the barrier layer and the resulting destabilization of the cap. Gas flow rate was not used as design criterion because no significant gas generation is expected. Instead the layer was designed to allow any gas that builds up below the geomembrane to migrate laterally to the gas vent structures. In order to facilitate lateral migration, the permeability of the layer material will be higher than the underlying sludge and the overlying barrier materials. One gas vent per acre will be provided through the cap. Because density of hydrogen sulfide is greater than air, a vertical gas cut off trench will be provided to minimize the potential for hydrogen sulfide to migrate laterally to the WWTP buildings.

Generally gas vent layers are constructed using either a geocomposite or a layer of granular material such as sand. While the geocomposite would perform well and use less air space than the granular material, the condition of the final sludge surface is unknown and may be unsuitable as a geomembrane subgrade. Therefore a six inch layer of a granular material has been selected that will provide both a smooth even surface for the barrier layer (geomembrane) and a way of

transmitting gas to the gas vents. The gradation of the gas vent sand will be specified to ensure that the permeability of the material is greater than underlying waste material and the overlying geomembrane.

The permeability of the Lagoon sludge was calculated by the laboratory using the results of the controlled-strain consolidation test of the composite sample collected from Lagoon 5. The permeability is presented in the test report (Appendix C) as a graph of permeability versus the vertical stress applied to the sample. Due to the cap soils, the in-place stress of the sludge material will be a minimum of 360 psf assuming three feet of cap material at a unit weight of 120 pcf. According to the graph, the permeability will be less than 2.54×10^{-6} cm/sec. A certain amount of granular soils will likely be excavated with the sludge and the sludge will likely be solidified using an admixture such as lime. The effect of adding granular soils and lime on the total permeability of the waste material is unknown. To be conservative, a permeability of no greater than 1×10^{-5} cm/sec has been assumed for the waste. The geomembrane is essentially impermeable in comparison. Therefore, the permeability of the gas vent sand will be greater than 1×10^{-5} cm/sec.

4.3.2 Barrier Layer

The cover system will include a barrier layer. Two barrier layers were evaluated for use in the landfill cap including a 2-foot thick layer of earthen material with a permeability of less than 1×10^{-5} cm/sec, and a geomembrane. The geomembrane was selected for the following reasons:

- The hydrologic performance of the geomembrane was superior to the soil barrier layer as determined by the HELP model study;
- The source of the barrier soil will be unknown until a borrow pit study is performed during construction to verify that a sufficient quantity of soil is available with the required properties. In contrast, the geomembrane is a manufactured material and quality tests are performed to check the consistency of material properties.
- Even with a borrow study, variations in the natural soil deposit can occur leading to the rejection of materials brought to the site. Manufacturer QC tests reduce the chance of receiving non-conforming geomembrane.
- The need to control water content can make the installation of fine grained soils, especially clay, very difficult. Geomembranes are relatively easy to install in comparison.
- Quality control tests on barrier soils are performed at discrete locations while essentially the whole geomembrane layer is tested via seam continuity tests.
- LLDPE geomembranes can accommodate much larger strains without failure in the event that differential settlement or some other movement occurs.
- The cost of the soil barrier layer was $268,300 according to the FS versus approximately $100,000 according to vendor quotes for geomembranes.
- The geomembrane provides more air space that can be used for waste containment.

4.3.3 Drainage Layer

The cover system will include a lateral drainage layer. A geocomposite material will be used as the drainage layer on the portions of the cap with vegetative cover. The riprap and crushed gravel bedding material are free draining and do not require a drainage layer. The purpose of the drainage layer is to limit the amount of water that can build up over the barrier layer. This has two consequences that have implications on cover system performance. Lowering the amount of water on the barrier layer further minimizes the amount of water that can percolate through the cover, and can eliminate or reduce pore water pressures and seepage forces that reduce the stability of the overlying soils. The drainage layer has been designed to maintain a maximum of 12 inches of water over the barrier layer for the top surface, and to promote drained conditions in the cover soils of the side slopes. The unit gradient method was used to determine the ultimate transmissivity for the drainage layer material.

The drainage layer design analysis is presented in Appendix G. The results of the analysis indicates the drainage layer should have a transmissivity of 6.0×10^{-3} m^2/sec or greater.

4.3.4 Vegetative Support Layer

A root penetration (vegetative support) layer has been included in the design. This layer will protect the barrier layer from erosion and will provide a medium for the support of vegetation. Typically a silty sand soil is selected for this layer to hold enough moisture for plant growth during summer months without becoming overly saturated and unstable during wet periods of the year. The vegetative support layer will be constructed using a minimum two feet of silty sand and gravel soil. The thickness of this layer at the top of the landfill will vary in order to allow a 2 percent surface slope and a five percent slope on the barrier and drainage layers. The specification will require a well graded soil to ensure internal stability and compatibility with the filtration requirements of the geocomposite geotextile.

4.3.5 Erosion Control Layer

The cover system will include an erosion control layer at the surface to resist erosion of the cover system. Two types of erosion control will likely be used on the landfill. A 6-inch thick layer of topsoil and herbaceous non-woody vegetation will be used on the top flatter area of the landfill. Due to the potential for erosion from river flow under extreme flood conditions, the steeper side slopes of the landfill near the River will be armored with riprap to at least the elevation of a 100-year flood event. The erosion control layer has been designed to resist the expected flow velocity from the 100-year flood in the over-bank area (8.5 fps).

4.3.6 Geotextile Filter or Separation Materials

Geotextiles are used in the design to function as a separator between materials and as a cushion for the geomembrane to prevent puncture. A geotextile is also included on the upper and lower surfaces of the geocomposite drainage layer. The geotextile on the geocomposite acts as a filter to prevent the migration of fine particles into the geonet core. The gradation of the vegetative

layer has been specified to prevent excessive migration of fine particles through the geotextile component of most commercially available geocomposites.

The selection of separation geotextiles will be based on the ability of the geotextile to survive the construction process (survivability). Survivability will be evaluated using the tensile strength, puncture resistance and impact resistance of the material. Structures that will likely require a separation geotextile include rip rap lined drainage and erosion control structures, and geotextiles under road gravel materials.

4.4 Geotechnical Design

There are a number of geotechnical concerns that are typically addressed as part of the design of a solid waste landfill and cap. The stability of the foundation soils, the waste mass, and the cover system has been evaluated for the selected configuration. Analyses have also been made to evaluate the effect settlement may have on the landfill cover system. A pre-design geotechnical study was performed to determine the engineering properties of existing soil and sludge materials for use in geotechnical evaluations.

4.4.1 Global Stability of Landfill

The ability of the existing site soils to support the landfill and the stability of the landfill waste mass itself was evaluated. The global stability analyses are included in Appendix H and summarized below:

- Geologic information gathered during the RI and the pre-design geotechnical investigation (Appendix C) was used to define the site geology for input into the global stability evaluations.
- One critical section through the landfill was identified and modeled using the XSTABL computer program to determine the stability using limit equilibrium analysis (method of slices). The section is located at the northern end of the proposed landfill and was selected because the height of the landfill is a maximum in this area. The 30% design landfill configuration was modified to reflect the final landfill design. Both the 30% and 90% (final) stability analyses are presented in Appendix H.
- The geometry of the subsurface geology and the proposed landfill were input into the model and the model was run using limit equilibrium analysis with Bishop's Method of slices to identify critical failure surfaces. A sliding block analysis was performed to check the results of the Bishop's Method for the landfill stability analysis.
- Soil and waste properties, including total unit weight and shear strength characteristics (cohesion and friction angle) were developed based on published literature (NAVFAC) values and measured values from the geotechnical investigation.
- The minimum undrained shear strength for the sludge material was input to achieve the required factor of safety.
- Ground water elevations measured during the RI were used in the model.

- Two failure types were evaluated including a failure through the landfill and underlying native soils, and a failure through the landfill only.
- Analyses were performed for the representative section under static loading conditions to evaluate the stability of the landfill and the underlying soils including the thick layer of medium stiff gray clay. An undrained shear strength of 100 psf for the sludge material was used to analyze the final landfill configuration. The analyses were therefore representative of undrained end-of–construction conditions. The factor of safety for the geometry analyzed was 1.78 based on the analyses performed and is greater than the minimum FS of 1.3 for undrained conditions and 1.5 for drained conditions. The undrained shear strength of stabilized sludge was measured at 872 psf after 3 days curing and 1310 psf after 7 days curing for the 8 percent quicklime and 4 percent Portland cement reagent mixture. The analysis therefore indicates the landfill will be stable under static conditions.
- The stability of the landfill waste was evaluated by focusing the search for failure surfaces to the landfill itself. The undrained shear strength for the sludge was adjusted to achieve the minimum required FS of 1.5. The factor of safety for the landfill was 1.66 using a sludge strength of 270 psf and 1.55 using a sludge strength of 250 psf. The result of the Bishop's Method was checked using the sliding block analysis function of XSTABL. The factor of safety using the sliding block analysis was 1.65 using a sludge strength of 250 psf. The undrained shear strength of stabilized sludge was measured at 872 psf after 3 days curing and 1310 psf after 7 days curing for the 8 percent quicklime and 4 percent Portland cement reagent mixture. The analysis therefore indicates the landfill will be stable under static conditions.

4.4.2 Cap Stability

The ability of the cap materials and material interfaces to remain stable has been evaluated. Any soil components at the surface of the cap must be stable at the maximum slope against sloughing and failure within the material. This was analyzed using the infinite slope method assuming the maximum slope is 33.33 percent. The minimum angle of internal friction for the cover soil (vegetative support layer) is 26.57 degrees based on the results of the infinite slope analysis and a factor of safety of 1.5. The vegetative support layer will be constructed using a well graded sand or well graded sand and gravel. Typical friction angles for well graded sands range between 30 and 34 degrees at ultimate strength and 34 to 40 degrees at peak strength (Lambe & Whitman, 1969). Therefore, the vegetative support layer is expected to be stable at the maximum slope of 33.33 percent.

In addition, the frictional resistance of all cap component interfaces must be sufficient to maintain stability. This is especially true of caps that employ geosynthetic materials. The minimum interface shear strength needed for stability was calculated using sliding block limit equilibrium analyses using assumed values for material properties. Permutations of the analysis were conducted to evaluate different conditions such as saturated cover soils versus drained cover soils. The analysis considering saturated cover soils include buoyant unit weights and seepage forces that may develop following the passing of a 100-year flood event. A minimum FS of 1.5 will be required for static drained conditions, and a minimum FS of 1.3 will be

required for static saturated conditions. The critical interface in the proposed cap will likely be one of the following:

- Gas vent sand to geomembrane;
- Geomembrane to geocomposite;
- Geocomposite to vegetative support sand.

The analytical procedure is the same for each case since each interface is at essentially the same depth within the cap. The cap veneer stability analyses considering interface strength are included in Appendix H and summarized below:

- The analyses considering drained conditions, and undrained conditions with seepage forces were performed using "Cover Slope Stability – Design Calculator" provided by Landfilldesign.com website.

- The following assumptions were used in the analyses with the vegetative support cover soil:

  - The permeability of the vegetative support cover soil was assumed to be 1×10^{-4} cm/sec. This is a typical permeability for a well graded silty sand and gravel.
  - The precipitation was set to 50 mm/hr to ensure that the permeability of the cover soil controls the percolation of water through the cover soil (unit gradient) and that the maximum possible flux of water into the drainage layer is achieved.
  - The design permeability for the drainage geocomposite was used in the calculation.
  - The same cover soil unit weight used in the global stability analysis was used in the veneer stability analysis.
  - The friction angle of the cover soil was conservatively assumed to be 30 degrees.
  - The maximum slope length was measured from the design drawing as 42.16 feet.

- The following assumptions were used in the analyses for the side slopes with riprap and crushed gravel bedding material:

  - A high permeability (10 cm/sec) was assumed for the riprap because the material is essentially free draining (i.e. negligible seepage forces).
  - The unit weight of the riprap and crushed gravel was assumed to be 130 pcf.
  - The friction angle of the riprap and crushed gravel was conservatively assumed to be 34 degrees.
  - The maximum slope length was measured from the design drawing as 63.24 feet.

- The capacity of the drainage geocomposite was sufficient to maintain drained conditions for the analysis of the cap section with vegetative cover soil. Therefore, an undrained condition was not analyzed. The interface friction angle was adjusted until a factor of safety of 1.5 was achieved.

- Undrained conditions for the side slopes with riprap and crushed gravel bedding were modeled by adjusting the precipitation and permeability of the drainage layer until a height of water in the cover soil was at least 12 inches. This ensured that seepage forces were developed for the maximum allowable height of water in the cap system. The interface friction angle was adjusted until a factor of safety of 1.3 was achieved.

Based on the analyses, a minimum peak interface friction angle of 23.8 degrees was required to maintain a static FS for drained conditions and a minimum peak interface friction angle of 25 degrees was required to maintain a static FS of 1.3 for undrained conditions.

During the pre-final design, interface friction tests were conducted using locally available soil materials and typical samples of geosynthetic materials. Samples of geosynthetic materials were obtained from GSE including a 40-mil textured LLDEP geomembrane and a 250-mil biaxial geocomposite with 6-ounce non-woven geotextile bonded to both sides. Nine soil samples were collected from five local borrow pits and tested for gradation. Gradation test reports are included in Appendix H. Table 5 summarizes the samples collected and the intended use.

Table 5: Summary of Soil Samples From Local Borrow Pits

	Intended Soil Use		
Sample ID	**Barrier Soil**	**Gas Vent Sand**	**Vegetative Support**
Bisson-BS-C/S	X		
Bisson-VS-VS			X
Bisson-CS-CS		X	
Burgess Brothers-VS-CB			X
Burgess Brothers-CS-SF		X	
Chapel Road-Denio-BS-S/C	X		
Strohmanier-VS-S			X
Strohmanier-VS-SG			X
W.E.Daily-CS-WS		X	

The Daily-CS-WS and Bisson-CS-CS samples were chosen as possible gas vent sand materials and tested for interface friction with the geomembrane. The Bisson-VS-VS and the Burgess Brothers-VS-CB samples were chosen as possible vegetative support soils and tested for interface friction with the geocomposite. The geomembrane and geocomposite were also tested for interface friction. All tests were conducted per ASTM D 5321 in a saturated condition using normal loads of 100 psf, 300 psf and 600 psf. Interface friction test laboratory reports are included in Appendix H.

Peak friction angles and cohesion values are presented in Table 6.

Table 6: Summary of Peak Interface Friction Values		
Interface Tested	**Peak friction Angle, degrees**	**Peak Cohesion, psf**
Gas Vent Sand/Geomembrane	28	14
Vegetative Support Soil/ Geocomposite	32	0
Geomembrane/Geocomposite	36	26

The results of the interface friction tests indicate that the cover system should be stable using standard materials. Interface friction testing using site-specific materials will be required in the construction specifications to ensure that the actual cover system materials will be stable.

4.4.3 Seismic Stability

United States Geological Survey (USGS) records were evaluated to determine if the Site is in a seismic impact zone as defined in the Resource Conservation and Recovery Act (RCRA) Subtitle D (258) Seismic Design Guidance for Municipal Solid Waste Landfill Facilities (RCRA Seismic Design Guidance). According to the USGS, the Site has a two percent probability of exceedance in 50 years for a peak ground (rock) acceleration of 0.12g. This is equivalent to a 90 percent probability of non-exceedance in 250 years. Therefore, the Site is in a seismic impact zone and analyses were performed to evaluate both global and cap veneer stability to resist the maximum horizontal acceleration in lithified earth material (rock) for the Site. Analyses to evaluate seismic stability only considered drained conditions. A minimum factor of safety of 1.1 is required for seismic stability under drained conditions.

A simplified site response analysis as described in the RCRA Seismic Design Guidance was performed to estimate the potential amplification of the peak ground acceleration due to local soil conditions. A free field peak ground acceleration of 0.18g was found for the existing ground surface at the Site. Because the landfill is relatively low in height, the free field acceleration (0.18g) was used in the analyses for global stability and for the landfill side slope veneer analysis. A peak ground acceleration at the top of the landfill of 0.24g was also determined using the simplified response analysis for use in veneer stability analyses for the top slope of the landfill. The seismic coefficient for pseudo-static stability analyses was taken as 50% of the peak ground acceleration. A seismic coefficient of 0.09 was used for global stability. A conservative seismic coefficient of 0.13 was used for veneer stability calculations based on a recommendation in the landfilldesign.com Design Calculator. Seismic analyses are included in Appendix H.

The global seismic stability analysis gave a factor of safety of 1.54 for the landfill. The minimum interface friction angle for the cap was found to be 25 degrees based on the analysis of the landfill side slope. Therefore, the minimum friction angle for any interface in the cap will be 25 degrees based on the static undrained veneer stability analysis.

4.4.4 Settlement

There are three types of settlement that can occur when soil materials are loaded including elastic settlement, consolidation settlement and secondary settlement. Settlement, and more importantly differential settlement of the cover system can result from the consolidation of both the waste material and the foundation soils. Possible negative results of differential settlement for this landfill include the following:

- Internal drainage disruption because of changes in design slopes;
- Surface water drainage disruption because of changes in design slopes;
- Surface water ponding.

Elastic settlement of the foundation soils will be relatively small as compared to consolidation settlement. Also this type of settlement typically occurs over a relatively short period of time (weeks) while construction is ongoing. Since elastic settlement should not result in any significant post-construction settlement, it will not be considered. Consolidation settlement of the natural clay layer below the Site is expected and was included in the evaluation. Much of the sludge was observed to be fine grained and clay-like during the geotechnical investigation. However, the sludge will be stabilized prior to placement in the landfill using quicklime and/or Portland cement. These stabilizing reagents will increase the shear strength of the sludge by developing a cemented matrix among the soil particles. For quicklime, the lime pozzolanically reacts with the clay particles in the sludge to form calcium-silicate-hydrate and calcium-aluminate-hydrate cemented products. These are the same hydrates that form during the hydration of Portland cement. Therefore, consolidation settlement of the stabilized sludge is not expected.

The possibility of large secondary settlement is also not likely due to the stabilization. Decomposition of organic matter in MSW can contribute to significant secondary settlement and the generation of large quantities of landfill gas (mainly methane and carbon dioxide). Experience with the existing sludge landfill at the Site indicates that significant landfill gas is not being generated by the sludge and therefore, no decomposition of the organic matter in the sludge is presumed. This may be due to the presence of tanning agents that are used to preserve the leather product from degradation. The possibility of large secondary settlements due to the decomposition of organic matter is low and will not be considered.

Large localized differential settlement in municipal solid waste (MSW) landfills can affect the integrity of the cap geomembrane. However, localized differential settlement is unlikely to occur at this landfill since the sludge material is relatively uniform and will be placed and compacted in a controlled manner. The effects of localized differential settlement were not evaluated.

Foundation and sludge settlement were evaluated at critical points on the landfill to determine the effects on drainage patterns. The surface of the landfill was designed to maintain the minimum required slopes following settlement. Drainage structures such as ditches and downchutes will be designed to convey flow from the design storm without overtopping following settlement.

The settlement analyses are presented in Appendix H. Only the consolidation settlement of native gray clay was calculated at the center of the landfill in the area of the thickest fill. The analysis is summarized below:

- The increase in stress in the foundation soils was estimated using Boussinesq equations for an embankment fill.
- The landfill was modeled as a 16 foot high embankment with 33.33% side slopes and a flat top.
- A compression ratio of 0.105 for the gray clay was measured by a consolidation test on an undisturbed sample collected from 25 to 27 feet below the existing ground surface.
- The clay layer was subdivided into 7 layers for calculating consolidation settlement.
- The average unit weight of the sludge was estimated using 90 percent of the maximum dry density and optimum water content of the six sludge samples tested by standard proctor.

The analysis indicated a maximum settlement of 14.4 inches would occur within the clay layer due to the placement of the landfill. Since stabilization with quick lime and/or Portland cement will be performed to strengthen the sludge, consolidation settlement within the stabilized waste is not anticipated and was not accounted for in the settlement calculations.

Differential settlement between the crest of the landfill and the outer edge of the top, flatter surface of the landfill may have a detrimental effect on cap drainage. The most likely area of the landfill where a detrimental effect could occur is the eastern end of the landfill where the longest length of two percent slope is located. The settlement at the edges and center of the top landfill surface in the Lagoon 3 area has been evaluated to determine the potential affect of differential settlement on the slope of the cap surface. The settlement calculation (see Appendix H) takes into account consolidation settlement in the native gray clay and the sludge materials in Lagoon 3 that will not be stabilized. Calculations show settlement of 13.33 inches at the crest of the landfill and 8.03 inches at the northern edge of the top cap surface. The difference in settlement of 5.3 inches over 145 feet would reduce the 2 percent slope by 0.03 percent to 1.97 percent. This reduction in slope would have no detrimental effect on cap drainage.

5.0 SITE DESIGN

5.1 Existing Site Conditions

The lagoon area is located adjacent to the Hoosic River, within the 100-year floodplain. The Hoosic River flows generally from south to north along the western boundary of the lagoon area, separated by a single, continuous elevated soil berm. Vegetation present along the surface of this soil berm varies from scrub vegetation to mature trees, which currently stabilizes the berm surface from erosion. During periods of flood flows within the Hoosic River, the water surface rises up the western face of this soil berm. Under extreme flood flow conditions (i.e., 100-year flood) this berm is over-topped, and the river waters spill into the lagoon area, submerging Lagoons 1, 4 and 5.

The current topography of the remaining lagoon area includes a series of soil berms surrounding Lagoons 1, 4 and 5. Each of these lagoons have a generally flat, low-lying surface within their respective surrounding soil berms. Surface topography of Lagoon 3 is higher than the elevation of the Lagoons 1, 4 and 5. Lagoon 2 has been subject to a removal action, which left the area as an isolated surface depression.

Within the lagoon area, ground cover consists mainly of small, scrub vegetation with some sparse immature trees emerging within Lagoon 4. Some structures and miscellaneous debris are also present throughout the lagoon area.

5.2 Existing Site Drainage

Storm water drainage patterns under current conditions are controlled by the elevated soil berms surrounding the individual lagoons and the lagoon area as a whole. Soil berms surrounding Lagoons 1, 4 and 5 contain any potential surface water runoff within the footprint of each respective lagoon. This runoff ponds and percolates through the sludge material, recharging shallow ground water.

Due to the topographic depression at Lagoon 2, no precipitation falling within this footprint is able to produce runoff. Also, any potential storm water runoff from areas immediately adjacent to Lagoon 2 flows into this depression. All accumulated water within the footprint of Lagoon 2 then percolates to the subsurface.

The ground surface elevation of Lagoon 3 is higher than that at the other lagoons. Storm water runoff from Lagoon 3 flows mainly westward towards Lagoon 4. However, some portions of Lagoon 3 contribute storm water flow to Lagoons 1 and 2. Any potential storm water runoff from Lagoon 4 is contained by the continuous soil berm which separates the Hoosic River and the lagoon area.

In addition to storm water runoff generated from within the footprint of the lagoons, portions of the lagoon area are periodically inundated with extreme flood flows of the Hoosic River. Under these extreme flood flow conditions, the surface of the lagoon area is subjected to significant erosive forces, potentially mobilizing contaminated materials down stream. As these flood

waters subside, the berms and the lagoon area will remain flooded for some period of time as the retained water percolates downward.

5.3 Cover System Storm Water Runoff Assessment

Design criteria employed during the development of the final site grades included providing positive drainage of storm water runoff away from the landfill cover system both during construction activities and under post construction conditions. Design efforts involved delineation of drainage flow paths, estimation of runoff flows associated with the design storm and the design of drainage swales sufficient to convey the estimated flows of the design storm. In addition to those considerations typically required for design of landfill cover storm water features, design efforts were also conducted to address potential issues associated with extreme flood flows. This was necessitated due to the location of the proposed landfill within the 100-year floodplain/floodway of the Hoosic River.

The following sections summarize the design basis for each design activity listed above. During each design activity, consideration was given to anticipated site conditions during the construction activities and the final site conditions as proposed in the site design.

5.3.1 Drainage Flow Paths

During Construction

Governing design criteria followed while designing storm water control features to be employed during construction activities focused on minimizing the potential for excessive erosion of exposed areas within the landfill footprint and deposition of sediment beyond the construction area. One of the most significant aspects of minimizing potential erosion is to minimize the time that easily eroded soils and/or sludges are exposed to precipitation events. Therefore, the overall approach to control of storm water runoff flows during construction involves designing specific control features along the perimeter of the landfill footprint together with performance criteria to be employed by the construction contractor within the construction area. This approach provides sufficient protection of areas beyond the landfill footprint, while providing the construction contractor a level of flexibility within this area to most efficiently complete construction activities.

The main storm water control feature to be employed during construction activities is the construction of the access road along the outer perimeter of the landfill footprint. This road will be constructed to elevations above the current site elevations, resulting in the construction of a soil berm around the outside perimeter of the landfill footprint. Over certain portions of the landfill footprint, storm water runoff will be allowed to drain back into the Lagoon 1 and 5 excavation. As the area between the Lagoon 1 and 5 excavation and the proposed landfill footprint will be a main path of transporting excavated material to the landfill area, construction of storm water control features in this area may significantly reduce the rate at which excavated materials can be transported away from the excavation. Storm water runoff within the landfill footprint will be directed towards this berm and conveyed into culverts. These culverts direct

storm water flows into sediment basins where suspended soils and/or sludges will settle out prior to overland discharge of the storm water.

Post Construction

Design of final site drainage patterns considered the proposed construction of a Waste Water Treatment Plant (WWTP) facility within the footprint of Lagoon 2 and the proximity of the site property line along the eastern edge of the proposed landfill. Storm water runoff flowing from the landfill cover towards the east is diverted away from these features via swales, which discharge this water within the current footprint of the lagoon area.

The design of the proposed landfill cover includes relatively flat ground surface slopes over the top portion, with steeper slopes (up to 33%) on the side. As discussed below, the steeper side slopes require armoring of the ground surface due to potential erosion issues associated with flooding events of the Hoosic River. Erosion of the top, flatter portion of the cover system was minimized by reducing the length of overland flow paths the runoff travels prior to entering an engineered storm water control feature (e.g., drainage swales).

Selection and maintenance of appropriate ground cover is also a critical component of minimizing surface runoff. The top, flatter portion of the landfill has a vegetative cover of grass that is appropriate for the region and provides for relatively low maintenance.

5.3.2 Estimation of Storm Water Runoff Flows

Peak storm water runoff flows were calculated for two different site condition scenarios using the Rational Method. The first condition represents a worst-case condition and assumes the sludge is in place and covered with a low permeability geomembrane. The volume and velocities of storm water runoff under this condition would be expected to be significantly higher than under any other conditions. This scenario assumes the entire landfill is covered with exposed geomembrane. In actuality, this scenario will not be likely as each area of the geomembrane will be covered as soon practical during construction.

The second case models final site conditions assuming established vegetation. An Intensity-Duration-Frequency curve (IDF) was derived for Pownal, Vermont using Technical Paper No. 40, the Rainfall Frequency Atlas of the United States and NOAA Technical Memorandum NWS Hydro-35, the 5- to 60- Minute Precipitation Frequency for the Eastern and Central United States. Table 7 below presents the calculated runoffs determined for each phase of construction. The culverts were designed using the pre-cap, worst case design flow. The calculations presented in **Appendix I** include a figure that shows drainage areas 1, 2 and 3 referenced in Table 7 below.

Table 7: Post Construction Peak Storm Water Flows				
Phase of Construction	Drainage Areas 1 & 2 (Acres)	Areas 1 & 2 Peak Discharge (cfs)	Drainage Area 3 (Acres)	Area 3 Peak Discharge (cfs)
Worst-case	3.3	22	2.6	17.4
Final Conditions	3.3	4	2.6	1.64

5.3.3 Drainage Swale Design

The drainage swales included in the final site grading are designed to convey the 25-year, 24-hour precipitation event, with 0.5 feet of freeboard. The culverts and associated structures are also designed to convey the 25-year, 24-hour precipitation event. Lining of each drainage swale was determined based on the calculated velocities within each respective swale. The portions of the drainage swales with flatter slopes and lower flow velocities were designed as grass-lined swales. The portions of the swale with steeper slopes and higher flow velocities were designed with riprap for stabilization. At the discharge location of each drainage structure, a stabilized outlet apron was designed to adsorb the energy of the storm water flow, dissipate runoff evenly over the ground surface, and direct runoff away from the toe of the landfill slope. The calculations for the design of the drainage swales and culverts are included in **Appendix I.**

5.3.4 Flood Flow Design Considerations

5.3.4.1 Riprap Side Slope Protection

Due to the anticipated encroachment of the Hoosic River into the lagoon area during flood events, the selection of landfill side slope ground cover considered the erosive forces associated with river flood flows. While the lagoon area is anticipated to be subjected to river flows only during relatively extreme events, the potential adverse environmental impacts from a failure of the side slope during such events are significant.

The side slope erosion protection was designed, conservatively, based on the 100-year, channel, flood flow velocity of 8.5 ft/sec provided by the State of Vermont, Department of Environmental Conservation. The design procedures followed are outlined in the U.S. Army Corps of Engineers Manual, "Hydraulic Design of Flood Control Channels" EM 1110-2-1601 (Appendix J). The size of the riprap was selected using the following equation:

Equation 1:

$$D_{30} = S_f C_s C_v C_T d \left[\left(\frac{\gamma_w}{\gamma_s - \gamma_w} \right)^{\frac{1}{2}} \left(\frac{V}{\sqrt{K_1 g d}} \right) \right]^{2.5}$$

Descriptions of the variables in this equation and the values assumed are explained in **Appendix J** of this report. The D_{30}, or riprap size of which 30% is finer by weight, was calculated to be 0.55 ft. Using Table 3.1 of EM 1110-2-1601, and assuming a riprap specific weight of 165 pcf,

the D_{100} value, the diameter of the largest stone size, is 15 inches; the D_{90}, is 11 inches; and the D_{30} value is 7 inches.

The slope toe protection was sized according to Method C, described in EM 1110-2-1601 **(see Plate B-43 in Appendix J)**. Method C is appropriate where little toe scour is expected. The access road, which runs just west of the landfill toe, provides a built up berm that protects the landfill toe from scour. Therefore Method C was selected. Method A was eliminated due to the high water table at the site. Implementation of this method requires excavation. Method B is appropriate for slope protection that terminates in a river channel bottom, which is not the case. Method D is appropriate for slopes subject to high toe scour. As noted above, the access road provides protection from toe scour.

The slope end protection was selected following Method C **(see Plate B-41 in Appendix J)**. Method C is appropriate for riprap protection that terminates in an area that is subject to eroding channel velocities. In this case, the western slope of the landfill terminates in the right over bank channel of the Hoosic River, which is subject to flow velocities of approximately 8.5 ft/sec as provided by the VTDEC. Method A is appropriate for riprap protection that is less than 12 inches thick. The riprap thickness, assumed to be 1.5 times D_{100} is approximately 24 inches thick. Therefore, Method A was not selected. Method B is appropriate for slope protection that terminates in areas that are not subject to eroding velocities. As mentioned above, this is not the case and therefore Method B was not selected.

5.3.4.2 Soil Berm Modifications

As directed by the VTDEC, the northern most portion of the soil berm that runs perpendicular to the Hoosic River and separates the Hoosic River from the lagoon area will be removed to an elevation of 500 feet over a minimum of 125 linear feet. VTDEC requires this modification to the berm to facilitate the merger of the right overbank floodwaters, flowing in the lagoon area, to the main river channel.

Rip rap stabilization for areas to be disturbed by this modification was designed using Equation 1 and assuming a flow velocity of 8.5 ft/sec and a flat slope. The D_{30} was calculated to be 3 inches. Using Table 3.1, provided in the calculations in **Appendix I**, the gradation was determined to be D_{100} of 9 inches, D_{90} of 6 inches and a D_{30} of 4 inches assuming a specific weight for riprap of 165 pcf. The riprap blanket thickness will be 1.5 times the D_{100} or 14 inches. This gradation closely matches the gradation of rip rap material to be placed on the landfill side slope area. For constructability reasons the same material specified for the side slopes of the landfill will also be used here.

5.4 Erosion and Sediment Control

During Construction

Due to the nature of the materials to be handled (sludge) and steep slopes to be constructed, there is a potential for significant erosion to occur during the remediation construction activities at the lagoon area. The overriding goal of erosion control during construction activities is the

introduction of no additional sediment to surface waters from the construction site. The lagoon area is separated from the Hoosic River by a continuous, elevated soil berm. This soil berm prevents normal storm water runoff flows from entering the Hoosic River directly from the lagoon area. However, given the fact that the sludge is anticipated to be contaminated, minimizing the migration of this material even within the lagoon area is desirable.

To minimize adverse impacts associated with erosion and sediment transport during remedial construction activities, a comprehensive sediment and erosion control plan was developed for the site (**Appendix K**). The development and implementation of the site sediment and erosion control plan has considered the requirements of the document "Vermont Handbook for Soil Erosion and Sediment Control on Construction Sites", Vermont Geological Survey, Department of Water Resources and Environmental Engineering, 1982.

The overall strategy for erosion control at the Pownal site during construction includes minimizing areas of disturbed soils and the duration of exposure, control of storm water run-on/runoff, control of storm water over the landfill, and on-site sediment control measures. Minimizing the area and duration of exposure of disturbed soils is accomplished through the sequencing of construction activities. Areas not being worked for extended durations will be covered with erosion control blankets.

The controls to address storm water run-on/runoff and sediment transport include silt fencing, hay bales, perimeter diversion swales, sediment trap(s), and stabilized construction entrance(s). The proposed layout of such features is presented in the Project Drawings and will be refined, as needed. During construction, the storm water runoff will run to two sedimentation traps. Sedimentation trap 1 is located by the northern toe of the landfill. Sedimentation trap 2 is located towards the southwest by the bend in the western footprint of the landfill. The flow areas to each trap will be limited to 5 acres throughout construction as required by the Vermont Erosion and Sediment Control Handbook.

Post Construction

Design consideration was given to the potential for erosion of the cover system due to concentration of storm water runoff over long and/or steep flow paths. The Revised Universal Soil Loss Equation (RUSLE), developed by the U.S. Department of Agriculture (USDA) was used to estimate soil loss for the post construction scenario. This analysis showed that due to the flat slopes over the vegetated area of the landfill and relatively short overland flow paths selected during design, soil erosion is estimated to be less than 2 tons per acre per year, as required in the U.S. Army Corps of Engineers document, "Checklist for Hazardous Waste Landfill Cover Design", ETL 1110-1-162, September 30, 2001.

6.0 ENVIRONMENTAL AND PUBLIC IMPACTS

A Final Plan for Minimizing Environmental and Public Impacts has been prepared and is included as Appendix E. The Plan includes a discussion of any engineering controls that will be included in the remedy design for sludge and water handling. The plan will describe monitoring and exposure control procedures, and other plans to mitigate the following possible impacts:

- The release of contaminated water;
- The release of contaminated sludge;
- Fugitive emissions of odor and dust;
- Noise;
- Traffic.

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7.0 COMPLIANCE WITH ARARS AND PERMITTING REQUIREMENTS

7.1 List of Applicable Permits

The design and construction of the selected remedy for the Pownal Tannery Superfund Site will comply with the intent of the applicable federal and state environmental permits. Possible permits include the following.

- ***Act 250 Permit,*** for triggering certain thresholds related to development of land.
- ***Stream Alteration Permit (10 VSA Chapter 41, Regulation of Stream flow)*** for excavation of greater than 10 cubic yards of material for stream bank stabilization work.
- ***National Pollutant Discharge Elimination System (NPDES) Construction General Permit*** for discharge of stormwater runoff from sites with construction activity, including clearing, grading, and excavation that will result in disturbance of five or more acres of land.
- ***National Pollutant Discharge Elimination System (NPDES)***, for discharge of construction water from an on-site treatment system to Hoosic River.
- ***National Pollutant Discharge Elimination System (NPDES) Multi-Sector General Permit (MSGP) Application*** for potential stormwater discharge from a site identified on the MSGP SIC code list to a receiving water.

EPA is exempt from obtaining formal permits and approvals because the work is under the Superfund Program.

7.2 Compliance With ARARS

The remedy will comply with all federal and any more stringent state ARARS that pertain to the Site. In particular, the remedy will comply with the following ARARS.

7.2.1 Vermont Solid Waste Management Rules

The Vermont regulations specify certain design requirements and performance standards for a solid waste disposal facility. A detailed evaluation of how the remedy will comply with the Vermont Solid Waste management Rules was performed during the FS and the results of that evaluation are presented in a Feasibility Study Addendum dated June 2002 that was appended to the FS report. Many of the requirements were found to be not applicable to the remedy and are not presented herein. In addition a discussion of the siting and setback requirements will not be discussed. Only the requirements that affect the design of the remedy are presented below.

- All new municipal solid waste discrete disposal facilities and lateral expansions located in seismic impact zones must have containment structures designed to resist the maximum horizontal acceleration in lithified earth material for the site. **The landfill and**

the cap have been designed to resist the maximum horizontal acceleration in lithified earth material for the site.

- Facilities shall assure the control and treatment, if determined necessary by the Secretary, of gases resulting from the decomposition of wastes to prevent hazards to public health and safety, the environment, or the creation of a nuisance. **The design includes a passive gas venting system.**
- Discrete disposal facility designs shall provide for the appropriate control of surface water run-on and run-off, as determined by the Secretary. **Project design includes the required run-on and run-off controls.**
- The engineering design and plan for lift development shall insure proper drainage on the discrete disposal facility site and prevent ponding of water on the facility surface. This requirement applies both during the working life of the facility and after the final cover system has been installed and vegetation established. **The cover system has been engineered to minimize and control ponding.**
- The final cover system design for unlined discrete disposal facilities shall include a minimum two-foot thick layer of earthen material with a permeability of less than 1×10^{-5} cm/sec and less than the permeability of the facility base soils, and a minimum six-inch thick earthen material layer capable of sustaining native plant growth. Alternately, a final cover system as described for lined discrete disposal facilities will be utilized for unlined discrete disposal facilities if required by the Secretary. **The cover system complies with this requirement.**
- The final cover system design for either lined or unlined discrete disposal facilities shall provide for a minimum slope of five (5) percent and a maximum slope of thirty-three and one third (33 1/3) percent. **The maximum cover system slopes will be thirty-three and one third (33 1/3) percent. A waiver for the five percent minimum slope requirement has been obtained from the VTDEC. The surface of the cap will have a two percent slope while the slope on the geomembrane barrier layer will be five percent.**

7.2.2 Executive Order 11988, Floodplain Management Guideline

Executive Order 11988, Floodplain Management Guideline directs federal agencies to avoid long- and short- term adverse impacts associated with occupancy and modification of floodplains. Each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains in carrying out its responsibilities for (1) acquiring, managing, and disposing of Federal lands and facilities; (2) providing Federally undertaken, financed, or assisted construction and improvements; and (3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities.

The Project lies within the current floodway and the 100-year floodplain of the Hoosic River. The preliminary design included the removal of portions of the soil berm between the river and the site to the south of Lagoons 1 and 5 and to the north of Lagoon 4. The Project is proposed in

the floodplain but it is the only practical and feasible alternative to address site contamination. Several actions are proposed that will reduce the risk of flood loss, minimize the impact of floods, and preserve the natural and beneficial values of the floodplain. These include regrading to make changes to the floodway shape and location, covering the waste materials in the lagoons with a protective cap, and consolidating some of the saturated waste to areas above the water table. All of these actions will be taken as part of the remedy with the goal of reducing the human health risk from exposure to site contaminants. The selected remedy minimizes impacts to the maximum extent practical to meet the requirement of Executive Order 11988.

7.2.3 ACT 250 – Vermont's Land Use and Development Law

Act 250 Land Use Permit

Act 250 requires that certain development and subdivision plans obtain a land use permit prior to construction. The District Commission reviews each application and bases their review and decision on Act 250's 10 criteria. The criteria focuses on projects impacts on air and water quality, water supplies, traffic, educational and municipal services, and historic and natural resources, including scenic beauty and necessary wildlife habitat. Although the formal Act 250 process is not required for the project, the design will minimize impacts that are the focus of the 10 criteria.

The Remedy has been designed to minimize air and water impacts during and after construction activities. The State of Vermont had determined that no mitigation measures are required at the Site for the loss of Class Three wetlands through implementation of the selected remedy. The Remedy will not result in the construction of a subdivision or development and thus will not create a burden on water supplies, education, or municipal services. Any potential traffic impacts during construction will be mitigated to the extent practical. The Remedy involves the betterment of the property and will be consistent with the visual character of the area and will not have an undue adverse impact on aesthetics or wildlife and endangered species habitat. A Final Plan for Minimizing Environmental and Public Impacts to address the 10 criteria of the Act 250 permit is included in Appendix E.

7.2.4 Vermont Wetland Rules (10 VSA, Chapter 37)

The Vermont Wetland Rules were adopted by the Water Resources Board pursuant to 10 VSA, Chapter 37. It is the policy of the State of Vermont to identify and protect significant wetlands and the values and functions, which they serve in such a manner that the goal of no net loss of such wetlands and their functions is achieved. The Vermont Wetland Rules are applicable to those wetlands, which are so significant that they merit protection under that program. Pursuant to Section 4 of the Rules, all wetlands in Vermont are designated as Class One, Class Two, or Class Three Wetlands. Those wetlands designated as Class One or Class Two have been deemed by the Board to be so significant that they merit protection.

Class Three Wetlands are those wetlands that have not been determined by the Board to be so significant that they merit protection under the Vermont Wetland Rules. The State of Vermont

DEC does not consider the man-made lagoons to be significant wetlands, and as such the work proposed in these areas is not subject to the Vermont Wetland Rules.

The design will incorporate DEC's recommendations for riparian and wetland buffer zone restoration. The restored buffer zone areas will provide: storage for floodwater and storm water, water quality protection, wildlife habitat, and some erosion control. A portion of this restoration work will be performed in the buffer zone of wetland areas bordering the Hoosic River (Wetland HR 2 Hoosic River Riparian Fringe) just south of Lagoons 1 and 5. This wetland area is classified as a Class Two Wetland. Accordingly, all work will be performed in accordance with the intent of the Vermont Wetland Rules.

Disturbance of the natural vegetation will be minimized to the extent practicable. The soil berm and vegetation along the riverbank will be maintained during construction to protect against erosion and siltation into the Hoosic River or wetland. Other temporary sedimentation and erosion controls will be installed until permanent vegetation has become established.

The temporary sediment and erosion controls will be left in place until exposed soils have successfully re-vegetated. Temporary devices and structures to control erosion and sedimentation in and around the mitigation site shall be disassembled and properly disposed of before November of the third full growing season after planting. Sediment collected by these devices will be removed and placed upland in a manner that prevents its erosion and transport to a waterway or wetland.

7.2.5 Stream Alteration Permit (10 VSA, Chapter 41, Regulation of Stream Flow)

The Vermont Department of Environmental Conservation regulates activities that take place in or along streams through the Stream Alteration Permit Program. The program is authorized in 10 VSA Chapter 41. The permit program is intended to prevent the creation of flood hazards, protect against damages to aquatic life, and protect the rights of neighboring landowners. The types of activities that are regulated include streambank stabilization, gold dredging, road improvements that encroach on streams, bridge construction or repair, and utility crossings under streambeds. The remedy includes streambank stabilization on the bank of the River at the north end of Lagoon 4.

A permit is required for movement, excavation or fill involving 10 or more cubic yards annually in any watercourse with a drainage area greater than 10 square miles or in any designated outstanding resource water.

The statute also prohibits the removal of gravel from any watercourse, regardless of size, primarily for construction or sale. There is an exemption for 50 cubic yards annually for riparian landowners, but the gravel must be used only on the landowner's property, and the Agency must be notified at least 72 hours prior to the excavation.

Pursuant to 10 VSA Chapter 41, Section 1023 a permit would be granted for this work, subject to such conditions determined to be warranted, since the proposed work:

1) will not adversely affect the public safety by increasing flood hazards, and
2) will not significantly damage fish life or wildlife,
3) will not significantly damage the rights of riparian owners, and
4) in case of any waters designated by the board as outstanding resource waters, will not adversely affect the values sought to be protected by designation.

The design will incorporate best management practices for the protection of sedimentation and erosion control as described above. The design will incorporate the applicable information required to complete the Stream Alteration Permit Application Form.

7.2.6 General Permit for Stormwater Runoff From Construction Sites (3-9001)

The General Permit for Stormwater Runoff from Construction Sites is issued in accordance with the following state and federal laws and rules: the Vermont Water Pollution Control statute, 10 VSA Chapter 47, including §§1259, 1263, and 1264; the Vermont Water Pollution Control Rules, Chapter 13, including the general permit rules in Section 13.12; the federal Clean Water Act, as amended, 33 U.S.C. 1251 et seq., including 33 USC 1342(p); and the regulations of the federal Environmental Protection Agency including 40 CFR 122.26 and 40 CFR 122.28.

This permit covers the discharge of stormwater runoff from sites with construction activity, including clearing, grading and excavation, which will result in the disturbance of five or more acres of total land area. The permit covers the discharge of stormwater runoff from construction sites to all Class B waters within the State of Vermont, with the exception of Class B waters listed under Part I (C)(3).

The design will meet the substantive conditions of the General Permit. Specifically, the design will include an Erosion and Sediment Control Plan that meets the provisions of Part III, of the General Permit. The objective of the Plan will be to minimize the erosion of disturbed land and to prevent the discharge of sediment and other construction-related pollutants to waters of the State. The Plan will be designed to provide, as a minimum, the protection outlined in the Vermont Handbook for Soil Erosion and Sediment Control on Construction Sites (Vermont Geological Survey, 1982, rev. 1987), or any update to that publication (the "Handbook") and developed using the principles described in the General Permit (e.g. fit the development plan to the site, preserve natural drainageways, minimize areas of disturbed soil and unnecessary removal of existing vegetative cover).

The design plans will include the information outlined in Part III, C of the General Permit: Location Map, Existing Site Conditions Site Plan, Grading Plan, Erosion and Sediment Control Plan.

7.2.7 Vermont Water Quality Standards

Vermont Water Quality Standards establish water quality criteria for the maintenance of water quality and rules for determining acceptable point and non-point discharges to state surface waters. The selected remedy includes discharge of treated water from the excavation and sludge

dewatering activities into the Hoosic River. Pursuant to Section 1-4 of the Vermont Water Quality Standards, new discharges to surface water may be allowed when all the criteria of that section are met. The proposed discharge will meet all the applicable criteria of that section, including the following.

1. The proposed discharge is in conformance with all applicable provisions of these rules including the classification of the receiving waters adopted by the Board as set forth in Chapter 4 of these rules.

2. There is neither an alternative method of waste disposal, nor an alternative location for waste disposal, that would have a lesser impact on water quality including the quality of ground water, or if there is such an alternative method or location, it would be clearly unreasonable to require its use.

3. The design and operation of any waste treatment or disposal facility is adequate and sufficiently reliable to ensure the full support of uses and to ensure compliance with these rules and with all applicable state and federal treatment requirements and effluent limitations.

4. Except as provided for in 10 VSA §1259(d) and (f), the discharge of wastes other than nonpolluting wastes and stormwater runoff is prohibited in Class A waters regardless of the degree of treatment provided.

5. Except as provided for in 10 VSA §1259, the discharge of wastes that, prior to treatment, contained organisms pathogenic to human beings into waters is prohibited.

6. The receiving waters will have sufficient assimilative capacity to accommodate the proposed discharge.

7. Assimilative capacity has been allocated to the proposed discharge consistent with the classification set forth in Chapter 4 of these rules.

8. The discharge of wastes to the thermocline or hypolimnion of any lake in a manner that may prevent the full support of uses is prohibited.

9. The discharge of sewage into Class B waters shall not pose more than a negligible risk to public health. Compliance with this criterion shall include an assessment of both the level and reliability of treatment achieved and the impact of the discharge on the water quality of the receiving waters.

The construction water treatment system will be designed such that applicable surface water quality standards for the Hoosic River, which is Class B water, would not be violated.

Water Quality Standards are described in Section 3-01 and 3-04. Criteria are provided for temperature, phosphorus, nitrates, solids, oil and grease, taste and odor, color, alkalinity, pH, toxic substances, stream flow, turbidity, DO, E. Coli, and other qualitative parameters. Specific

discharge criteria for the project have been determined during design with input and concurrence from the VTDEC.

The treated effluent water will be sampled and analyzed prior to being discharged to the river. The Technical Specifications include the list of constituents that will be analyzed for.

Sample collection, preservation, handling, and analysis are included in the Sampling and Analysis Plan (SAP) attached to the Technical Specifications. The requirements of the SAP shall conform as closely as practicable to methods established in the most current edition of the sources listed in Section 2-01.

7.2.8 National Pollutant Discharge Elimination System (NPDES) (40 CFR Parts 122 and 125)

The 1972 amendments to the Federal Water Pollution Control Act (known as the Clean Water Act or CWA) provide the statutory basis for the NPDES permit program and the basic structure for regulating the discharge of pollutants from point sources to waters of the United States. Section 402 of the CWA specifically required EPA to develop and implement the NPDES program.

The CWA gives EPA the authority to set effluent limits on an industry-wide (technology-based) basis and on a water-quality basis that ensure protection of the receiving water. The CWA requires anyone who wants to discharge pollutants to first obtain an NPDES permit.

The CWA allowed EPA to authorize the NPDES Permit Program to state governments, enabling states to perform many of the permitting, administrative, and enforcement aspects of the NPDES Program. In states that have been authorized to implement CWA programs, EPA still retains oversight responsibilities. In Vermont, the Discharge Permit Section of the Wastewater Management Division administers the NPSDES Permit Program. The selected alternative includes discharge of treated construction water from the soil/sludge excavation and stabilization work into the Hoosic River. The Remedy will comply with the NPDES through compliance with the Vermont Water Quality Standards as described above, and the Clean Water Act (CWA) Ambient Water Quality Criteria (40 CFR 120).

7.2.9 Vermont Groundwater Protection Rule and Strategy, EPA Ch. 12 (10 VSA Ch. Sec. 1390-1394)

The goal of this statute is to protect and manage ground water resources to maintain high quality drinking water by minimizing the risks of ground water quality deterioration. In order to assess the ground water quality at an activity regulated by the Secretary, the Secretary may require ground water monitoring as part of a regulatory or permit process. The remedy will include a long-term environmental monitoring program. As part of this program, long-term ground water sampling will be performed to ensure that contaminant concentrations are at or below their currently low concentrations. The monitoring program will be designed in accordance with the Ground Water Protection Rule and Strategy as applicable.

Sampling frequency, location, constituents, sampling procedures, and action levels will be detailed in the site long-term monitoring plan and submitted to the regulatory agencies for review prior to implementation.

7.2.10 Multi-Sector General Permit for Stormwater Discharges Associated with Industrial Activity (General Permit 3-9003)

The Multi-Sector General Permit (MSGP) is a Federally mandated National Pollutant Discharge Elimination System (NPDES) five-year permit that covers new and existing discharges of stormwater associated with certain types of industrial activity. This general permit protects water quality by requiring that the regulated industrial activities undertaken by both private and municipal entities be conducted in a manner that prevents and minimizes contamination of stormwater runoff. The permit is required by private and municipal industries identified on the MSGP Standard Industrial Classification (SIC) code list that have a stormwater discharge to either a municipal separate storm sewer system (MS4) or to Waters of the State. In a meeting at the Vermont State offices on October 16, 2002, the VTDEC stated that the landfill would not need a NPDES permit to operate. Therefore, the design will not include provisions to comply with the intent of the NPDES Multi-Sector General Permit requirements.

Website links:

Vermont Agency of Natural Resources, Department of Environmental Conservation:
http://www.anr.state.vt.us/dec/ww/wwmd.cfm

Vermont Agency of Natural Resources, Department of Environmental Conservation, Wastewater Management Division (for Discharge Permit to Surface Water):
http://www.anr.state.vt.us/dec/ww/wwmd.cfm

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8.0 TECHNICAL SPECIFICATIONS

The Technical Specifications are presented in Appendix L.

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9.0 OPERATION AND MAINTENANCE REQUIREMENTS

Requirements for operation and maintenance of the remedy are consistent with those of a typical closed landfill. Operation activities are not required. Maintenance includes regular mowing of the cover, removal of woody plants, repair of erosion, and repair of storm water controls and gas vents. Regularly scheduled inspections will be performed to confirm that the remedial action elements remain protective of human health and the environment.

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APPENDIX A

DESIGN DRAWINGS

APPENDIX B

VTDEC CORRESPONDENCE AND SOLID WASTE REGULATIONS WAIVER

Mischel, Greg

From: Brian Woods [Brianw@dec.anr.state.vt.us]
Sent: Monday, April 07, 2003 1:29 PM
To: McVickar, Leslie; Dale Weiss
Cc: Mischel, Greg
Subject: Pownal Tannery 30% Design - VTDEC Comments

0407.vtdec.30%.design.comments...

0311.surwilo.HELP.model.review...

Attached are the VTDEC comments on the 30% design, along with a separate memorandum from Buzz Surwilo on the HELP model analysis performed by TRC. I am available tomorrow mid-morning to discuss, but I am unsure whether Buzz Surwilo or John Schmeltzer can participate. I believe we should plan to have the call, and if questions come up that I cannot answer I will follow up later.

--

Brian Woods
Vermont Department of Environmental Conservation
Waste Management Division
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POWNAL TANNERY #770066 VTDEC COMMENTS ON 30% BASIS OF DESIGN REPORT
April 7, 2003
Prepared by Brian Woods, VTDEC

Section 1 – Introduction: No comments

Section 2 – Waste Characterization
Section 2.1, Demolition Debris: As discussed at the March 27, 2003 meeting, opportunities for reuse or recycling of demolition and other debris in the lagoon area should be explored prior to disposal of this material in the landfill.

Section 3 – Waste Excavation and Consolidation

Section 3.1, Site Preparation : The site clearing and grubbing plan needs to be modified to reflect the plan (discussed further in comments on Section 5 below) to maintain the riverside berm between the river and lagoons 1 and 5 at its current elevation and present vegetated condition. The area to be cleared and grubbed along the river should be relocated away from the river so that the existing vegetation on the berm is maintained. Also depicted on Sheet C-4.

Similarly, haybales and silt fence planned for placement at the base of the riverside berm as depicted on Sheet C-6A can be relocated or removed.

To address the potential that vegetation may have accumulated contaminants of concern, vegetation cleared and grubbed from the lagoon 1 and Lagoon 5 areas should be shredded or chipped as appropriate and placed within the confines of the landfill.

Section 3.2 – Excavation of Sludge: Cross sections generated from data collected during the geotechnical sampling program suggest that there are several feet of soils overlying sludge in the Lagoon 3 area. Has excavation of this material prior to placement of excavated sludge from Lagoons 1 and 5 been considered in order to minimize the size of the landfill? Can excavated material be used to backfill lagoons 1, 2 or 5, reducing the need for imported fill? Are there analytical results from this material to document the presence or absence of contaminants?

Discharge of surface water from Lagoon 5 should be treated similarly as water extracted during excavation of groundwater.

Section 3.3 – Excavation Dewatering: The VTDEC Wastewater Management Division has reviewed the proposal for indirect discharge of wastewater generated as a result of dewatering activities. Wastewater discharges are allowed that meet the contaminant concentration limits in the Vermont Groundwater Rule and Strategy (Groundwater Enforcement Standards). For contaminants of concern that do not have corresponding Groundwater Enforcement Standards, the EPA Region 3 Risk Based Concentration or the EPA Region 9 Preliminary Remediation Goal for tap water (whichever is lower) will be used. The Wastewater Management Division has also indicated that a direct discharge of dewatering-derived wastewater is also acceptable. Contaminant concentrations must meet the limits set forth in the Vermont Water Quality Regulations. The Wastewater Management Division is still considering if the alternate discharge

concentrations calculated for the discharge of accumulated leachate at the sludge landfill in 1999 can be applied to this discharge.

Section 3.4 – Confirming Limits of Excavation - Vertical excavation limits have been defined as reaching the gravel/cobble layer underlying the sludge material in lagoons 1 and 5. No confirmation samples from the bottom of the excavation are planned. The horizontal extent of excavation will be determined by the visual distinction between the sludge material and surrounding soils. As discussed during the design review meeting of March 27, 2003, there are also physical and property-line constraints to recognize in regard to the possible lateral extent of excavation in the lagoon area. The 30% design report did not recommend confirmation sampling at the lateral excavation limits. This proposal should be modified to incorporate the following confirmation sampling plan outline:

A. If sludge material is not visible at the end of an excavation face, and that face is not at a physical or property-line barrier, confirmation samples for the contaminants of concern shall be collected, and if cleanup goals are not met additional excavation will be performed until uncontaminated soils are encountered or a physical or property-line barrier is reached.
B. If excavation proceeds to a physical or property-line barrier, confirmation samples for the contaminants of concern shall be collected, and if cleanup goals are not met this information will be noted for incorporation into the proposed institutional controls for the site.

Section 3.5 – Backfilling – No comments

Section 3.6 – Sludge Conditioning – The addition of quicklime to the sludge will likely raise the pH of the sludge, perhaps significantly. An evaluation of the effect of sludge conditioning on the character of the sludge, and particularly regarding contaminant mobility, should be performed.

Section 3.7 – Sludge Placement and Compaction

Section 3.8 – Worker Health, Safety and Air Emissions

Section 4 – Consolidation Landfill

The VTDEC has performed a supplemental floodplain modeling analysis to augment the work performed by TRC and presented in the "Hoosic River Modeling Study Report", dated June 2002. Our comments on the site design are based in large part on this modeling effort. The preliminary site grading concept that served as the basis for this floodplain modeling exercise provided for a vegetated shallow slope (~0.4%) overbank channel starting at elevation 500 at the extreme downstream (north) end of Lagoon 4 and ending at approximately elevation 508-509 in the Lagoon 1 area near the railroad tracks. The riverside berm adjacent to Lagoons 1 and 5 was left intact. Refinements to this model and the information generated from it are expected as the final concept for the configuration of the site is more fully developed. Due to staff resource issues the technical report providing the details of the VTDEC modeling effort will be provided at a future date.

Landfill Location – In order to minimize the effect of the landfill on the floodplain, the landfill footprint should be modified so that the distance between the landfill toe and the toe of the existing riverside berm is at least 145 feet. This is best accomplished by pulling the north end of the landfill back to the south approximately 200 feet from its presently planned location. Terminating the landfill at this point is preferred; however, tapering the landfill toe to maintain the 145 foot separation distance is an acceptable alternative. See additional comments on landfill location and design in comments on Section 5 – Site Design.

4.2 Hydrologic Evaluation of Landfill Cover: See attached March 11, 2003 memorandum from Buzz Surwilo, VTDEC Solid Waste Section with comments on the Hydrologic Evaluation of Cover System Performance report prepared by TRC and dated December 23, 2002.

4.3 Proposed Cover System Components

Foundation/Gas Management Layer – Where will the gas vents discharge to? Where will the cut-off trench discharge to? Gas outlets should be placed and designed to minimize the potential for exposure to landfill gas to WWTP workers and other site visitors.

Drainage layer – Design specifies a synthetic geocomposite. Performance specification is transmissivity of 7.55x10-4m2/sec or greater. Will the geocomposite be bi-axial or triaxial?

Barrier Layer – We agree that the hydrologic performance of a geomembrane is superior to that of any soil layer. However, given the stable, non-leaching waste mass such as the tannery sludge, that superiority is almost immaterial. The critical factors to consider are constructability, maintenance, and cost.

While variability in natural soils are to be expected, the quantities involved in this project are relatively small and the hydraulic conductivity standard is moderate. It should be relatively straightforward to identify a material source with confidence that sufficient quantity and quality is available. Clays are difficult to install as moisture content is critical both to obtain the necessary density, but also to be able simply place the soils. Soils in the 1 $x10^{-5}$ cm/sec range, however, remain workable over a wider range of conditions.

Under normal conditions, FMLs are faster to install, but rain, snow, and cold temperatures prevent placement, and our experience is that set scheduling of small rural installations can be problematic.

We agree that LLDPE membrane withstands strain better than HDPE, but question whether that holds true for LLPDE as compared to soil.

As the State is liable for long term maintenance of the facility, the ease and cost of any repair to the capping system needs to be considered particularly with future use of the capped landfill and surrounding areas unknown at this time. For instance, there have been discussions of a fence or guardrail around the perimeter of the upper surface of the landfill. Will the posts penetrate the

FML? If these structures are damaged, or moved, or augmented, will this require repair to the membrane? Our sense is that O&M for a soil cap would prove easier and less expensive.

The cost of a soil based capping system versus a geomembrane-based system was discussed at our March 27, 2003 meeting, and that conversation was helpful. We are expecting a written comparison of the total costs of these two approaches. The 30% design report was not clear whether preliminary contact with local borrow pits had been made. Any information on costs, distance and availability of low permeability soil would be useful in determining the optimum capping system for this particular situation.

Simply considering your assumptions and methodologies, the global stability and cap stability evaluation is satisfactory, and the factors of safety are adequate. This is a small landfill with short, moderately angled sideslopes, and no unusual design parameters. Based on experience, intuitively, it should be stable.

Vegetative Support Layer – The text states the thickness of this layer will vary in order to provide for a shallow surface slope and 5% barrier layer slope. Reiterate that minimum thickness will be 24 inches. It is not clear at this stage in the design whether the shallow top surface will be constructed over the entire landfill surface or only in the area of the landfill over existing Lagoon 3A-3B. If only the Lagoon 3 Area will be built at the 1-2% grade, the transition between this portion and the proposed 3:1 grade will need to be carefully designed in order to minimize the increased erosion potential in such an area.

Surface Layer – The design indicates that top surface of the landfill will be designed to resist erosion. The VTDEC supplemental modeling study resulted in a 100-year overbank channel velocity of 6.5 feet/second that should be used as the basis for sizing the erosion protection on the landfill sideslopes (note that this figure is lower than the main channel velocity presented at the March 27 2003 Design Review meeting). Also, the design should incorporate extension of the presumed rock armoring to four feet below ground surface at the toe of the landfill slope facing the river.

Section 4.4 Geotechnical Analysis

Landfill Stability Analysis – As discussed at the meeting, the undrained conditions case will be rerun with the cover soils fully saturated to develop the worse-case boundary condition.

Settlement – The text in the second paragraph of section 4.4.4 on page 4-17 states "Consolidation settlement of the sludge will be evaluated if the material is placed in the landfill without the addition of any amendments (e.g. Portland cement)". The current sludge amendment under consideration is quicklime. While lime amendment is expected to increase the strength of the sludge material, its effect on consolidation was not discussed in the report or at the design meeting. Evaluation of consolidation settlement of the lime-amended sludge should be incorporated into pre-design activities, as is stated on page 4-18. Final grades should reflect anticipated long-term settlement so as not to cause ponding on the upper landfill surface.

Section 5 – Site Design
The general conceptual design for the landfill footprint, slope, grading and drainage is acceptable. This includes the proposal to construct a top working surface of the landfill at a 1%-2% grade, versus the 5% top slope specified in the VT SWMR. Additional vegetative support layer material will be incorporated into the cap in order to construct this cap configuration.

The drainage swale design parameter of the 25-year, 24-hour storm event is acceptable even though the facility will be located in the 100-year floodplain and so is being designed to withstand the 100-year flood. It is understood that under extreme flood events the drainage structures are likely to be inundated by the river and so will be non-functional. Drainage swale design also needs to take into account the stormwater management plan for the proposed WWTP.

Section 5.4 Soil Berm Modifications
Based on supplemental floodplain modeling performed by the VTDEC, the following modifications to the berm modifications presented in the report should be incorporated:

A. The southernmost portion of the berm separating the lagoon area from the Hoosic River (between the river and lagoons 1 and 5) shall be maintained in its current condition and elevation, with the vegetation intact, to the extent that is possible given the proposed excavation in lagoons 1 and 5. Additional detail is required concerning the outfall of the proposed wastewater treatment plant, including the design of the outfall, construction plans and erosion control measures.

B. The limits of the berm removal at the extreme northern end of Lagoon 4 should include the removal of an approximately 80 linear foot section of the berm that runs perpendicular to the channel in addition to removal of an approximately 125 linear foot section of berm along the bank. These berms shall be reduced to an elevation between 495-500. Permanent erosion control measures will need to be employed in this area to stabilize the modified berms The existing berms between lagoons 1 and 5 and lagoons 5 and 4 will also be removed/reduced to an as-yet-to-be determined elevation consistent with the final grading plan.

The VTDECs preliminary site grading concept that served as the basis for our floodplain modeling exercise provided for a vegetated shallow slope (~0.4%) overbank channel starting at elevation 500 at the extreme downstream (north) end of Lagoon 4 and ending at approximately elevation 508-509 in the Lagoon 1 area near the railroad tracks. The riverside berm removal was as described above. This concept was intended to reduce the potential for ponded water in the area, provide a conduit for overbank flows and to be easy to maintain and provide easy access to the landfill toe and any monitoring points in the overbanks area. However, as was pointed out in the design meeting, this concept could require a substantial amount of fill to construct, and would require disturbance of the entire overbank area. There may also be an ecological benefit in minimizing the amount of fill placed in the overbank area, allowing the development of a riverine wetland. In response to those concerns, the VTDEC has developed an alternative overbank grading concept. This concept provides for less fill and less disturbance of the Lagoon 4 overbank area than the original proposal. It should also provide for conveyance

through the right overbank at least equal to the original proposal. However, as there exists no proposed grading plan for the site as a whole in its final configuration, including the right overbank area and the proposed wastewater treatment plan area, there has been no confirmation of this through modeling. Such confirmation should be included in the design process. A brief synopsis of the VTDECs alternative site grading concept follows:

> Backfill and grade lagoons 1 and 5 at a constant slope of 0.4%, from beginning of lagoon 1 at elevation 503 into lagoon 4 at elevation 499. Tie this slope into the existing grade in lagoon 4. Leave remainder of lagoon 4 undisturbed. Construct lagoon 4 outlet with invert at elevation <500. This concept will require additional transition in lagoon 1 of approximately 20% to bring grade up from elevation 503 to elevation 510-513 of the surrounding road and wastewater treatment plan area.

It would be useful to see a comparison of costs for each of the overbank grading area concepts.

The proposal for construction of a permanent access road along the west toe of the landfill needs to be more fully developed and evaluated for its potential effect upon the floodplain. For example, at the meeting it was mentioned that the road may be raised several feet above grade in order to accommodate drainage culverts underneath the access road. This is not a configuration that was evaluated during our floodplain modeling exercise.

The preliminary plan for the site access road improvements prepared by Forcier-Aldrich was just recently received by VTDEC. The elements of the road improvement project that will be incorporated into the remedial action need additional development. Questions regarding this portion of the project include:

A. According to Forcier-Aldrich, it is not clear who is providing the final design for the access road, although they are clear that most of the improvements will be made by EPA's contractor during the performance of the remedial action.
B. The new road alignment is located to the west of the current road, particularly at the south end of the access road. F-A's concept appears to have been to provide as much clearance from the railroad as possible. However, this alignment creates the need for additional fill in the river. VTDEC would prefer a road alignment closer to the river and requiring less fill. In conjunction with or as an alternative to road realignment, consider the use of gabions to construct a retaining wall that minimizes encroachment in the floodplain/floodway.
C. The proposed fill area is directly across the river from the riverbank area that was excavated during the removal action. At the time there were concerns expressed by residents that the removal action excavation would aggravate flood conditions in the area. A project to place fill in this area will also likely alarm local residents, and it will be more difficult to address their concerns since a fill project could potentially adversely affect flood heights in the area.
D. The river bank in this area is relatively steep, but well vegetated. Construction in this area will almost certainly require removal of vegetation, with the concurrent risk of erosion and introduction of sediment into the river.

E. Additional geotechnical characterization of soils in this area is required prior to final design. It is not clear if the soils in this area will be able to support the load of fill, particularly over the long term under flooding conditions.
F. Once a pre-final design has been developed, the proposal will need to be evaluated for potential effects on flood water surface elevations.

Section 6 – Environmental and Public Impacts
No comments

Section 7 – Compliance with ARARs and Permitting Requirements

Vermont Solid Waste Rules – The information presented in section 4 regarding the non-compliant features of the proposed landfill design is sufficient for a finding by the VTDEC that the project will not adversely affect public health, safety or the environment. The Solid Waste Program will proceed with documenting such a finding. However, since this is the first such finding to be made under the new provisions of the Solid Waste Rules, additional questions may arise between now and the completion of this activity.

Act 250 – Appendix E appears to adequately address the substantive aspects of the project that might otherwise be regulated by Act 250.

Vermont Wetland Rules – No comments.

Stream Alteration Permit – A number of aspects of the project fall under the auspices of the River Corridor Management program. The concerns of this program have been previously stated above.

Stormwater Runoff – This section has been reviewed by the Stormwater Management Section (Kim Greenwood) and is acceptable. Note that the permit is under revision and when the new "five acre" permit is issued, you will need to apply for coverage under it.

Vermont Water Quality Standards – See discussion above regarding management of wastewater.

Section 8 Technical Specifications
No comments

Section 9 Operation and Maintenance Requirements
No comments at this time. The VTDEC understands that TRC will be preparing a draft of the Operation and Maintenance Plan for the site.

Mischel, Greg

From: Brian Woods [Brianw@dec.anr.state.vt.us]
Sent: Friday, April 11, 2003 4:51 PM
To: McVickar, Leslie; Dale Weiss
Cc: Mischel, Greg; Jim Surwilo
Subject: Pownal Tannery - Proposed Cover

As promised, the state has made a determination regarding the proposed cover components of the proposed cap at the Pownal Tannery Lagoon area. I spoke to Greg Mischel about this earlier today.

The state concurs with the proposal included in the 30% design which incorporates a geomembrane as the primary barrier layer.

The state was able to identify one or potentially two additional sources of barrier soil material in the Pownal vicinity. However, the remaining uncertainties regarding the availability, quality, volume and price of soil material, and the additional complexity of placing it make such a choice unviable for this project if it is to stay on its current schedule.

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Brian Woods
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Mischel, Greg

From: Brian Woods [Brianw@dec.anr.state.vt.us]
Sent: Monday, April 14, 2003 8:34 AM
To: dweiss@ix.netcom.com
Cc: Jim Surwilo; Mischel, Greg; Mcvickar.Leslie@epamail.epa.gov
Subject: Pownal Tannery - Design Concept for Lagoon 4 Outlet

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et.design.co...

Attached is a sketch of the design concept for the Lagoon 4 outlet. As drawn, the concept incorporates the berm modifications suggested by Barry Cahoon, and attempts to minimize the disturbance to the berm and the amount of work that needs to occur on the adjoining property. The sketch assumes an invert elevation of 500', which VTDEC believes is the maximum height allowable, but lower invert elevations can be propsed. The slope of the berm transitions is also conceptual, and TRC should propose actual slopes and erosion control measures. Please let me know if you have any questions.

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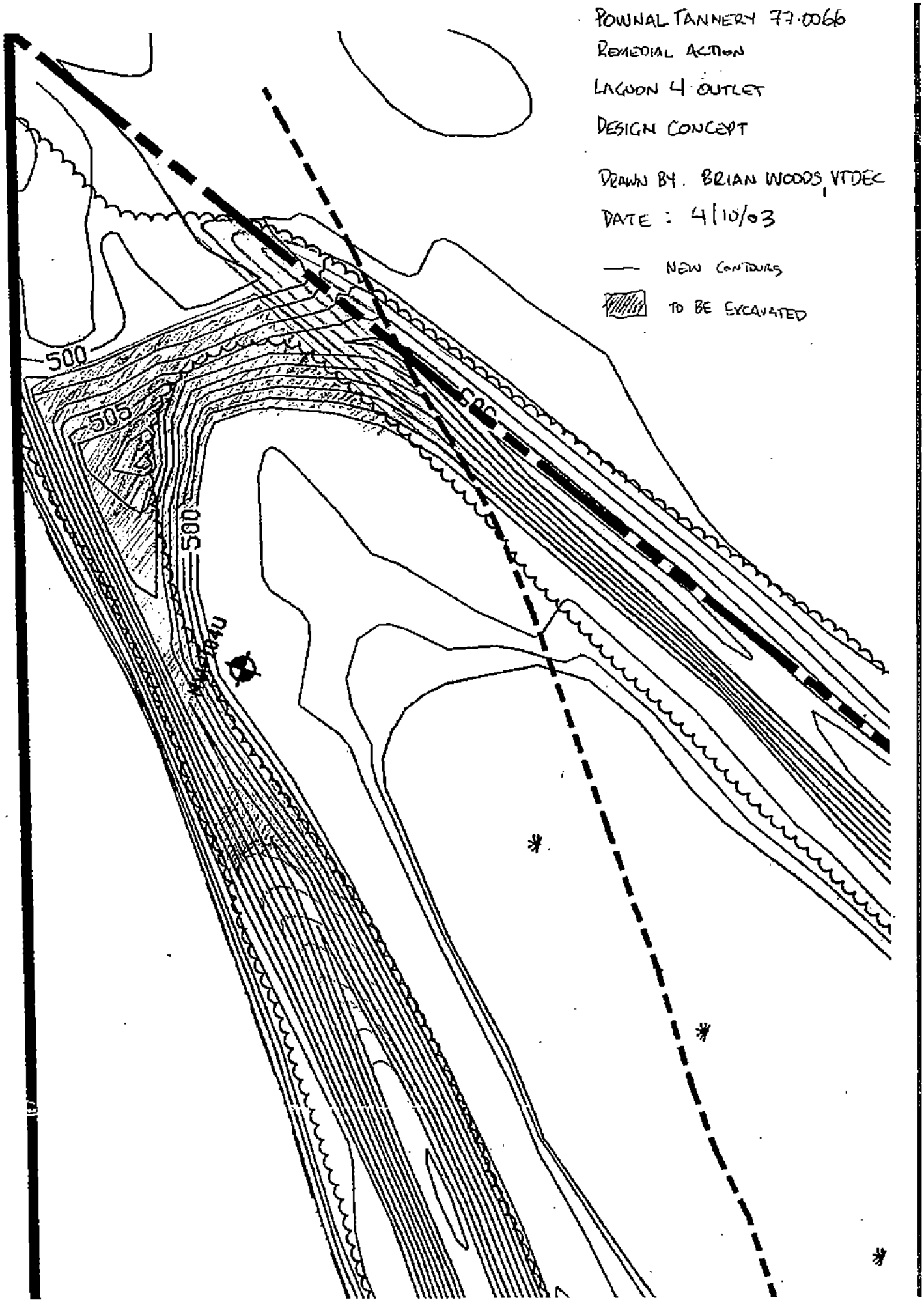
POWNAL TANNERY 77-0066
REMEDIAL ACTION
LAGOON 4 OUTLET
DESIGN CONCEPT
DRAWN BY. BRIAN WOODS, VTDEC
DATE : 4/10/03
NEW CONTOURS
TO BE EXCAVATED
500
505
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OUTLET

Mischel, Greg

From: Brian Woods [Brianw@dec.anr.state.vt.us]
Sent: Thursday, April 24, 2003 3:07 PM
To: Dale Weiss; Mischel, Greg
Cc: Mcvickar.Leslie@epamail.epa.gov; John Schmeltzer; Barry Cahoon
Subject: Pownal Tannery - Lagoon 4 Outlet Design Criteria

Following are the proposed design criteria for the outlet at the downstream end of lagoon 4:

Invert elevation - between 495' and 500'

Right Overbank Velocity at outlet - 8.5 ft/sec

Berm Removal - remove all of berm that is perpendicular to the Hoosic River down to the invert elevation. Remove a minimum of 125 linear feet of berm that is adjacent and parallel to the Hoosic River down to the invert elevation.

Extension of the berm coinciding with the Burden property line is not recommended by VTDEC. However, if this berm must be extended it should be along the current berm alignment to the extent possible.

This information, along with the conceptual drawing that was previously provided, should allow your design team to proceed with the design of this element of the project.

If you have any additional questions, please contact me.

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Agency of Natural Resources
Department of Environmental Conservation

Waste Management Division
West Building
802-241-3888

MEMORANDUM

To: Wibs McLain, Secretary

Thru: Skip Flanders, Director, Waste Management Division
Andrea Cohen, Manager, Solid Waste Program

From: Buzz Surwilo, Technical Assistance Section

Date: August 14, 2003

Subject: Pownal Tannery Remediation Waiver

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10 V.S.A. §6614 was added in 2002 to allow the Secretary of the Agency of Natural Resources to waive certain statutory requirements for lining landfills (§6605(d)), and certain siting and technical standards of the Solid Waste Management Rules for State or EPA-lead Superfund response actions. The waiver may only be granted if the action does not adversely affect public health, safety, or the environment, and if the standards will be complied with to the extent practical.

There are a number of issues associated with the Pownal Tannery lagoon remediation that make it technically infeasible or prohibitively expensive to be in complete conformance with statute and rule criteria. Nonetheless, it is the Program's belief that the objective of the remediation will be met by the chosen action, with no adverse affects and with the minimum deviation from State standards.

Individual Findings are attached. If you agree, please sign and return the waiver.

Vermont Agency of Natural Resources
Office of the Secretary

In the Matter of:
Pownal Tanning Co. Inc., Wastewater Lagoon Remediation

August 13, 2003

General:

The Pownal Tannery Superfund Site (Site) consists of a 28-acre set of parcels located off VT 346 in North Pownal, Vermont. The site is the former location of a hide tanning and finishing facility owned by the Pownal Tanning Co., Inc. The Site has been inactive since 1988, when the Company declared bankruptcy. The Site originally consisted of three contamination sources: the former tannery building, the sludge landfill, and the wastewater lagoon system. In 2001, The U.S. Environmental Protection Agency (EPA) performed a Non-Time Critical Removal Action that permanently capped the landfill and removed the building. The Vermont Agency of Natural Resources (ANR) is responsible for maintenance of the former building site and capped landfill.

The cleanup of the five wastewater lagoons is the third and final major cleanup action EPA will take at the site. The primary goal is to prevent human contact with and eliminate erosion of contaminated soils from the 18-acre area of former lagoons into the Hoosic River. The proposed remediation is outlined in the September 30, 2002, Record of Decision (ROD), which was concurred with by the ANR. The selected remedy for the remaining lagoons includes the excavation of contaminated sludge materials from Lagoons 1 and 5, consolidation over Lagoon 3 and the southeast corner of Lagoon 4, and capping the consolidated sludge with a cover system.

The selected remedy is considered by the ANR to be a solid waste disposal facility. As such, the facility must conform to the standards contained in 10 V.S.A. §6605(d), and the Solid Waste Management Rules (Rules). The Rules specify certain requirements for siting, design, and performance standards for solid waste disposal facilities. A June 2002 Addendum was prepared and appended to the Feasibility Study (FS) to analyze how the selected remedy would achieve the substantive requirements of the Applicable or Relevant and Appropriate Requirements (ARARs), including the Vermont Solid Waste Management Rules. The analysis showed that the selected remedy would not meet some of the standards.

10 V.S.A §6614 allows the secretary to waive the requirements of subsection 6605(d) of this title and the technical and siting requirements of the solid waste management rules adopted pursuant to subdivision 6603(1) of this title, provided the following conditions are met:

> *(1) The secretary intends to perform a removal or remedial action, pursuant to chapter 159 of this title, or the President of the United States intends to perform a response action, as defined in 42 U.S.C. § 9601(25), in response to a release or threatened release of hazardous substances; and*

(2) The secretary makes a prior written determination that:

(A) the proposed response action will not adversely affect the public health, safety, or the environment; and

(B) the technical and siting requirements will be complied with to the extent practical in light of the overall objectives of the response.

Findings:

1. Solid Waste Management Rule §6-502(a)(3) prohibits facilities from being sited in Class I and Class II wetlands and their associated buffer zones, as defined in the Vermont Wetlands Rules, unless a Conditional Use Determination has been issued by the Agency. Construction of a disposal facility in Class III wetlands, as defined by the Vermont Wetlands Rules, is prohibited unless a Water Quality Certification has been issued pursuant to 40 CFR Part 401, or has been waived by the Agency.

   Response: Per an August 15, 2001 memorandum from Alan Quackenbush, District Wetland Ecologist, Department of Environmental Conservation (DEC), Water Quality Division, the wetlands in the lagoon area are classified as Class III and the State will not seek replacement of these man-made lagoon wetlands due to lack of significant function. Class II fringe wetlands along the Hoosic riverbank may be disturbed during excavation activities. These disturbed areas in the fringe wetland will be stabilized using native vegetation.

2. Solid Waste Management Rule §6-502(a)(3) prohibits discrete disposal facilities from being sited within the floodway or within the one hundred-year flood plain.

   The proposed landfill facility does lie within both the current floodway and the 100-year floodplain of the Hoosic River. Based on the evaluations presented in the FS, there is no other practical on-site location to construct the landfill and off-site disposal was determined to be cost prohibitive.

   A pre-design hydraulic modeling study was completed by USEPA's contractor to evaluate the affect of the proposed facility on the Hoosic River. The model was then modified by the DEC. The DEC generated baseline flood elevation is different than the FEMA generated elevations, as the original FEMA model did not account for the obstruction of flow from the transverse berms within the wastewater lagoons. The DEC model results indicate that the proposed landfill footprint will not have an adverse impact on the floodplain when compared to the revised 100-year baseline. On the contrary, the remedial action will likely improve flood conditions as it exposes the right bank for conveyance of flow.

Furthermore, the upper elevation of the proposed landfill is projected to lie well above the 100-year flood elevation, therefore scour of the upper landfill surface is not a concern. Given the location of the proposed facility, the landfill slopes facing the Hoosic River will be armored with rock or other design features to prevent erosion during flood events.

3. Solid Waste Management Rule §6-503(b)(1) requires that facilities be located such that the isolation distances to seasonal high groundwater, bedrock and surface waters are sufficient to assure that an emission or discharge from the facility will meet all applicable environmental quality and public health standards and rules.

Response: Based on historical and recent ground water monitoring data, including five rounds of ground water sampling at 14 ground water monitoring wells in the Lagoon Area and ten private drinking water supply wells located nearby, the Remedial Investigation concluded that there is no active leachate source in the Lagoon Area. Furthermore, part of the proposed remedy will include a ground water monitoring well network and a long-term monitoring plan to provide an early warning of any ground water impacts. Although the generation and migration of leachate is not a concern, the proposed facility will reduce the volume of waste that is currently below the water table from approximately 29,700 cubic yards to 4,400 cubic yards.

4. Solid Waste Management Rule §6-503(b)(2) requires that facilities be located such that the isolation distance to public and private drinking water supplies is sufficient to assure that an emission or discharge from the facility will not adversely affect drinking water.

Current ground water users in the areas are located upgradient from the proposed facility and withdraw drinking water from individual wells in the bedrock aquifer. The bedrock aquifer underlies the lagoon area by over 100 feet in some places and is protected from leachate infiltration by a thick (over 50 feet) layer of low permeability clay. This clay not only prevents any contaminated ground water from infiltrating to the bedrock, but also provides a confining layer above the bedrock aquifer that causes upward vertical hydraulic ground water pressure in the Lagoon Area. Since flow is directed upward from the bedrock, and private ground water users are located upgradient of the proposed facility, the proposed facility will not adversely affect private drinking water supplies.

5. Solid Waste Management Rule §6-503(b)(3)(A) requires that facilities be located such that that the isolation distances to property lines, homes, public buildings, or places of public assembly are sufficient to assure that the facility will not result in objectionable odors off site of the facility.

The sludge is similar in composition to the sludge disposed of in the Tannery Landfill, and gas emissions and odors from that facility have not been noted. The sludge is not expected to decompose further and produce emissions of gas, and should not cause any odor problems. Any potential air emissions during construction would be managed through monitoring and controls.

6. Solid Waste Management Rule §6-503(b)(3)(B) requires that facilities be located such that that the isolation distances to property lines, homes, public buildings, or places of public assembly are sufficient to assure that the facility will not result in unreasonable visual impact for anyone off site of the facility.

   Response: Once capped, the facility will resemble a low, visually appealing, grassy knoll. The completed project will greatly improve the current aesthetics of the area.

7. Solid Waste Management Rule §6-503(b)(3)(C) requires that facilities be located such that the isolation distances to property lines, homes, public buildings, or places of public assembly are sufficient to assure that the facility will not increase the level of noise detectable by persons off site of the facility.

   Response: Other than during construction, there will not be any noise associated with the closed and capped facility.

8. Solid Waste Management Rule §6-503(b)(3)(D) requires that facilities be located such that the isolation distances to property lines, homes, public buildings, or places of public assembly are sufficient to assure that the facility will not otherwise adversely affect public health.

   Response: The proposed facility is intended to reduce impacts to public health and is based on the results of the Remedial Investigation and the Human Health Risk Assessment. Based on these studies, it is apparent that the existing site poses unacceptable risks to trespassers, and the proposed remedial actions are designed to mitigate these adverse effects. Further, past contamination of Hoosic River sediments by upstream industries continue to pose an unacceptable risk to users of the river. The remediation of site will be designed to not encourage public access to the river.

9. Solid Waste Management Rule §6-503(b)(3)(D) requires that discrete disposal facilities meet these minimum criteria:

Minimum vertical separation from high seasonal water table	6'
Minimum vertical separation to bedrock	10'
Minimum distance to waters of the state, including intermittent streams and all larger water bodies	300'
Distance to drinking water source from waste management boundary	1000'
Distance to property line	50'

Response: There are two layers of soils below the proposed disposal facility. The uppermost layer is thin (less than 10 feet) and comprised of sand, silt and gravel. The second soil layer that underlies the proposed facility is a very low permeability clay (estimated hydraulic conductivity of 1 x 10^{-6} cm/sec). This layer is over 50 feet thick beneath the proposed facility and will provide a very good low permeability lower boundary for any potential leachate from the proposed facility. However, as noted above, five rounds of ground water sampling at 14 ground water monitoring wells in the Lagoon Area and ten private drinking water supply wells located nearby, indicate that there is no active leachate source in the Lagoon Area and the potential for generating leachate will be severely limited by the construction of the landfill cap.

The proposed facility will meet the vertical separation criteria to bedrock. Since some waste in Lagoon 3 is currently in the saturated zone and is not proposed to be removed, the proposed facility will not meet the 6' minimum vertical separation from the high seasonal water table requirement. The entire lagoon site has shallow depths to groundwater, and building a soil base pad to attain the requisite separation distance is cost prohibitive for little environmental gain. As noted above, five rounds of ground water sampling at 14 ground water monitoring wells in the Lagoon Area and ten private drinking water supply wells located nearby, there is no active leachate source in the Lagoon Area and the landfill is not expected to generate leachate.

The proposed facility will also not meet the 300-foot setback requirement from waters of the state, as the site abuts the Hoosic River. However, there is no other practical location alternative and no impacts to the adjacent surface water were identified during the Remedial Investigation.

10. 10 V.S.A 6605(d) and the Vermont Solid Waste Management Rules require new discrete disposal facilities or new operational units at an existing facility, placed in operation after July 1, 1987, to have liner and leachate collection systems and appropriate provisions for leachate treatment, except as otherwise provided in Section 6-309(b) or in Section 6-606(b)(2)(B) of the rules. The Secretary may further waive the liner requirement for discrete disposal facilities or portions of discrete disposal facilities that are designated solely to receive particular waste components that are not the source of leachate harmful to public health and safety or the environment or the creation of nuisance conditions.

The Remedial Investigation sampling of the 14 ground water monitoring wells and adjacent surface water in the Hoosic River indicate that there are no existing leachate impacts to ground water or surface water, even though there is no engineered liner or leachate collection system below the lagoons. In addition, the majority of the contaminated sludge will be removed from the lagoons and placed above the groundwater table and covered by a landfill cap. Therefore, the potential for leachate generation will be significantly reduced relative to the existing condition.

11. The Vermont Solid Waste Management Rules require that the final cover system for a discrete disposal facility provide for a minimum slope of five percent and a maximum slope of 33 1/3 percent.

Response: The final cover system is being designed with an upper surface of less than 5% slope to allow the possibility of future recreational uses on the disposal facility. The USEPA HELP model was used to evaluate the hydrologic performance of potential cover system configurations including the standard cover required by the Rules, a "typical" Vermont-approved landfill cover, and a custom cover system that utilizes barrier and drainage layers at a minimum slope of five percent and a surface slope of between one and two percent. The HELP model results indicated no appreciable difference in the hydraulic performance between the design utilizing 5% slopes, and the design utilizing 1 or 2% slopes.

The shallow sloped design requires additional soil to form the flattened upper surface therefore increasingly the cost of the project. This increase is likely less than $200,000 and is not considered substantial as it represents 2-3% of the total project budget.

I do affirmatively find that the proposed response action will not adversely affect the public health, safety, or the environment; and the technical and siting requirements of the Solid Waste Management Rules will be complied with to the extent practical in light of the overall objectives of the response. Hence, as allowed by 10 V.S.A. §6614, I waive the requirements of subsection 6605(d) of this title and the specific technical and siting requirements of the solid waste management rules outlined above for the siting, design and construction of the Pownal Tanning Co., Inc., Lagoon Remediation Project. All other applicable sections of the Rules will be met.

The Secretary's issuance of this waiver for the siting and design of a solid waste management facility relies upon the data, judgment and other information supplied by the USEPA, the hired professional consultants and other experts who have participated in the preparation of the supporting documentation.

Dated this 18 day of August, 2003 at Waterbury, Vermont.

Elizabeth McLain, Secretary
Agency of Natural Resources

Agency of Natural Resources
Department of Environmental Conservation

Waste Management Division
West Building
802-241-3888

MEMORANDUM

Date: October 14, 2003

To: Brian Woods, SMS Project Manager for Pownal Tannery

From: John Schmeltzer, Environmental Analyst

Re: Supplemental River Modeling of Hoosic River and Lagoon Area at Pownal Tannery

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In support of the planned remedial action at the Pownal Tannery Lagoon site, TRC Environmental performed a floodplain modeling study of the proposed project area in the Hoosic River. The results of their study were presented in the report "Hoosic River Modeling Study" (TRC, June 2002). The VT DEC had concerns that the 100-year hydraulic model prepared by TRC for the Hoosic River through the project reach did not accurately reflect actual baseline and proposed conditions. Given these concerns with TRC's modeling, the VT DEC was unable to evaluate whether the proposed changes in the right overbank area and to the riverside berm were adequate. The VT DEC received the HEC-2 and HEC-RAS input and output files for TRC's models and made changes to theses models to better reflect existing and proposed conditions.

Based on their modeling results, the VT DEC believes that modifications to TRC's recommendations contained in the original report are necessary. TRC recommended a landfill footprint configuration known as Option 2. This footprint is designed to maximize the area available for conveyance in the right overbank area. In addition, TRC recommended that the existing riverside berm be lowered in two reaches: one reach between cross section XC 27.2 to XC 27.4 and the other at the downstream end of lagoon 4. The objective of the VTDEC modeling was to determine a landfill configuration that does not cause a one foot or greater increase in the 100-year water surface elevations when compared to a more realistic model of baseline conditions, at least in the view of VTDEC, and which minimizes the disturbance to the channel and riverside berm. The VTDEC developed four models. Based on these models, the VTDEC recommends the following proposed changes to the project reach:

- Lower the riverside berm and downgradient berm at the downstream (northern) end of Lagoon 4 to an elevation of no greater than 500 feet. The limits of the berm removal at the extreme northern end of Lagoon 4 should include the removal of an approximately 80 linear foot section of the berm that runs perpendicular to the channel in addition to removal of an approximately 125 linear foot section of berm along the bank;

- In order to minimize the effect of the landfill on the floodplain, the landfill footprint should be modified so that the distance between the landfill toe and the toe of the existing riverside berm is at least 145 feet. This is best accomplished by pulling the north end of the landfill back to the south approximately 200 feet from its presently planned location. Terminating the landfill at this point is preferred; however, tapering the landfill toe to maintain the 145 foot separation distance is an acceptable alternative;

- Grade the right overbank area to remove the berms currently separating Lagoon 4 and Lagoon 1. This recommendation is consistent with TRC's recommendation.

- Do not disturb the riverside berm adjacent to Lagoon 1 between XC 27.2 to XC 27.4. The VTDEC modeling showed that water surface elevations for the VTDEC Option 2 model, which did not remove the riverside berm between XC 27.4 and XC 27.4, were below the VTDEC baseline levels, except for one cross section (XC 28.2), which had a water surface elevation of less than 0.5 above the baseline level. The VTDEC believes maintaining the well-vegetated berm adjacent to Lagoon 1 will be more beneficial in the long term than removing this berm and exposing the area to potential increased erosion.

- Erosion protection at the outlet of Lagoon 4 should be designed to withstand a velocity of 8.5 ft/sec.

- Erosion protection along the lagoon side of the landfill should be designed to withstand a velocity of 6.5 feet/second.

ANALYSIS

Table 1 shows a comparison in water surface elevations between the FEMA, TRC, and VTDEC baseline model. Table 2 shows a comparison in water surface elevations between the VTDEC baseline and VTDEC Option 2 models Table 3 lists the VTDEC computed velocities for the channel and right overbank areas. Figure 1 shows the TRC cross sections and the VTDEC modifications made to the cross sections in plan view for baseline conditions. Figure 2 shows the TRC cross sections and the VTDEC modifications made to the cross sections in plan view for Option 2 conditions. The four HEC-RAS project models developed by VT DEC are as follows:

vtdec_baseline.prj: Depicts VTDEC baseline conditions during a 100-year flood, except that discharge estimated to flow into the right overbank between XC 28.2 and XC 27.7 was subtracted from this model. The remaining discharge between XC 28.2 and XC 27.2 was confined primarily to the main channel.

vtdec_baseline_rightbank.prj: Depicts VTDEC baseline conditions during a 100-year

flood for the right overbank between the downstream end of Lagoon 4 and XC 27.7. This model assumed the berm at the downstream end of Lagoon 4 was not disturbed, which means that the outlet elevation from the downgradient end of Lagoon 4 is 505 feet.

vtdec_option2_no275: Depicts VTDEC Option 2 conditions during a 100-year flood, except that discharge estimated to flow into the right overbank between XC 28.2 and XC 27.7 was subtracted from this model. The remaining discharge between XC 28.2 and XC 27.2 was confined primarily to the main channel.

VTopt2rbonly500.prj: Depicts VTDEC Option 2 conditions during a 100-year flood for the right overbank area between the downstream end of Lagoon 4 and XC 27.7. This model assumed the berm at the downstream end of Lagoon 4 was modified as specified earlier in this memorandum.

Appendix 1 lists general assumptions and limitations of the VT DEC modeling effort. Appendix 2 provides more detail on the VT DEC models and lists changes made to the TRC models.

Comparison of the Results between the VT DEC Supplemental and TRC models

The major differences in the results between the models were in the water surface elevations and velocities. The VT DEC models generally have higher water surface elevations than the FEMA model and the TRC models through the river reach adjacent to the lagoons because the VTDEC models account for the obstruction to flow by the berm on the downgradient end of Lagoon 4, the internal lagoon berms, and the berm protecting the offsite farm field (See Table 1). In general, the channel velocities for a given cross section are higher in the VTDEC models than the TRC models because the VTDEC model identified the right channel bank as the riverside berm, whereas the TRC model, in general, included the lagoon area as part of the channel as well as the main channel. HEC-RAS provides an average channel velocity for a given cross section. Because the depth of flow in the lagoon area was less than that of the main channel, the average channel velocity for a given cross section in the TRC models is generally lower.

The right bank velocities were also different between the VTDEC and TRC models. Between the downstream berm of Lagoon 4 and XC 27.7, the TRC model considered the lagoon area as part of the channel. To account for the reduction in flow conveyance by the narrowing of Lagoon 4 at the downgradient end, the VTDEC modeled the section between the downstream end of Lagoon 4 and XC 27.7 separately. This was accomplished by added another cross section XC 28.3 for the right overbank section only near the downgradient end of Lagoon 4. The VTDEC believes that the outlet of Lagoon 4 controls the flow capacity of the lagoon area. Based on the VTDEC modeling effort, it was determined that during baseline conditions, the 100-year

discharge in the lagoon area from XC 27.7 to the end of Lagoon 4 was approximately 4,000 cfs.

For Option 2 conditions, the VTDEC modeling effort showed that the 100-year discharge for this same overbank reach was 6,000 cfs. The right overbank velocities at XC 28.3 for Option 2 conditions in the VTDEC model was 8.3 ft/sec compared to an average channel velocity of 6.3 ft/sec for the XC 28.2 in the TRC model. In the TRC model, XC 28.2 was the closest cross section to the end of Lagoon 4. The VTDEC recommended to TRC that the outlet from the Lagoon 4 area should be designed assuming a right overbank flow of 8.5 ft/sec. For the landfill slope facing the lagoon, the slope protection should be able to withstand a velocity of 6.5 ft/sec.

The results of the VTDEC modeling determined that the removal of the riverside berm between XC 27.2 and XC 27.4 was not considered necessary because the outlet from Lagoon 4 controls right overbank flow. In addition, the quantity of flow in the area right of the riverside berm is likely less than quantity identified in the TRC model because the alignment of XC 27.4 was oblique to flow in the lagoon area, which can result in the model overestimating flow capacity.

The TRC and the VTDEC modeling efforts attempted to use a steady flow one-dimensional models to describe unsteady and multi-dimensional flow. HEC-RAS has an option to model unsteady flow, which may be better adapted to model flow moving in and out of the lagoon area. However, other data necessary for the unsteady flow option was not readily available. In addition, the steady state option was used because TRC used the steady state option in their models and the steady state option is an acceptable approach to model rivers as long as the limitations of the model are recognized.

Summary

The objective of the VTDEC modeling effort was to determine a landfill configuration that does not have a greater than one foot increase in the 100-year water surface elevations when compared to the a baseline model reflective of existing conditions, and to minimize the disturbance of existing vegetation along the riverside berm. As long as the recommendations in this memorandum are followed, the VTDEC believes that the proposed activities in the lagoon areas will not have an adverse effect on the channel and floodplain of the Hoosic River. If in the future a Letter of Map Revision for this reach is submitted to FEMA, as is recommended, additional modeling and support documentation will be required.

Appendix 1

Assumptions and Limitations of the VT DEC Modeling Effort

- Assumed that TRC's geometry data for the cross sections in the model was correct for existing conditions and the topographic map provided by TRC for the project area is correct.

- Assumed 100-year discharge was that used by FEMA, which is 28,900 cubic feet per second through the project reach.

- Assumed channel geometry, including the riverside berm, does not change during the 100-year flow event. This assumption is standard practice, but not always realistic, in floodplain modeling. Since the proposed changes do not encroach into the active channel, the major focus of this modeling effort is to assess whether the proposed encroachment of the landfill in the right overbank is having an adverse effect of flood flows or 100-year water surface elevations during an 100-year flow event.

- Assumed split flow for the reach between the downstream end of Lagoon 4 and XC 27.7; therefore, an additional model for this lagoon reach was developed for baseline and Option 2 conditions. During a 100-year flood, flow could overtop the riverside berm into the lagoon area and outlet, at least initially, over the berm at the downstream end of Lagoon 4. Due to the limitation of the steady-state flow option of HEC-RAS, the model cannot recognize that the distribution of flow divided by a berm cannot change between cross sections. The split flow analysis was attempted to determine the capacity of the right overbank of the Lagoon 4 area during a 100-year flood event so that an assessment can be made whether the encroachment of the landfill would have an adverse effect on the conveyance of flow through the lagoon area.

- Assumed that baseline conditions reflect the lagoons and their respective berms, including the riverside berm. Aerial photographs show that the lagoons and berms were present before the FEMA study was completed.

- Assumed VT DEC modeling will not be used to revise the current Flood Insurance Rate Maps (FIRM) that were developed by FEMA. The purpose of the VT DEC modeling was to determine if the proposed modifications in the right overbank by EPA would have an adverse effect to the channel and the 100-year water surface elevation.

- Recognized that water surface elevation at XC 28.2 is 0.3 feet lower than the

immediate downstream cross section 29.0. Modeling the obstruction of the berm at the downgradient end of Lagoon 4 confined more flow to the main channel. This restriction of flow to the channel resulted in a higher velocity for the VT DEC models compared to the TRC models. The VTDEC recognizes that FEMA would not accept a model with a water surface elevation for a upgradient cross section lower than the immediate downgradient cross section. Additional changes to downgradient cross sections would have been necessary to address this problem. However, the VTDEC believes that their models were sufficient to achieve the objective of the supplemental modeling.

- Recognized that water surface elevations in the right overbank models are in some cases 1 ½ feet higher than the elevation of the riverside berm, which means flow from the right overbank could transfer back to the main channel. The VTDEC model setup likely over estimates the capacity of the right overbank because it does not allow overtopping of flow back into the main channel. However, for the purpose of comparing baseline to proposed conditions, the VTDEC believes their models were sufficient.

Appendix 2

VT DEC Models

Baseline Models

vtdec_baseline_rightbank.prj.

This model depicts the right overbank at multiple discharges from the downgradient end of the lagoon area (XC 28.3) to XC 27.7 for baseline conditions. The model consists of 6 profiles, with discharges ranging from 2,000 cfs to 5,500 cfs at 500 cfs increments for this reach. Note that XC 28.3 was added to this model to better reflect the reduction in conveyance at the downstream end of Lagoon 4. The channel geometry at this downgradient end controls the conveyance capacity of the right overbank for this reach. This model assumes the berm is not disturbed, which means the outlet elevation from the downgradient end of lagoon 4 is the top of the berm at 505 feet.

vtdec_baseline.prj

This model depicts baseline conditions during a 100-year flood, except that discharge that is estimated to flow into the overbank between XC 28.2 and 27.7 was subtracted from the main channel flow. XC 27.7 appears to be the last cross section in the lagoon where flow can interchange unencumbered between the right overbank and the channel. This model consists of 6 profiles. Each profile had a different amount of discharge subtracted from the main channel between cross section XC 28.2 and 27.7 ranging from 2,500 cfs to 5,000 cfs at 500 cfs increments.

Methodology for determining which profile to use from each model

The amount of flow subtracted from the main channel was determined by matching up as closely as possible the water surface elevations at XC 27.7 between the two baseline models described above for each of the 6 profiles. For baseline conditions, the best water surface elevation match at XC 27.7 was 4,000 cfs in the right overbank and 24,900 cfs (28,900 cfs minus 24900 cfs) in the main channel. The VTDEC understands that this model approach has uncertainty, but believes it provides a more realistic prediction of the conveyance capacity of the lagoon area separated by the riverside berm during a 100-year flood event.

Below is a list of other changes made to the TRC Baseline

- XC 29.0-Modified effective flow. Assumed no effective flow right of the railroad tracks (Station 642 in cross section). It does not appear that the area right of the railroad tracks can convey flow; therefore, the area to the right of station 642 was assumed to be ineffective flow. Also, changed right channel station to correspond with right channel bank of active channel.

- XC 29.0 through XC 27.3-Adjusted length between several cross sections through this reach, particularly the lengths between the right overbank area after checking lengths between cross section on the TRC and FEMA topographic maps.

- XC 28.2 through XC 27.3- Changed right channel stations to correspond to riverside berm.

- XC 27.7- Changed cross section alignment for right overbank so that cross section is perpendicular to flow between riverside berm and berm protecting the adjacent farm field.

- XC 27.7 through XC 27.3-Ineffective flow areas were added to several cross sections through this reach to account for the obstruction to flow by the farm field berm.

- XC 27.5-Removed this cross section from model. The relatively short distance between the cross sections resulted in the 100-year water surface elevation at XC 27.5 to be lower than the elevation at the downstream cross section (XC 27.6). The removal of this cross section resulted in a more realistic water surface elevation profile.

- XC 27.4- through 27.3-bottom elevation of right overbank area was modified to reflect obstruction to flow by berm separating Lagoon 4 and Lagoon 1.

- XC 27.2- Removed this cross section from model. Same reason as for XC 27.5

Option 2 Models

VTopt2rbonly500.prj

This model depicts the right overbank at multiple discharges from the downgradient end of the lagoon area (XC 28.3) to XC 27.7 for Option 2 conditions. The model consists of 4 profiles with discharges ranging from 5,000 cfs to 6,500 cfs at 500 increments for this reach. As in the case of the baseline right overbank model, XC 28.3 was added to this model to better reflect the reduction in conveyance at the downstream end of Lagoon 4. This model assumes the berm is modified so that the outlet elevation from the downgradient end of Lagoon 4 is 500 feet.

vtdec_option2_no275.prj

This model depicts Option 2 conditions during a 100-year flood, except that discharge that is estimated to flow into the overbank between XC 28.2 and 27.7 was subtracted from the main channel flow. XC 27.7 appears to be the last cross section in the lagoon where flow can interchange unencumbered between the right overbank and the channel. This model consists of

4 profiles. Each profile has a different amount of discharge subtracted from the main channel between cross section XC 28.2 and 27.7 ranging from 5,000 cfs to 6,000 cfs at 500 cfs increments.

Methodology for determining which profile to use from each model

The amount of flow to subtract from the main channel was determined by matching up as closely as possible the water surface elevations at XC 27.7 between the two baseline models for each of the 4 profiles. For Option 2 conditions, the best water surface elevation match at XC 27.7 was 6,000 cfs in the right overbank and 22,900 cfs (28,900 cfs minus 22,900 cfs) in the main channel.

Below is a list of other changes made to the TRC Option 2 Model

- XC 29.0-Modified effective flow. Same as for baseline model.
- XC 29.0 through XC 27.3- Same as for baseline model.
- XC 28.2 through 27.3- Changed right channel stations to correspond to riverside berm.
- XC 28.2 through 27.3-Right overbank was modified to reflect a uniform slope of 0.04 ft/ft. At the time of the model, the final grading of the right over bank was not known. As long as the recommendations in this memorandum are followed, the conveyance through the right overbank should not be adversely affected.
- XC 27.7-The cross section alignment for this cross section was not changed from the TRC alignment for Option 2 conditions.
- XC 27.4- Changed XC alignment for right overbank so that cross section is perpendicular to flow during Option 2 conditions.
- 27.7 through 27.3-Ineffective flow areas were added to account for the obstruction by the landfill to flow by the farm field berm that is perpendicular to right overbank flow.
- XC 27.5 and 27.2-Removed these cross section from model to be consistent with baseline model.

TABLE 1

BASELINE WATER SURFACE ELEVATIONS - 100-YR FLOODPLAIN

HEC-RAS River Sta	FEMA River Station	Original FEMA Floodplain (ft)	TRC PF1 - Revised Baseline (ft)	VTDEC Baseline (ft)	VTDEC Baseline - Right OB, PF 5 (ft)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
28	24	514.29	515.48	515.06	
27	25.1	514.2	515.46	515.02	
26.5	Bridge #3				
26	25.2	512.52	515.07	514.61	
25	26	512.48	515.07	514.61	
24	27	511.42	514.67	514.14	
23	27.1		514.31	513.73	
22	27.2		509.98		
21	27.3		509.63	512.31	
20	27.4		509.89	511.87	
19	27.5		509.57		
18	27.6		509.3	511.38	
17	27.7		509.22	510.36	510.61*
16	28	508.01	508.86	509.7	510.59*
15	28.1		508.35	508.17	510.57*
14	28.2		507.96	506.9	510.56*
13.5	28.3				508.58*
13	29	507.27	507.51	507.4	
12	30	505.97	506.27	506.27	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

The water surface elevations in Column 5 were taken from Profile 4 in the VTDEC model named *vtdec_baseline.prj.*

*For cross sections XC 28.3 through XC 27.2, the right overbank (OB) elevations (Column 6) were taken from Profile 4K in the VTDEC model named *vtdec_baseline_rightbank.prj*.

TABLE 2

VTDEC BASELINE AND OPTION 2 WATER SURFACE ELEVATIONS

HEC-RAS River Sta	FEMA River Station	VTDEC Baseline	VTDEC Option 2	VTDEC Baseline Right OB	VTDEC Option 2 - Right OB, PF 3
		(ft)	(ft)	(ft)	(ft)
[illegible]	[illegible]22	[illegible]529.26	[illegible]529.26		
30	[illegible]23.1	[illegible]528.95	[illegible]528.95		
29.5	[illegible]	[illegible]	[illegible]		
29	[illegible]23.2	[illegible]515.99	[illegible]515.69		
28	24	515.06	514.66		
27	25.1	515.02	514.6		
26.5	Bridge #3				
26	25.2	514.61	514.18		
25	26	514.61	514.18		
24	27	514.14	513.63		
23	27.1	513.73	513.21		
22	27.2				
21	27.3	512.31	511.86		
20	27.4	511.87	511.56		
19	27.5				
18	27.6	511.38	510.46		
17	27.7	510.36	509.97	510.61	509.99
16	28	509.7	509.37	510.59	509.46
15	28.1	508.17	508.08	510.57	509.11
14	28.2	506.9	507.12	510.56	508.7
13.5	28.3			508.58	507.21
13	29	507.4	507.42		
12	30	506.27	506.27		
[illegible]	[illegible]31	[illegible]502.47	[illegible]502.47		
10	[illegible]32	[illegible]501.[illegible]	[illegible]501.[illegible]		
9	[illegible]33	[illegible]500.[illegible]	[illegible]500.[illegible]		
8	[illegible]34.1	[illegible]499.[illegible]	[illegible]499.[illegible]		
5	Bridge #2				
[illegible]	[illegible]34.2	[illegible]498.94	[illegible]498.[illegible]		
[illegible]	[illegible]35	[illegible]498.[illegible]	[illegible]498.[illegible]		
[illegible]	[illegible]36.1	[illegible]498.[illegible]	[illegible]498.[illegible]		
[illegible] 5	Bridge #1				
4	[illegible]36.2	[illegible]496.[illegible]	[illegible]496.[illegible]		
3	[illegible]37	[illegible]495.[illegible]	[illegible]495.[illegible]		
2	[illegible]38	[illegible]493.[illegible]	[illegible]493.[illegible]		
1	[illegible]39	[illegible]490.[illegible]	[illegible]490.[illegible]		

Water surface elevations in Column 3 were taken from Profile 4 in the VT DEC model named *vtdec_baseline.prj*. Water surface elevations in Column 4 were taken from Profile 22.9K in the VT DEC model named *vtdec_option2_no275.prj.*

For cross sections XC 28.3 through XC 27.2, the right overbank (OB) water surface elevations in Column 5 were taken from Profile 4 in *vtdec_baseline_rightbank.prj*. For cross sections XC 28.3 and XC 27.2, the right OB water surface elevation in Column 6 were taken from Profile 6.0K in *VTopt2rbonly500.prj.*

TABLE 3

VELOCITIES - VTDEC OPTION 2

HEC-RAS River Sta	FEMA River Station	VTDEC Option 2 - Main Channel, PF 3	VTDEC Option 2 - Right OB, PF 3
		ft/sec	ft/sec
[illegible]	[illegible]	[illegible]	3.9
[illegible]	[illegible]	[illegible]	1.37
[illegible]			
[illegible]	[illegible]	[illegible]	
28	24	8.66	
27	25.1	8.13	
26.5	Bridge #3		
26	25.2	8.51	
25	26	7.86	5.68
24	27	6.8	
23	27.1	7.6	1.74
22	27.2		
21	27.3	9.42	3.4
20	27.4	8.33	4.05
19	27.5		
18	27.6	9.31	4.86
17	27.7	9.14	4.16*
16	28	8.44	4.59*
15	28.1	10.96	4.95*
14	28.2	10.96	4.87*
13.5	28.3	5.43	8.34*
13	29	6.45	5.43
12	30	7.49	6.45
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Bridge #2		
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Bridge #1		
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

Main average channel velocities for VT DEC baseline conditions (Column 3) were taken from *VTopt2rbonly500.prj*. Except for cross sections XC 28.3 through XC 27.2, right overbank (OB) velocities (Column 4) were also taken from *VTopt2rbonly500.prj*.

*For cross section XC 28.3 through XC 27.2, the right overbank (OB) velocities in Column 4 were taken from Profile 6.0K in *VTopt2rbonly500.prj*.

Figure 1 - VTDEC Changes to TRC Cross Sections for Baseline Conditions

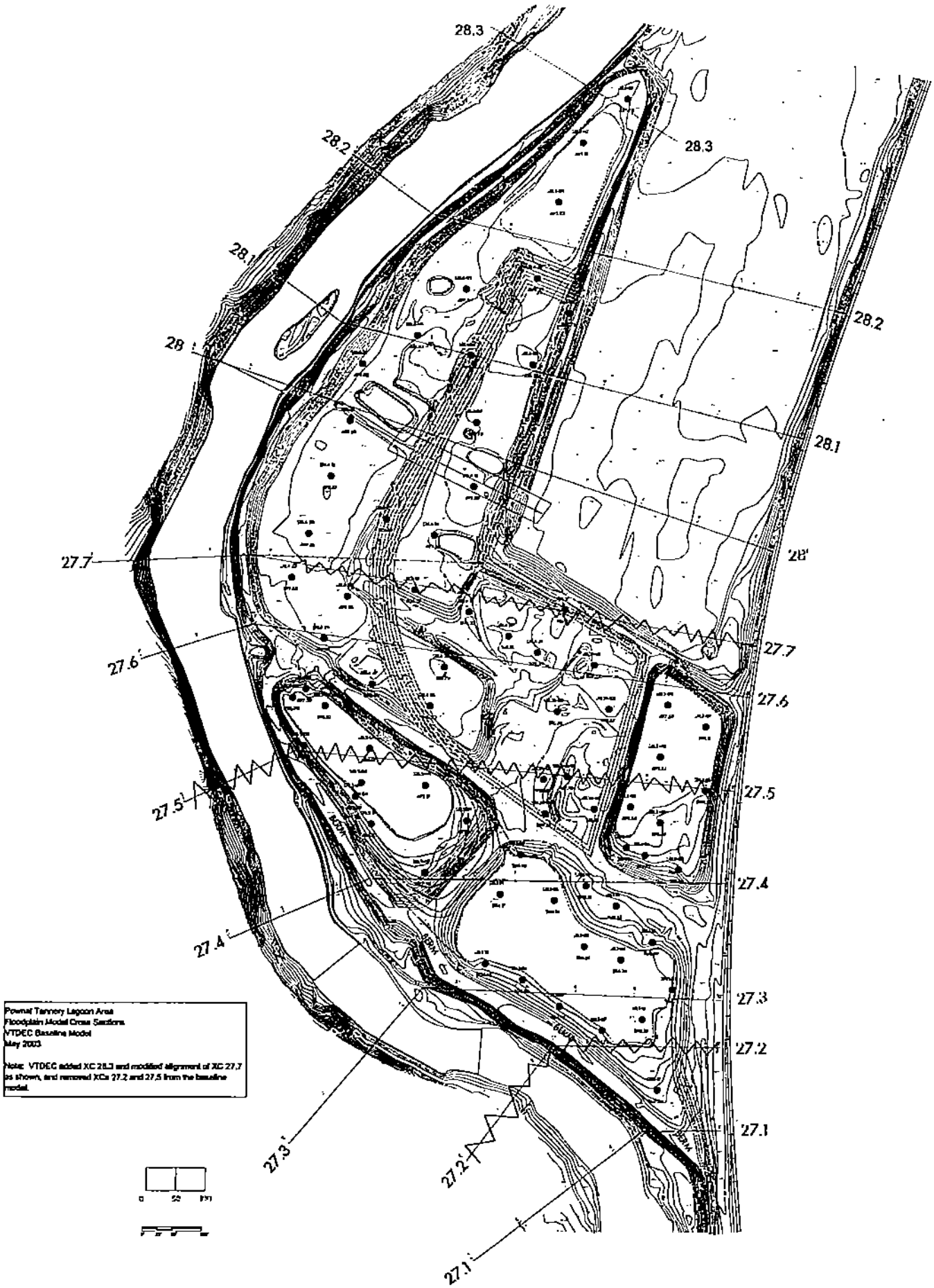
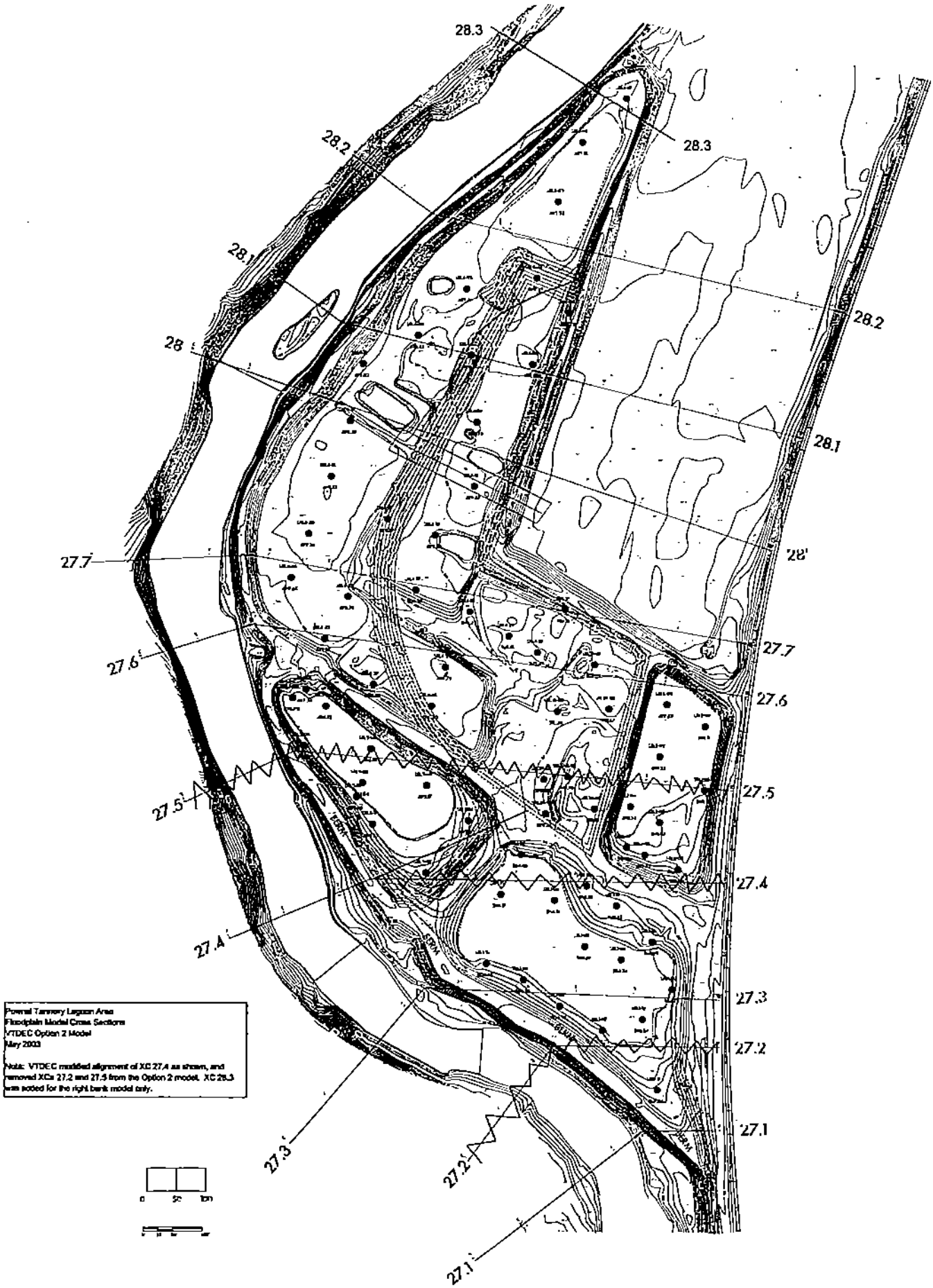


Figure 2 - VTDEC Changes to TRC Cross Sections for Option 2 Conditions



APPENDIX C

FINAL DATA EVALUATION REPORT FOR GEOTECHNICAL INVESTIGATIONS

EPA CONTRACT NO. 68-W6-0042
EPA WORK ASSIGNMENT NO. 052-RICO-01N9

EPA Project Officer: Diana King
EPA Remedial Project Manager: Leslie McVickar

FINAL DATA EVALUATION REPORT FOR GEOTECHNICAL INVESTIGATIONS TO SUPPORT REMEDIAL DESIGN

Pownal Tannery Superfund Site
Pownal, Vermont

December 2003

Prepared By:

Metcalf & Eddy, Inc.
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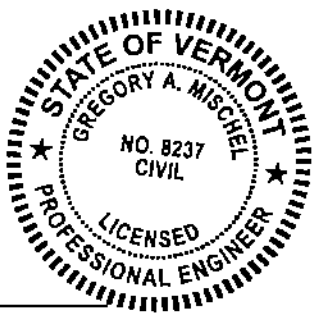

Gregory A Mischel, P.E.
Senior Project Engineer

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APPENDICES

A Boring Logs and Geologic Cross Sections
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C Geotechnical Test Reports

1.0 INTRODUCTION

Metcalf & Eddy (M&E) received Work Assignment (WA) No. 147-RORO-01N9 under the EPA Response Action Contract No. 68-W6-0042 (RAC) to complete a Remedial Design (RD) at the Pownal Tannery Superfund (Site) in North Pownal, Vermont. M&E assigned primary responsibilities for implementation of most of the tasks in the RD to RAC Team Subcontractor, TRC Environmental Corporation (TRC). M&E will retain primary responsibility for procurement of specialty subcontractors and overall project management.

The RD involves the design of a cover system to enclose tannery sludge material to be excavated from Lagoons 1 and 5. The excavated sludge and cover system will be located over Lagoon 3 and a portion of Lagoon 4. A geotechnical investigation was performed to characterize subsurface conditions and collect samples for testing to evaluate the physical properties of both in-place soil materials on which the landfill will be constructed, and tannery sludge from Lagoons 1 and 5, which will be excavated and placed in the landfill under the cap. The data will be used in the RD to determine sludge handling and dewatering procedures, estimate settlement of foundation materials and sludge, and evaluate the stability of the stockpiled sludge and cover system.

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2.0 SUMMARY OF EXISTING DATA

2.1 Site Description

Figure 2-1 shows the location of the former Pownal Tannery site in the Village of North Pownal, Vermont, approximately 20 miles southwest of the City of Bennington, Vermont at 42° 47' 49.8" north latitude and 73° 15' 56.7" west longitude.

Figure 2-2 presents a map of the site. The former Tannery consisted of two properties located one-half mile apart. The larger property is an elongate shaped property occupying approximately 30 acres. The larger parcel has frontage on State Route 346 to the south, and is bordered by the Hoosic River to the west, railroad tracks and a residential area to the east, and cornfields to the north. The property includes five lagoons, a screen house, a clarifier building, the former tanning building, and a warehouse. A landfill was constructed on a separate property across the River and one-half mile south of the tannery process building and was reportedly used by the tannery to receive sludge from the clarifier and lagoons. The tannery building, screen house, and clarifier building were demolished and contaminated materials were placed in the landfill, which was capped in 2000 as part of a Non-Time Critical Removal Action (NTCRA).

The Lagoon Area (Site) is where the contaminated sludge is located and is the focus of the Remedial Design. The geotechnical investigation was conducted in the Lagoon Area. TRC conducted a Remedial Investigation (RI) in 2000. Based on the findings of the RI, TRC completed a Feasibility Study (FS) in 2001.

The topography on the Site is generally flat, lying in the floodplain of the Hoosic River. Soil berms currently separate the Lagoon Area from the Hoosic River. With the exception of soil berms separating the lagoons, the majority of the Site is wetland with small areas of standing water.

The community of Pownal has a population of approximately 3,500. The nearest residence is approximately 75 feet from the Site. Adjacent residents rely upon a mix of public and private ground water sources for drinking water. Within a mile radius from the Site, approximately 275 people are served by private drinking water sources in the area completed in either the overburden or bedrock.

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Figure 2-1: Site Location Map

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Figure 2-2: Site Plan

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3.0 SUMMARY OF REMEDIAL INVESTIGATION FINDINGS

3.1.1 Geology

During the RI, TRC identified several stratigraphic units underlying the Lagoon Area. General descriptions of these units are provided below.

Surficial Clay (Lagoon Cap): A layer of clay was observed capping the lagoon fill material in Lagoons 1 and 3, with a thickness ranging between 1 and 4 feet. This material generally consisted of moist, brown to gray clay with some silt, organics, and trace to little amounts of gravel. Lagoons 2 and 4 appeared to have been excavated of cover material and fill, and Lagoon 5 (where the majority of the lagoon was filled with standing water) does not appear to have a clay cap.

Surficial Soil (Lagoon Cover Material): A layer of soil was observed covering various areas of Lagoons 1, 2, 3, and 4. This material generally consisted of brown to gray, very fine to medium sand with small amounts of silt. In Lagoon 3, this material also included some gravel.

Lagoon Sludge: Figure 3-1 shows an isopach map of the lagoon sludge observed at the site. TRC documented the presence of Lagoon sludge in Lagoons 1, 3, and 5, as well as in a limited area of Lagoon 4. The thickness of this material varied from location to location, with the thickest deposits being 4 to 9 feet in Lagoon 1, and up to 11 feet in Lagoon 3. Deposits of sludge in Lagoon 5 were less than 4 feet in thickness. The majority of sludge appeared to have been removed from Lagoon 2. Except for the southern end of Lagoon 4 (adjacent to Lagoon 3), there was no sludge in Lagoon 4.

The sludge present in Lagoon 1 generally consisted of moist organic silt including layers of gray clay and varying quantities of hair and hide fragments. The sludge in Lagoon 1 contains layers of various colors (black, blue, white, red, and gray). The upper surface of this deposit was often coated with thin (<1 inch) layers of dry white powder, which may be lime that was added to the sludge to minimize odors.

The sludge present in Lagoon 3 was generally black to gray in color, not as consistent in thickness as that observed in Lagoon 1, and appeared to include an increased percentage of sand relative to Lagoon 1. This sludge generally consisted of fine organic silt and sand with trace amounts of hair and hide fragments.

The limited amount of sludge observed in the southern portion of Lagoon 4 generally consisted of black organic silt with trace amounts of hair. The thin white layers (presumably lime) were also observed in this area.

The layers of sludge present in Lagoon 5 generally consisted of moist, black to gray organic silt with little quantities of clay and trace amounts of hair.

Gravel Layer: Beneath all of the lagoons, TRC observed a basal layer of gravel under the Fill. This material generally consisted of brown to black, poorly sorted gravel, with little amounts of

sand and silt, and appeared to be alluvial in origin (based on rounded gravel pieces). This layer of gravel was black, underlying Lagoons 1, 3, 5 and part of 4, and was brown in the majority of the remaining lagoon areas (the majority of Lagoons 2 and 4). Based on several borings through this layer, the gravel is underlain by either gray to brown, very fine sand and silt, or homogeneous, light gray, cohesive clay.

Gray Clay: Beneath all of the sludge and granular soils, TRC observed a light gray cohesive clay. The clay appears to lie directly over the bedrock surface and ranges in thickness from less than 10 feet at the west side of Lagoon 4 to over 70 feet beneath Lagoons 1 and 3.

Copies of the geologic cross sections from the RI are included in Appendix A for reference. Included in Appendix A are Figure 3.4-2 which shows the locations of five cross sections and the cross sections (Figures 3.4-3, 3.4-4, 3.4-5, 3.4-6 and 3.4-7).

Figure 3-1: Isopach Map of Lagoon Sludge

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4.0 SUBSURFACE INVESTIGATION

Test pits and soils borings were performed at the Site between November 25 and December 5, 2002. The locations of the test pits and borings conducted as part of this subsurface investigation are shown on Figure 4-1. Geologic information recorded on test pit and boring logs (Appendix A) are consistent with the observations made during the RI. Table 4-1 summarizes the types and thickness of soil and sludge materials encountered during the geotechnical subsurface investigation.

The purpose of this sampling program is to perform field geotechnical testing and collect samples of soil and sludge for laboratory geotechnical testing. The data will be used in the RD to determine sludge handling and dewatering procedures, and estimate settlement of foundation materials and sludge, and evaluate the stability of the stockpiled sludge and cover system.

4.1.1 Sludge Fill Material

Test pits were excavated in Lagoon 1 (TPL1-101, TPL1-102, and TPL1-103) and Lagoon 5 (TPL5-101, TPL5-102, and TPL5-103) between December 2 and December 5, 2002 using a track-mounted hydraulic excavator. Due to the presence of saturated and soft surface soils, plastic "swamp mats" were used in Lagoon 1 to provide a stable surface for the excavator. The Lagoon 5 test pits were excavated by reaching into the lagoon from the bottom edge of the soil berm forming the lagoon.

Test pits were conducted in accordance with TRC Standard Operating Procedure (SOP) No. 007, Test Pit Logging Procedures" to collect bulk samples of sludge from Lagoons 1 and 5. TRC SOP No. 007 is included in Appendix B. Encountered soils were logged as described in TRC SOP No. 005, "Soil Description, Visual – Manual Procedure of the Unified Classification System"

The test pits were used to visually characterize the sludge materials and collect samples of sludge for laboratory testing. The sludge was easily identified by a distinctive color and consistency. The color of the sludge was generally black in Lagoon 5 and multi-colored in Lagoon 1. The sludge was cohesive and clay-like. When excavated the sludge materials remained intact and did not appear to loose strength or become suspended when disturbed. Water did not readily drain from the sludge material into the excavation and free water was not encountered until the underlying gravel layer was reached.

The side slopes of the berms were observed to overlie the sludge material around the perimeter of Lagoons 1 and 5. The black sludge was easily identified from the brown granular berm soils and the lateral extent of the sludge was observed at several test pit locations (TPL5-104, TPL5-105, TPL5-106 and TPL5-107) excavated around Lagoon 5. The vertical extent of the sludge was also easily identified by the presence of a gravel layer that was encountered below the sludge throughout the Lagoon area.

The gravel layer below the sludge was composed of rounded gravel and cobbles with minor amounts of silt and sand. Once encountered, water flowed easily into the excavation.

Excavation through the gravel layer was not possible because the saturated gravel was unstable and gravel continually sloughed into the test pit.

Test pits TPB-101 and TPB-102 were excavated into the berm separating Lagoon 1 from the River in and attempt to define the extent of sludge. Sludge was not observed in either test pit.

4.1.2 Landfill Base Material Evaluation

Six test borings were advanced in Lagoons 3 and 4 to evaluate geotechnical properties of the base material on which the landfill is to be constructed. The borings were advanced using a drive and wash drilling method between November 25 and December 5, 2002. Split spoon samples or Shelby tube samples were collected at a minimum of every five feet of drilling for visual classification and laboratory testing.

At a minimum, all six test borings were advanced to the top surface of the underlying natural clay. Boring SBL4-103 was advanced to the bottom of the clay. Split spoon samples were collected every five vertical feet of boring. The number of blows to drive the split spoon sampler were recorded to determine the standard penetration test "N" value.

The soils encountered in Lagoons 3 and 4 were consistent with previous investigation. In summary the subsurface soils encountered at Lagoon 3 (SBL3-101 and SBL3-102) and the east end of Lagoon 4 (SBL4-101i, and SBL4-101ii) included the following, from top to bottom:

- A layer of fill material consisting of silty sand or clay and silt;
- Black silty or sandy sludge;
- Layers of sand and gravel;
- Gray clay.

The following subsurface soils were encountered at the west end of Lagoon 4 (SBL4-102, SBL4-103 and SBL4-104) from top to bottom:

- A layer of silty sand;
- A layer of sand and gravel or gravel;
- A layer of silt (SBL4-104 only); and,
- Gray clay.

Figure 4-1: Geotechnical Sampling Location Map

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Table 4-1 Pownal Geotechnical Investigation
Exploration Locations and Subsurface Descriptions
Pownal Tannery Superfund Site
Pownal, Vermont

LOCATION	SURFICIAL CLAY		SURFICIAL SOIL (SILTY SAND)		LAGOON SLUDGE		GRAVEL LAYER		GRAY CLAY		Total Depth of Boring (feet)
Borings	Depth range (feet bgs)	Layer thickness (feet)	Depth range (feet bgs)	Layer thickness (feet)	Depth range (feet bgs)	Layer thickness (feet)	Depth range (feet bgs)	Layer thickness (feet)	Depth range (feet bgs)	Layer thickness (feet)	
SBL3-101	1 to 6	6	0 to 1	1	6 to 16	10	16 to 28	12	28 to 30	2	30
SBL3-102	NA	NA	0 to 2.3	2.3	2.3 to 13	10.7	13 to 24.2	11.2	24.2 to 26	1.8	26
SBL4-101-I	0 to 6	6	NA	NA	6 to 10	4	10 to 24.2	14.2	24.2 to 26	1.8	26
SBL4-101-II	NA	NA	NA	Na	4 to 10	6	NA	NA	NA	NA	10
SBL4-102	NA	NA	0 to 9	9	NA	NA	9 to 14.7	5.7	14.7 to 21	6.3	21
SBL4-103	NA	NA	0 to 5	5	NA	NA	5 to 9.5	4.5	9.5 to 71	61.5	71
SBL4-104	NA	NA	0 to 4	4	NA	NA	4 to 13	9	13 to 21	8	21
Test Pits											
TPB-101	NA	NA	0 to 4	4	NA	NA	4 to 8	4	NA	NA	8
TPB-102	NA	NA	0 to 6.5	6.5	NA	NA	NA	NA	NA	NA	6.5
TPL1-101	0 to 3	3	NA	NA	3 to 10	7	10 to 11	1	NA	NA	11
TPL1-102	0 to 1.5	1.5	NA	NA	1.5 to 9	7.5	9 to 10	1	NA	NA	10
TPL1-103	0 to 1.5	1.5	NA	NA	1.5 to 9	7.5	9 to 10	1	NA	NA	10
TPL5-101	NA	NA	0 to 3	3	3 to 6	3	6 to 7	1	NA	NA	7
TPL5-102	NA	NA	NA	NA	0 to 3	3	3 to 5	2	NA	NA	5
TPL5-103	NA	NA	NA	NA	0 to 3.5	3.5	3.5 to 5	1.5	NA	NA	5
TPL5-104	NA	NA	0 to 3	3	3 to 6	3	6 to 7	1	NA	NA	7
TPL5-105	NA	NA	0 to 6	6	6 to 9	3	9 to 10	1	NA	NA	10
TPL5-106	NA	NA	0 to 5	5	5 to 7	2	7 to 10	3	NA	NA	10
TPL5-107	NA	NA	0 to 5	5	5 to 6	1	6 to 9	3	NA	NA	9

NA - Not Applicable (soil type not encountered in given exploration location).

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5.0 LABORATORY TESTING PROGRAM

5.1 Analytical Parameters

A summary of geotechnical testing methods is presented in Table 5-1. The table lists the method, scope, and significance of the specified tests. Table 5-2 presents the samples collected and the tests performed as part of the geotechnical investigation.

5.2 Lagoon 1 and 5 Sludge

5.2.1 Sample Collection

Test pits were excavated in Lagoons 1 and 5 to evaluate geotechnical properties of the sludge material to be placed under the cap. Bulk samples of the sludge material from the test area were placed in 5-gallon buckets.

Two 5-gallon buckets of material were collected from each sample location. Each bucket was permanently labeled with the sample location and date and delivered to the laboratory using chain of custody procedures.

5.2.2 Sample Testing

The sludge samples were analyzed at the Geotesting Express laboratory in Boxboro, Massachusetts.

Index Tests: Once submitted to the laboratory, the sludge samples were first tested for particle size distribution, specific gravity of solids, standard proctor, Atterberg limits and organic content. Results of these tests were used to classify the materials and to determine the method of test specimen preparation for strength and consolidation tests.

Consolidation Test: A controlled-strain loading test (ASTM D 4186) was performed on a composite sample of sludge from Lagoon 5 to obtain one-dimensional consolidation properties. The test specimen was prepared by mixing equal proportions of samples TPL5-101, TPL5-102 and TPL5-103 and compacting the material with moderate effort into the test ring.

Unconfined Compression Tests: An unconfined compression test was performed on each sample at the in-place moisture content. The test specimen for the unconfined compression test was prepared by pushing a tube into the sample bucket and extracting the sludge sample.

A series of test specimens from sample TPL5-102 were then prepared and tested in unconfined compression at five different moisture contents. The test specimens were prepared at 90 percent of the maximum dry density as determined by the standard proctor test on sample TPL5-102. The water contents ranged between the optimum water content and the liquid limit. The purpose of the tests was to evaluate the relationship between water content and strength.

Solidification Admixtures: The strength of the sludge material may need to be improved in order to allow placement of the material in the landfill. Excessive water content, as is the case for Lagoon 5, appears be the parameter controlling strength. The sludge could be spread thin and tilled to encourage drying. However, the required drying time is unknown and the weather is unpredictable and would certainly prolong the process if wet and cool conditions prevail. Another method for improving strength would involve the solidification of the sludge using an admixture such as Portland cement.

There are several concerns regarding the use of Portland cement including the following:

- A pug mill will likely be required to introduce the Portland cement in a controlled manner. The operation of a pug mill is time consuming and relatively expensive when compared to air drying.

- Portland cement is relatively expensive when compared to other admixtures.

- Excessive dust may be generated by an insitu application of cement to the sludge.

Because of the above-mentioned concerns, quicklime is currently being evaluated as an admixture. The Field Sampling Plan originally called for Portland cement to be mixed with remolded samples from Lagoons 1 and 5 using three different cement proportions (3%, 5%, and 7% by weight), and tested in unconfined compression at three different curing times (3 days, 7 days and 28 days). These procedures may be revised if quicklime is chosen as the admixture. No testing has been performed to date to evaluate the strength of solidified sludge.

5.3 Lagoons 3 and 4

5.3.1 Sample Collection

Six test borings were advanced in Lagoons 3 and 4 to evaluate the geotechnical properties of the base material on which the landfill is to be constructed. Split spoon sampling was conducted to collect samples for index tests. The standard penetration test (SPT) was performed at the same time to estimate the engineering properties of the landfill foundation soils.

An attempt was made to collect undisturbed samples of the Lagoon 3 and Lagoon 4 sludge for laboratory testing. Undisturbed sludge samples were successfully collected at soil borings SBL3-102 and SBL4-101. An attempt was also made to collect an undisturbed sample of sludge from SBL3-101. However, the driller was not able to collect a sample because the Shelby tube was not able to retain the sludge. An undisturbed sample of clay was also collected from boring SBL4-103 at a depth of 25 feet to 27 feet below grade.

The undisturbed samples from Lagoons 3 and 4 were collected using Shelby Tubes in accordance with ASTM D 1587, "Standard Practice for This-Walled Tube Sampling of Soils for Geotechnical Purposes."

5.3.2 Sample Testing

Index Tests: Split spoon samples of the upper silty sand layer, the sludge and the gray clay were submitted to the laboratory and tested for index parameters including particle size distribution, specific gravity of solids, and Atterberg limits.

Consolidation Tests: Consolidation tests using ASTM D 2435 were performed on undisturbed samples of sludge and clay. Undisturbed samples of sludge were collected from boring SBL3-102 from six to eight feet below grade, and from boring SBL4-101 from eight to 10 feet below grade. The undisturbed sample of gray clay was collected from boring SBL4-103 from 25 to 27 feet below grade.

Unconfined Compression Tests: Unconfined compression tests were performed on undisturbed samples of sludge (SBL3-102 6-8') and gray clay (SBL4-103 25-27').

Geotechnical testing results will be evaluated to assess the base material stability and its potential for settlement under loading from the fill material and cap construction.

5.4 Stabilized Sludge

The samples of sludge collected for index testing were also used to evaluate the effectiveness of two reagents for stabilization purposes. Samples from Lagoon 1 (TPL1-101, TPL1-102 and TPL1-103) and Lagoon 5 (TPL5-102) were mixed with either Portland cement or high calcium quicklime, allowed to cure and tested for unconfined compressive strength. The samples chosen for testing were considered worst case because of the high organic content, water content and atterberg limits. Quicklime and Portland cement were chosen as stabilizing reagents because of their proven effectiveness for stabilization and availability. Quicklime also has the added benefits of reducing odors, reduced potential for dust generation if applied in the dry form, and the ability to reduce the water content of the sludge by absorbing water (if added in the dry form).

5.4.1 Sample Preparation and Testing

Specimens of stabilized sludge were prepared in the laboratory for unconfined compression testing using the sludge samples collected for this geotechnical investigation, commercially available Type II Portland cement, and a sample of quicklime provided by Graymont (QC) Inc. of Boucherville, Quebec, Canada. The sample preparation method was developed to most closely simulate the field conditions and construction methods that might be experienced during actual full scale stabilization.

Prior to adding the reagents, a portion of each sample was removed from the bucket and the water content was adjusted to initial level as it was received by the laboratory. The reagents were added as a weight percent of the wet sludge. A spoon was used to mix the reagents with the sludge in an attempt to simulate the construction equipment that may be used in the field (i.e. hydraulic excavator, auger, or disc/tiller). Quicklime was always added in the dry form. Portland cement was added in both the dry form and in a 1:1 water to cement slurry.

Initially quicklime was added to the first specimens to be prepared by mixing with a spoon until the individual pieces of quicklime were no longer visible. The number of passes with the spoon were counted and recorded on the laboratory report. The number of passes ranged between 180 and 330. The number was considered excessive and not practical for full-scale application. The remainder of the specimens were prepared by mixing the reagents with the sludge using a spoon until the reagents were uniformly distributed. Streaks of color variation, and small clods of sludge were acceptable in the prepared samples. The samples were then placed in specimen cylinder molds using a moderate compactive effort and allowed to cure. Specimens were tested in unconfined compression using ASTM D 1633 after one and three days to evaluate the short-term strength. The short-term strength was important to evaluate whether the stabilized material could be placed and compacted in a reasonable amount of time. Additional specimens were tested after 7 or more days of curing to evaluate the long-term strength.

Table 5-1 Summary of Geotechnical Testing Methods
Pownal Tannery Superfund Site
Pownal, Vermont

METHOD	SCOPE	SIGNIFICANCE AND USE
ASTM D 422-63 Standard Test Method for Particle-Size Analysis of Soils	This test method covers the quantitative determination of the distribution of particle sizes in soils.	Information obtained from this test is required for several test methods described in this table.
ASTM D 854-00 Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer	These test methods cover the determination of the specific gravity of soil solids that pass the 4.75-mm (No. 4) sieve, by means of a water pycnometer.	(1) The specific gravity of soil solids is used in calculating the phase relationship of soils, such as void ratio and degree of saturation. (2) The specific gravity of soil solids is used to calculate the density of the soil solids. This is done by multiplying its specific gravity by the density of water (at proper temperature). (3)
ASTM D 1557-00 Standard Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (Modified Proctor Test)	These test methods cover laboratory compaction methods used to determine the relationship between water content and dry unit weight of soils (compaction curve) compacted in a 4- or 6-in. (101.6 or 152.4 mm) diameter mold with a 10-lbf. (44.5-N) rammer dropped from a height of 18 in. (457 mm) producing a compactive effort of 56,000 ft-lbf/ft3 (2,700 kN-m/m3).	(1) Soil placed as engineering fill (embankments, foundation pads, road bases) is compacted to a dense state to obtain satisfactory engineering properties such as, shear strength, compressibility, or permeability. Also, foundation soils are often compacted to improve their engineering properties. Laboratory compaction tests provide the basis for determining the percent compaction and water content needed to achieve the required engineering properties, and for controlling construction to assure that the required compaction and water contents are achieved. (2) During design of an engineered fill, shear, consolidation, permeability, or other tests require preparation of test specimens by compacting at some water content to some unit weight. It is common practice to first determine the optimum water content (? $_o$) and maximum dry unit weight (?$_{dmax}$) by means of a compaction test. Test specimens are compacted at a selected water content (?), either wet or dry of optimum (? $_o$) or at optimum (? $_o$), and at a selected dry unit weight related to a percentage of maximum dry unit weight (?$_{dmax}$). The selection of water content (w), either wet or dry of optimum (? $_o$) or at optimum (? $_o$) and the dry unit weight (?$_{dmax}$) may be based on past experience, or a range of values may be investigated to determine the necessary percent of compaction.

Table 5-1 Summary of Geotechnical Testing Methods
Pownal Tannery Superfund Site
Pownal, Vermont

METHOD	SCOPE	SIGNIFICANCE AND USE
ASTM D 1586-99 Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils	This test method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative soil sample and a measure of the resistance of the soil to penetration of the sampler.	(1) This test method provides a soil sample for identification purposes and for laboratory tests appropriate for soil obtained from a sampler that may produce large shear strain disturbance in the sample. (2) This test method is used extensively in a great variety of geotechnical exploration projects. Many local correlations and widely published correlations which relate SPT blowcount, or N-value, and the engineering behavior of earthworks and foundations are available.
ASTM D 2166-00 Standard Test Method for Unconfined Compressive Strength of Cohesive Soil	This test method covers the determination of the unconfined compressive strength of cohesive soil in the undisturbed, remolded, or compacted condition, using strain-controlled application of the axial load.	The primary purpose of the unconfined compression test is to quickly obtain the approximate compressive strength of soils that possess sufficient cohesion to permit testing in the unconfined state.
ASTM D 2216-98 Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass	This test method covers the laboratory determination of the water (moisture) content by mass of soil, rock, and similar materials where the reduction in mass by drying is due to loss of water.	(1) For many materials, the water content is one of the most significant index properties used in establishing a correlation between soil behavior and its index properties. (2) The water content of a material is used in expressing the phase relationships of air, water, and solids in a given volume of material. (3) In fine-grained (cohesive) soils, the consistency of a given soil type depends on its water content. The water content of a soil, along with its liquid and plastic limits as determined by Test Method D 4318, is used to express its relative consistency or liquidity index.

Table 5-1 Summary of Geotechnical Testing Methods
Pownal Tannery Superfund Site
Pownal, Vermont

METHOD	SCOPE	SIGNIFICANCE AND USE
ASTM D 2435-96 Standard Method for One-Dimensional Consolidation Properties of Soil	This test method covers procedures for determining the magnitude and rate of consolidation of soil when it is restrained laterally and drained axially while subjected to incrementally applied controlled-stress loading.	The data from the consolidation test are used to estimate the magnitude and rate of both differential and total settlement of a structure or earthfill. Estimates of this type are of key importance in the design of engineered structures and the evaluation of their performance.
ASTM D 2974-00 Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils	These test methods cover the measurement of moisture content, ash content, and organic matter in peats and organic soils, such as organic clays, silts, and mucks.	(1) This test method can be used to determine the moisture content, ash content, and percent organic matter in soil. (2) The percent organic matter is important in classifying a peat or other organic soil.
ASTM D 3080-98 Standard Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions	This test method covers the determination of the consolidated drained shear strength of a soil material in direct shear. The test is performed by deforming a specimen at a controlled strain rate on or near a single shear plane determined by the configuration of the apparatus. Generally, three or more specimens are tested, each under a different normal load, to determine the effects upon shear resistance and displacement, and strength properties such as Mohr strength envelopes.	(1) The direct shear test is suited to the relatively rapid determination of consolidated drained strength properties because the drainage paths through the test specimen are short, thereby allowing excess pore pressure to be dissipated more rapidly than with other drained stress tests. The test can be made on all soil materials and undisturbed, remolded or compacted materials. The test results are applicable to assessing strength in a field situation where complete consolidation has occurred under the existing normal stresses. Failure is reached slowly under drained conditions so that excess pore pressures are dissipated. The results from several tests may be used to express the relationship between consolidation stress and drained shear strength.

Table 5-1 Summary of Geotechnical Testing Methods
Pownal Tannery Superfund Site
Pownal, Vermont

METHOD	SCOPE	SIGNIFICANCE AND USE
ASTM D 4318-00 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils (Atterberg Limits)	These test methods cover the determination of the liquid limit, plastic limit, and the plasticity index of soils.	These test methods are used as an integral part of several engineering classification systems to characterize the fine grained fractions of soils (see Practices D 2487 and D 3282) and to specify the fine-grained fraction of construction materials (see Specification D 1241). The liquid limit, plastic limit, and plasticity index of soils are also used extensively, either individually or together, with other soil properties to correlate with engineering behavior such as compressibility, hydraulic conductivity (permeability), compactibility, shrink-swell, and shear strength.
ASTM D 5084-00 Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter	These test methods cover laboratory measurement of the hydraulic conductivity (also referred to as coefficient of permeability) of water-saturated porous materials with a flexible wall permeameter at temperatures between about 15 and 30°C (59 and 86°F).	These test methods apply to one-dimensional, laminar flow of water within porous materials such as soil and rock.

Note: Copies of ASTM methods are provided in Appendix B.

Table 5-2 Geotechnical Sampling Matrix
Pownal Superfund Site
Pownal, Vermont

Location		Sample Volume or Inches Recovery	Material Type	Particle Size D 422	Specific Gravity D 854	Standard Proctor D 698	Unconfined Compression D 2166	Moisture Content D 2216	Consolidation Parameters		Organic Content D 2974	Remolded Unconfined Compression D 2166	Atterberg Limits D 4318	Compressive Strength Soil - Cement D 1633
									D 2435	D 4186				
Lagoon 1	TPL1-101	10 gal	Sludge	B	B	B	B(1)	B			B		B	
	TPL1-102	10 gal	Sludge	B	B	B	B(1)	B		Hold	B	Hold	B	Hold
	TPL1-103	10 gal	Sludge	B	B	B	B(1)	B			B		B	
Lagoon 5	TPL5-101	10 gal	Sludge	B	B	B	B(1)	B			B		B	
	TPL5-102	10 gal	Sludge	B	B	B	B(1)	B		B(1)(2)	B	B(3)	B	Hold
	TPL5-103	10 gal	Sludge	B	B	B	B(1)	B			B		B	
Lagoon 3	SBL3-101	20 inches	Sludge	NR	NR	--	NR	NR	NR		--	--	NR	--
	SBL3-102	20 inches	Sludge	ST	ST	--	ST	ST	ST		--	--	ST	--
Lagoon 4	SBL4-101	20 inches	Sludge	ST	ST	--	--	ST	ST		--	--	ST	--
	SBL4-101	24 inches	Granular	SS	--	--	--	--	--		--	--	--	--
	SBL4-102	24 inches	Clay	SS	--	--	--	SS	--		--	--	SS	--
	SBL4-102	24 inches	Granular	NR	--	--	--	--	--		--	--	--	--
	SBL4-103	20 inches	Clay	ST	ST	--	ST	ST	ST		--	--	ST	--
	SBL4-103	24 inches	Granular	NR	--	--	--	--	--		--	--	--	--
	SBL4-104	24 inches	Clay	SS	--	--	--	SS	--		--	--	SS	--
	SBL4-104	24 inches	Granular	SS	--	--	--	--	--		--	--	--	--

Notes:

B = Bulk Sample
ST = Shelby Tube Sample
SS = Split Spoon
NR = No Sample Recovery
Hold = Test on hold

(1) Tests performed at natural water content
(2) Laboratory to take equal mass from each of the three lagoon samples, mix and remold before testing
(3) Tests to be run at 90% of maximum dry density over range of five moisture contents

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6.0 GEOTECHNICAL TEST RESULTS

The laboratory test data are presented in Tables 6-1, 6-2, 6-3 and 6-4. Table 6-1 presents test results used to classify the materials including particle size analyses, specific gravity of solids, organic content and Atterberg limits. Table 6-2 presents densities and unit weights of the sludge and clay materials. Table 6-3 presents the results of unconfined compression tests. Table 6-4 presents the results of unconfined compression test results on samples of Lagoon 5 sludge at five water contents. Geotechnical test reports are included in Appendix C.

6.1 Standard Penetration Tests

Table 6-5 presents the uncorrected SPT "N" values collected during the subsurface investigation. The SPT "N" value is calculated by adding the number of blows to drive the split spoon sampler one foot from a depth of six inches to a depth of 18 inches. The SPT "N" value is used in empirical correlations to estimate soils properties such as unit weight, relative density, angle of internal friction, and undrained compressive strength.

The average SPT "N" value for the soil units encountered at the site are presented in Table 6-6:

6.2 Lagoon 3 and 4 Test Results

6.2.1 Granular Fill

Two split spoon samples of granular materials were collected from the test borings. Both samples, SBL4-101 12-14' and SBL4-104 4-6', were from the gravel layer. Results of the gradation test indicate the material is a gravel and sand mixture. Based on the gradation text results an ASTM group symbol was not available to classify the gravel.

6.2.2 Clay

Classification: Three samples of the gray clay were tested for gradation. Gradation test results indicate two of the samples were classified as a lean clay (ASTM symbol CL) and the third was classified as a sandy silty clay (CL-ML). The Atterberg limits of the lean clay samples were similar with an average plastic limit of 24.45 and an average plasticity index of 23.15. The sandy silty clay was found to have a plastic limit of 14.8 and a plasticity index of 6.6.

Unconfined Compression Test: The unconfined compression test performed on the undisturbed sample of clay gave an unconfined compressive strength of 1447.34 pounds per square foot (psf) and an undrained shear strength of 723.67 psf.

Consolidation Parameters: A consolidation test was performed on the clay sample collected at 25 to 27 feet below grade at test boring SBL4-103. The output of the test is a graph of percent strain versus vertical stress. A compression ratio of 0.105 was calculated using the graph of percent strain versus vertical stress.

6.2.3 Sludge

Classification: The sludge sample collected from SBL3-101 at six to eight feet below grade was classified as a lean clay with sand (CL). The Atterberg limit test on this sample showed a plastic limit of 21.5 with a plasticity index of 12.6.

The sludge sample collected from SBL4-102 at eight to ten feet below grade was classified as a silty sand (SM). The Atterberg limit test on this sample showed the material was non-plastic.

The specific gravities of the sludge samples from Lagoons 3 and 4 were 2.77 and 2.75, respectively.

Consolidation Parameters: Consolidation tests were also performed on two samples of sludge collected from Lagoon 3 (SBL3-102 6-8') and Lagoon 4 (SBL4-101 8-10'). Results of the consolidation tests show compression ratios of 0.0775 for sample SBL3-102 6-8' and 0.076 for SBL4-101 8-10'.

Unconfined Compression Test: Unconfined compression tests were performed on the undisturbed sludge sample collected from boring SBL3-102 from six to eight feet below grade. The unconfined compressive strength of the sample was 351.49 psf and the undrained shear strength was 175.74 psf.

6.3 Test Results for Lagoon 1 and 5 Sludge

6.3.1 Classification and Index Properties

Five of the six sludge samples collected from Lagoons 1 and 5 were classified as an organic silt or clay with medium to high plasticity (OH). One sample from Lagoon 5 (TPL5-103) was classified as an inorganic silt with slight plasticity (ML).

The organic content of the sludge from Lagoon 1 was higher than from Lagoon 5. Organic content ranged between 17.4 percent and 55.8 percent in Lagoon 1 while the organic content of the Lagoon 5 sludge ranged between 3.6 percent and 10.3 percent.

In general the specific gravity of the solids decreased with increasing organic content. The specific gravity of the Lagoon 1 sludge ranged between 2.27 and 2.35 while the specific gravity of the Lagoon 5 sludge ranged between 2.51 and 2.71.

The Atterberg limits of the sludge also appeared to correlate to the organic content of the material. Higher plastic limits and plasticity indexes were found for Lagoon 1 sludge than for Lagoon 5 sludge. The liquidity index of the Lagoon 1 sludge was between zero and one indicating the material will behave like a plastic when sheared. On the other hand, the liquidity indexes of the Lagoon 5 sludge were all greater than one indicating the material will loose strength and behave as a very viscous liquid when sheared.

6.3.2 Consolidation Tests

A controlled-strain loading consolidation test was performed on the sludge sample collected from Lagoon 5. The output of the test is a graph of percent strain versus vertical stress. The maximum stress within the landfill is expected to be less than one ton per square foot (tsf). Therefore, the portion of the graph from 0.1 and 1 tsf was used to calculate the compression ration for the sludge. A compression ratio of 0.1925 was calculated using the graph of percent strain versus vertical stress.

6.3.3 Unconfined Compression Test

Unconfined compression tests were performed on six sludge samples at the natural in-place water content. The test specimens were obtained by driving a Shelby tube into the 5-gallon bucket samples. Unconfined compressive strengths ranged between 103.5 psf and 132.18 psf for Lagoon 1 sludge and between 69.4 psf and 151.08 psf for Lagoon 5 sludge. Undrained shear strengths ranged between 51.82 psf and 66.08 psf for Lagoon 1 sludge and between 34.7 psf and 75.54 psf for Lagoon 5 sludge.

A series of test specimens from sample TPL5-102 were then prepared and tested in unconfined compression at five different moisture contents to evaluate the relationship between water content and strength. The unconfined compressive strength (763.2 psf) of the test specimen prepared at 90 percent of the maximum dry density and optimum water content (32 percent) was nearly 10 times the strength of the samples tested at the in-place water content. The unconfined compressive strength actually increased slightly to 864 psf and 921.6 psf when the water content was increased to 40 and 49 percent, respectively. The test specimens collapsed under their own weight when the water content was increased to 60 and 80 percent.

6.4 Test Results for Stabilized Sludge

The results of the unconfined compression tests on the stabilized sludge samples are presented in Table 6-7. The laboratory test reports are included in Appendix C.

6.4.1 Quicklime

Quicklime was used at 3, 5 and 7 percent by weight to stabilize sample TPL1-102, and 11 and 13 percent to stabilize sample TPL1-101. The unconfined compression test results showed a general increase in strength with curing time for the 3, 5 and 7 percent specimens. However, the strength at 1 and 3 days curing time were considered too low to support construction equipment for placement and compaction. Test results for the 11 and 13 percent specimens showed an improvement in the short-term strength but the strengths were considered marginal for both the 3-day and 7-day specimens.

6.4.2 Portland Cement

Portland cement was initially applied in slurry form at percentages of 1, 3 and 5 percent by weight to samples TPL1-103 and TPL5-102. Results of unconfined compression tests on the specimens were unacceptable for both short-term (1-day cure) and long-term (7-day cure) strength. Specimens were then prepared using sample TPL1-101 and Portland cement (9 percent by weight) in both a dry form and a slurry form in order to test the effect of the reagent form on strength. Results of the unconfined compression tests on the 9 percent specimens showed a higher strength for the specimen prepared using the dry form of Portland cement. However, the unconfined compressive strength was considered marginal, and two additional specimens were prepared using TPL1-101 and 11 and 13 percent Portland cement in the dry form. Unconfined compression tests showed acceptable strengths for both the 11 and 13 percent specimens at 3 and 7 days cure time.

6.4.3 Portland Cement/Quicklime

Specimens were also prepared using TPL1-101 and quicklime/Portland cement combinations of 10/2, 8/4 and 6/6 percent by weight. The unconfined compressive strength of the specimen with 10 percent quicklime and 2 percent Portland cement was unacceptable at both 3 and 7 days curing time. The unconfined compressive strength of the specimen with 6 percent quicklime and 6 percent Portland cement was marginal at both 3 and 7 days curing time. However, the unconfined compressive strength of the specimen with 8 percent quicklime and 4 percent Portland cement was acceptable at both 3 and 7 days curing time.

Table 6-1 Index Properties of Materials
Pownal Tannery Superfund Site
Pownal, Vermont

Sample Location	Sample I.D.	Material	Depth	Particle Size D 422	Specific Gravity D 854	Organic Content D 2974	Moisture Content D 2216	Atterberg Limits D 4318			
						%	%	LL	PL	PI	LI
Lagoon 1	TPL1-101	sludge	5-7'	OH	2.28	17.4	91.8	112.4	51.4	61	0.66
	TPL1-102	sludge	2-4'	OH	2.27	30.2	189.4	198.5	78.2	120.3	0.92
	TPL1-103	sludge	2-4'	OH	2.35	55.8	264.8	273.2	102.2	171	0.95
Lagoon 5	TPL5-101	sludge	3-5'	OH	2.71	9.4	82.8	82.4	38.4	44	1.01
	TPL5-102	sludge	1-2'	OH	2.51	10.3	118.7	99.7	40.7	59	1.32
	TPL5-103	sludge	1-3'	ML	2.52	3.6	50.6	38.1	29.7	8.3	2.5
Lagoon 3	SBL3-101	sludge	NR	No sample recovery		--	--	--	--	--	--
	SBL3-102	sludge	6-8'	CL	2.77	--	32.3	34.1	21.5	12.6	0.86
Lagoon 4	SBL4-101	granular	12-14'	gravel & sand	--	--	--	--	--	--	--
		sludge	8-10'	SM	2.75	--	24.7	Non Plastic			
	SBL4-102	clay	19-21'	CL	--	--	28.8	46.7	23.3	23.4	0.23
		granular	NR	No sample recovery		--	--	--	--	--	--
	SBL4-103	clay	25-27'	CL	2.79/2.83	--	50.3	48.5	25.6	22.9	1.08
		granular	5.7-6'	Insufficient sample		--	--	--	--	--	--
	SBL4-104	clay	19-21'	CL-ML	--	--	20.4	21.4	14.8	6.6	0.84
		granular	4-6'	gravel & sand	--	--	--	--	--	--	--

-- = Test not performed
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
LI = Liquidity Index

Table 6-2 Material Densities and Unit Weights
Pownal Tannery Superfund Site
Pownal, Vermont

Sample Location	Sample I.D.	Material	Depth	Standard Proctor D 698 Max. Density	Standard Proctor D 698 Opt. Moisture	Wet Unit Weight at 90% Max. Density	Sample Dry Unit Wt.(1)	Sample Water Content (1)	Sample Wet Unit Wt.
				pcf	%	pcf	pcf	%	pcf
Lagoon 1	TPL1-101	sludge	5-7'	63.4	50.1	95.1634	37.286	91.82	71.52
	TPL1-102	sludge	2-4'	53.5	64.3	87.9005	23.496	194.03	69.09
	TPL1-103	sludge	2-4'	45.2	63.8	74.0376	21.734	191.46	63.35
Lagoon 5	TPL5-101	sludge	3-5'	83.1	27.7	106.1187	70.42	51.48	106.67
	TPL5-102	sludge	1-2'	71.9	31.6	94.6204	41.89	101.35	84.35
	TPL5-103	sludge	1-3'	97.2	21.1	117.7092	74.26	42.48	105.81
Lagoon 3	SBL3-102	sludge	6-8'	--	--		83.68	26.67	106.00
Lagoon 4	SBL4-103	clay	25-27'	--	--		81.9	38.88	113.74

(1) = Data obtained from unconfined compression test report for sample

pcf = pounds per cubic foot

Table 6-3 Unconfined Compression Test Results for Sample TPL5-102
Pownal Tannery Superfund Site
Pownal, Vermont

Sample Location	Sample I.D.	Material	Depth	Unconfined Comp. Strength		Undrained Shear Strength	
				Cu, psi	Cu, psf	Su, psi	Su, psf
Lagoon 1	TPL1-101	sludge	5-7'	0.72	103.50	0.36	51.82
	TPL1-102	sludge	2-4'	0.92	132.18	0.46	66.08
	TPL1-103	sludge	2-4'	0.76	109.69	0.38	54.85
Lagoon 5	TPL5-101	sludge	3-5'	0.48	69.40	0.24	34.70
	TPL5-102	sludge	1-2'	0.63	90.56	0.31	45.28
	TPL5-103	sludge	1-3'	1.05	151.08	0.52	75.54
Lagoon 3	SBL3-102	sludge	6-8'	2.44	351.49	1.22	175.74
Lagoon 4	SBL4-103	clay	25-27'	10.05	1447.34	5.03	723.69

Note: All test specimens from Lagoons 1 and 5 were obtained by driving a Shelby tube into a 5-gallon bucket of remolded sample. Samples from Lagoons 3 and 4 are undisturbed samples collected during drilling.
pcf = pounds per cubic foot
pci = pounds per cubic inch
psf = pounds per square foot

Table 6-4 Unconfined Compression Test Results For Sample TPL5-102
Pownal Tannery Superfund Site
Pownal, Vermont

Water Content	Dry Density	Unconfined Compressive Strength	
%	pcf	psi	psf
32	64.3	5.3	763.2
40	65.1	6	864
49	65.2	6.4	921.6
60	Sample collapsed under own weight		
80	Sample collapsed under own weight		

Note: All samples were remolded and compacted in the specimen mold to 90% of maximum dry density at various moisture contents.

pcf = pounds per cubic foot

psi = pounds per square inch

psf = pounds per square foot

Table 6-5 Uncorrected SPT "N" Values
Pownal Tannery Superfund Site
Pownal, Vermont

BORING I.D.	Depth (feet)	SPT "N"	Soil Type
SBL3-101	1	27	SILT and CLAY
	3	24	SILT and CLAY
	5	6	SILT and CLAY
	17	100	GRAVEL
	21	38	SAND
	23	67	silty SAND
	25	61	silty SAND
	27	49	silty SAND
	29	22	CLAY
SBL3-102	1	12	silty SAND
	3	24	SLUDGE
	14	27	SAND
	21	46	SAND
	23	64	SAND
	25	23	CLAY
SBL4-101	1	6	SILT and CLAY
	3	8	SILT and CLAY
	5	6	SILT and CLAY
	7	26	SLUDGE
	11	42	silty SAND
	13	39	GRAVEL
	20	87	GRAVEL
	25	28	SILT and CLAY
SBL4-102	1	8	silty SAND
	5	8	silty SAND
	10	30	SAND and GRAVEL
	15	17	CLAY
	20	9	CLAY
SBL4-103	1	10	silty SAND
	5	14	silty SAND
	10	22	CLAY
	16	10	CLAY
	30	5	CLAY
	35	5	CLAY
	40	4	CLAY
	45	5	CLAY
	50	4	CLAY
	55	7	CLAY
	60	6	CLAY
	65	8	CLAY
	70	7	CLAY and SILT
SBL4-104	1	16	silty SAND
	5	58	GRAVEL
	10	20	silty SAND
	15	12	CLAY
	20	9	CLAY

Table 6-6 Average SPT "N" Values Pownal Tannery Superfund Site Pownal, Vermont	
Soil Unit	**Average SPT "N" Value**
Silt and Clay (sludge soil cover)	13
Silty Sand	11
Gravel	44
Clay (upper 10 feet)	17
Clay (below 10 feet)	5.5

Table 6-7
UC Test Results for Stabilized Sludge
Pownal Tannery Superfund Site
Pownal, Vermont

Sample	Additives			1 Day Curing Time						
Location	Lime	Cement	Mixing	w	D.D.	S	e	UCS	Su	Fail. Strain
	(%) by Weight*		State	(%)	(pcf)	(%)		(psi)/(psf)	(psi)/(psf)	(%)
TPL1-102	3		Dry	168.6	27.9	90.6	4.9	2.30 331.0	1.1 165.5	8.5
	5		Dry	152.6	30.3	90.7	4.5	3.79 546.1	1.9 273.0	6.0
	7		Dry	135.0	33.1	89.6	4.0	4.81 693.2	2.4 346.6	5.1
TPL1-103		1	Slurry	249.0	18.8	84.5	7.9	0.65 93.6	0.3 46.8	20.0
		3	Slurry	222.0	20.8	84.1	7.1	1.20 172.8	0.6 86.4	20
		5	Slurry	201.0	22.2	82.4	6.6	1.62 233.3	0.81 116.6	13
TPL5-102		1	Slurry	136.0		Sample Collapsed under its own weight				
		3	Slurry	125.7	35.9	91.7	3.7	0.43 61.9	0.22 31.0	4.6
		5	Slurry	123.5	34.9	87.1	3.8	1.24 178.6	0.62 89.3	5
TPL1-101		9	Dry							
		9	Slurry							
		11	Dry							
		13	Dry							
	13		Dry							
	11		Dry							
	10	2	Dry							
	8	4	Dry							
	6	6	Dry							

* = Percent by wet weight of sludge.

Table 6-7
UC Test Results for Stabilized Sludge
Pownal Tannery Superfund Site
Pownal, Vermont

Sample	Additives			3 Day Curing Time						
Location	Lime	Cement	Mixing	w	D.D.	S	e	UCS	Su	Fail. Strain
	(%) by Weight*		State	(%)	(pcf)	(%)		(psi)/(psf)	(psi)/(psf)	(%)
TPL1-102	3		Dry	170.2	27.5	89.9	5.0	3.4 488.9	1.7 244.4	5.4
	5		Dry	153.7	29.9	89.9	4.5	5.5 794.5	2.8 397.2	5.4
	7		Dry	154.88	31.13	91.4	4.5	5.73 825.3	2.87 412.7	4.6
TPL1-103		1	Slurry							
		3	Slurry							
		5	Slurry							
TPL5-102		1	Slurry							
		3	Slurry							
		5	Slurry							
TPL1-101		9	Dry	69.40	53.40	87.0	2.2	8.54 1229.3	4.27 614.7	3.5
		9	Slurry	55.35	58.60	79.6	1.9	4.76 685.4	2.38 342.7	4.1
		11	Dry	62.30	57.83	87.9	1.9	11.21 1614.2	5.61 807.1	4.3
		13	Dry	63.11	57.99	89.4	1.9	11.11 1599.8	5.56 799.9	4.2
	13		Dry	42.11	67.13	75.2	1.5	9.17 1320.6	4.59 660.3	3.8
	11		Dry	44.52	64.27	74.1	1.6	9.66 1390.6	4.83 695.3	3.6
	10	2	Dry	63.70	56.06	85.7	2.0	5.57 801.9	2.78 401.0	6.5
	8	4	Dry	58.34	57.11	80.7	2.0	12.11 1744.3	6.06 872.1	4.2
	6	6	Dry	63.25	55.02	82.8	2.1	10.11 1456.4	5.06 728.2	4.8

* = Percent by wet weight of sludge.

Table 6-7
UC Test Results for Stabilized Sludge
Pownal Tannery Superfund Site
Pownal, Vermont

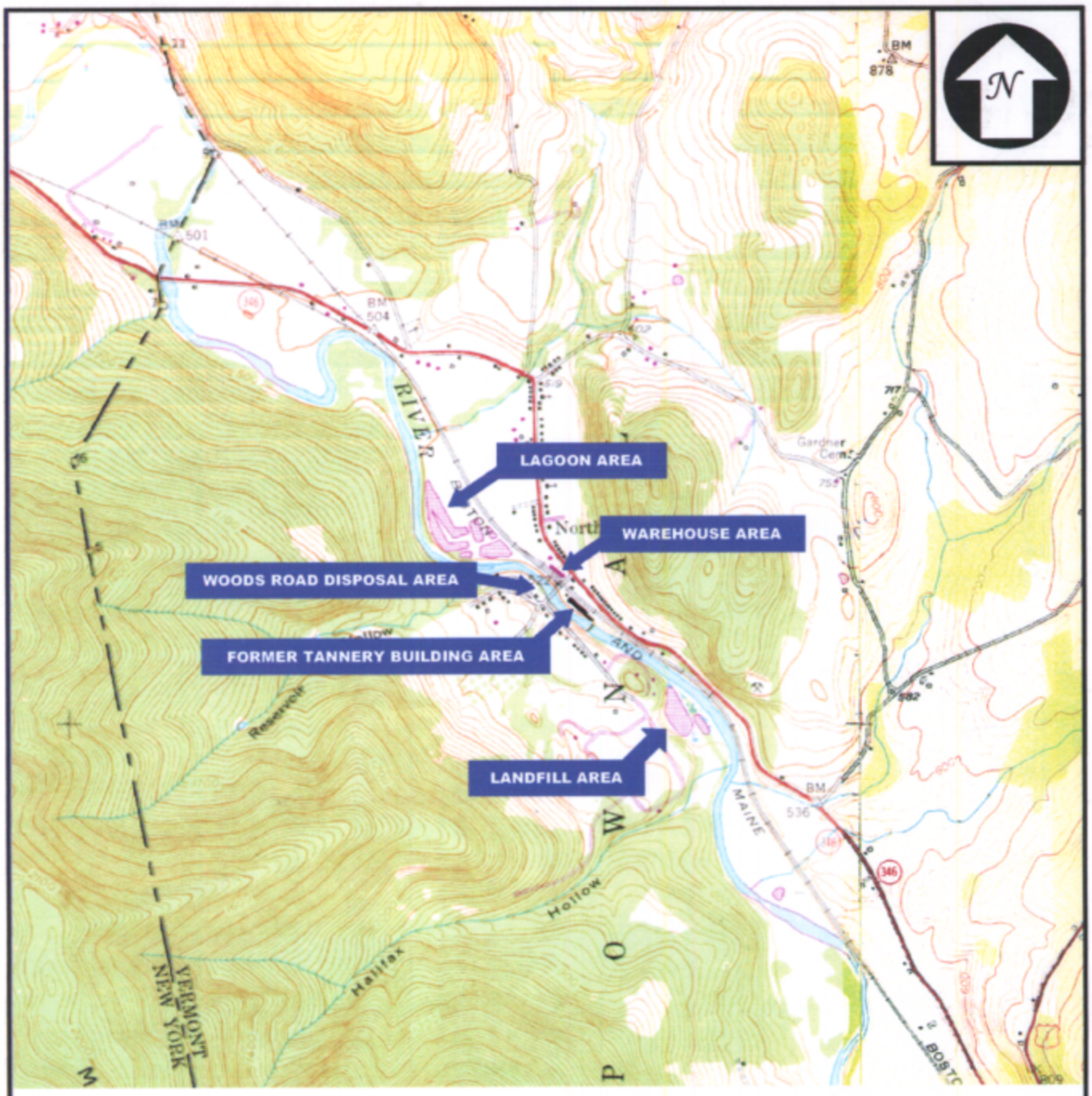
Sample	Additives			7 Day Curing Time						
Location	Lime	Cement	Mixing	w	D.D.	S	e	UCS	Su	Fail. Strain
	(%) by Weight*		State	(%)	(pcf)	(%)		(psi)/(psf)	(psi)/(psf)	(%)
TPL1-102	3		Dry	168.65	28.05	91.3	4.9	5.58 803.7	2.79 401.9	4.6
	5		Dry	157.59	29.71	91.3	4.6	8.71 1253.9	4.35 626.9	3.4
	7		Dry	161.40	29.16	91.5	4.7	7.98 1149.3	3.99 574.7	3.7
TPL1-103		1	Slurry							
		3	Slurry	214.20	22.00	86.9	6.7	1.15 165.6	0.58 82.8	15
		5	Slurry							
TPL5-102		1	Slurry							
		3	Slurry							
		5	Slurry							
TPL1-101		9	Dry							
		9	Slurry							
		11	Dry	73.30	53.60	92.3	2.2	13.50 1944.0	6.75 972.0	3.2
		13	Dry	60.40	59.57	89.2	1.8	23.84 3433.0	11.92 1716.5	2.3
	13		Dry	42.88	62.39	68.0	1.7	9.15 1317.6	4.57 658.8	2.6
	11		Dry	47.26	62.64	75.5	1.7	7.16 1031.6	3.58 515.8	7.4
	10	2	Dry	56.49	56.57	77.1	2.0	9.90 1425.6	4.95 712.8	4
	8	4	Dry	61.93	55.36	81.8	2.0	18.20 2620.8	9.10 1310.4	3.3
	6	6	Dry	59.01	56.24	79.8	2.0	10.65 1533.6	5.33 766.8	2.8

* = Percent by wet weight of sludge.

Table 6-7
UC Test Results for Stabilized Sludge
Pownal Tannery Superfund Site
Pownal, Vermont

Sample	Additives			23 Day Curing Time						
Location	Lime	Cement	Mixing	w	D.D.	S	e	UCS	Su	Fail. Strain
	(%) by Weight*		State	(%)	(pcf)	(%)		(psi)/(psf)	(psi)/(psf)	(%)
TPL1-102	3		Dry							
	5		Dry							
	7		Dry	340.3	17.6	107.5	8.6	13.9 1995.8	6.9 997.9	3.3
TPL1-103		1	Slurry							
		3	Slurry							
		5	Slurry							
TPL5-102		1	Slurry							
		3	Slurry							
		5	Slurry							
TPL1-101		9	Dry							
		9	Slurry							
		11	Dry							
		13	Dry							
	13		Dry							
	11		Dry							
	10	2	Dry							
	8	4	Dry							
	6	6	Dry							

* = Percent by wet weight of sludge.



BASE MAP IS A PORTION OF THE FOLLOWING 7.5' USGS TOPOGRAPHIC QUADRANGLES: POWNAL, VT, 1954; NORTH POWNAL, VT-NY, 1954, PHOTOREVISED 1980

0 1000 2000 3000

approximate scale in feet

Figure 2-1

SITE LOCATION MAP

REMEDIAL INVESTIGATION/FEASIBILITY STUDY
POWNAL TANNERY
POWNAL, VERMONT

Metcalf & Eddy

TRC

Boott Mills South
Foot of John Street
Lowell, MA 01852
978-970-5600

QUADRANGLE LOCATION

VT

TRC PROJ. NO.: 02136-0220-01N91

EPA CONTRACT NO.: 68-W6-0042

RAC SUBCONTRACTOR NO.: 107061

01236/POWNAL/ENVIRON IMPACT/SITE LOCATION

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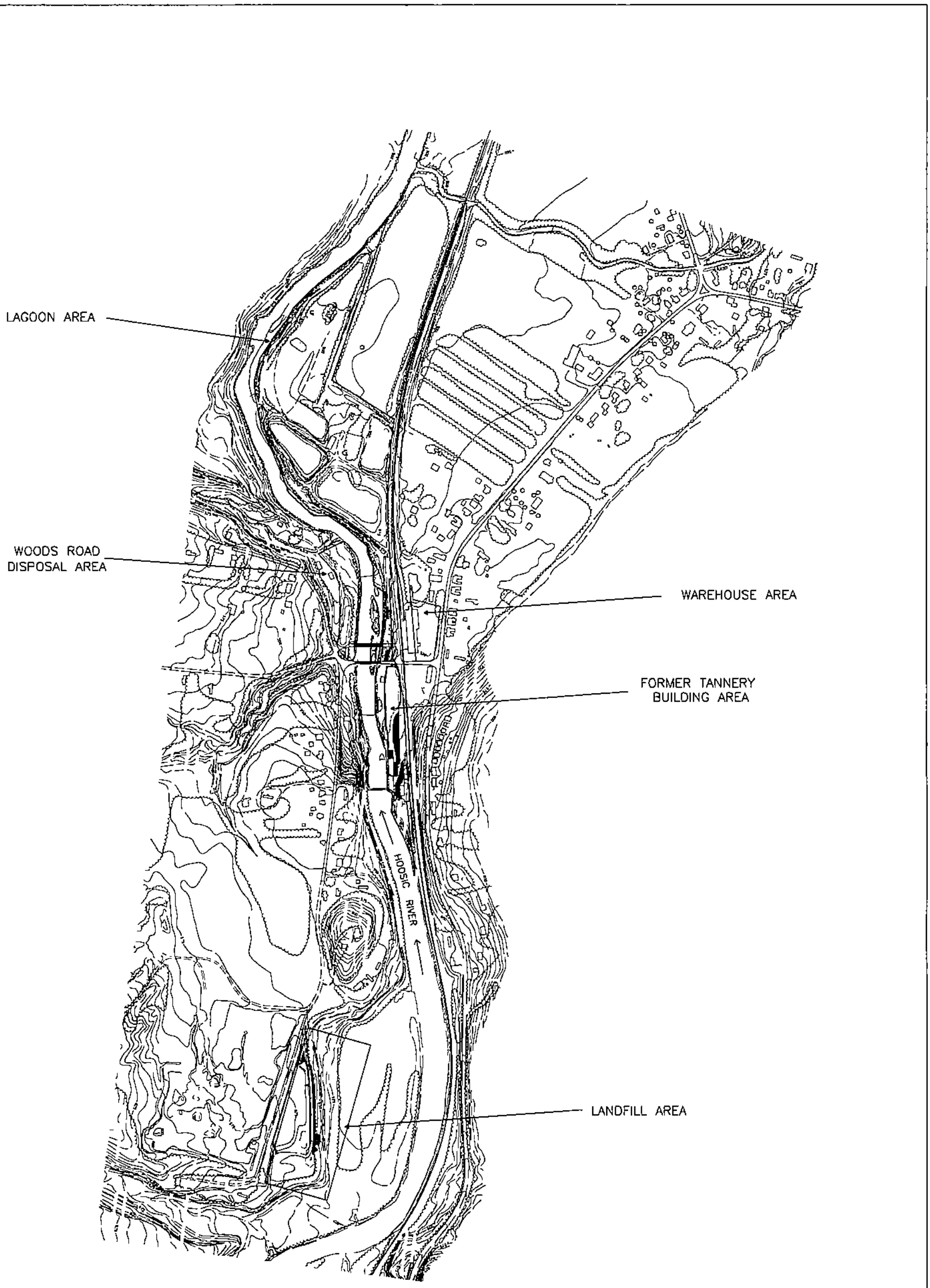


0 200 400 600 800 1000

SCALE IN FEET

LEGEND

TANNERY PROPERTY BOUNDARY

02136/POWNAL/GEOTECH FSP/ SITE PLAN

TRC

Boott Mills South
Foot of John Street
Lowell, MA 01852
978-970-5600

TRC PROJ. NO.: 02136-0220-01N93

EPA CONTRACT NO.: 68-W6-0042

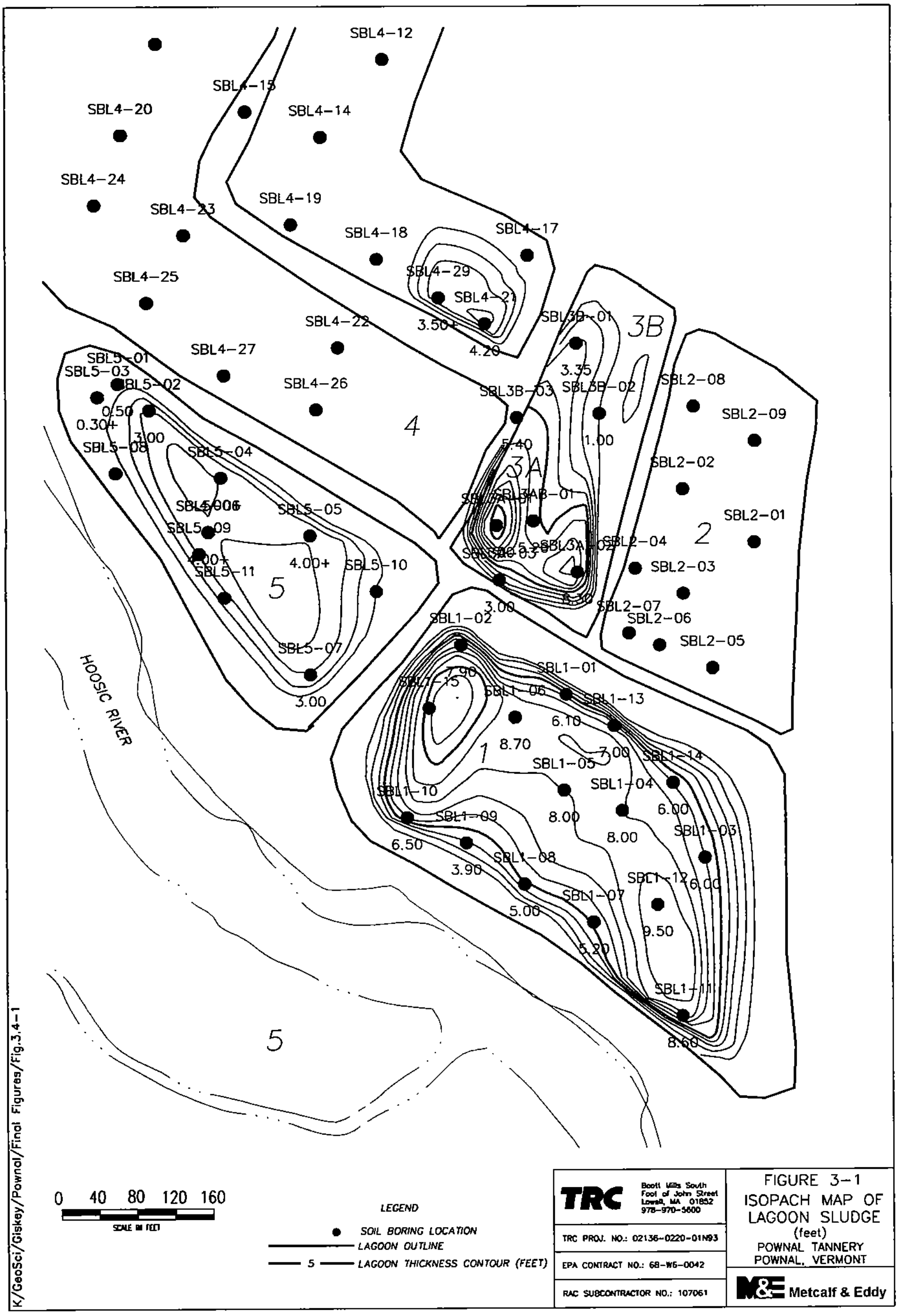
RAC SUBCONTRACTOR NO.: 107061

FIGURE 2-2

SITE PLAN

POWNAL TANNERY
POWNAL, VERMONT

M&E Metcalf & Eddy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SBL3B-01
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4.20
SBL4-27
3.35
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SBL4-26
SBL3B-03
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SBL2-08
SBL2-09
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4
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SBL5-08
SBL5-04
3A
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SBL5-06
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SBL3AB-01
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SBL5-09
SBL3A-02
SBL2-04
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4.00+
4.00+
SBL5-10
SBL5-11
5
SBL2-03
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SBL1-02
SBL2-07
SBL2-06
SBL2-05
SBL5-07
SBL1-01
HOOSIC RIVER
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SBL1-06
SBL1-13
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SBL1-14
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SBL1-07
5.00
9.50
5.20
SBL1-11
8.60
5
0 40 80 120 160
SCALE IN FEET
LEGEND
SOIL BORING LOCATION
LAGOON OUTLINE
5 LAGOON THICKNESS CONTOUR (FEET)
TRC
Booth Mills South
Foot of John Street
Lowell, MA 01852
978-970-5600
TRC PROJ. NO.: 02136-0220-01N93
EPA CONTRACT NO.: 68-W6-0042
RAC SUBCONTRACTOR NO.: 107061
FIGURE 3-1
ISOPACH MAP OF
LAGOON SLUDGE
(feet)
POWNAL TANNERY
POWNAL, VERMONT
M&E Metcalf & Eddy
K/GeoSci/Giskey/Pownal/Final Figures/Fig.3.4-1

APPENDIX A

BORING LOGS AND GEOLOGIC CROSS SECTIONS

TRC Environmental
Boott Mills South, Foot of John Street
Lowell, MA 01852
Telephone: (978)970-5600
Fax: (978)453-1995

BORING/WELL CONSTRUCTION LOG
POWNAL TANNERY

PROJECT NUMBER	02136-0510-01N93	**BORING/WELL NUMBER**	SBL3-101
LOCATION		**DATE DRILLED**	12/4/02
DRILLING CONTRACTOR	Geologic	**CASING TYPE/DIAMETER**	No well installed.
DRILLING METHOD	Drive and Wash 4" Casing	**SCREEN TYPE/SLOT**	No well installed.
SAMPLING METHOD	2' Split Spoon (2"), 140 lb. hammer	**FILTER PACK TYPE**	No well installed.
GROUND ELEVATION		**SEAL TYPE**	Medium Bentonite Chips
TOP OF PVC		**DEPTH TO WATER (Feet)**	
LOGGED BY	A. Hamilton	**GROUND WATER ELEVATION**	

REMARKS Level B; Health & Safety monitoring coducted using PhotoVac 2020 PID & I.S. H2S/LEL Meter

DEPTH (ft. BGL)	BLOW COUNTS	RECOVERY (feet)	SAMPLE ID.	U.S.C.S.	GRAPHIC LOG	LITHOLOGIC DESCRIPTION	FID (ppm)	H2S/LEL (ppm/%)	WELL DIAGRAM
1	17-15 12-12	1.0/2	SBL3-101, 7-9'			Dark brown, medium dense, fine to coarse SAND, trace silt.			
						Grayish-brown, dry, CLAY and SILT.	ND	ND	
2						Grayish-brown, dry, very stiff, CLAY and SILT, trace gravel.			
3	6-12 12-14	0.3/2					ND	ND	
4						No Recovery.			
	12-3	0.0/1					NA	NA	
5						No Recovery.			
	3-3	0.0/1					NA	NA	
6		0.0/0.5				Push spoon from 6 to 6.5 ft. Black sludge in tip.	NA	NA	
		0.5/0.5				Black, wet, SILT and SAND (sludge).	NA	NA	
7						Collect Shelby Tube. Recovery is ~10/29".			
8		10/29"					NA	NA	
9						Collect Shelby Tube. No Recovery.			
10		0/29"					NA	NA	
11						Drive and Wash to 16 ft.			
12									
13									
							NA	NA	
14									
15									

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Fax: (978)453-1995

BORING/WELL CONSTRUCTION LOG
POWNAL TANNERY

PROJECT NUMBER 02136-0510-01N93 **BORING/WELL NUMBER** SBL3-101

DATE DRILLED 12/4/02

DEPTH (ft. BGL)	BLOW COUNTS	RECOVERY (feet)	SAMPLE ID.	U.S.C.S.	GRAPHIC LOG	LITHOLOGIC DESCRIPTION	FID (ppm)	H2S/LEL (ppm/%)	WELL DIAGRAM
									Grout to Surface
16						Black, wet, coarse GRAVEL.			
	41 100/6"	0.4/1					ND	ND	
17						Drive and Wash to 20 ft.			
18									
							NA	NA	
19									
20						Black, coarse GRAVEL.			
						Grayish-brown, wet, dense, fine SAND, trace silt.			
21	14-12 26-29	1.3/2					ND	ND	
22						Black, wet, coarse SAND.			
						Fine SAND.			
23	28-35 34-36	1.6/2				Coarse SAND. Grayish-brown, very dense, fine SAND and SILT.	ND	ND	
24						Grayish-brown, wet, very dense, fine SAND and SILT.			
25	32-27 34-23	0.9/2					ND	ND	
26						Grayish-brown, wet, dense, fine SAND and SILT.			
27	29-28 21-23	0.8/2					ND	ND	
28						Grayish-brown, medium dense, fine SAND w/ some silt and clay.			
29	12-11 11-11	1.8/2				Gray-brown, wet, very stiff, CLAY w/ silt.	ND	ND	
30						End of Boring.			

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BORING/WELL CONSTRUCTION LOG
POWNAL TANNERY

PROJECT NUMBER	02136-0510-01N93	**BORING/WELL NUMBER**	SBL3-102
LOCATION		**DATE DRILLED**	12/4/02 - 12/5/02
DRILLING CONTRACTOR	Geologic	**CASING TYPE/DIAMETER**	No well installed.
DRILLING METHOD	Drive and Wash 4" Casing	**SCREEN TYPE/SLOT**	No well installed.
SAMPLING METHOD	2' Split Spoon (2"), 140 lb. hammer	**FILTER PACK TYPE**	No well installed.
GROUND ELEVATION		**SEAL TYPE**	Medium Bentonite Chips
TOP OF PVC		**DEPTH TO WATER (Feet)**	
LOGGED BY	A. Hamilton	**GROUND WATER ELEVATION**	

REMARKS Level B; Health & Safety monitoring coducted using PhotoVac 2020 PID & I.S. H2S/LEL Meter

DEPTH (ft. BGL)	BLOW COUNTS	RECOVERY (feet)	SAMPLE ID.	U.S.C.S.	GRAPHIC LOG	LITHOLOGIC DESCRIPTION	FID (ppm)	H2S/LEL (ppm/%)	WELL DIAGRAM
1	12-8 4-4	0.45/2				Dark brown, dry, medium dense SAND, some silt. Top 0.1' organics, uniform sand.	ND	ND	
2						Dark brown, dry, medium dense SAND w/ silt, some coarse gravel. Black sludge w/ hair.			
3	4-10 14-4	1.4/2					110	12/ND	
4						Collect Shelby Tube. Recovery is < 9/29"			
5		9/29"	SBL3-102, 4-6'				NA	NA	
6						Collect Shelby Tube. Recovery is 27/29".			
7		27/29"	SBL3-102, 6-8'				NA	NA	
8						Drive and Wash to 13 ft.			
9									
10							NA	NA	
11									
12									
13						Grayish brown, uniform, medium dense, fine SAND.			Grout to Surface
14									

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Fax: (978)453-1995

BORING/WELL CONSTRUCTION LOG
POWNAL TANNERY

PROJECT NUMBER 02136-0510-01N93 **BORING/WELL NUMBER** SBL3-102

DATE DRILLED 12/4/02 - 12/5/02

DEPTH (ft. BGL)	BLOW COUNTS	RECOVERY (feet)	SAMPLE ID.	U.S.C.S.	GRAPHIC LOG	LITHOLOGIC DESCRIPTION	FID (ppm)	H2S/LEL (ppm/%)	WELL DIAGRAM
	6-7 20-43	1.3/2				Blackish-brown, coarse SAND.	ND	ND	
15						Drive and Wash to 20 ft.			
16									
17									
							NA	NA	
18									
19									
20						Rock fragments. Grayish-brown, wet, uniform, dense, fine SAND.			
21	18-17 29-27	1.0/2					ND	ND	
22						Grayish-brown, wet, uniform, very dense, fine SAND.			
23	31-29 35-35	1.7/2					ND	ND	
24						Rock fragments. Grayish-brown, very stiff, CLAY, trace sand and silt.			
25	14-8 15-16	1.8/2					ND	ND	
26						End of Boring.			

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Lowell, MA 01852
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BORING/WELL CONSTRUCTION LOG

POWNAL TANNERY

PROJECT NUMBER	02136-0510-01N93	**BORING/WELL NUMBER**	SBL4-101-A
LOCATION		**DATE DRILLED**	12/2/02
DRILLING CONTRACTOR	Geologic	**CASING TYPE/DIAMETER**	No well installed.
DRILLING METHOD	Drive and Wash 4" Casing	**SCREEN TYPE/SLOT**	No well installed.
SAMPLING METHOD	2' Split Spoon (2"), 140 lb. hammer	**FILTER PACK TYPE**	No well installed.
GROUND ELEVATION		**SEAL TYPE**	Medium Bentonite Chips
TOP OF PVC		**DEPTH TO WATER (Feet)**	
LOGGED BY	A. Hamilton	**GROUND WATER ELEVATION**	

REMARKS Level B; Health & Safety monitoring coducted using PhotoVac 2020 PID & I.S. H2S/LEL Meter

DEPTH (ft. BGL)	BLOW COUNTS	RECOVERY (feet)	SAMPLE ID.	U.S.C.S.	GRAPHIC LOG	LITHOLOGIC DESCRIPTION	FID (ppm)	H2S/LEL (ppm/%)	WELL DIAGRAM
1	2-3 3-4	1.0/2				Brown-gray, SILT and CLAY, trace sand, trace organics and grass at top.	ND	ND	
2						Brown-gray, medium stiff, SILT and CLAY, trace black silt towards bottom.			
3	2-3 5-5	1.0/2					ND	ND	
4						Brownish-gray, moist - wet, medium stiff, SILT and CLAY.			
5	3-3 3-5	0.3/2					ND	ND	
6						Gray-black, wet, very stiff, SILT and CLAY.			
7	2-12 14-18	2.0/2				Black, wet, SILT and SAND (sludge).	ND	ND	
8						Collect Shelby Tube. No Recovery.			
9		0/29"					ND	ND	
10						Grayish-brown, moist, dense, fine SAND and SILT, trace gravel.			
11	12-15 27-45	0.2/2					NA	NA	
12						GRAVEL w/ grayish-brown, moist, dense, fine sand, trace silt.			
13	22-21 18-30	2.0/2	SBL4-101, 12-14'				ND	ND	Grout to Surface
14									

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BORING/WELL CONSTRUCTION LOG
POWNAL TANNERY

PROJECT NUMBER 02136-0510-01N93 **BORING/WELL NUMBER** SBL4-101-A

DATE DRILLED 12/2/02

DEPTH (ft. BGL)	BLOW COUNTS	RECOVERY (feet)	SAMPLE ID.	U.S.C.S.	GRAPHIC LOG	LITHOLOGIC DESCRIPTION	FID (ppm)	H2S/LEL (ppm/%)	WELL DIAGRAM
15						Drive and Wash to 19 ft.	NA	NA	
16									
17									
18									
19						GRAVEL w/ trace, moist sand.			
						Grayish-brown, very dense, fine SAND, trace silt.			
20	8-42 45-45	1.0/2					ND	ND	
21						Drive and Wash to 24 ft.			
22							NA	NA	
23									
24						Wet GRAVEL w/ trace sand and silt.			
						Gray-brown, medium dense, SILT and CLAY, trace fine sand.			
25	24-14 14-20	1.1/2					ND	ND	
26						End of Boring.			

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BORING/WELL CONSTRUCTION LOG
POWNAL TANNERY

PROJECT NUMBER	02136-0510-01N93	**BORING/WELL NUMBER**	SBL4-101-B
LOCATION		**DATE DRILLED**	12/3/02
DRILLING CONTRACTOR	Geologic	**CASING TYPE/DIAMETER**	No well installed.
DRILLING METHOD	Drive and Wash 4" Casing	**SCREEN TYPE/SLOT**	No well installed.
SAMPLING METHOD	2' Split Spoon (2"), 140 lb. hammer	**FILTER PACK TYPE**	No well installed.
GROUND ELEVATION		**SEAL TYPE**	Medium Bentonite Chips
TOP OF PVC		**DEPTH TO WATER (Feet)**	
LOGGED BY	A. Hamilton	**GROUND WATER ELEVATION**	

REMARKS Level B; Health & Safety monitoring coducted using PhotoVac 2020 PID & I.S. H2S/LEL Meter

DEPTH (ft. BGL)	BLOW COUNTS	RECOVERY (feet)	SAMPLE ID.	U.S.C.S.	GRAPHIC LOG	LITHOLOGIC DESCRIPTION	FID (ppm)	H2S/LEL (ppm/%)	WELL DIAGRAM
1						This boring is drilled ~15 ft from SBL4-101-I in an attempt to get good recovery in a Shelby Tube. Drive and Wash to 4 ft.			
2							NA	NA	
3									
4						1" of brown silty sand at top. Black, stiff, SILT w/ trace clay (sludge).			
5	3-5 6-7	2.0/2					217	17/ND	← Grout to Surface
6						Black, stiff, SILT w/ trace clay (sludge).			
7	7-5 3-2	2.0/2					5.8	ND	
8			SBL4-101, 8-10'			Collect Shelby Tube. Recovery is ~20/29".			
9		20/29"					NA	NA	
10						End of Boring.			

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BORING/WELL CONSTRUCTION LOG

POWNAL TANNERY

PROJECT NUMBER	02136-0510-01N93	**BORING/WELL NUMBER**	SBL4-102
LOCATION		**DATE DRILLED**	11/27/02
DRILLING CONTRACTOR	Geologic	**CASING TYPE/DIAMETER**	No well installed.
DRILLING METHOD	Drive and Wash 4" Casing	**SCREEN TYPE/SLOT**	No well installed.
SAMPLING METHOD	2' Split Spoon (2"), 140 lb. hammer	**FILTER PACK TYPE**	No well installed.
GROUND ELEVATION		**SEAL TYPE**	Medium Bentonite Chips
TOP OF PVC		**DEPTH TO WATER (Feet)**	
LOGGED BY	S. Weymouth	**GROUND WATER ELEVATION**	

REMARKS Level B; Health & Safety monitoring coducted using PhotoVac 2020 PID & I.S. H2S/LEL Meter

DEPTH (ft. BGL)	BLOW COUNTS	RECOVERY (feet)	SAMPLE ID.	U.S.C.S.	GRAPHIC LOG	LITHOLOGIC DESCRIPTION	FID (ppm)	RAS/DAS ID#	WELL DIAGRAM
1	3-4 4-3	1.0/2				Green-brown, moist, loose, SILT and fine SAND, trace medium sand, roots.	NA		
2						Drive and Wash to 4 ft.			
3									
4						Green-brown, wet, loose, fine SAND, trace silt, some rusty mottling.			
5	5-4 4-11	1.1/2					NA		
6						Drive and Wash to 9 ft.			
7									
8									
9						Green-brown, wet, dense, fine SAND and GRAVEL.			
						Green-brown, wet, dense, fine SAND.			
10	19-15 15-21	1.0/2				SAND and GRAVEL. (From boring logs SBL4-23 through SBL4-27)	NA		← Grout to Surface
11						Drive and Wash to 14 ft.			
12									
13									
14									

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BORING/WELL CONSTRUCTION LOG

POWNAL TANNERY

PROJECT NUMBER 02136-0510-01N93 **BORING/WELL NUMBER** SBL4-102

DATE DRILLED 11/27/02

DEPTH (ft. BGL)	BLOW COUNTS	RECOVERY (feet)	SAMPLE ID.	U.S.C.S.	GRAPHIC LOG	LITHOLOGIC DESCRIPTION	FID (ppm)	RAS/DAS ID#	WELL DIAGRAM
						Green-brown, wet, medium dense, fine SAND.			
15	8-8 9-10	1.3/2				Gray, wet, very stiff, CLAY, little silt and fine sand.	NA		
16						Drive and Wash to 19 ft.			
17									
18									
19						Gray, moist, stiff, CLAY.			
20	2-4 5-7	1.9/2					NA		
21						End of Boring.			

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BORING/WELL CONSTRUCTION LOG
POWNAL TANNERY

PROJECT NUMBER 02136-0510-01N93
BORING/WELL NUMBER SBL4-103
LOCATION
DATE DRILLED 11/26/02
DRILLING CONTRACTOR Geologic
CASING TYPE/DIAMETER No well installed.
DRILLING METHOD Drive and Wash 4" Casing
SCREEN TYPE/SLOT No well installed.
SAMPLING METHOD 2' Split Spoon (2"), 140 lb. hammer
FILTER PACK TYPE No well installed.
GROUND ELEVATION
SEAL TYPE Medium Bentonite Chips
TOP OF PVC
DEPTH TO WATER (Feet)
LOGGED BY S. Weymouth
GROUND WATER ELEVATION
REMARKS Health & Safety monitoring coducted using PhotoVac 2020 PID & I.S. H2S/LEL Meter

DEPTH (ft. BGL)	BLOW COUNTS	RECOVERY (feet)	SAMPLE ID.	U.S.C.S.	GRAPHIC LOG	LITHOLOGIC DESCRIPTION	FID (ppm)	RAS/DAS ID#	WELL DIAGRAM
1	2-4 6-7	1.5/2				Green-gray, moist, loose to medium dense, SILT, little fine sand, trace medium sand, rusty layering roots.	NA		
2						Drive and Wash to 4 ft.			
3							NA		
4						Green-brown, wet, medium dense, SILT and fine SAND, rusty layering.			
5	3-2 12-35	1.35/2				Green-brown, wet, medium dense, SILT and fine to coarse SAND, little fine to medium gravel.	NA		
6						Drive and Wash to 9 ft. Brown/olive, saturated, poorly sorted SAND and GRAVEL, trace silt. (From boring log SBL4-12)			
7							NA		
8									
9						Slough.			
10	11-12 10-6	0.65/2				Green-gray, moist, medium stiff, CLAY, little silt and fine to coarse sand.	NA		
11						Drive and Wash to 15 ft.			
12									
13							NA		
14									

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BORING/WELL CONSTRUCTION LOG
POWNAL TANNERY

PROJECT NUMBER 02136-0510-01N93 **BORING/WELL NUMBER** SBL4-103

DATE DRILLED 11/26/02

DEPTH (ft. BGL)	BLOW COUNTS	RECOVERY (feet)	SAMPLE ID.	U.S.C.S.	GRAPHIC LOG	LITHOLOGIC DESCRIPTION	FID (ppm)	RAS/DAS ID#	WELL DIAGRAM
15						Gray, moist, stiff, CLAY, trace silt and fine to coarse sand, rolls to 1/16".			
16	2-4 6-7	2.0/2					NA		
17						Collect Shelby Tube. No Recovery.			
18		0/29"					NA		
19			SBL4-103, 19-21'			Collect Shelby Tube. Recovery is 17/30".			
20		17"/29"					NA		
21						Collect Shelby Tube. No Recovery.			
22		0/29"					NA		
23						Collect Shelby Tube. No Recovery.			
24		0/29"					NA		
25			SBL4-103, 25-27			Collect Shelby Tube. Recovery is 26/30".			
26		26"/29"					NA		
27						Drive and Wash to 29 ft.			
28							NA		
29						Gray, moist, medium stiff, CLAY, trace silt and fine sand in <1mm layers spaced >1 ft apart. Rolls to 1/16".			
30									

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BORING/WELL CONSTRUCTION LOG
POWNAL TANNERY

PROJECT NUMBER 02136-0510-01N93 **BORING/WELL NUMBER** SBL4-103

DATE DRILLED 11/26/02

DEPTH (ft. BGL)	BLOW COUNTS	RECOVERY (feet)	SAMPLE ID.	U.S.C.S.	GRAPHIC LOG	LITHOLOGIC DESCRIPTION	FID (ppm)	RAS/DAS ID#	WELL DIAGRAM
	2-3 4-6	2.0/2					NA		
31						Drive and Wash to 34 ft.			
32							NA		
33									
34						Gray, moist, medium stiff CLAY, trace silt and fine sand in <1mm layers spaced >1 ft apart. Rolls to 1/16".			
35	2-2 3-4	2.0/2					NA		← Grout to Surface
36						Drive and Wash to 39 ft.			
37							NA		
38									
39						Gray, moist, soft to medium stiff, CLAY, trace silt and fine sand in <1mm layers spaced >1 ft apart. Rolls to 1/16".			
40	2-2 2-5	2.0/2					NA		
41						Drive and Wash to 44 ft.			
42							NA		
43									
44						Gray, moist, medium stiff CLAY. Rolls to 1/16".			
45	2-2 3-4	2.0/2					NA		
46									

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PROJECT NUMBER 02136-0510-01N93 **BORING/WELL NUMBER** SBL4-103

DATE DRILLED 11/26/02

DEPTH (ft. BGL)	BLOW COUNTS	RECOVERY (feet)	SAMPLE ID.	U.S.C.S.	GRAPHIC LOG	LITHOLOGIC DESCRIPTION	FID (ppm)	RAS/DAS ID#	WELL DIAGRAM
47						Drive and Wash to 49 ft.	NA		
48									
49						Gray, moist, soft to medium stiff CLAY. Rolls to 1/16".			
50	1-2 2-4	2.0/2					NA		
51						Drive and Wash to 54 ft.			
52							NA		
53									
54						Gray, moist, medium stiff CLAY. Rolls to 1/16".			
55	1-3 4-4	2.0/2					NA		
56						Drive and Wash to 59 ft.			
57							NA		
58									
59						Gray, moist, medium stiff CLAY. Rolls to 1/16".			
60	WOR-3 3-4	2.0/2					NA		
61						Drive and Wash to 64 ft.			
62									

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POWNAL TANNERY

PROJECT NUMBER 02136-0510-01N93 **BORING/WELL NUMBER** SBL4-103

DATE DRILLED 11/26/02

DEPTH (ft. BGL)	BLOW COUNTS	RECOVERY (feet)	SAMPLE ID.	U.S.C.S.	GRAPHIC LOG	LITHOLOGIC DESCRIPTION	FID (ppm)	RAS/DAS ID#	WELL DIAGRAM
63							NA		
64						Gray, moist to wet at bottom, medium stiff to stiff CLAY, trace silt and fine sand. Increasing silt and fine sand towards bottom of spoon, no longer cohesive.			
65	2-4 4-7	2.0/2					NA		
66						Drive and Wash to 69 ft.			
67									
68							NA		
69						Gray, moist to wet, medium stiff CLAY and SILT. Open boring in clay starting to collapse due to increased silt.			
70	3-3 4-4	2.0/2					NA		
71						End of Boring.			

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BORING/WELL CONSTRUCTION LOG
POWNAL TANNERY

PROJECT NUMBER 02136-0510-01N93
BORING/WELL NUMBER SBL4-104
LOCATION
DATE DRILLED 11/25/02
DRILLING CONTRACTOR Geologic
CASING TYPE/DIAMETER No well installed.
DRILLING METHOD Drive and Wash 4" Casing
SCREEN TYPE/SLOT No well installed.
SAMPLING METHOD 2' Split Spoon (2"), 140 lb. hammer
FILTER PACK TYPE No well installed.
GROUND ELEVATION
SEAL TYPE Medium Bentonite Chips
TOP OF PVC
DEPTH TO WATER (Feet)
LOGGED BY S. Weymouth
GROUND WATER ELEVATION
REMARKS Health & Safety monitoring coducted using PhotoVac 2020 PID & I.S. H2S/LEL Meter

DEPTH (ft. BGL)	BLOW COUNTS	RECOVERY (feet)	SAMPLE ID.	U.S.C.S.	GRAPHIC LOG	LITHOLOGIC DESCRIPTION	FID (ppm)	H2S/LEL (ppm/%)	WELL DIAGRAM
1	3-6 10-12	1.25/2				Green-gray, moist, loose to medium dense, SILT, little to some fine sand, rusty layering, roots.	NA	NA	
2						Drive and Wash to 4 ft.			
3							NA	NA	
4						Brown-gray-green, wet, very dense, fine to coarse SAND and GRAVEL, rock in tip, poor recovery.			
5	8-18 40-33	0.65/2					NA	NA	
6						Drive and Wash to 9 ft.			
7									
8							NA	NA	
9						Green-gray, wet, medium dense, SILT, little fine sand.			
10	25-10 10-13	0.6/2					NA	NA	← Grout to Surface
11						Drive and Wash to 14 ft.			
12									
13							NA	NA	
14									

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POWNAL TANNERY

PROJECT NUMBER 02136-0510-01N93 **BORING/WELL NUMBER** SBL4-104

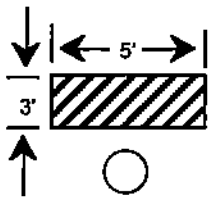
DATE DRILLED 11/25/02

DEPTH (ft. BGL)	BLOW COUNTS	RECOVERY (feet)	SAMPLE ID.	U.S.C.S.	GRAPHIC LOG	LITHOLOGIC DESCRIPTION	FID (ppm)	H2S/LEL (ppm/%)	WELL DIAGRAM
15	4-4 8-9	2.0/2				Gray, moist, stiff, CLAY, trace silt and fine to coarse sand, rolls to 1/16". Clay first encountered at ~13 ft according to driller.	NA	NA	
16						Drive and Wash to 19 ft.			
17							NA	NA	
18									
19						Gray, moist, stiff, CLAY, trace silt and fine sand, rolls to 1/16". This sample has more silt and fine sand than 14-16 ft interval.			
20	2-4 5-6	2.0/2					NA	NA	
21						End of Boring.			

TRC	Project: Pownal Tannery - Geotech	Date: 12/5/02	Sheet 1 of 1
Test Pit Log	Contractor Personnel: Geologic / John	TRC Personnel: S. Weymouth	
Equipment/Contractor Used: JCB JS220L	Location: Lagoon 1	Test Pit Number: TPL1 – 101	
Reach/Capacity: 20 ft	Total Depth: 11 ft.	Piezometer Installed? No	
Depth to Ground Water: 9-10 ft.	Weather: Cold, cloudy, 24°F	Elevation: NA Top of Pit: NA	

Depth	Sample Number	Stratigraphic Description	REMARKS:
1 – 3		Olive-gray, moist, CLAY and SILT, little fine to coarse gravel, roots/organics.	Clay and Silt
3 – 10		Black-blue-gray, moist, organic SILT and CLAY, hair. Different colored layers are varved.	Sludge Air readings over pile: H_2S = 5 ppm PID = 120 ppm LEL = 0%
10		Black, wet, SAND and GRAVEL, little silt.	Gravel

TEST PIT PLAN



Vol. = _____ cu. yd.

PROPORTIONS USED

Trace (TR).	0 - 10%
Little (LI.)	10 - 20%
Some (SO.)	20 - 35%
And	35 - 50%

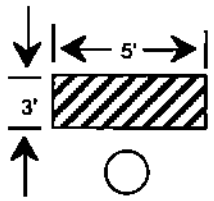
GRAIN SIZE

Boulder	>203 mm	>8 in.
Cobble	76 - 203 mm	3 - 8 in.
C. Gravel	19 - 76 mm	3/4 - 3 in.
F. Gravel	4.75 - 19 mm	3/16 - 3/4 in.
C. Sand	2.0 - 4.75 mm	5/64 - 3/16 in.
M. Sand	0.4 - 2.0 mm	1/64 - 5/64 in.
F. Sand	0.075 - 0.4 mm	
Silt	0.002 - 0.075 mm	
Clay	<0.002 mm	

TRC	Project: Pownal Tannery - Geotech	Date: 12/5/02	Sheet 1 of 1
Test Pit Log	Contractor Personnel: Geologic / John	TRC Personnel: S. Weymouth	
Equipment/Contractor Used: JCB JS220L	Location: Lagoon 2	Test Pit Number: TPL1 – 102	
Reach/Capacity: 20 ft	Total Depth: ~10 ft.	Piezometer Installed? No	
Depth to Ground Water: 9 ft.	Weather: Cold, cloudy, 24°F	Elevation: NA Top of Pit: NA	

Depth	Sample Number	Stratigraphic Description	REMARKS:
1		Olive-gray, moist, CLAY and SILT, little fine to coarse gravel, roots/organics.	Clay and Silt
2–8		Black-gray-blue, moist, organic SILT and CLAY, hair. Different colored layers are varved.	Sludge Air readings over pile: H_2S = 30 ppm PID = 415 ppm LEL = 0%
9		Black, wet, SAND and GRAVEL, little silt.	Gravel
10		End of Test Pit.	

TEST PIT PLAN



Vol. = _____ cu. yd.

PROPORTIONS USED

Trace (TR).	0 - 10%
Little (LI.)	10 - 20%
Some (SO.)	20 - 35%
And	35 - 50%

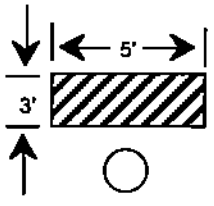
GRAIN SIZE

Boulder	>203 mm	>8 in.
Cobble	76 - 203 mm	3 - 8 in.
C. Gravel	19 - 76 mm	3/4 - 3 in.
F. Gravel	4.75 - 19 mm	3/16 - 3/4 in.
C. Sand	2.0 - 4.75 mm	5/64 - 3/16 in.
M. Sand	0.4 - 2.0 mm	1/64 - 5/64 in.
F. Sand	0.075 - 0.4 mm	
Silt	0.002 - 0.075 mm	
Clay	<0.002 mm	

TRC	Project: Pownal Tannery - Geotech	Date: 12/5/02	Sheet 1 of 1
Test Pit Log	Contractor Personnel: Geologic / John	TRC Personnel: S. Weymouth	
Equipment/Contractor Used: JCB JS220L	Location: Lagoon 1	Test Pit Number: TPL1 – 103	
Reach/Capacity: 20 ft	Total Depth: 10 ft.	Piezometer Installed? No	
Depth to Ground Water: 8-9 ft.	Weather: Cold, cloudy, 24°F	Elevation: NA Top of Pit: NA	

Depth	Sample Number	Stratigraphic Description	REMARKS:
1		Olive-gray, moist, CLAY and SILT, little fine to coarse gravel, roots/organics.	Clay and Silt
2–8		Black-gray-blue, moist, organic SILT and CLAY, hair. Different colored layers are varved.	Sludge Air readings over pile: H_2S = 140 ppm PID = 300 ppm LEL = 0%
9		Black, wet, SAND and GRAVEL, little silt.	Gravel
10		End of Test Pit.	

TEST PIT PLAN



Vol. = _____ cu. yd.

PROPORTIONS USED

Trace (TR).	0 - 10%
Little (LI.)	10 - 20%
Some (SO.)	20 - 35%
And	35 - 50%

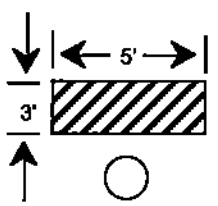
GRAIN SIZE

Boulder	>203 mm	>8 in.
Cobble	76 - 203 mm	3 - 8 in.
C. Gravel	19 - 76 mm	3/4 - 3 in.
F. Gravel	4.75 - 19 mm	3/16 - 3/4 in.
C. Sand	2.0 - 4.75 mm	5/64 - 3/16 In.
M. Sand	0.4 - 2.0 mm	1/64 - 5/64 in.
F. Sand	0.075 - 0.4 mm	
Silt	0.002 - 0.075 mm	
Clay	<0.002 mm	

TRC	Project: Pownal Tannery - Geotech	Date: 12/2/02	Sheet 1 of 1
Test Pit Log	Contractor Personnel: Geologic / John	TRC Personnel: S. Weymouth	
Equipment/Contractor Used: JCB JS220L	Location: Lagoon 5	Test Pit Number: TPL5 – 101	
Reach/Capacity: 20 ft	Total Depth: ~7 ft.	Piezometer Installed? No	
Depth to Ground Water: 6 ft.	Weather: Cold, 28°F, west wind	Elevation: NA Top of Pit: NA	

Depth	Sample Number	Stratigraphic Description	REMARKS:
1 – 2		Brown-gray, moist, fine to coarse SAND and GRAVEL, roots.	Fill H_2S/LEL = ND
3 – 5		Black-gray, moist, SILT and CLAY, hair/leather pieces, purple gel. Rotten egg shell smell. Silt and clay layers are similar to varves.	Sludge H_2S/LEL = ND
6		Black, saturated, fine to coarse SAND and GRAVEL and Cobbles.	Gravel
7		End of Test Pit due to water/cave-in.	
8 – 10			

TEST PIT PLAN



Vol. = _____ cu. yd.

PROPORTIONS USED

Trace (TR).	0 - 10%
Little (LI.)	10 - 20%
Some (SO.)	20 - 35%
And	35 - 50%

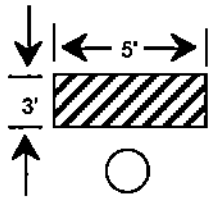
GRAIN SIZE

Boulder	>203 mm	>8 in.
Cobble	76 - 203 mm	3 - 8 in.
C. Gravel	19 - 76 mm	3/4 - 3 in.
F. Gravel	4.75 - 19 mm	3/16 - 3/4 in.
C. Sand	2.0 - 4.75 mm	5/64 - 3/16 in.
M. Sand	0.4 - 2.0 mm	1/64 - 5/64 in.
F. Sand	0.075 - 0.4 mm	
Silt	0.002 - 0.075 mm	
Clay	<0.002 mm	

TRC	Project: Pownal Tannery - Geotech	Date: 12/2/02	Sheet 1 of 1
Test Pit Log	Contractor Personnel: Geologic / John	TRC Personnel: S. Weymouth	
Equipment/Contractor Used: JCB JS220L	Location: Lagoon 5	Test Pit Number: TPL5 – 102	
Reach/Capacity: 20 ft	Total Depth: ~5 ft.	Piezometer Installed? No	
Depth to Ground Water: Test Pit under water	Weather: Cold, 28°F, west wind	Elevation: NA Top of Pit: NA	

Depth	Sample Number	Stratigraphic Description	REMARKS:
		Green, saturated, silty SAND, rotten egg smell. Top 2 ft of test pit is water.	
1–2		Black-green-purple, moist, SILT and CLAY, yellow-purple gel substance. Strong rotten egg odor. Silt and clay layers are similar to varves.	Sludge Layer Air readings over pile: H_2S = ND PID = ND LEL = 0%
3–4		Black, saturated, fine to coarse SAND and GRAVEL, cobbles, some silt.	Gravel Layer
5		End of Test Pit due to cave-in.	
6			
7			
8			
9			
10			

TEST PIT PLAN



Vol. = _____ cu. yd.

PROPORTIONS USED

Trace (TR).	0 - 10%
Little (LI.)	10 - 20%
Some (SO.)	20 - 35%
And	35 - 50%

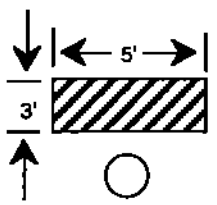
GRAIN SIZE

Boulder	>203 mm	>8 in.
Cobble	76 - 203 mm	3 - 8 in.
C. Gravel	19 - 76 mm	3/4 - 3 in.
F. Gravel	4.75 - 19 mm	3/16 - 3/4 in.
C. Sand	2.0 - 4.75 mm	5/64 - 3/16 in.
M. Sand	0.4 - 2.0 mm	1/64 - 5/64 in.
F. Sand	0.075 - 0.4 mm	
Silt	0.002 - 0.075 mm	
Clay	<0.002 mm	

TRC	Project: Pownal Tannery - Geotech	Date: 12/3/02	Sheet 1 of 1
Test Pit Log	Contractor Personnel: Geologic / John	TRC Personnel: S. Weymouth	
Equipment/Contractor Used: JCB JS220L	Location: Lagoon 5	Test Pit Number: TPL5 – 103	
Reach/Capacity: 20 ft	Total Depth: ~5 ft.	Piezometer Installed? No	
Depth to Ground Water: Test Pit under water	Weather: Cold, 21°F	Elevation: NA Top of Pit: NA	

Depth	Sample Number	Stratigraphic Description	REMARKS:
		Brown, wet, fine to coarse SAND and GRAVEL, organics. Top 1 ft of test pit is under water.	
1 – 3		Black-gray-purple, moist, SILT and CLAY, little fine to coarse sand, trace gravel, hair. Silt/clay layers are similar to varves. Increasing sand towards bottom.	Sludge
4		Black, saturated, fine to coarse SAND and GRAVEL, trace cobbles, trace silt.	Sand and Gravel
5		End of Test Pit.	Air readings over pile: H_2S = ND PID = ND LEL = 0%
6 – 10			

TEST PIT PLAN



Vol. = _____ cu. yd.

PROPORTIONS USED

Trace (TR).	0 - 10%
Little (LI.)	10 - 20%
Some (SO.)	20 - 35%
And	35 - 50%

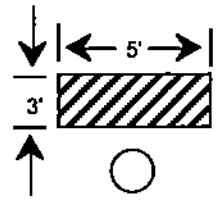
GRAIN SIZE

Boulder	>203 mm	>8 in.
Cobble	76 - 203 mm	3 - 8 in.
C. Gravel	19 - 76 mm	3/4 - 3 in.
F. Gravel	4.75 - 19 mm	3/16 - 3/4 in.
C. Sand	2.0 - 4.75 mm	5/64 - 3/16 in.
M. Sand	0.4 - 2.0 mm	1/64 - 5/64 in.
F. Sand	0.075 - 0.4 mm	
Silt	0.002 - 0.075 mm	
Clay	<0.002 mm	

TRC	Project: Pownal Tannery - Geotech	Date: 12/4/02	Sheet 1 of 1
Test Pit Log	Contractor Personnel: Geologic / John	TRC Personnel: S. Weymouth	
Equipment/Contractor Used: JCB JS220L	Location: Lagoon 5	Test Pit Number: TPL5 – 104	
Reach/Capacity: 20 ft	Total Depth: 7 ft.	Piezometer Installed? No	
Depth to Ground Water: 6 ft.	Weather: Cold, 20°F	Elevation: NA Top of Pit: NA	

Depth	Sample Number	Stratigraphic Description	REMARKS:
1–3		Brown, moist, fine SAND and SILT, little medium to coarse sand, trace fine sand.	Sandy Fill
3–6		Black, moist, fine SAND, trace medium sand, trace silt, hair. Slight odor of rotten egg.	Sludge Air readings over pile: H_2S = ND PID = ND LEL = 0%
6–7		Black, saturated, GRAVEL, water pours in little silt.	Gravel
7–10		End of Test Pit	

TEST PIT PLAN



Vol. = _____ cu. yd.

PROPORTIONS USED

Trace (TR).	0 - 10%
Little (LI.)	10 - 20%
Some (SO.)	20 - 35%
And	35 - 50%

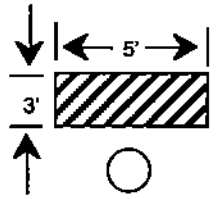
GRAIN SIZE

Boulder	>203 mm	>8 in.
Cobble	76 - 203 mm	3 - 8 in.
C. Gravel	19 - 76 mm	3/4 - 3 in.
F. Gravel	4.75 - 19 mm	3/16 - 3/4 in.
C. Sand	2.0 - 4.75 mm	5/64 - 3/16 in.
M. Sand	0.4 - 2.0 mm	1/64 - 5/64 in.
F. Sand	0.075 - 0.4 mm	
Silt	0.002 - 0.075 mm	
Clay	<0.002 mm	

TRC	Project: Pownal Tannery - Geotech	Date: 12/4/02	Sheet 1 of 1
Test Pit Log	Contractor Personnel: Geologic / John	TRC Personnel: S. Weymouth	
Equipment/Contractor Used: JCB JS220L	Location: Lagoon 5	Test Pit Number: TPL5 – 105	
Reach/Capacity: 20 ft	Total Depth: 10 ft.	Piezometer Installed? No	
Depth to Ground Water: 9 ft.	Weather: Cold, 20°F	Elevation: NA Top of Pit: NA	

Depth	Sample Number	Stratigraphic Description	REMARKS:
1 – 5		Brown, moist, fine SAND and SILT, little fine to coarse gravel.	FILL
6 – 9		Green-black, moist to wet, fine to medium sand, trace coarse sand, trace fine gravel, hair.	Sludge? Air readings over pile: H_2S = ND PID = ND LEL = 0% wood
9 – 10		Black, saturated, GRAVEL, little silt.	Gravel
10		End of Test Pit.	

TEST PIT PLAN



North

Vol. = _____ cu. yd.

PROPORTIONS USED

Trace (TR).	0 - 10%
Little (LI.)	10 - 20%
Some (SO.)	20 - 35%
And	35 - 50%

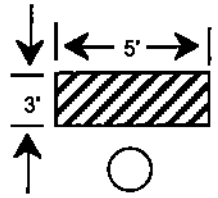
GRAIN SIZE

Boulder	>203 mm	>8 in.
Cobble	76 - 203 mm	3 - 8 in.
C. Gravel	19 - 76 mm	3/4 - 3 in.
F. Gravel	4.75 - 19 mm	3/16 - 3/4 in.
C. Sand	2.0 - 4.75 mm	5/64 - 3/16 in.
M. Sand	0.4 - 2.0 mm	1/64 - 5/64 in.
F. Sand	0.075 - 0.4 mm	
Silt	0.002 - 0.075 mm	
Clay	<0.002 mm	

TRC	Project: Pownal Tannery - Geotech	Date: 12/4/02	Sheet 1 of 1
Test Pit Log	Contractor Personnel: Geologic / John	TRC Personnel: S. Weymouth	
Equipment/Contractor Used: JCB JS220L	Location: Lagoon 5	Test Pit Number: TPL5 – 106	
Reach/Capacity: 20 ft	Total Depth: 10 ft.	Piezometer Installed? No	
Depth to Ground Water: 8 ft.	Weather: Cold, 20°F	Elevation: NA Top of Pit: NA	

Depth	Sample Number	Stratigraphic Description	REMARKS:
1 – 4		Brown, moist, fine SAND and SILT, little fine to coarse gravel.	Fill
5		Black-gray, moist, SILT and fine SAND, hair.	Sludge –pinches out Air readings over pile: H_2S = ND PID = ND LEL = 0%
7		Brown, moist to wet, fine SAND and SILT, little fine to coarse gravel.	Fill
8 – 9		Black, saturated, GRAVEL, little fine to coarse sand, little silt.	Gravel
10		End of Test Pit.	

TEST PIT PLAN



Vol. = _____ cu. yd.

PROPORTIONS USED

Trace (TR).	0 - 10%
Little (LI.)	10 - 20%
Some (SO.)	20 - 35%
And	35 - 50%

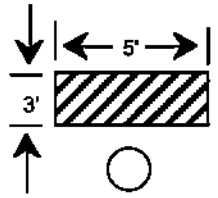
GRAIN SIZE

Boulder	>203 mm	>8 in.
Cobble	76 - 203 mm	3 - 8 in.
C. Gravel	19 - 76 mm	3/4 - 3 in.
F. Gravel	4.75 - 19 mm	3/16 - 3/4 in.
C. Sand	2.0 - 4.75 mm	5/64 - 3/16 in.
M. Sand	0.4 - 2.0 mm	1/64 - 5/64 in.
F. Sand	0.075 - 0.4 mm	
Silt	0.002 - 0.075 mm	
Clay	<0.002 mm	

TRC	Project: Pownal Tannery - Geotech	Date: 12/4/02	Sheet 1 of 1
Test Pit Log	Contractor Personnel: Geologic / John	TRC Personnel: S. Weymouth	
Equipment/Contractor Used: JCB JS220L	Location: Lagoon 5	Test Pit Number: TPL5 – 107	
Reach/Capacity: 20 ft	Total Depth: 9 ft.	Piezometer Installed? No	
Depth to Ground Water: 7 ft.	Weather: Cold, 20°F	Elevation: NA Top of Pit: NA	

Depth	Sample Number	Stratigraphic Description	REMARKS:
1–4		Brown, moist, fine SAND and SILT, little fine to coarse gravel.	Fill Air readings over pile: H_2S = ND PID = ND LEL = 0%
5		Black-gray, moist, SILT and fine SAND, hair.	Sludge – pinches out
6		Brown, moist to wet, fine SAND and SILT, little fine to coarse gravel.	Fill
7–8		Black, saturated, GRAVEL, little fine to coarse sand, little silt.	Gravel
9		End of Test Pit.	
10			

TEST PIT PLAN



Vol. = _____ cu. yd.

PROPORTIONS USED

Trace (TR).	0 - 10%
Little (LI.)	10 - 20%
Some (SO.)	20 - 35%
And	35 - 50%

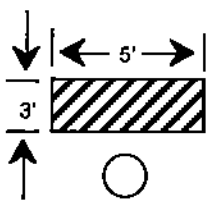
GRAIN SIZE

Boulder	>203 mm	>8 in.
Cobble	76 - 203 mm	3 - 8 in.
C. Gravel	19 - 76 mm	3/4 - 3 in.
F. Gravel	4.75 - 19 mm	3/16 - 3/4 in.
C. Sand	2.0 - 4.75 mm	5/64 - 3/16 in.
M. Sand	0.4 - 2.0 mm	1/64 - 5/64 in.
F. Sand	0.075 - 0.4 mm	
Silt	0.002 - 0.075 mm	
Clay	<0.002 mm	

TRC	Project: Pownal Tannery - Geotech	Date: 12/4/02	Sheet 1 of 1
Test Pit Log	Contractor Personnel: Geologic / John	TRC Personnel: S. Weymouth	
Equipment/Contractor Used: JCB JS220L	Location: Berm btw. L1 and L2 and river	Test Pit Number: TPB – 101	
Reach/Capacity: 20 ft	Total Depth: 8 ft.	Piezometer Installed? No	
Depth to Ground Water: ~6 ft.	Weather: Cold, 20°F, clear	Elevation: NA Top of Pit: NA	

Depth	Sample Number	Stratigraphic Description	REMARKS:
1 – 4		Brown, moist, fine SAND and SILT, little medium to coarse sand, trace gravel.	Sand
4 – 6		Brown, moist to wet, SAND and GRAVEL, trace silt. Gravel is rounded.	Gravel
6 – 8		Black, wet, SAND and GRAVEL, trace silt. Gravel is rounded.	Gravel
8 – 10		End of Test Pit.	

TEST PIT PLAN



Vol. = _____ cu. yd.

PROPORTIONS USED

Trace (TR).	0 - 10%
Little (LI.)	10 - 20%
Some (SO.)	20 - 35%
And	35 - 50%

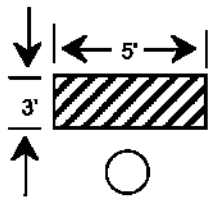
GRAIN SIZE

Boulder	>203 mm	>8 in.
Cobble	76 - 203 mm	3 - 8 in.
C. Gravel	19 - 76 mm	3/4 - 3 in.
F. Gravel	4.75 - 19 mm	3/16 - 3/4 in.
C. Sand	2.0 - 4.75 mm	5/64 - 3/16 in.
M. Sand	0.4 - 2.0 mm	1/64 - 5/64 in.
F. Sand	0.075 - 0.4 mm	
Silt	0.002 - 0.075 mm	
Clay	<0.002 mm	

TRC	Project: Pownal Tannery - Geotech	Date: 12/4/02	Sheet 1 of 1
Test Pit Log	Contractor Personnel: Geologic / John	TRC Personnel: S. Weymouth	
Equipment/Contractor Used: JCB JS220L	Location: Berm bt. L1 and River	Test Pit Number: TPB – 102	
Reach/Capacity: 20 ft	Total Depth: 6.5 ft.	Piezometer Installed? No	
Depth to Ground Water: NA	Weather: Cold, clear, 15°F	Elevation: NA Top of Pit: NA	

Depth	Sample Number	Stratigraphic Description	REMARKS:
1–5		Brown, moist, fine SAND and SILT, little medium to coarse sand.	Sand
5–6		Black, moist, FILL containing brick, sand and gravel, wood, leather fragments, glass. Petroleum odor.	Fill
7–10		Test pit terminated. Lack of space to stockpile excavated soil.	Air readings over pile: H_2S = ND PID = ND LEL = 0%

TEST PIT PLAN



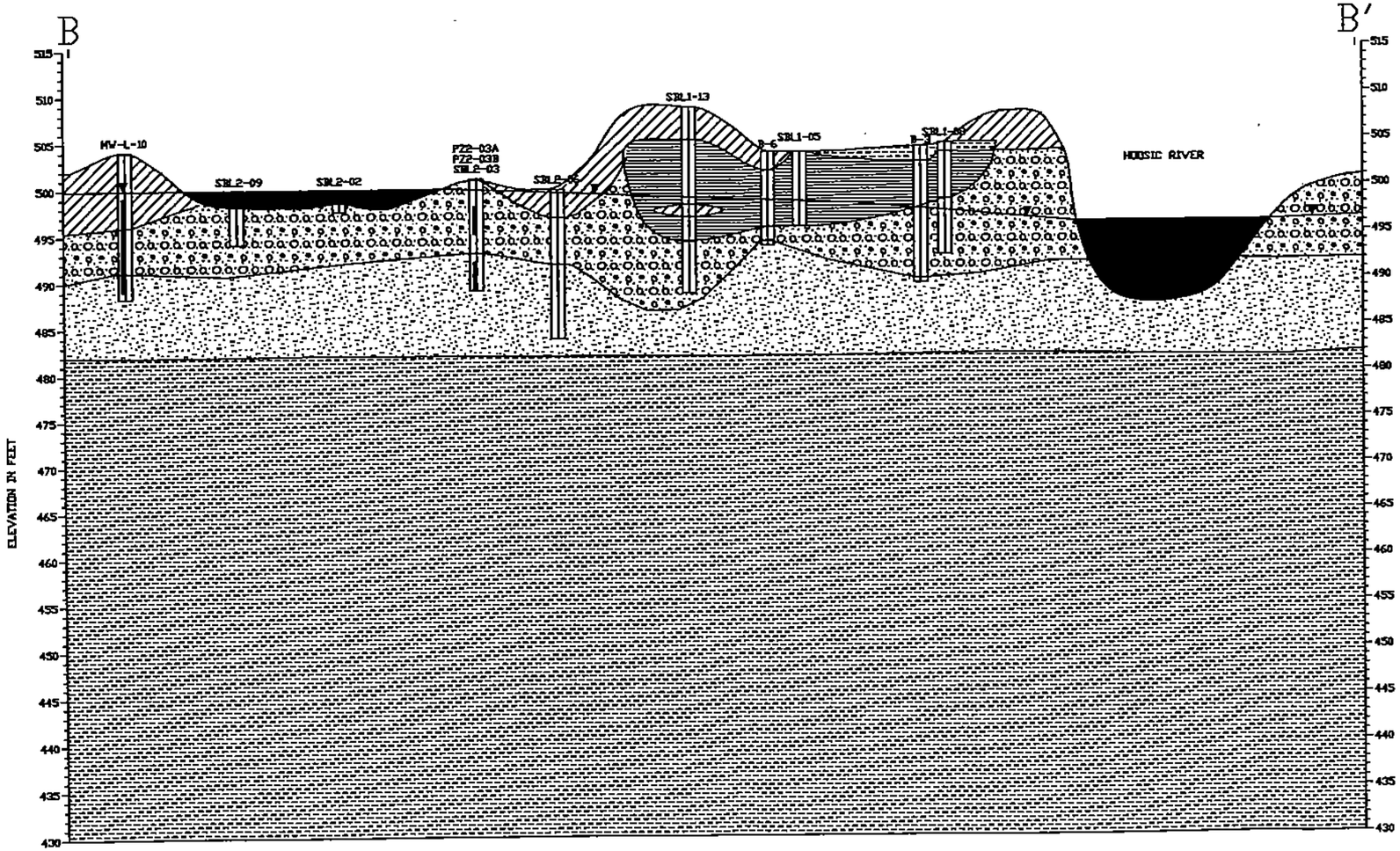
Vol. = ____ cu. yd.

PROPORTIONS USED

Trace (TR).	0 - 10%
Little (LI.)	10 - 20%
Some (SO.)	20 - 35%
And	35 - 50%

GRAIN SIZE

Boulder	>203 mm	>8 in.
Cobble	76 - 203 mm	3 - 8 in.
C. Gravel	19 - 76 mm	3/4 - 3 in.
F. Gravel	4.75 - 19 mm	3/16 - 3/4 in.
C. Sand	2.0 - 4.75 mm	5/64 - 3/16 in.
M. Sand	0.4 - 2.0 mm	1/64 - 5/64 in.
F. Sand	0.075 - 0.4 mm	
Silt	0.002 - 0.075 mm	
Clay	<0.002 mm	



LEGEND

- SANDY FILL
- LAGOON SLUDGE
- SANDY, SILTY, GRAVEL
- SILT AND SAND
- CLAY
- WATER TABLE (7/7/2000)

0 50 100
FEET

TRC
Boott Mills South
Foot of John Street
Lowell, MA 01852
978-970-5600

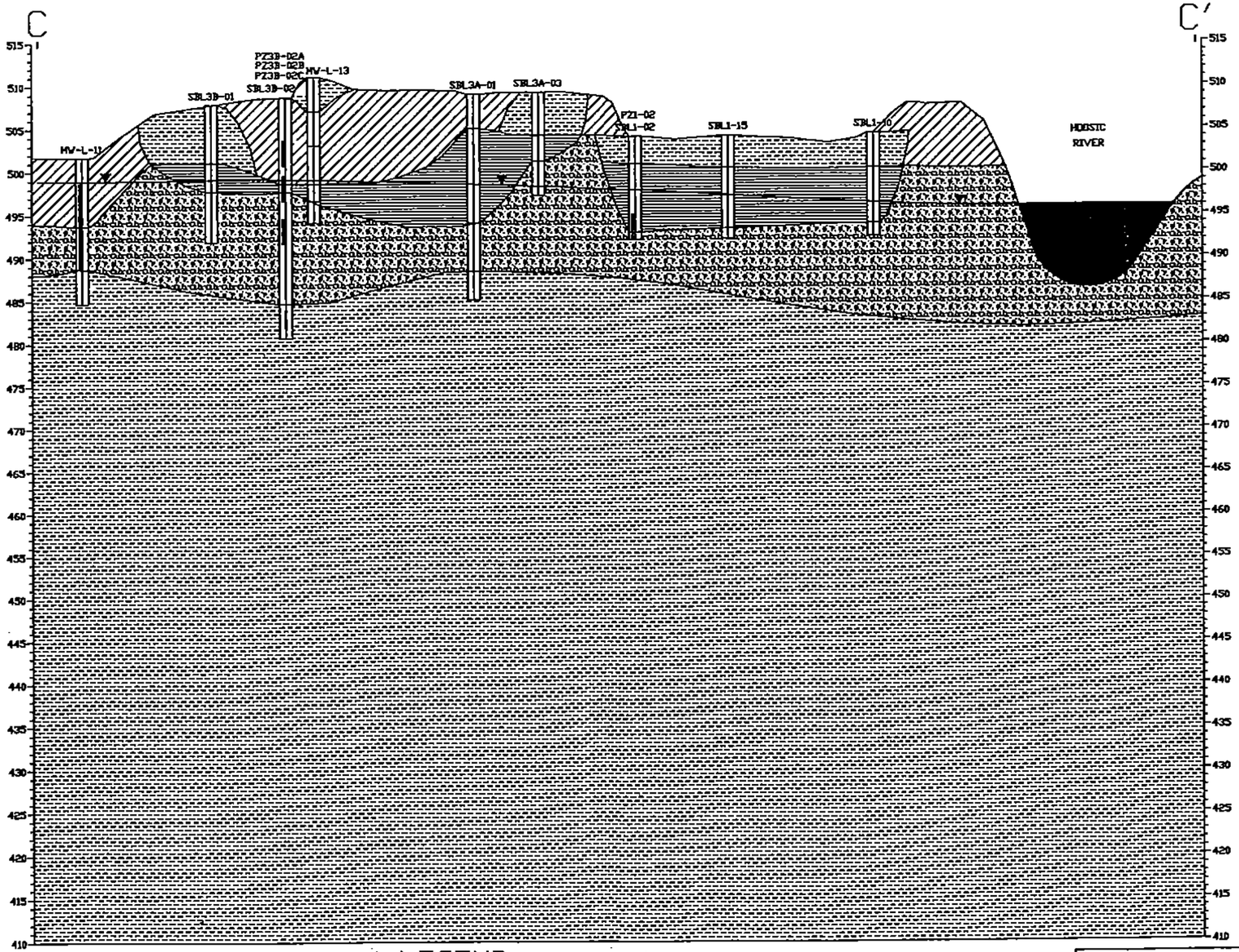
TRC PROJ. NO.: 02136-0220-01N93

EPA CONTRACT NO.: 68-W6-0042

RAC SUBCONTRACTOR NO.: 107061

FIGURE 3.4-3
CROSS SECTION
B-B'
POWNAL TANNERY
POWNAL, VERMONT

M&E Metcalf & Eddy

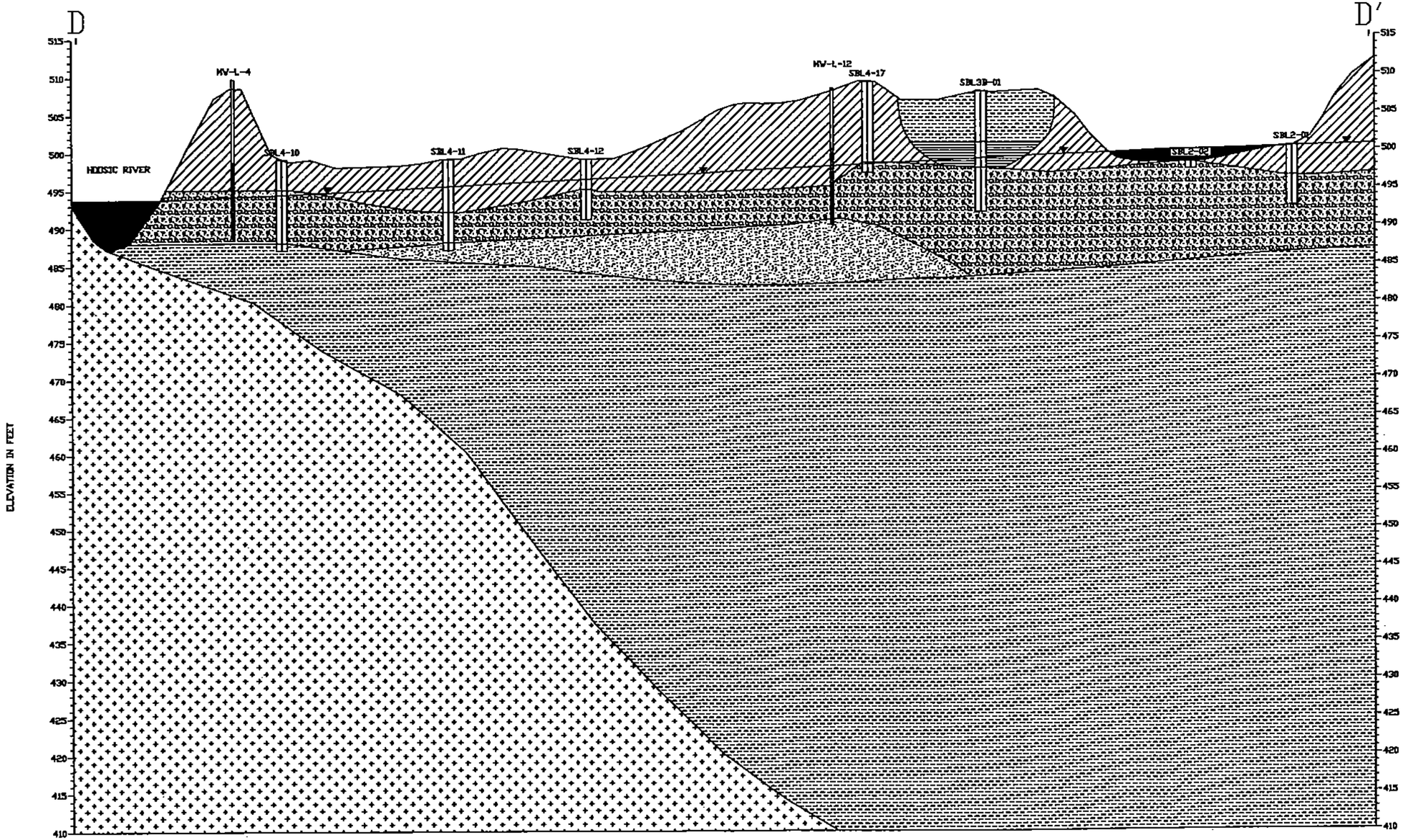


LEGEND

- SANDY FILL
- LAGOON SLUDGE
- SANDY, SILTY, GRAVEL
- SILT AND SAND
- CLAY
- WATER TABLE (7/7/2000)

0 50 100
FEET

TRC — Boott Mills South, Foot of John Street, Lowell, MA 01852, 978-970-5600	FIGURE 3.4-4 CROSS SECTION C-C' POWNAL TANNERY POWNAL, VERMONT
TRC PROJ. NO.: 02136-0220-01N93	
EPA CONTRACT NO.: 68-W6-0042	
RAC SUBCONTRACTOR NO.: 107061	M&E Metcalf & Eddy



LEGEND

SANDY FILL

LAGOON SLUDGE

SANDY, SILTY, GRAVEL

SILT AND SAND

CLAY

BEDROCK

WATER TABLE (7/7/2000)

0 50 100

FEET

TRC
Boott Mills South
Foot of John Street
Lowell, MA 01852
978-970-5600

TRC PROJ. NO.: 02136-0220-01N93

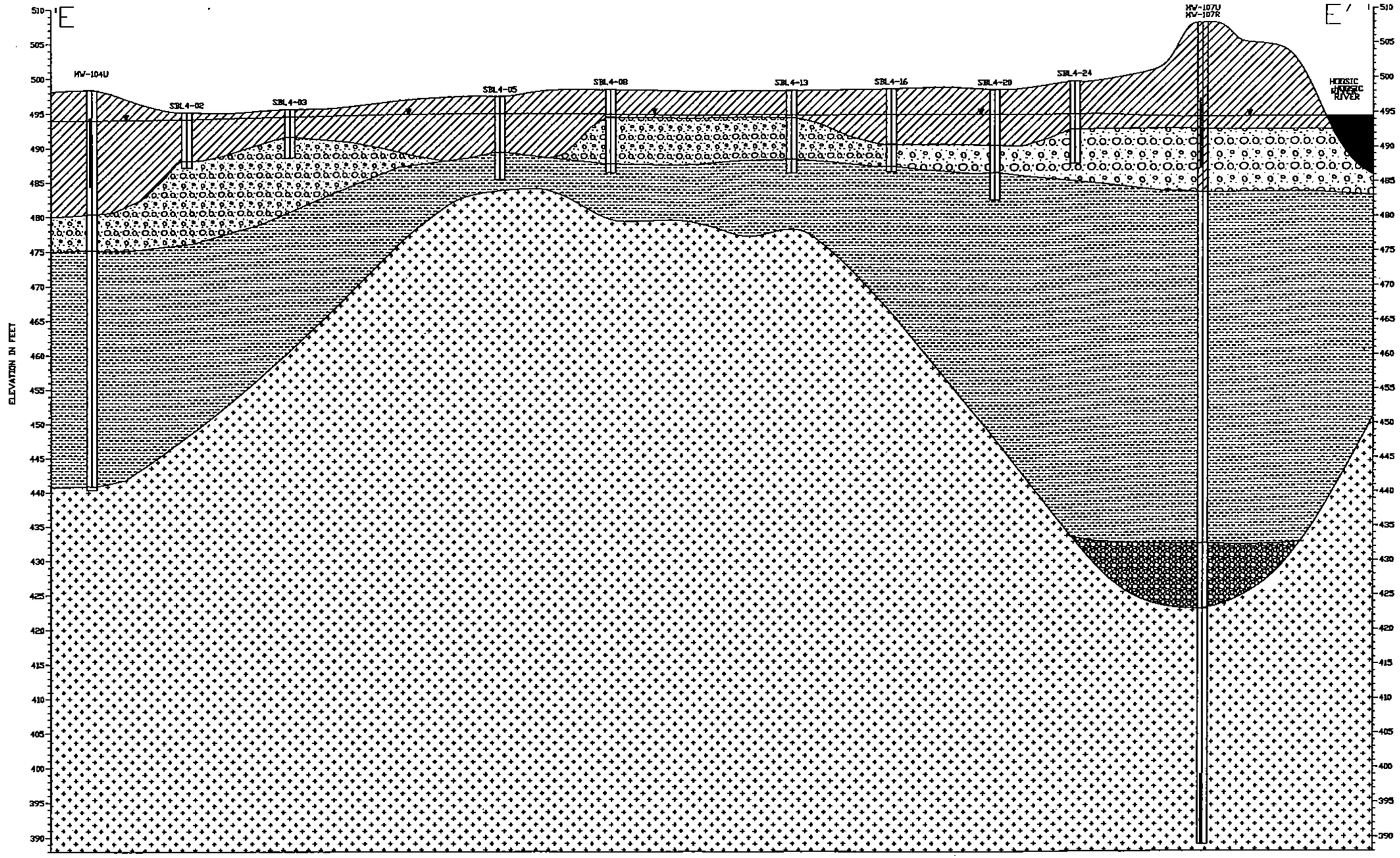
EPA CONTRACT NO.: 68-W6-0042

RAC SUBCONTRACTOR NO.: 107061

FIGURE 3.4-5
CROSS SECTION D-D'

POWNAL TANNERY
POWNAL, VERMONT

M&E Metcalf & Eddy



LEGEND

SANDY FILL

SANDY, SILTY, GRAVEL

CLAY

GLACIAL TILL

BEDROCK

WATER TABLE (7/7/2000)

0 50 100
FEET

TRC
Brett Mills South
Foot of John Street
Lowell, MA 01852
978-970-5600

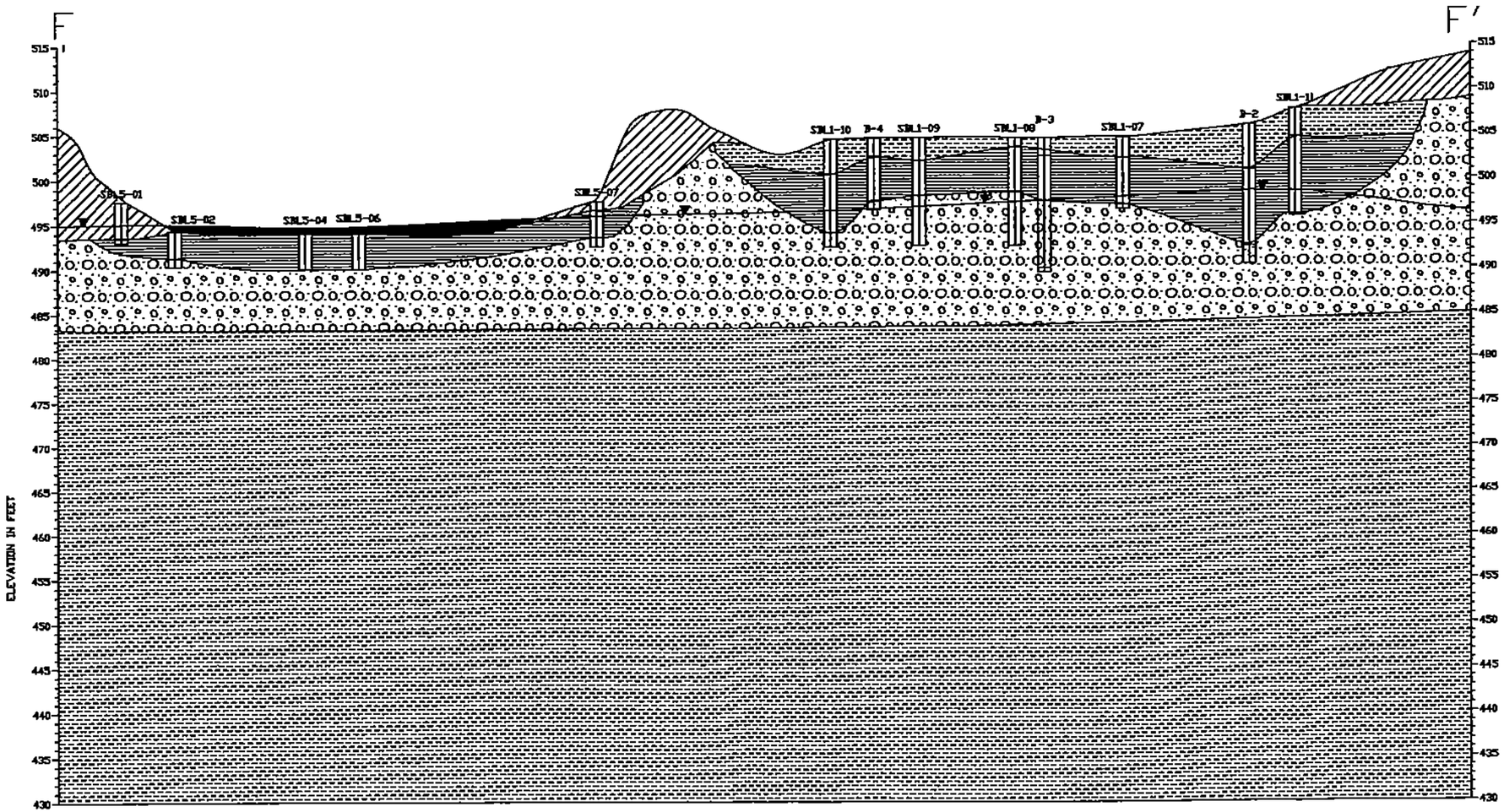
TRC PROJ. NO.: 02138-0220-01M93

EPA CONTRACT NO.: 68-W8-0042

RAC SUBCONTRACTOR NO.: 107061

FIGURE 3.4-6
CROSS SECTION
E-E'
POWNAL TANNERY
POWNAL, VERMONT

M&E Metcalf & Eddy



LEGEND

SANDY FILL

CLAY

LAGOON SLUDGE

WATER TABLE (7/7/2000)

SANDY, SILTY, GRAVEL

0 50 100
FEET

0 50 100
FEET

TRC — Boott Mills South, Foot of John Street, Lowell, MA 01852, 978-970-5600	FIGURE 3.4-7 CROSS SECTION F-F'
TRC PROJ. NO.: 02136-0220-01N93	POWNAL TANNERY POWNAL, VERMONT
EPA CONTRACT NO.: 68-W6-0042	
RAC SUBCONTRACTOR NO.: 107061	M&E Metcalf & Eddy

APPENDIX B

TRC STANDARD OPERATING PROCEDURES

TRC STANDARD OPERATING PROCEDURE NO. 007

TEST PIT LOGGING PROCEDURES

Prepared by: _____ 10/22/99
Adam Balogh, P.G. Date

Reviewed by: _____ 10/22/99
Dale Weiss, P.G., Project Manager Date

Approved by: _____ 10/25/99
Peter Spawn, Program Manager Date

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	1.1	Objectives	1
	1.2	Equipment	1
2.0	PROCEDURES		2

ATTACHMENT A

Test Pit Log

TRC STANDARD OPERATING PROCEDURE NO. 007
TEST PIT LOGGING PROCEDURES

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the methods for completing and logging test pits during field investigations at hazardous and non-hazardous waste sites. This procedure is consistent with "A Compendium of Superfund Field Operations Methods (EPA/540/P-87/001)," and other pertinent technical publications.

1.1 Objectives

The objectives of completing test pits are to document subsurface conditions, investigate anomalous magnetic readings, observe subsurface geology, identify the vertical extent of contamination, confirm depth to bedrock, complete drum removal activity, conduct percolation tests, obtain subsurface soil samples and identify potential subsurface conduits for ground water flow and potential contaminant migration.

1.2 Equipment

The following list of equipment includes the necessary items to be used by TRC personnel during the conduct of test pits. Subcontractor personnel typically provide and operate all excavation and steam cleaning equipment. Site-specific conditions may warrant the use of additional or deletion of items from this list.

- Electronic water level indicators;
- Measuring tape with weight (0.1 foot increments);
- Any necessary personal protective equipment (hardhat, gloves, eyewear, tyvek suits, boots, etc);
- Air Monitoring instruments as required (Hnu, OVM, etc.);
- Field logbook;
- Test pit log sheets;
- Oil/water interface probe;
- Camera; and
- Sampling materials (jars, bowls, spoons, etc.).

2.0 PROCEDURES

The following procedures should be used during the conduct of test pitting. Procedures may vary depending on the equipment used, excavation requirements, sampling strategy and contaminants present at the site. Site specific conditions may warrant the use of stringent air monitoring, personal protective equipment and potentially substantial access constraints. These are defined in the site-specific health and safety plan.

1. The scope of the investigation, objectives, potential contaminants, spoils pile segregation and health and safety plan should be reviewed with all subcontractor personnel prior to initiation of the test pitting activity. All intended hand signals to be used during the excavation should be reviewed and understood between the personnel directing the operation and the equipment operator. One individual will be designated to direct the operator, and record the geology and observations. The second individual will conduct continuous air monitoring and recording, photography, and sample collection, storage and documentation.

2. Initiate the excavation in approximate one to two foot loose lifts. Observations of visual contamination, buried containers or potential conduits should be recorded and operations suspended while photos and measurements to a location of interest within the pit are made and recorded.

3. Once the excavation has been completed to the desired depth, the soil should be logged as described in SOP No. 5. If samples from specific layers for geologic description are desired, the bucket should be used to gain samples from the edges of the pit in the desired location.

4. The dimensions of the final test pit should be measured and recorded. A sketch of the test pit and any unusual features should be completed on the test pit log sheet. Photographs of at least one side of the pit or any features should be taken and recorded in the field logbook. The depth to water should be measured from a location on the side of the pit at the original grade.

5. Locations within the pit desired for laboratory analysis should be obtained with the bucket. Samples for volatile organic analysis should be filled immediately from available material and additional aliquots withdrawn from the center of the bucket, homogenized in a stainless steel bowl and placed in the required sample jars. All sample jars should be pre-labeled, wiped off, documented and stored.

6. Backfill and return the excavated area to the original grade. Make certain the subcontractor packs down the backfilled soil and does not leave any surface holes or other hazards when completed.

7. Stake, label, and flag the test pit location for future reference or surveying.

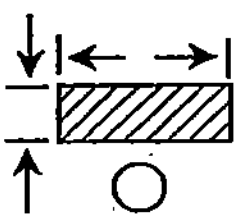
8. If segregation of contaminated soil has occurred, the disposition of these soils should be in accordance with the site-specific work plan and applicable guidance. Frequently these are not backfilled into the original pit, but the pit is backfilled with DOT approved fill. In addition, lining of the pit with polyethylene sheeting, mounding, covering of the excavation, and surrounding the excavation with gravel to direct surface runoff away may be required.

TRC
Test Pit Log

	Project: Project No.:	Date/Time:	Sheet ___ of ___
	Contractor Personnel:	TRC Personnel:	
Equipment/Contractor Used:	Location:	Test Pit Number:	
Reach/Capacity:	Total Depth:	Piezometer Installed? Yes No	
Depth to Ground Water:	Weather:	Elevation: Top of Pit _____	

Depth	Sample Number	Stratigraphic Description	REMARKS:

TEST PIT PLAN



Vol. = _____ cu. yd.

PROPORTIONS USED

Trace (TR).	0 - 10%
Little (LI.)	10 - 20%
Some (SO.)	20 - 35%
And	35 - 50%

GRAIN SIZE

Boulder	>203 mm	>8 in.
Cobble	76 - 203 mm	3 - 8 in.
C. Gravel	19 - 76 mm	3/4 - 3 in.
F. Gravel	4.75 - 19 mm	3/16 - 3/4 in.
C. Sand	2.0 - 4.75 mm	5/64 - 3/16 in.
M. Sand	0.4 - 2.0 mm	1/64 - 5/64 in.
F. Sand	0.075 - 0.4 mm	
Silt	0.002 - 0.075 mm	
Clay	<0.002 mm	

TRC STANDARD OPERATING PROCEDURE NO. 005

SOIL DESCRIPTION
VISUAL - MANUAL PROCEDURE OF THE
UNIFIED CLASSIFICATION SYSTEM

Prepared by: _____ 10/22/99
Adam Balogh, P.G. Date

Reviewed by: _____ 10/22/99
Dale Weiss, P.G., Project Manager Date

Approved by: _____ 10/25/99
Peter Spawn, Program Manager Date

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ATTACHMENT A

TRC Boring Log

TRC STANDARD OPERATING PROCEDURE NO. 005

SOIL DESCRIPTION VISUAL - MANUAL PROCEDURE OF THE UNIFIED CLASSIFICATION SYSTEM

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the method for describing soil samples in test pits, soil borings, and soil grab samples. The SOP conforms to ASTM Standard D 2488, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure) and other pertinent technical publications.

1.1 Objective

The objective of soil sample description is to provide geological information useful for the purpose of hydrogeological or geotechnical evaluation of a site. This objective requires a soil description method that is based upon widely accepted geological criteria.

1.2 Equipment

The following equipment may be necessary during soil description activities:

- Sand grading chart
- Field logbook
- Pocket knife, spoon, small spatula
- Folding Ruler or Yard Stick
- Portable table
- Polyethylene sheeting
- Hand lens
- Deionized water in squeeze bottle
- Required personal protective equipment (gloves, boot, eye wear, hard hat, etc.)
- Air monitoring equipment (as required)
- Duct tape
- Boring logs (if applicable)
- Small squirt bottle with dilute hydrochloric acid

2.0 PROCEDURES

2.1 General

The general description of a soil sample should be in the following order:

1. Color
2. Density
3. Moisture content
4. Geologic modifiers or classifications
5. Major Constituent - capitalized
6. Minor Constituent (s)
7. Geologic Description (in parentheses)

Example: Tan, loose, wet, stratified, medium SAND, little fine sand, trace coarse sand, trace silt (Till).

When logging a soil sample collected from a split spoon where more than one soil type is present, describe each one separately, using additional line(s) on the boring log form. Start the description from the top of the split spoon, and log each change in stratigraphy in sequence to the bottom of the spoon. Provide an interval or length (i.e., 0-0.5 ft.:) at the beginning of each separate sequence description, followed by a colon. Draw a line below the bottom of the complete sample description.

2.2 ColorError! Bookmark not defined.

The main color value should be stated, along with an appropriate modifier. For example

- light brown
- dark brown
- reddish brown
- brown

The presence of mottling should be included in the description, where present. For example:

- Gray, slightly mottled, dense, damp, poorly sorted angular fine to medium SAND, some silt, trace angular coarse sand, trace clay (lodgement glacial till).

2.3 Density

In borings, density should be based on the sum of the middle two 6-inch blow counts of a two foot split spoon or the last two 6-inch blow counts of an 18-inch split spoon. Professional judgement should be used when applying the density modifier. If high blow counts are due to the presence of a cobble, boulder or large piece of gravel that impedes forward progress of the split spoon, density should based upon the character of the material in the split spoon, if any, or omitted from the description. A notation should be made in the sample description when this situation occurs. Appropriate modifiers are described in the following table.

Granular Soils		Cohesive Soils	
Blows/ft	**Density**	**Blows/ft**	**Density**
0-4	very loose	<2	very soft
4-10	Loose	2-4	soft
10-30	medium dense	4-8	medium stiff
30-50	Dense	8-15	stiff
>50	very dense	15-30 >30	very stiff hard

In test pits, density is subjective and should be based upon the ease of excavation. The above adjectives for granular and cohesive soils should be used in the description.

2.4 Moisture content

Moisture content should be described using the following modifiers:

- **Dry** - no moisture.
- **Damp**- very slight moisture content, no visible water droplets.
- **Moist** - very slight moisture content, soils will not stick together.
- **Wet** – enough moisture for soils to stick together.
- **Saturated** – water dripping from sample; soils below the water table.

2.5 Geologic Modifiers

Sedimentological descriptions aid in the geologic classification of a soil material. Only insert geologic modifiers when present.

2.5.1 Stratification

The presence of alternating layers of non-cohesive materials of different grain sizes or color with layers ***at least 6 mm*** thick. Note thickness of layers.

2.5.2 Lamination or Varves

The presence of alternating very thin layers of fine materials or color, such as silt and clay, with layers ***less than 6 mm*** thick. Note thickness.

2.5.3 Sorting

A geological term used to describe how close in size the grains in a sample are to each other. For example, a well sorted sample contains grains of similar size; a poorly sorted sample contains grains of many sizes.

2.5.4 Grading

An engineering term used to describe the range in grain sizes present in a sample. For example, a narrowly graded sample contains grains of similar size; a widely graded sample contains grains of different sizes.

2.5.5 Angularity or Rounding

Geological terms that are used to describe the general appearance of visible grains in the soil sample. Useful in determining the origin and depositional environment of a material. Water transported materials may be rounded. Glacial tills will be more angular.

- **Angular** – Particles have sharp edges and relatively plane sides with unpolished surfaces.
- **Subangular** – Particles are similar to angular description but have rounded edges.
- **Subrounded** – Particles have nearly plane sides but have well-rounded corners and edges.
- **Rounded** – Particles have smoothly curved sides and no edges.

2.5.6 Shape

A term used to describe the shape of gravel, cobbles, and boulders. Terms are as follows where the particle shape shall be described where the length, width, and thickness refer to the greatest, intermediate, and least dimensions of a particle.

- **Flat** – Particles with width/ thickness > 3.
- **Elongated** – Particles with length/ width > 3
- **Flat and Elongated** – Particles meet criteria for both flat and elongated.

2.5.7 Odor

Describe the odor if organic or unusual. Soils containing a significant amount of organic material have a distinct odor of decaying vegetation. Always utilize appropriate breathing zone air monitoring equipment as specified in the site specific health and safety plan.

2.5.8 HCL Reaction

As appropriate for the geologic environment, describe the reaction with HCL as none, weak, or strong. As calcium carbonate is a common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is appropriate for certain projects.

- **None** – No visible reaction.
- **Weak** – Some reaction, with bubbles forming slowly.
- **Strong** – Violent reaction, with bubbles forming immediately.

2.5.9 Cementation

Describe the cementation of intact coarse-grained soils as follows.

- **Weak** – Crumbles or breaks with handling or little finger pressure.
- **Moderate** – Crumbles or breaks with considerable finger pressure.
- **Strong** – Will not crumble or break with finger pressure.

2.5.10 Identification of Peat

A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor. When present the sample shall be designated as highly organic soil.

2.6 Major/Minor Constituents

2.6.1 Grain-size scales

Grain size classification should be based on an accepted classification system such as, the Unified System. The predominate grain size should be listed in the soil description in all capital letters.

Boulder	> 300 mm
Cobble:	75 - 300 mm,
C. Gravel:	19 - 75 mm,

F. Gravel:	4.75 - 19 mm,
C. Sand:	2.0 - 4.75 mm,
M. Sand:	0.425 - 2.0 mm,
F. Sand:	0.075 - 0.425 mm
Silt:	0.002 - 0.075 mm
Clay:	<0.002 mm

2.6.2 Proportions

For geologic description, proportions of grain sizes will be based upon the following nomenclature:

- Trace: 0-10%
- Little: 10-20%
- Some: 20-35%
- And: 35-50%

The major soil sample constituent is always capitalized and listed first.

Minor constituents also include ancillary materials such as mica flakes, dark minerals, or naturally occurring organic matter, such as humus, peat, or other vegetative material.

2.7 Geologic Description

Where possible based on existing site data, local research, or geologic understanding of the local region, include a geologic description of the sample. Examples include till, fluvial, glaciofluvial, fill material, Lowell Formation. Do not utilize geologic description if not certain.

TRC	Project/Client	Project No.	Boring No.	Sheet
			Well No.	___ of ___
	Location Description		TRC Geologist	

Drilling Contractor/Foreman	Drill Rig Make/Model	Auger/Drive Casing Size/Type

Sampler Description	Drilling Method	Coordinates X= Y=
Filter Seal Amount/Type:	Drill Bit/Auger Diameter:	Ref. EL:
Sand Pack Amount/Type:	Hammer Weight/Fall:	Riser Stick Up:
Screen Length/Type:	Water Table Depth:	Surface Elevation:
Riser Length/Type:	Total Depth:	Date Start: / Date Finish:

Depth	Sample Number	Blows/ RQD	Pen/Rec Core Rec	Sample Description	Strati-graphic Description	Field Testing	Lab Sample Number	Well Construction

Granular Soils

Blows/ft	Density
0-4	v. loose
4-10	loose
10-30	m. dense
30-50	dense
>50	v. dense

Proportions

trace	0-10%	some	20-35%
little	10-20%	sand	35-50%

Cohesive Soils

Blows/ft	Density
>2	v. soft
2-4	soft
4-8	m. stiff
8-15	stiff
15-30	v. stiff
>30	hard

Grain Size (USCS)

silt/clay	<0.06 mm
f. sand	0.43-0.06 mm
m. sand	2.0-0.43 mm
c. sand	4.8-2.0 mm
f. gravel	19-4.8 mm
c. gravel	75-19 mm
cobble	300-75 mm
boulder	>300 mm

Notes

JI-310

TRC

Project/Client	Project No.	Boring No.	Sheet
		Well No.	___ of ___
Location Description		TRC Geologist	

Depth	Sample Number	Blows/ ROD	Pen/Rec Core Rec	Sample Description	Stratigraphic Description	Field Testing	Lab Sample Number	Well Construction

Granular Soils

Blows/ft	Density
0-4	v. loose
4-10	loose
10-30	m. dense
30-50	dense
>50	v. dense

Proportions

trace	0-10%	some	20-35%
little	10-20%	sand	35-50%

Cohesive Soils

Blows/ft	Density
>2	v. soft
2-4	soft
4-8	m. stiff
8-15	stiff
15-30	v. stiff
>30	hard

Grain Size (USCS)

silt/clay	<0.06 mm
f. sand	0.43-0.06 mm
m. sand	2.0-0.43 mm
c. sand	4.8-2.0 mm
f. gravel	19-4.8 mm
c. gravel	75-19 mm
cobble	300-75 mm
boulder	>300 mm

Notes

APPENDIX C

GEOTECHNICAL TEST REPORTS

GeoTesting Express Inc.

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FOR THE LABORATORY AND FIELD

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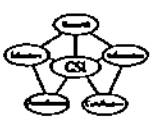

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(978) 635-0424 - Fax (978) 635-0266

LETTER OF TRANSMITTAL

Mr. Don Dwight
Metcalf & Eddy
30 Harvard Mill Square
Wakefield, MA 01888

DATE: 01/06/03	GTX NO: 4363
RE: Pownal Tannery Superfund Site Project	
Pages (excluding transmittal):	

are sending you ☑ Attached ☐ Under separate cover via _____ the following items:
☑ Test results ☐ Proposal ☑ Report ☐ Samples ☐ Specifications ☐ Invoice
☐ Copy of letter ☐ Change order
☐ Other

COPIES	DATE	DESCRIPTION
1	01/06/03	**November – December 2002 Laboratory Test Reports**

SE ITEMS ARE TRANSMITTED as checked below:
☐ For approval ☐ Approved as submitted ☐ Resubmit _____ Copies for approval
☑ For your use ☐ Approved as noted ☐ Submit _____ Copies for distribution
☑ As requested ☐ Returned for corrections ☐ Return
☐ For review and comment
☐ For bids due _____, 20
☐ _____

IARKS

PY TO Mr. Greg Mischel
TRC Environmental
Foot of John Street
Lowell, MA 01852

SIGNED _____

Joseph D. Tomei – Laboratory Manager

Geotechnical Test Report

Pownal Tannery Superfund Site Project

Pownal, VT

Prepared for:

Metcalf & Eddy
Wakefield, MA

Prepared by:

GeoTesting Express, Inc.
Boxborough, MA

January 6, 2003

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SECTION 1 ..... Index Test Results

SECTION 2 ..... Unconfined Compression Test Results

SECTION 3 ..... Consolidation Test Results

SECTION
ONE

1

Specific Gravity of Soils by ASTM D 854

Client: Metcalf & Eddy
Project Name: Pownal Tannery Superfund Site
Project Location: Pownal, VT

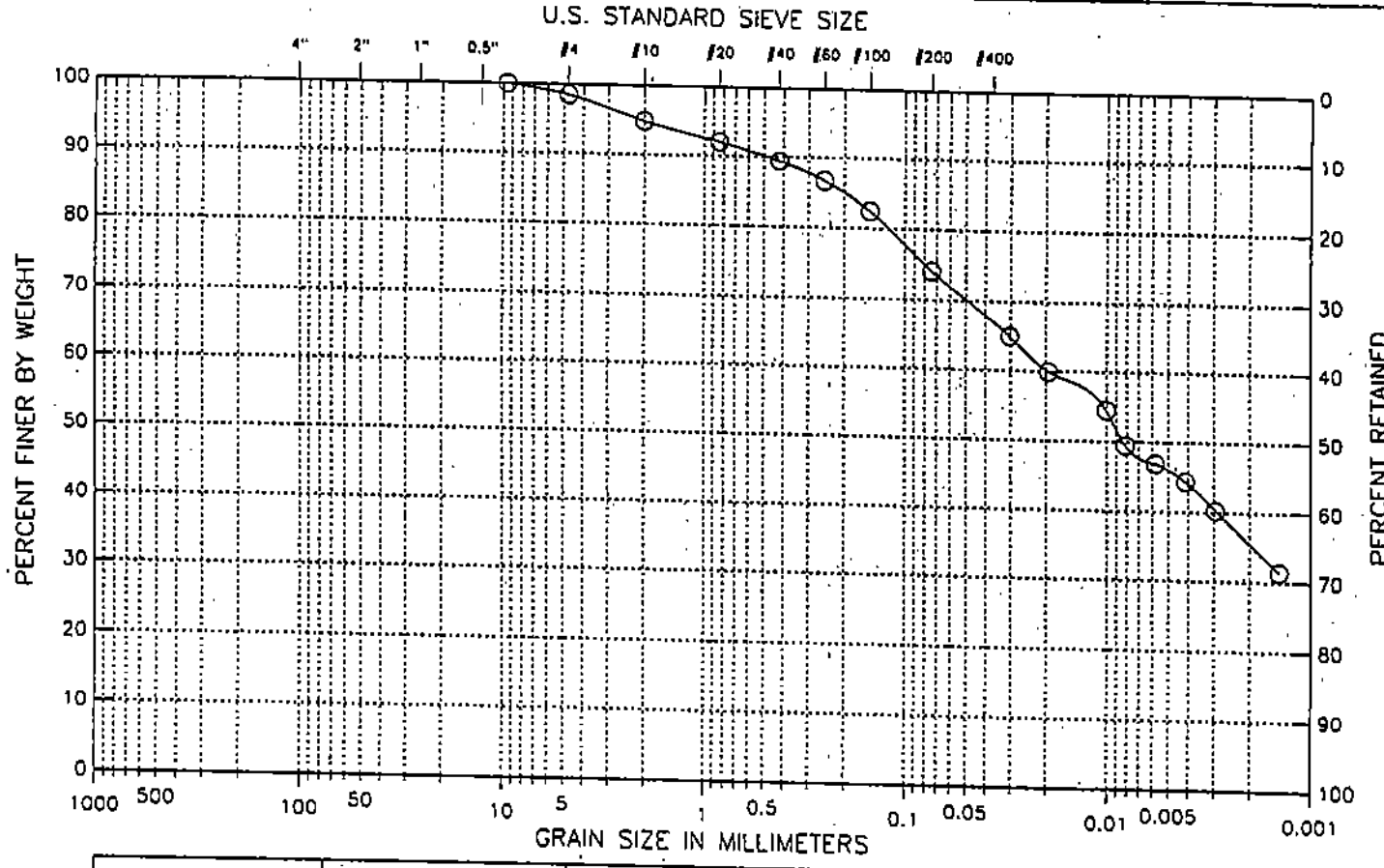
GTX #: 4363
Test Date: 12/19/02
Tested By: tje
Checked By: jdt

Boring #	Sample ID	Depth, ft	Visual Description	Specific Gravity @ 20 C
SBL3	102	6-8	Moist, dark greenish gray clay with sand	2.77

Notes: Specific gravity performed by using method A (oven dried specimens) of ASTM D 854

Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material.

	Boring No.: SBL3 Sample No: 102 (6-8) Test Method ASTM D 422 Filename : SBL31026	Project : Pownal Tannery Superfund Site Project No.: GTX-4363 Location: Pownal, VT Date : Fri Jan 03 2003



Classification :
(CL) lean clay with sand
Visual Description :
Moist, dark greenish gray clay with sand

Remarks :

Figure 1

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GEOTECHNICAL LABORATORY TEST DATA

Project : Pownal Tannery Superfund Site
Project No. : GTX-4363
Boring No. : SBL3
Sample No. : 102 (6-8)
Location : Pownal, VT
Soil Description : Moist, dark greenish gray clay with sand
Remarks :

Depth : 6-8 ft.
Test Date : 12/19/02
Test Method : ASTM D 422

Filename : SBL31026
Elevation : ---
Tested by : tje/srp
Checked by : jdt

HYDROMETER

Hydrometer ID : 457488
Weight of air-dried soil = 28.78 gm
Specific Gravity = 2.77

Hydroscopic Moisture Content :
Weight of Wet Soil = 0 gm
Weight of Dry Soil = 0 gm
Moisture Content = 0

Elapsed Time (min)	Reading	Temperature (deg. C)	Corrected Reading	Particle Size (mm)	Percent Finer (%)	Adjusted Particle Size
2.00	32.50	21.50	25.83	0.030	65	0.030
5.00	30.50	21.50	23.83	0.019	60	0.019
19.00	28.00	22.00	21.67	0.010	54	0.010
30.00	26.00	22.00	19.67	0.008	49	0.008
60.00	25.00	22.00	18.67	0.006	47	0.006
120.00	24.00	22.00	17.67	0.004	44	0.004
240.00	22.00	22.50	16.00	0.003	40	0.003
1080.00	19.50	21.00	12.50	0.001	31	0.001

FINE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Millimeters	Height Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
0.375"	0.374	9.51	0.00	0.00	100
#4	0.187	4.75	0.58	0.58	99
#10	0.079	2.00	1.39	1.97	95
#20	0.033	0.84	1.11	3.08	92
#40	0.017	0.42	1.04	4.12	89
#60	0.010	0.25	1.07	5.19	87
#100	0.006	0.15	1.63	6.82	82
#200	0.003	0.07	3.22	10.04	74
Pan			28.78	38.82	0

Total Dry Weight of Sample = 158.06

D85 : 0.2045 mm
D60 : 0.0196 mm
D50 : 0.0083 mm
D30 : N/A
D15 : N/A
D10 : N/A

Soil Classification
ASTM Group Symbol : CL
ASTM Group Name : lean clay with sand
AASHTO Group Symbol : A-6(9)
AASHTO Group Name : Clayey Soils

ATTERBERG LIMITS

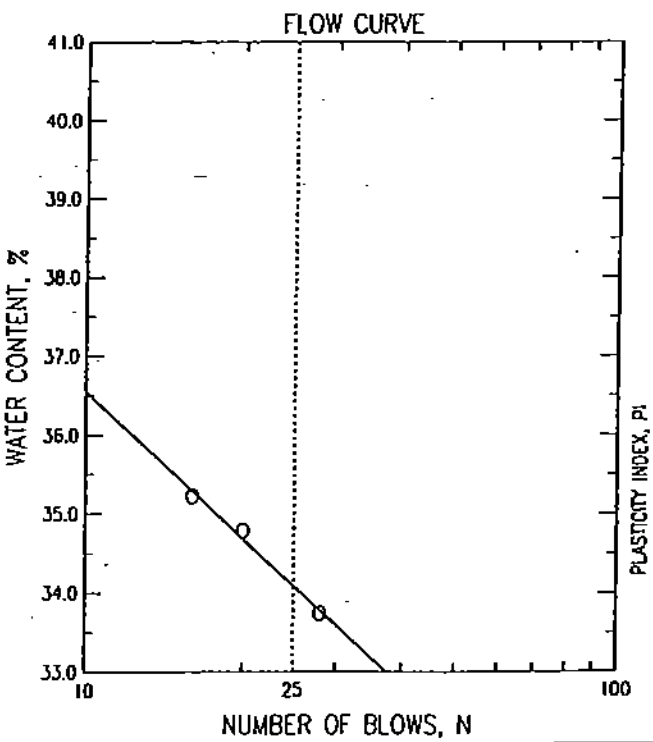
PROJECT	PROJECT NUMBER	TESTED BY	BORING NUMBER
Pownal Tannery Superfund Site	GTX-4363	tje/srp	SBL3
LOCATION		CHECKED BY	SAMPLE NUMBER
Pownal, VT		jdl	102 (6-8)
SAMPLE DESCRIPTION		DATE	FILENAME
Moist, dark greenish gray clay with sand		Thu Dec 19 2002	SBL31026

LIQUID LIMIT DETERMINATIONS

CONTAINER NUMBER	21	166	2		
WT. WET SOIL + TARE	26.17	23.04	27.93		
WT. DRY SOIL + TARE	23.44	20.02	24.88		
WT. WATER	2.73	3.02	3.05		
TARE WT.	15.69	11.34	15.84		
WT. DRY SOIL	7.75	8.68	9.04		
WATER CONTENT, W_N (%)	35.23	34.79	33.74		
NUMBER OF BLOWS, N	16	20	28		
ONE-POINT LIQUID LIMIT, LL	33.37	33.87	34.20		

PLASTIC LIMIT DETERMINATIONS

CONTAINER NUMBER	9124	21			
WT. WET SOIL + TARE	31	28.73			
WT. DRY SOIL + TARE	29.45	27.21			
WT. WATER	1.55	1.52			
TARE WT.	22.2	20.16			
WT. DRY SOIL	7.25	7.05			
WATER CONTENT (%)	21.38	21.56			



SUMMARY OF RESULTS	
NATURAL WATER CONTENT, W (%)	32.3
LIQUID LIMIT, LL	34.1
PLASTIC LIMIT, PL	21.5
PLASTICITY INDEX, PI	12.6
LIQUIDITY INDEX, LI*	0.86

*LI = (W - PL)/PI

PLASTICITY CHART

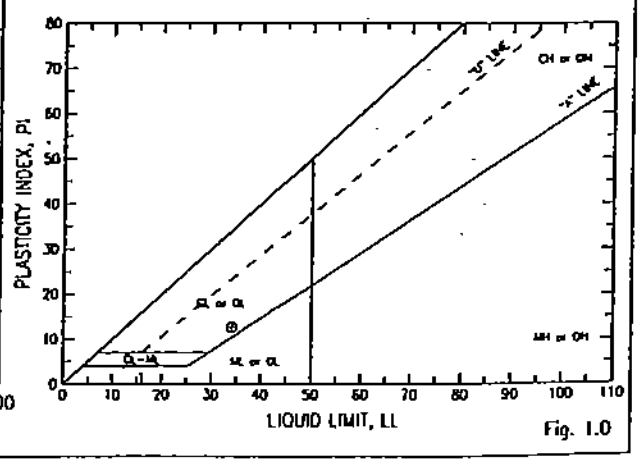


Fig. 1.0

Moisture Content of Soil by ASTM D 2216

Client:	Metcalf & Eddy	GTX #:	4363
Project Name:	Pownal Tannery Superfund Site	Test Date:	12/19/02
Project Location:	Pownal, VT	Tested By:	tje
		Checked By:	jdt

Boring #	Sample ID	Depth, ft	Visual Description	Moisture Content, %
SBL4	101	8-10	Moist, dark greenish gray silty sand	25

Notes: Moisture content determined by Method A & reported as a percentage of oven-dried mass; dried to constant mass at temperature of 110 C
Ash content and organic matter determined by Method C; dried to constant mass at temperature of 440 C

Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material.

Specific Gravity of Soils by ASTM D 854

Client: Metcalf & Eddy
Project Name: Pownal Tannery Superfund Site
Project Location: Pownal, VT

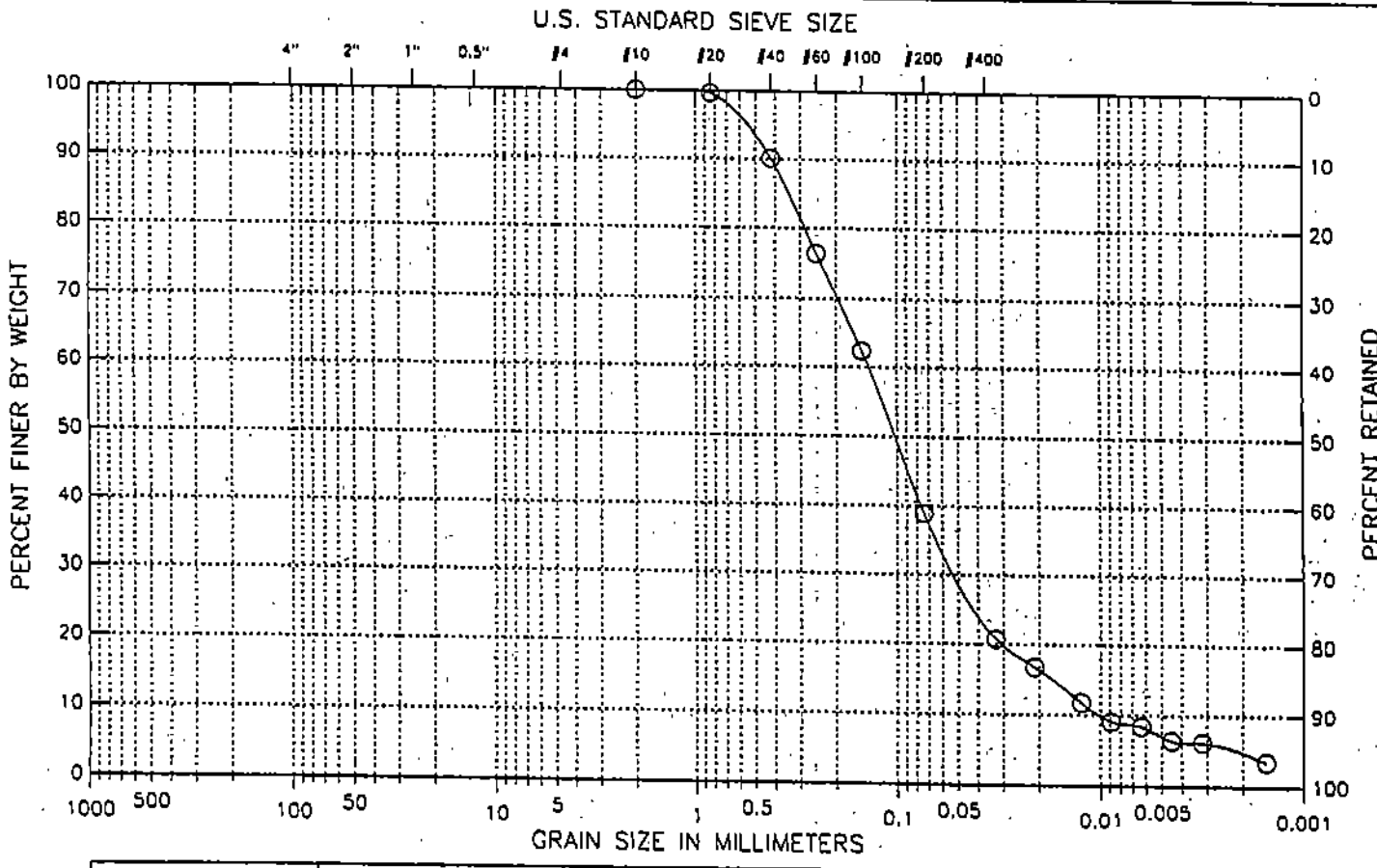
GTX #: 4363
Test Date: 12/19/02
Tested By: tje
Checked By: jdt

Boring #	Sample ID	Depth, ft	Visual Description	Specific Gravity @ 20 C
SBL4	101	8-10	Moist, dark greenish gray silty sand	2.75

Notes: Specific gravity performed by using method A (oven dried specimens) of ASTM D 854

Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material.

	Boring No. : SBL4 Sample No: 101 (8-10) Test-Method ASTM D 422 Filename : SBL41018	Project : Pownal Tannery Superfund Site Project No.: GTX-4363 Location: Pownal, VT Date : Mon Jan 06 2003



Classification :
(SM) Silty sand
Visual Description :
Moist, dark greenish gray silty sand

Remarks :

Figure 1

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GEOTECHNICAL LABORATORY TEST DATA

Project : Pownal Tannery Superfund Site
Project No. : GTX-4363
Boring No. : SBL4
Sample No. : 101 (8-10)
Location : Pownal, VT
Soil Description : Moist, dark greenish gray silty sand
Remarks :

Depth : 8-10 ft.
Test Date : 12/19/02
Test Method : ASTM D 422

Filename : SBL41018
Elevation : ---
Tested by : tje/srp
Checked by : jdt

HYDROMETER

Hydrometer ID : 457488
Weight of air-dried soil = 28.12 gm
Specific Gravity = 2.75

Hydroscopic Moisture Content :
Weight of Wet Soil = 0 gm
Weight of Dry Soil = 0 gm
Moisture Content = 0

Elapsed Time (min)	Reading	Temperature (deg. C)	Corrected Reading	Particle Size (mm)	Percent Finer (%)	Adjusted Particle Size
2.00	22.00	21.50	15.33	0.033	21	0.033
5.00	19.00	21.50	12.33	0.021	17	0.021
15.00	15.00	22.00	8.67	0.012	12	0.012
30.00	13.00	22.00	6.67	0.009	9	0.009
60.00	12.50	22.00	6.17	0.006	8	0.006
120.00	11.00	22.00	4.67	0.004	6	0.004
240.00	10.50	22.50	4.50	0.003	6	0.003
1080.00	9.50	21.00	2.50	0.002	3	0.002

FINE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
#10	0.079	2.00	0.00	0.00	100
#20	0.033	0.84	0.29	0.29	100
#40	0.017	0.42	6.87	7.16	90
#60	0.010	0.25	9.87	17.03	76
#100	0.006	0.15	10.11	27.14	62
#200	0.003	0.07	17.05	44.19	39
Pan			28.12	72.31	0

Total Dry Weight of Sample = 191.28

D85 : 0.3460 mm
D60 : 0.1385 mm
D50 : 0.1029 mm
D30 : 0.0496 mm
D15 : 0.0176 mm
D10 : 0.0100 mm

Soil Classification
ASTM Group Symbol : SM
ASTM Group Name : Silty sand
AASHTO Group Symbol : A-4(0)
AASHTO Group Name : Silty Soils

ATTERBERG LIMITS

PROJECT	PROJECT NUMBER	TESTED BY	BORING NUMBER
Pownal Tannery Superfund Site	GTX-4363	lje/srp	SBL4
LOCATION		CHECKED BY	SAMPLE NUMBER
Pownal, VT		jdl	101 (8-10)
SAMPLE DESCRIPTION		DATE	FILENAME
Moist, dark greenish gray silty sand		Thu Dec 19 2002	SBL41018

LIQUID LIMIT DETERMINATIONS					
CONTAINER NUMBER					
WT. WET SOIL + TARE					
WT. DRY SOIL + TARE					
WT. WATER					
TARE WT.					
WT. DRY SOIL					
WATER CONTENT, W_N (%)					
NUMBER OF BLOWS, N					
ONE-POINT LIQUID LIMIT, LL					

PLASTIC LIMIT DETERMINATIONS					
CONTAINER NUMBER					
WT. WET SOIL + TARE					
WT. DRY SOIL + TARE					
WT. WATER					
TARE WT.					
WT. DRY SOIL					
WATER CONTENT (%)					

Determined to be Non-plastic.

SUMMARY OF RESULTS	
NATURAL WATER CONTENT, W (%)	24.7
LIQUID LIMIT, LL	
PLASTIC LIMIT, PL	
PLASTICITY INDEX, PI	
LIQUIDITY INDEX, LI*	

*LI = (W - PL)/PI

PLASTICITY CHART

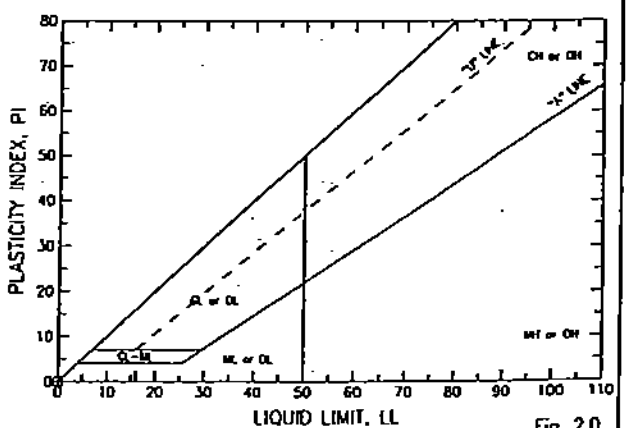
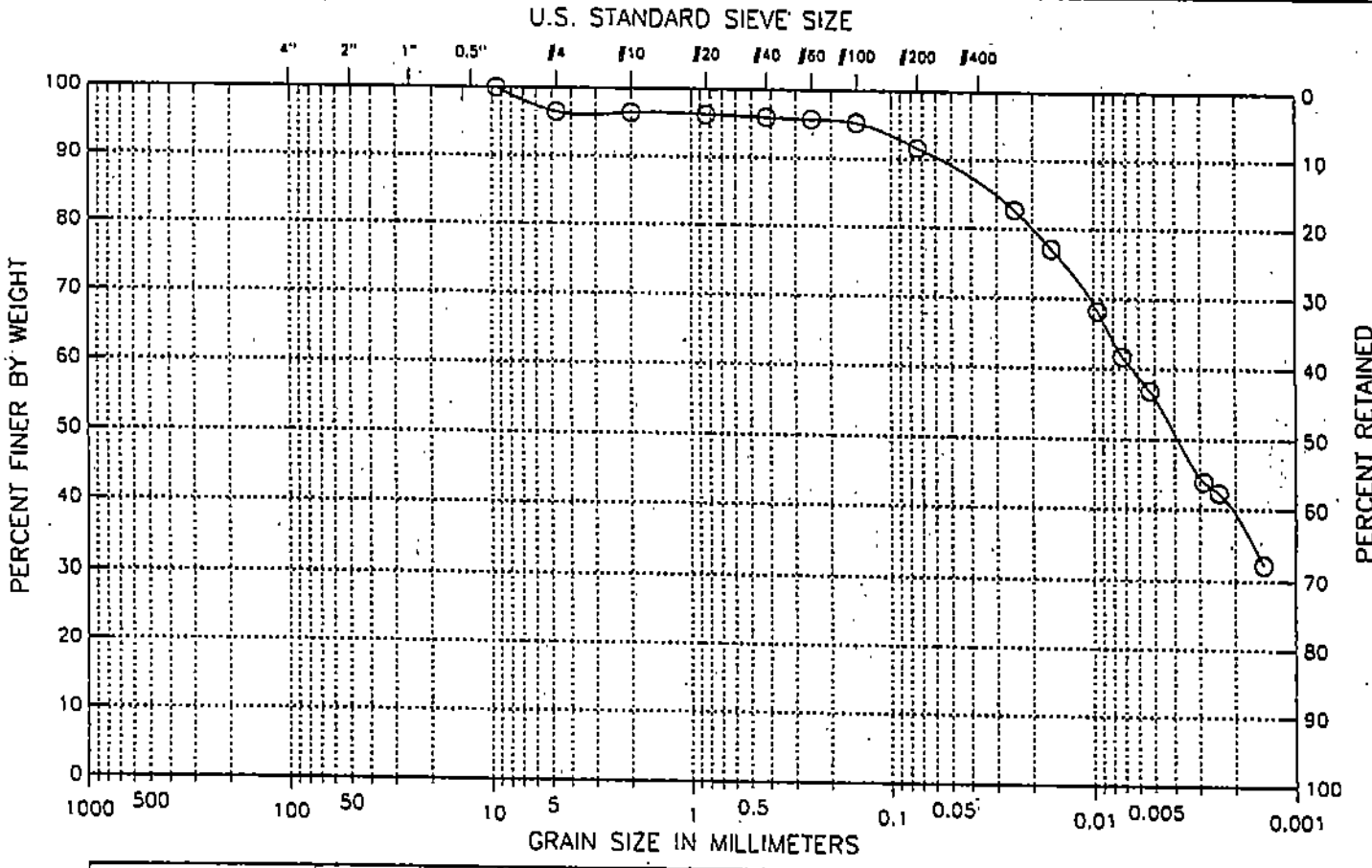


Fig. 2.0

	Boring No. : SBL4 Sample No: 102 (19-21) Test Method ASTM D 422 Filename : SBL4102	Project : Pownal Tannery Superfund Site Project No.: GTX-4363 Location: Pownal, VT Date : Mon Jan 06 2003



Classification :
(CL) lean clay
Visual Description :
Moist, dark gray clay

Remarks :

Figure 2

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GEOTECHNICAL LABORATORY TEST DATA

Project : Pownal Tannery Superfund Site
Project No. : GTX-4363
Boring No. : SBL4
Sample No. : 102 (19-21)
Location : Pownal, VT
Soil Description : Moist, dark gray clay
Remarks :

Depth : 19-21 ft.
Test Date : 12/04/02
Test Method : ASTM D 422

Filename : SBL4102
Elevation : ---
Tested by : jlg
Checked by : jdt

HYDROMETER

Hydrometer ID : 343664
Weight of air-dried soil = 56.31 gm
Specific Gravity = 2.7

Hydroscopic Moisture Content :
Weight of Wet Soil = 0 gm
Weight of Dry Soil = 0 gm
Moisture Content = 0

Elapsed Time (min)	Reading	Temperature (deg. C)	Corrected Reading	Particle Size (mm)	Percent Finer (%)	Adjusted Particle Size
2.00	58.00	21.00	51.25	0.025	83	0.025
5.00	54.50	21.00	47.75	0.016	77	0.016
16.00	49.00	21.00	42.25	0.010	68	0.010
30.00	45.00	21.00	38.25	0.007	62	0.007
60.00	42.00	21.00	35.25	0.005	57	0.005
229.00	34.00	21.00	27.25	0.003	44	0.003
329.00	33.00	21.00	26.25	0.002	42	0.002
1013.00	27.00	20.50	20.00	0.001	32	0.001

FINE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
0.375"	0.374	9.51	0.00	0.00	100
#4	0.187	4.75	2.11	2.11	97
#10	0.079	2.00	0.03	2.14	97
#20	0.033	0.84	0.13	2.27	96
#40	0.017	0.42	0.17	2.44	96
#60	0.010	0.25	0.13	2.57	96
#100	0.006	0.15	0.29	2.86	95
#200	0.003	0.07	2.22	5.08	92
Pan			56.31	61.39	0

Total Dry Weight of Sample = 178.46

D85 : 0.0324 mm
D60 : 0.0065 mm
D50 : 0.0038 mm
D30 : N/A
D15 : N/A
D10 : N/A

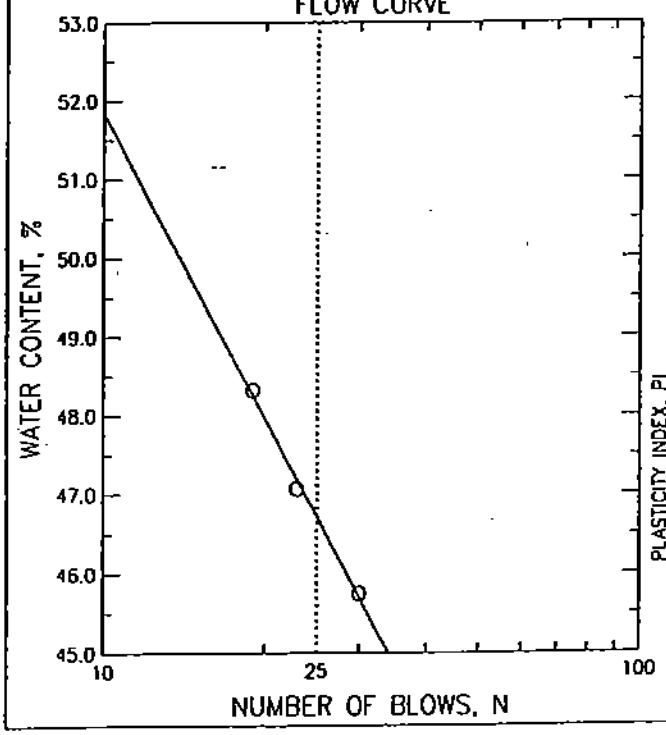
Soil Classification
ASTM Group Symbol : CL
ASTM Group Name : lean clay
AASHTO Group Symbol : A-7-6(26)
AASHTO Group Name : Clayey Soils

ATTERBERG LIMITS

PROJECT	PROJECT NUMBER	TESTED BY	BORING NUMBER
Pownal Tannery Superfund Site	GTX-4363	jg	SBL4
LOCATION		CHECKED BY	SAMPLE NUMBER
Pownal, VT		jdl	102 (19-21)
SAMPLE DESCRIPTION		DATE	FILENAME
Moist, dark gray clay		Mon Jan 06 2003	SBL4102

LIQUID LIMIT DETERMINATIONS					
CONTAINER NUMBER	AL-18	29	T-2A		
WT. WET SOIL + TARE	29.49	25.94	27.19		
WT. DRY SOIL + TARE	25.19	22.65	23.45		
WT. WATER	4.3	3.29	3.74		
TARE WT.	15.79	15.66	15.71		
WT. DRY SOIL	9.4	6.99	7.74		
WATER CONTENT, W_N (%)	45.74	47.07	48.32		
NUMBER OF BLOWS, N	30	23	19		
ONE-POINT LIQUID LIMIT, LL	46.77	46.59	46.74		

PLASTIC LIMIT DETERMINATIONS					
CONTAINER NUMBER	P-12	T-1			
WT. WET SOIL + TARE	35.97	36.72			
WT. DRY SOIL + TARE	34.66	35.29			
WT. WATER	1.31	1.43			
TARE WT.	29.11	29.08			
WT. DRY SOIL	5.55	6.21			
WATER CONTENT (%)	23.60	23.03			



SUMMARY OF RESULTS	
NATURAL WATER CONTENT, W (%)	28.8
LIQUID LIMIT, LL	46.7
PLASTIC LIMIT, PL	23.3
PLASTICITY INDEX, PI	23.4
LIQUIDITY INDEX, LI*	0.23

*LI = (W - PL)/PI

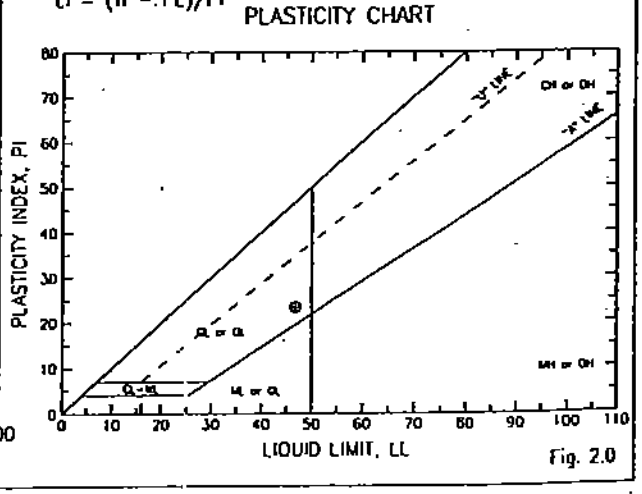


Fig. 2.0

Specific Gravity of Soils by ASTM D 854

Client: Metcalf & Eddy
Project Name: Pownal Tannery Superfund Site
Project Location: Pownal, VT

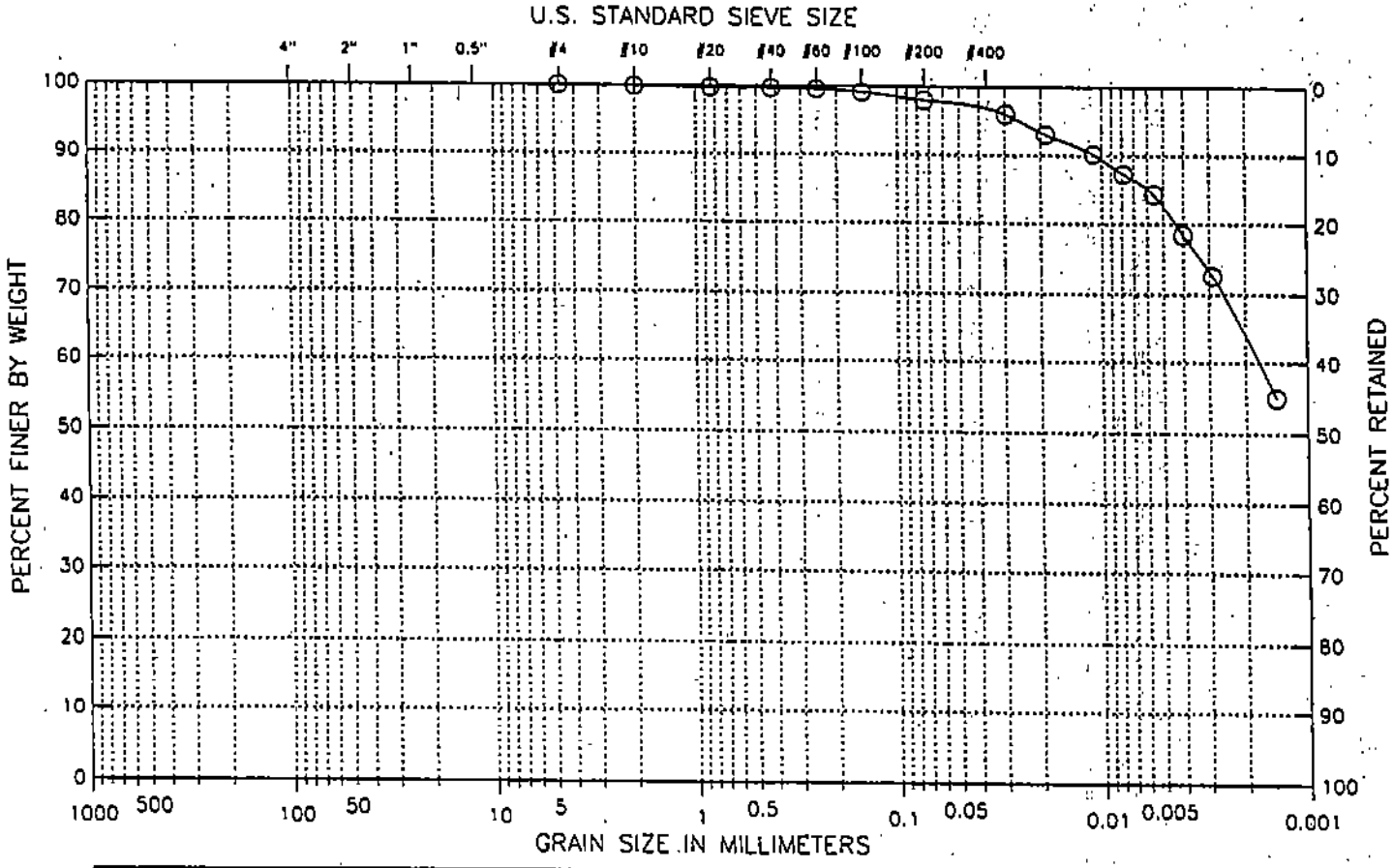
GTX #: 4363
Test Date: 12/05/02
Tested By: tje
Checked By: jdt

Boring #	Sample ID	Depth, ft	Visual Description	Specific Gravity @ 20 C
SBL4	103	25-27	Moist, dark gray clay	2.83

Notes: Specific gravity performed by using method A (oven dried specimens) of ASTM D 854

Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material.

	Boring No. : SBL4 Sample No: 103 (25-27) Test Method ASTM D 422 Filename : SBL4103	Project : Pownal Tannery Superfund Site Project No.: GTX-4363 Location: Pownal, VT Date : Mon Jan 06 2003



Classification :
(CL) lean clay
Visual Description :
Moist, dark gray clay

Remarks :

Figure 3

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GEOTECHNICAL LABORATORY TEST DATA

Project : Pownal Tannery Superfund Site
Project No. : GTX-4363
Boring No. : SBL4
Sample No. : 103 (25-27)
Location : Pownal, VT
Soil Description : Moist, dark gray clay
Remarks :

Depth : 25-27 ft.
Test Date : 12/30/02
Test Method : ASTM D 422

Filename : SBL4103
Elevation : ---
Tested by : tje
Checked by : jdt

HYDROMETER

Hydrometer ID : 343664
Height of air-dried soil = 33.46 gm
Specific Gravity = 2.65

Hydroscopic Moisture Content :
Weight of Wet Soil = 0 gm
Weight of Dry Soil = 0 gm
Moisture Content = 0

Elapsed Time (min)	Reading	Temperature (deg. C)	Corrected Reading	Particle Size (mm)	Percent Finer (%)	Adjusted Particle Size
2.00	39.00	22.00	32.75	0.030	96	0.030
5.00	38.00	22.00	31.75	0.019	93	0.019
15.00	37.00	22.00	30.75	0.011	90	0.011
30.00	36.00	22.00	29.75	0.008	87	0.008
60.00	35.00	22.00	28.75	0.006	84	0.006
120.00	33.00	22.00	26.75	0.004	78	0.004
240.00	31.00	22.00	24.75	0.003	73	0.003
1067.00	25.00	22.00	18.75	0.001	55	0.001

FINE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
#4	0.187	4.75	0.00	0.00	100
#10	0.079	2.00	0.05	0.05	100
#20	0.033	0.84	0.05	0.10	100
#40	0.017	0.42	0.01	0.11	100
#60	0.010	0.25	0.04	0.15	100
#100	0.006	0.15	0.14	0.29	99
#200	0.003	0.07	0.39	0.68	98
Pan			33.46	34.14	0

Total Dry Weight of Sample = 139.12

D85 : 0.0060 mm
D60 : 0.0017 mm
D50 : N/A
D30 : N/A
D15 : N/A
D10 : N/A

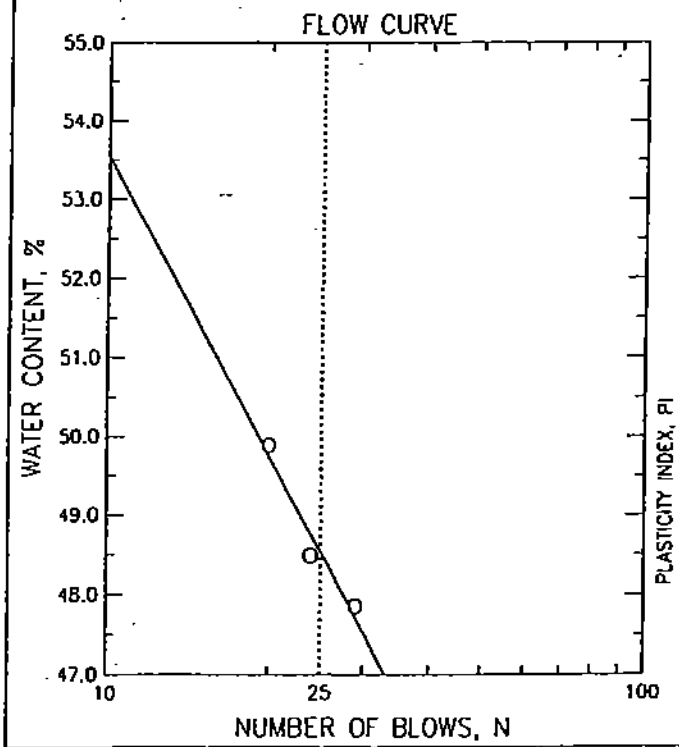
Soil Classification
ASTM Group Symbol : CL
ASTM Group Name : lean clay
AASHTO Group Symbol : A-7-6(28)
AASHTO Group Name : Clayey Soils

ATTERBERG LIMITS

PROJECT	PROJECT NUMBER	TESTED BY	BORING NUMBER
Pownal Tannery Superfund Site	GTX-4363	lje	SBL4
LOCATION		CHECKED BY	SAMPLE NUMBER
Pownal, VT		jdt	103 (25-27)
SAMPLE DESCRIPTION		DATE	FILENAME
Moist, dark gray clay		Mon Jan 06 2003	SBL4103

LIQUID LIMIT DETERMINATIONS					
CONTAINER NUMBER	16	17	1		
WT. WET SOIL + TARE	29.37	31.22	30.08		
WT. DRY SOIL + TARE	25.21	26.43	25.6		
WT. WATER	4.16	4.79	4.48		
TARE WT.	16.63	16.42	16.62		
WT. DRY SOIL	8.58	10.01	8.98		
WATER CONTENT, W_N (%)	48.48	47.85	49.89		
NUMBER OF BLOWS, N	24	29	20		
ONE-POINT LIQUID LIMIT, LL	48.25	48.72	48.56		

PLASTIC LIMIT DETERMINATIONS					
CONTAINER NUMBER	9	24			
WT. WET SOIL + TARE	37.3	23.74			
WT. DRY SOIL + TARE	35.69	22.11			
WT. WATER	1.61	1.63			
TARE WT.	29.41	15.75			
WT. DRY SOIL	6.28	6.36			
WATER CONTENT (%)	25.64	25.63			



SUMMARY OF RESULTS	
NATURAL WATER CONTENT, W (%)	50.3
LIQUID LIMIT, LL	48.5
PLASTIC LIMIT, PL	25.6
PLASTICITY INDEX, PI	22.9
LIQUIDITY INDEX, LI*	1.08

*LI = (W - PL)/PI

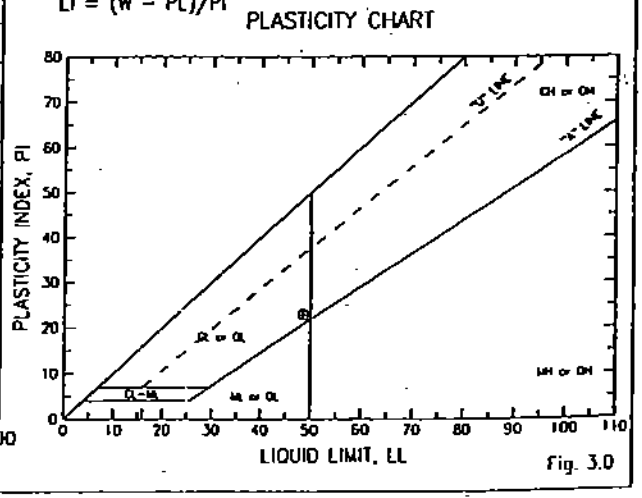
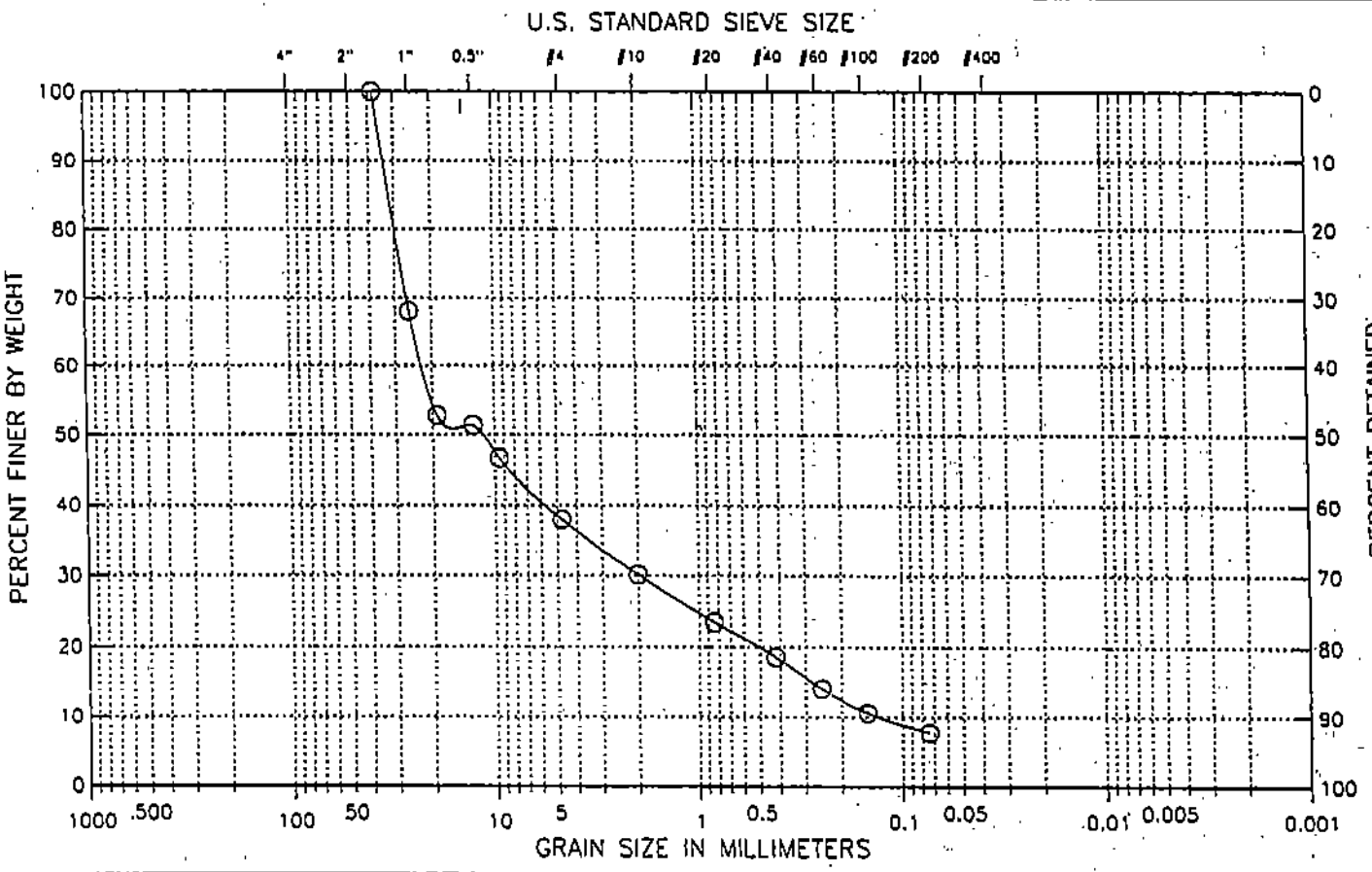


Fig. 3.0

	Boring No. : SBL4 Sample No.: 104 (4-6) Test Method ASTM D 422 Filename : SBL41044	Project : Pownal Tannery Superfund Site Project No.: GTX-4363 Location: Pownal, VT Date : Mon Jan 06 2003



Classification :

Remarks :

Visual Description :
Moist, olive gravel with silt and sand

Figure 4

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GEOTECHNICAL LABORATORY TEST DATA

Project : Pownal Tannery Superfund Site
Project No. : GTX-4363
Boring No. : SBL4
Sample No. : 104 (4-6)
Location : Pownal, VT
Soil Description : Moist, olive gravel with silt and sand
Remarks :

Depth : 4-6 ft.
Test Date : 12/5/02
Test Method : ASTM D 422

Filename : SBL41044
Elevation : ---
Tested by : tje/ccp
Checked by : jdt

FINE SIEVE SET

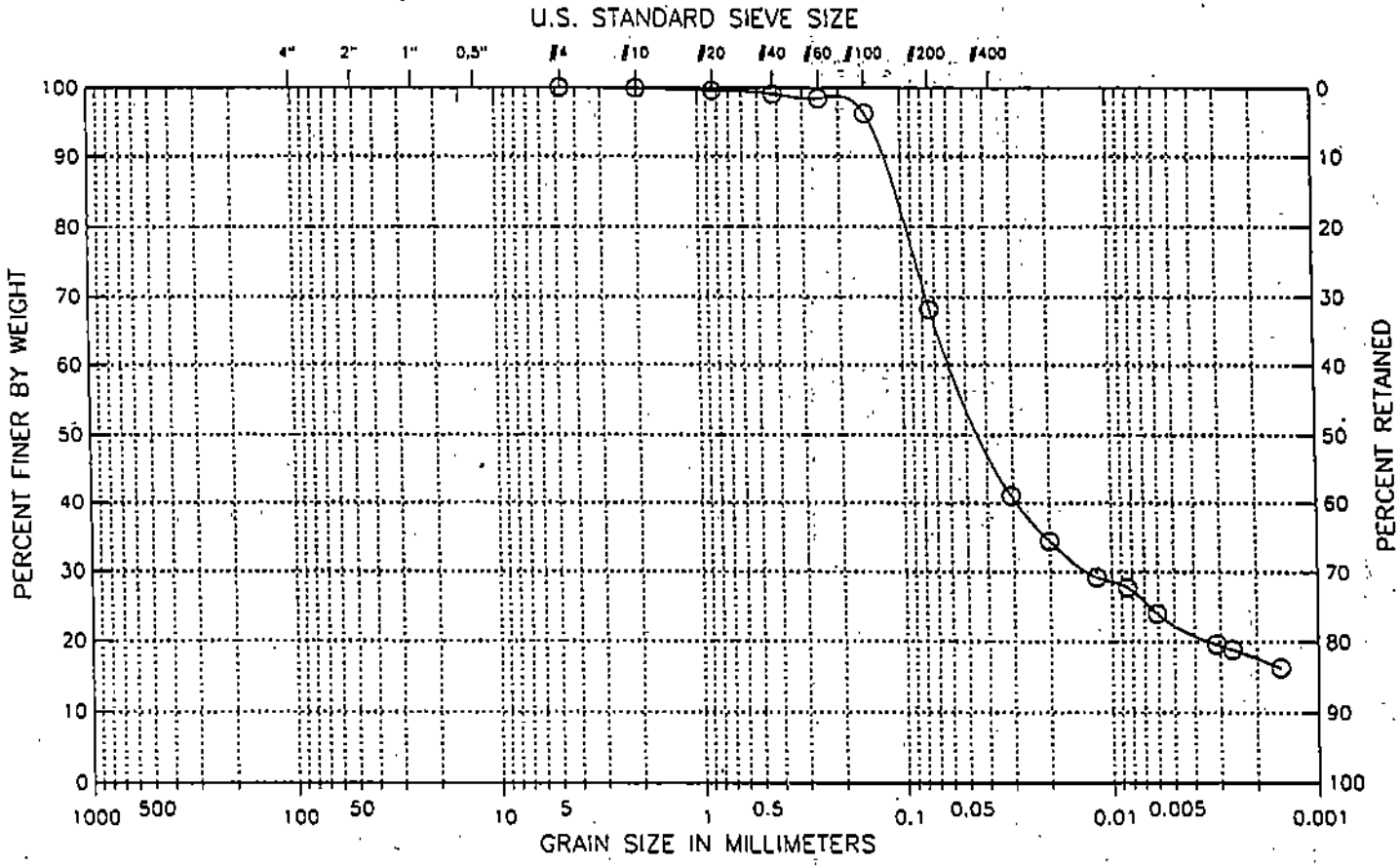
Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
1.5"	1.500	38.10	0.00	0.00	100
1"	1.012	25.70	98.41	98.41	68
0.75"	0.748	19.00	47.35	145.76	53
0.5"	0.500	12.70	4.29	150.05	51
0.375"	0.374	9.51	14.31	164.36	47
#4	0.187	4.75	26.87	191.23	38
#10	0.079	2.00	24.07	215.30	30
#20	0.033	0.84	20.66	235.96	23
#40	0.017	0.42	14.97	250.93	19
#60	0.010	0.25	14.11	265.04	14
#100	0.006	0.15	10.47	275.51	11
#200	0.003	0.07	8.83	284.34	8
Pan			23.90	308.24	0

Total Dry Weight of Sample = 316.34

D85 : 31.6656 mm
D60 : 21.9275 mm
D50 : 11.6970 mm
D30 : 1.9611 mm
D15 : 0.2795 mm
D10 : 0.1281 mm

Soil Classification
ASTM Group Symbol : N/A
ASTM Group Name : N/A
AASHTO Group Symbol : A-1-a(0)
AASHTO Group Name : Stone Fragments, Gravel and Sand

Boring No. : SBL4 Sample No: 104 (19-21) Test Method ASTM D 422 Filename : SBL4104	Project : Pownal Tannery Superfund Site Project No.: GTX-4363 Location: Pownal, VT Date : Mon Jan 06 2003



Classification :
(CL-ML) Sandy silty clay
Visual Description :
Moist, dark gray sandy silty clay

Remarks :

Figure 5

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Mon Jan 06 07:11:09 2003

GEOTECHNICAL LABORATORY TEST DATA

Project : Powual Tannery Superfund Site
Project No. : GTX-4363
Boring No. : SBL4
Sample No. : 104 (19-21)
Location : Powual, VT
Soil Description : Moist, dark gray sandy silty clay
Remarks :

Depth : 19-21 ft.
Test Date : 12/04/02
Test Method : ASTM D 422

Filename : SBL4104
Elevation : ---
Tested by : jlg
Checked by : jdt

HYDROMETER

Hydrometer ID : 343664
Weight of air-dried soil = 45.6 gm
Specific Gravity = 2.7

Hydroscopic Moisture Content :
Weight of Wet Soil = 0 gm
Weight of Dry Soil = 0 gm
Moisture Content = 0

Elapsed Time (min)	Reading	Temperature (deg. C)	Corrected Reading	Particle Size (mm)	Percent Finer (%)	Adjusted Particle Size
2.00	34.50	21.00	27.75	0.031	41	0.031
5.00	30.00	21.00	23.25	0.020	34	0.020
15.00	26.50	21.00	19.75	0.012	29	0.012
30.00	25.50	21.00	18.75	0.008	28	0.008
60.00	23.00	21.00	16.25	0.006	24	0.006
234.00	20.00	21.00	13.25	0.003	20	0.003
335.00	19.50	21.00	12.75	0.003	19	0.003
1013.00	18.00	20.50	11.00	0.002	16	0.002

FINE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
#4	0.187	4.75	0.00	0.00	100
#10	0.079	2.00	0.07	0.07	100
#20	0.033	0.84	0.23	0.30	100
#40	0.017	0.42	0.30	0.60	99
#60	0.010	0.25	0.44	1.04	98
#100	0.006	0.15	1.43	2.47	96
#200	0.003	0.07	18.87	21.34	68
Pan			45.60	66.94	0

Total Dry Weight of Sample = 170.8

D85 : 0.1125 mm
D60 : 0.0568 mm
D50 : 0.0410 mm
D30 : 0.0128 mm
D15 : N/A
D10 : N/A

Soil Classification
ASTM Group Symbol : CL-ML
ASTM Group Name : Sandy silty clay
AASHTO Group Symbol : A-4(1)
AASHTO Group Name : Silty Soils

ATTERBERG LIMITS

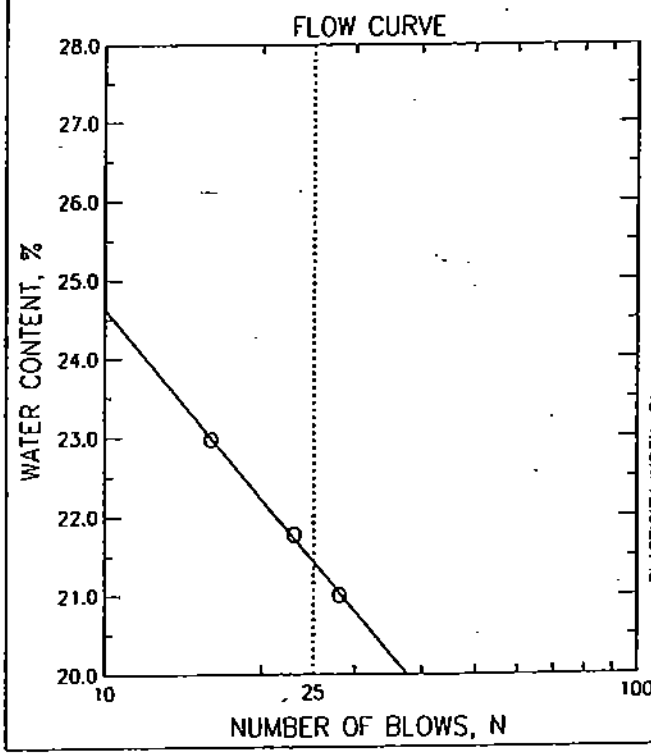
PROJECT	PROJECT NUMBER	TESTED BY	BORING NUMBER
Pownal Tonnery Superfund Site	GTX-4363	jfg	SBL4
LOCATION		CHECKED BY	SAMPLE NUMBER
Pownal, VT		jdt	104 (19-21)
SAMPLE DESCRIPTION		DATE	FILENAME
Moist, dark gray sandy silty clay		Mon Jan 06 2003	SBL4104

LIQUID LIMIT DETERMINATIONS

CONTAINER NUMBER	K-10	K-8	BM-1		
WT. WET SOIL + TARE	26.81	28.93	27.02		
WT. DRY SOIL + TARE	24.92	26.57	24.92		
WT. WATER	1.89	2.36	2.1		
TARE WT.	15.92	15.73	15.78		
WT. DRY SOIL	9	10.84	9.14		
WATER CONTENT, W_N (%)	21.00	21.77	22.98		
NUMBER OF BLOWS, N	28	23	16		
ONE-POINT LIQUID LIMIT, LL	21.29	21.55	21.77		

PLASTIC LIMIT DETERMINATIONS

CONTAINER NUMBER	AL-16	K-7			
WT. WET SOIL + TARE	36.01	36.99			
WT. DRY SOIL + TARE	35.15	36.04			
WT. WATER	0.86	0.95			
TARE WT.	29.42	29.56			
WT. DRY SOIL	5.73	6.48			
WATER CONTENT (%)	15.01	14.66			



SUMMARY OF RESULTS	
NATURAL WATER CONTENT, W (%)	20.4
LIQUID LIMIT, LL	21.4
PLASTIC LIMIT, PL	14.8
PLASTICITY INDEX, PI	6.6
LIQUIDITY INDEX, LI*	0.84

*LI = (W - PL)/PI

PLASTICITY CHART

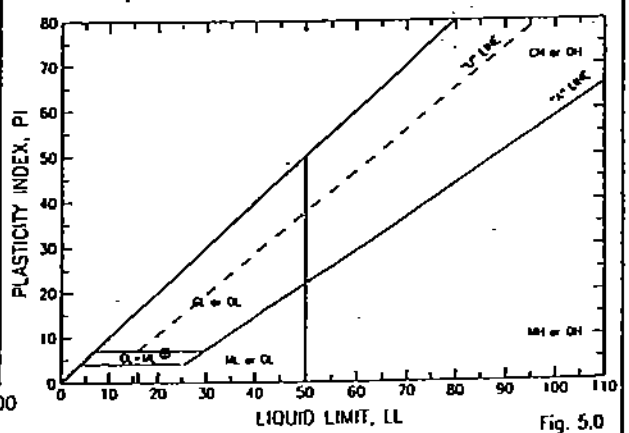


Fig. 5.0

Moisture, Ash, and Organic Matter of Peat and Other Organic Soils by ASTM D 2974

Client:	Metcalf & Eddy	GTX #:	4363
Project Name:	Pownal Tannery Superfund Site	Test Date:	12/16/02
Project Location:	Pownal, VT	Tested By:	tje
		Checked By:	jdl

Boring #	Sample ID	Depth, ft	Visual Description	Moisture Content, %	Ash Content, %	Organic Matter, %
TPL1	101	5-7	Wet, very dark grayish brown organic silt with sand	92	82.6	17.4
TPL1	102	2-4	Wet, very dark grayish brown organic silt	189	69.8	30.2
TPL1	103	2-4	Wet, very dark grayish brown organic silt with sand	265	44.2	55.8

Notes: Moisture content determined by Method A & reported as a percentage of oven-dried mass; dried to constant mass at temperature of 110 C
Ash content and organic matter determined by Method C; dried to constant mass at temperature of 440 C

...ser: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material.

Moisture Content of Soil by ASTM D 2216

Client:	Metcalf & Eddy	GTX #:	4363
Project Name:	Pownal Tannery Superfund Site	Test Date:	12/16/02
Project Location:	Pownal, VT	Tested By:	tje
		Checked By:	jdt

Boring #	Sample ID	Depth, ft	Visual Description	Moisture Content, %
TPL1	101	5-7	Wet, very dark grayish brown organic silt with sand	92
TPL1	102	2-4	Wet, very dark grayish brown organic silt	189
TPL1	103	2-4	Wet, very dark grayish brown organic silt with sand	265

Notes: Moisture content determined by Method A & reported as a percentage of oven-dried mass; dried to constant mass at temperature of 110 C
Ash content and organic matter determined by Method C; dried to constant mass at temperature of 440 C

Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material.

Specific Gravity of Soils by ASTM D 854

Client: Metcalf & Eddy
Project Name: Pownal Tannery Superfund Site
Project Location: Pownal, VT

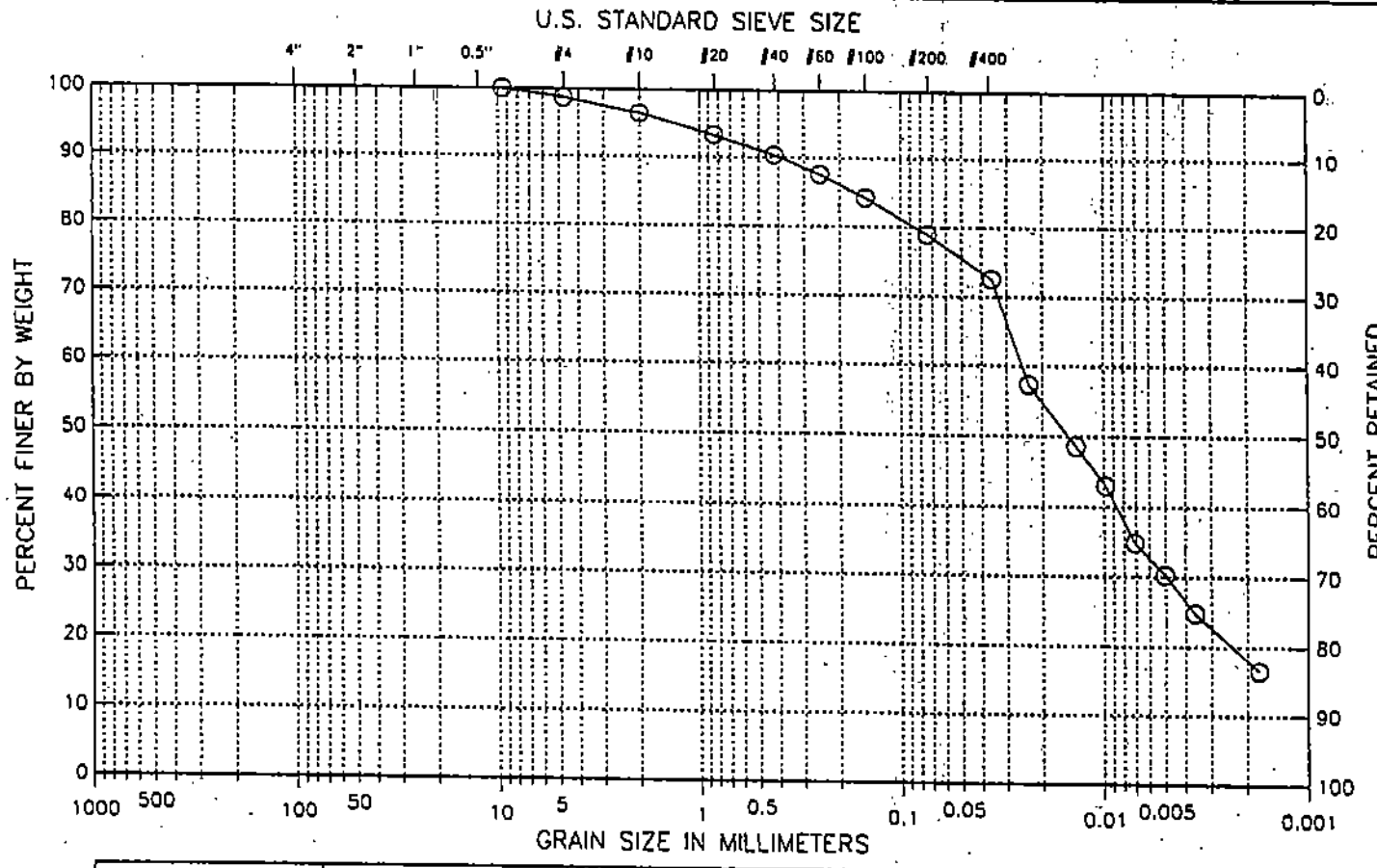
GTX #: 4363
Test Date: 12/31/02
Tested By: tje
Checked By: jdt

Boring #	Sample ID	Depth, ft	Visual Description	Specific Gravity @ 20 C
TPL1	101	5-7	Wet, very dark grayish brown organic silt with sand	2.28
TPL1	102	2-4	Wet, very dark grayish brown organic silt	2.27
TPL1	103	2-4	Wet, very dark grayish brown organic silt with sand	2.35

Notes: Specific gravity performed by using method A (oven dried specimens) of ASTM D 854

Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material.

	Boring No. : TPL1 Sample No: 101 (5-7) Test Method ASTM D 422 Filename : TPL1101	Project : Pownal Tannery Superfund Site Project No.: GTX-4363 Location: Pownal, VT Date : Mon Jan 06 2003



Classification :
(OH) organic silt with sand
Visual Description :
Wet, very dark grayish brown organic silt w/ sand

Remarks :

Figure 1

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GEOTECHNICAL LABORATORY TEST DATA

Project : Pownal Tannery Superfund Site
Project No. : GTX-4363
Boring No. : TPL1
Sample No. : 101 (S-7)
Location : Pownal, VT
Soil Description : Wet, very dark grayish brown organic silt w/ sand
Remarks :

Depth : 5-7 ft.
Test Date : 12/16/02
Test Method : ASTM D 422

Filename : TPL1101
Elevation : ---
Tested by : tje
Checked by : jdt

HYDROMETER

Hydrometer ID : 457488
Weight of air-dried soil = 30.92 gm
Specific Gravity = 2.28

Hydroscopic Moisture Content :
Weight of Wet Soil = 0 gm
Weight of Dry Soil = 0 gm
Moisture Content = 0

Elapsed Time (min)	Reading	Temperature (deg. C)	Corrected Reading	Particle Size (mm)	Percent Finer (%)	Adjusted Particle Size
2.00	33.00	21.50	26.33	0.036	73	0.036
5.00	27.50	21.50	20.83	0.023	57	0.023
15.00	24.00	22.00	17.67	0.014	49	0.014
30.00	22.00	22.00	15.67	0.010	43	0.010
60.00	19.00	22.00	12.67	0.007	35	0.007
120.00	17.00	22.50	11.00	0.005	30	0.005
240.00	15.00	22.50	9.00	0.004	25	0.004
1081.00	13.00	21.00	6.00	0.002	17	0.002

FINE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
0.375"	0.374	9.51	0.00	0.00	100
#4	0.187	4.75	0.48	0.48	99
#10	0.079	2.00	0.88	1.36	97
#20	0.033	0.84	1.25	2.61	93
#40	0.017	0.42	1.16	3.77	90
#60	0.010	0.25	1.10	4.87	88
#100	0.006	0.15	1.30	6.17	84
#200	0.003	0.07	2.08	8.25	79
Pan			30.92	39.17	0

Total Dry Weight of Sample = 159.09

D85 : 0.1675 mm
D60 : 0.0251 mm
D50 : 0.0149 mm
D30 : 0.0050 mm
D15 : N/A
D10 : N/A

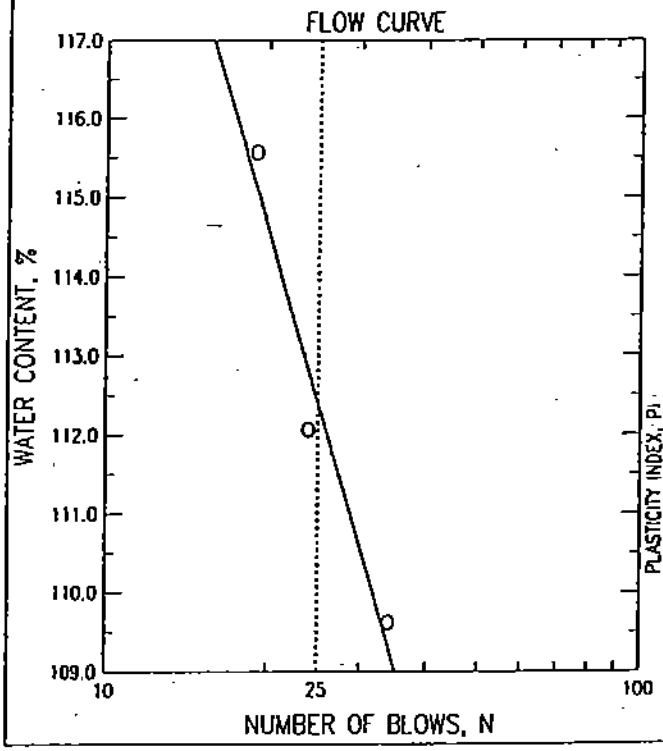
Soil Classification
ASTM Group Symbol : OH
ASTM Group Name : organic silt with sand
AASHTO Group Symbol : A-7-5(65)
AASHTO Group Name : Clayey Soils

ATTERBERG LIMITS

PROJECT	PROJECT NUMBER	TESTED BY	BORING NUMBER
Pownal Tannery Superfund Site	GTX-4363	tje	TPL1
LOCATION		CHECKED BY	SAMPLE NUMBER
Pownal, VT		jdt	101 (5-7)
SAMPLE DESCRIPTION		DATE	FILENAME
Wet, very dark grayish brown organic silt w/ sand		Mon Jan 06 2003	TPL1101

LIQUID LIMIT DETERMINATIONS					
CONTAINER NUMBER	114	122	110		
WT. WET SOIL + TARE	20.98	23.09	18.21		
WT. DRY SOIL + TARE	17.49	18.53	14.68		
WT. WATER	3.49	4.56	3.53		
TARE WT.	14.47	14.37	11.53		
WT. DRY SOIL	3.02	4.16	3.15		
WATER CONTENT, W_N (%)	115.56	109.62	112.06		
NUMBER OF BLOWS, N	19	34	24		
ONE-POINT LIQUID LIMIT, LL	111.79	113.77	111.51		

PLASTIC LIMIT DETERMINATIONS					
CONTAINER NUMBER	9120	8			
WT. WET SOIL + TARE	29.16	24			
WT. DRY SOIL + TARE	26.87	21.41			
WT. WATER	2.29	2.59			
TARE WT.	22.32	16.48			
WT. DRY SOIL	4.55	4.93			
WATER CONTENT (%)	50.33	52.54			



SUMMARY OF RESULTS	
NATURAL WATER CONTENT, W (%)	91.8
LIQUID LIMIT, LL	112.4
PLASTIC LIMIT, PL	51.4
PLASTICITY INDEX, PI	61.0
LIQUIDITY INDEX, LI*	0.66

*LI = (W - PL)/PI

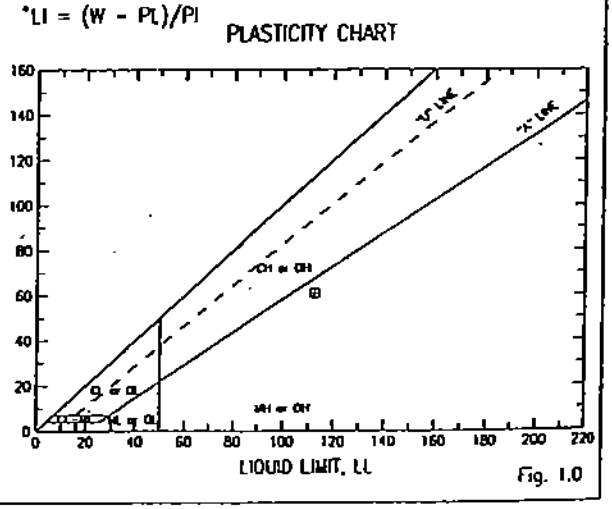
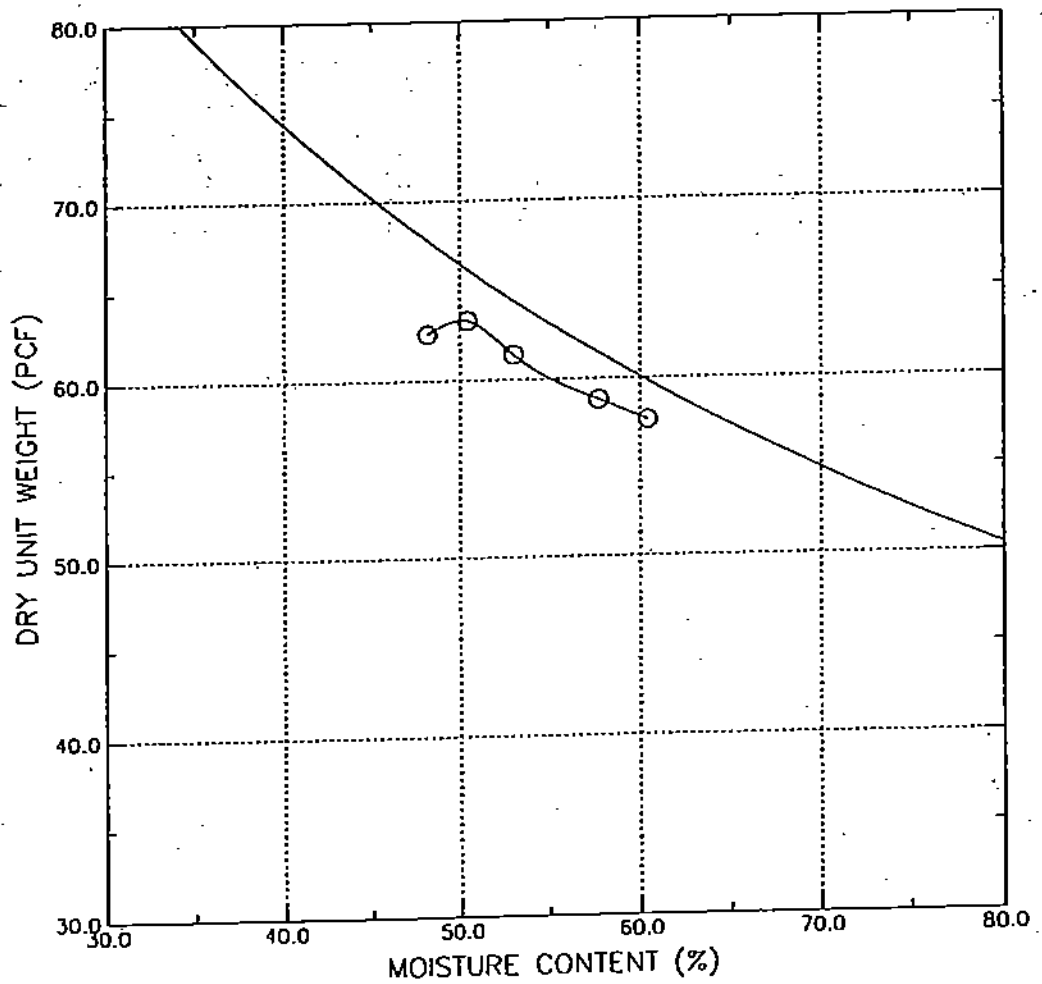


Fig. 1.0

	Boring No. : TPL1 Sample No. : 101 (5-7) Test Method : ASTM D 698 Filename : TPL1101	Project : Pownal Tannery Superfund Site Project No.: GTX-4363 Location : Pownal, VT Test Date : 12/16/02

Moisture-Density Relationship



Sample Description	: Wet, very dark grayish brown organic silt w/ sand
Compaction Test Designation	: ASTM D698-A
Maximum Dry Density	: 63.4 pcf
Optimum Moisture Content	: 50.1 %

Figure 1

GEOTECHNICAL LABORATORY TEST DATA

Project : Pownal Tannery Superfund Site
Project No. : GTX-4363
Boring No. : TPL1
Sample No. : 101 (5-7)
Location : Pownal, VT
Soil Description : Wet, very dark grayish brown organic silt w/ sand
Remarks :

Depth : 5-7 ft.
Test Date : 12/16/02
Test Method : ASTM D 698

Filename : TPL1101
Elevation : ---
Tested by : tje
Checked by : jdt

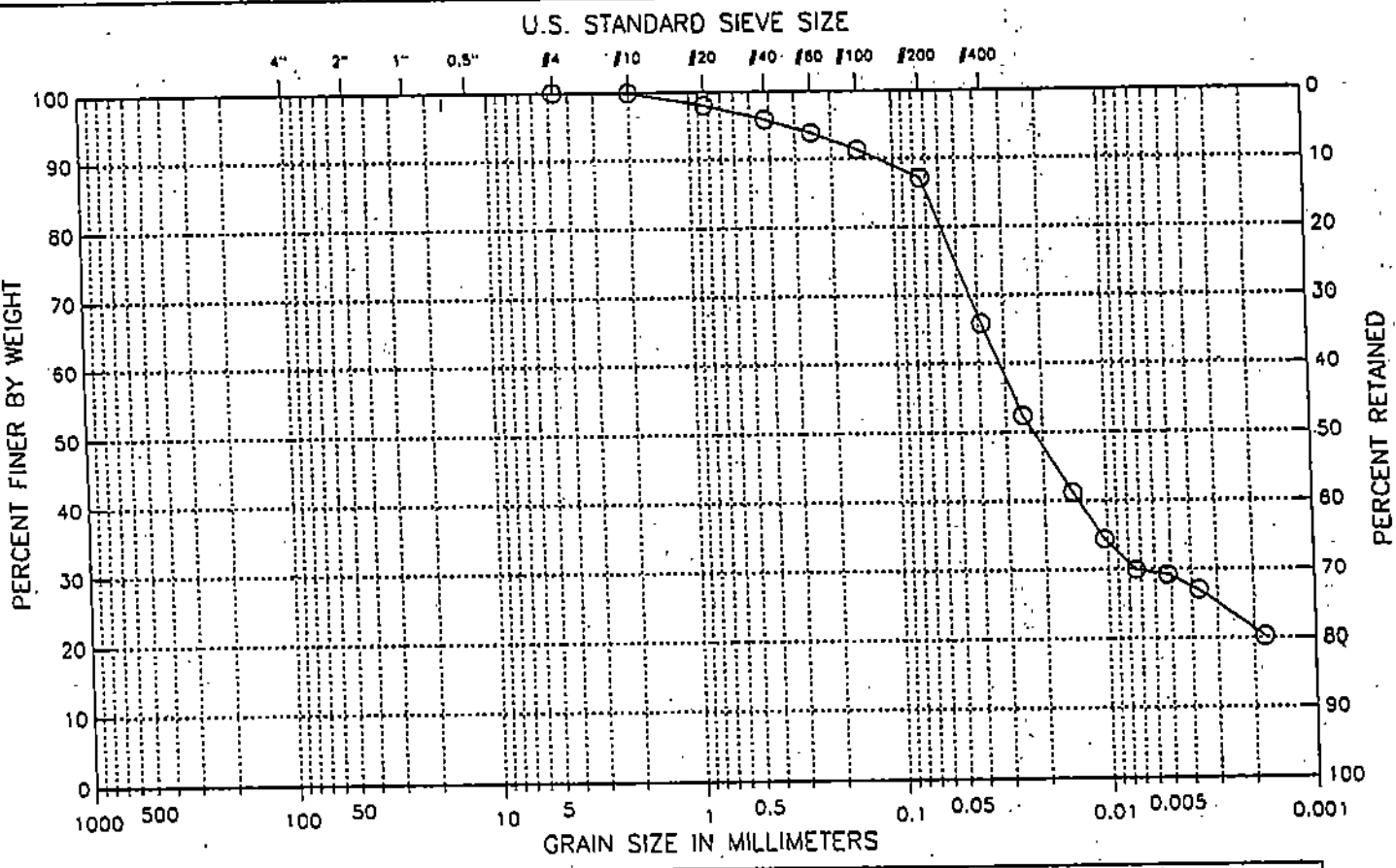
COMPACTION TEST

Mold ID :
Method Used : ASTM D698-A
Volume of Mold : 0.0333 ft^3
Mass of Mold : 5303 gm
Specific Gravity : 2.28

Moisture Content ID	Mass of Container (gm)	Mass of Container + Moist Soil (gm)	Mass of Container + Dry Soil (gm)	Mass of Mold + Specimen (gm)	Moisture Content (%)	Dry Density (pcf)
1	8.15	164.67	113.82	6704.00	48.1	62.6
2	8.14	110.23	76.01	6742.00	50.4	63.3
3	8.28	162.00	108.73	6722.00	53.0	61.4
4	8.16	132.24	86.84	6704.00	57.7	58.8
5	8.23	229.70	146.28	6700.00	60.4	57.7

Optimum Dry Density = 63.4 pcf
Optimum Moisture Content = 50.1 %

	Boring No. : TPL1 Sample No: 102 (2-4) Test Method ASTM D 422 Filename : TPL1102	Project : Pownal Tannery Superfund Site Project No.: GTX-4363 Location: Pownal, VT Date : Mon Jan 06 2003



Classification :
(OH) organic silt
Visual Description :
Wet, very dark grayish brown organic silt

Remarks :

Figure 2

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GEOTECHNICAL LABORATORY TEST DATA

Project : Pownal Tannery Superfund Site
Project No. : GTX-4363
Boring No. : TPL1
Sample No. : 102 (2-4)
Location : Pownal, VT
Soil Description : Wet, very dark grayish brown organic silt
Remarks :

Depth : 2-4 ft.
Test Date : 12/16/02
Test Method : ASTM D 422

Filename : TPL1102
Elevation : ---
Tested by : tje
Checked by : jdt

HYDROMETER

Hydrometer ID : 457488
Weight of air-dried soil = 20.96 gm
Specific Gravity = 2.27

Hydroscopic Moisture Content :
Weight of Wet Soil = 0 gm
Weight of Dry Soil = 0 gm
Moisture Content = 0

Elapsed Time (min)	Reading	Temperature (deg. C)	Corrected Reading	Particle Size (mm)	Percent Finer (%)	Adjusted Particle Size
2.00	21.00	22.00	14.67	0.038	66	0.038
5.00	18.00	22.00	11.67	0.025	52	0.025
15.00	15.50	22.00	9.17	0.015	41	0.015
30.00	14.00	22.00	7.67	0.010	34	0.010
60.00	13.00	22.00	6.67	0.007	30	0.007
120.00	12.50	22.50	6.50	0.005	29	0.005
240.00	12.00	22.50	6.00	0.004	27	0.004
1081.00	11.50	21.00	4.50	0.002	20	0.002

FINE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
#4	0.187	4.75	0.00	0.00	100
#10	0.079	2.00	0.02	0.02	100
#20	0.033	0.84	0.45	0.47	98
#40	0.017	0.42	0.51	0.98	96
#60	0.010	0.25	0.48	1.46	94
#100	0.006	0.15	0.62	2.08	91
#200	0.003	0.07	1.02	3.10	87
Pan			20.96	24.06	0

Total Dry Weight of Sample = 139.28

D85 : 0.0693 mm
D60 : 0.0318 mm
D50 : 0.0221 mm
D30 : 0.0074 mm
D15 : N/A
D10 : N/A

Soil Classification
ASTM Group Symbol : OH
ASTM Group Name : organic silt
AASHTO Group Symbol : A-7-5(148)
AASHTO Group Name : Clayey Soils

ATTERBERG LIMITS

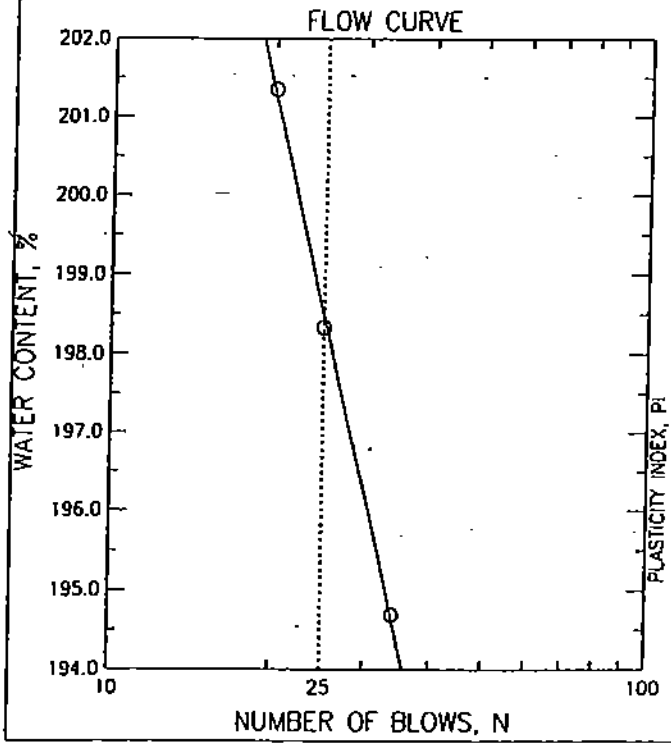
PROJECT	PROJECT NUMBER	TESTED BY	BORING NUMBER
Pownal Tannery Superfund Site	GTX-4363	tje	TPL1
LOCATION		**CHECKED BY**	**SAMPLE NUMBER**
Pownal, VT		jdl	102 (2-4)
SAMPLE DESCRIPTION		**DATE**	**FILENAME**
Wet, very dark grayish brown organic silt		Mon Jan 06 2003	TPL1102

LIQUID LIMIT DETERMINATIONS

CONTAINER NUMBER	33	156	36		
WT. WET SOIL + TARE	29.81	19.51	30.75		
WT. DRY SOIL + TARE	23.58	13.55	23.61		
WT. WATER	6.23	5.96	7.14		
TARE WT.	20.38	10.59	20.01		
WT. DRY SOIL	3.2	2.96	3.6		
WATER CONTENT, W_N (%)	194.69	201.35	198.33		
NUMBER OF BLOWS, N	34	20	25		
ONE-POINT LIQUID LIMIT, LL	202.07	195.99	198.33		

PLASTIC LIMIT DETERMINATIONS

CONTAINER NUMBER	21	11			
WT. WET SOIL + TARE	22.99	21.65			
WT. DRY SOIL + TARE	19.8	19.05			
WT. WATER	3.19	2.6			
TARE WT.	15.71	15.73			
WT. DRY SOIL	4.09	3.32			
WATER CONTENT.(%)	78.00	78.31			



SUMMARY OF RESULTS	
NATURAL WATER CONTENT, W (%)	189.4
LIQUID LIMIT, LL	198.5
PLASTIC LIMIT, PL	78.2
PLASTICITY INDEX, PI	120.3
LIQUIDITY INDEX, LI*	0.92

*LI = (W - PL)/PI

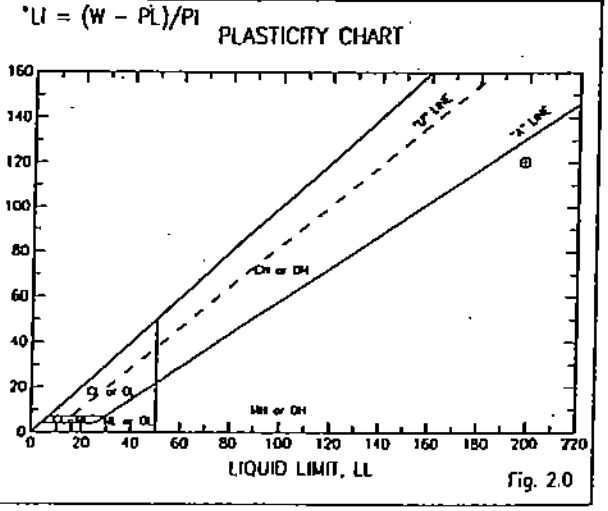
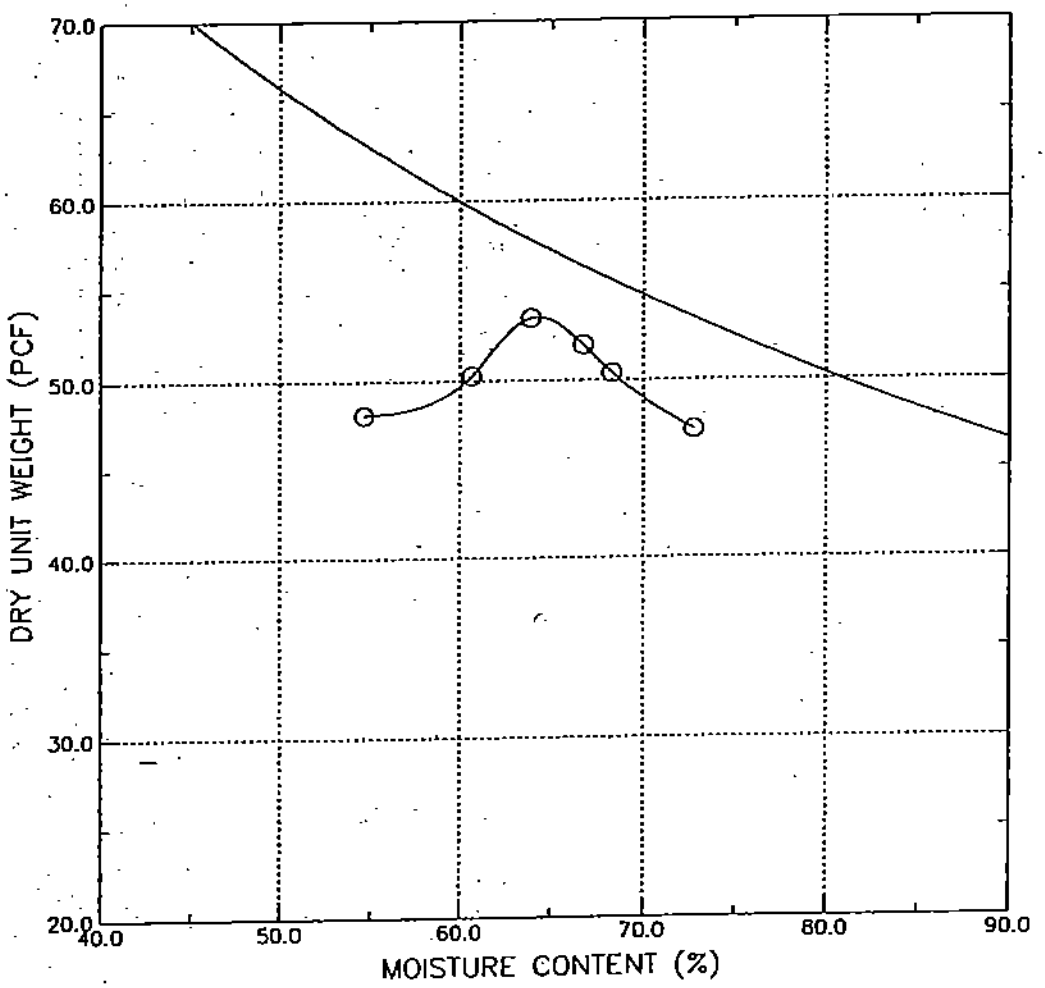


Fig. 2.0

	Boring No. : TPL1 Sample No. : 102 (2-4) Test Method : ASTM D 698 Filename : TPL1102	Project : Pownal Tannery Superfund Site Project No. : GTX-4363 Location : Pownal, VT Test Date : 12/16/02

Moisture-Density Relationship



Sample Description : Wet, very dark grayish brown organic silt
Compaction Test Designation : ASTM D698-A
Maximum Dry Density : 53.5 pcf
Optimum Moisture Content : 64.3 %

Figure 2

GEOTECHNICAL LABORATORY TEST DATA

Project : Pownal Tannery Superfund Site
Project No. : GTX-4363
Boring No. : TPL1
Sample No. : 102 (2-4)
Location : Pownal, VT
Soil Description : Wet, very dark grayish brown organic silt
Remarks :

Depth : 2-4 ft.
Test Date : 12/16/02
Test Method : ASTM D 698

Filename : TPL1102
Elevation : ---
Tested by : tje
Checked by : jdt

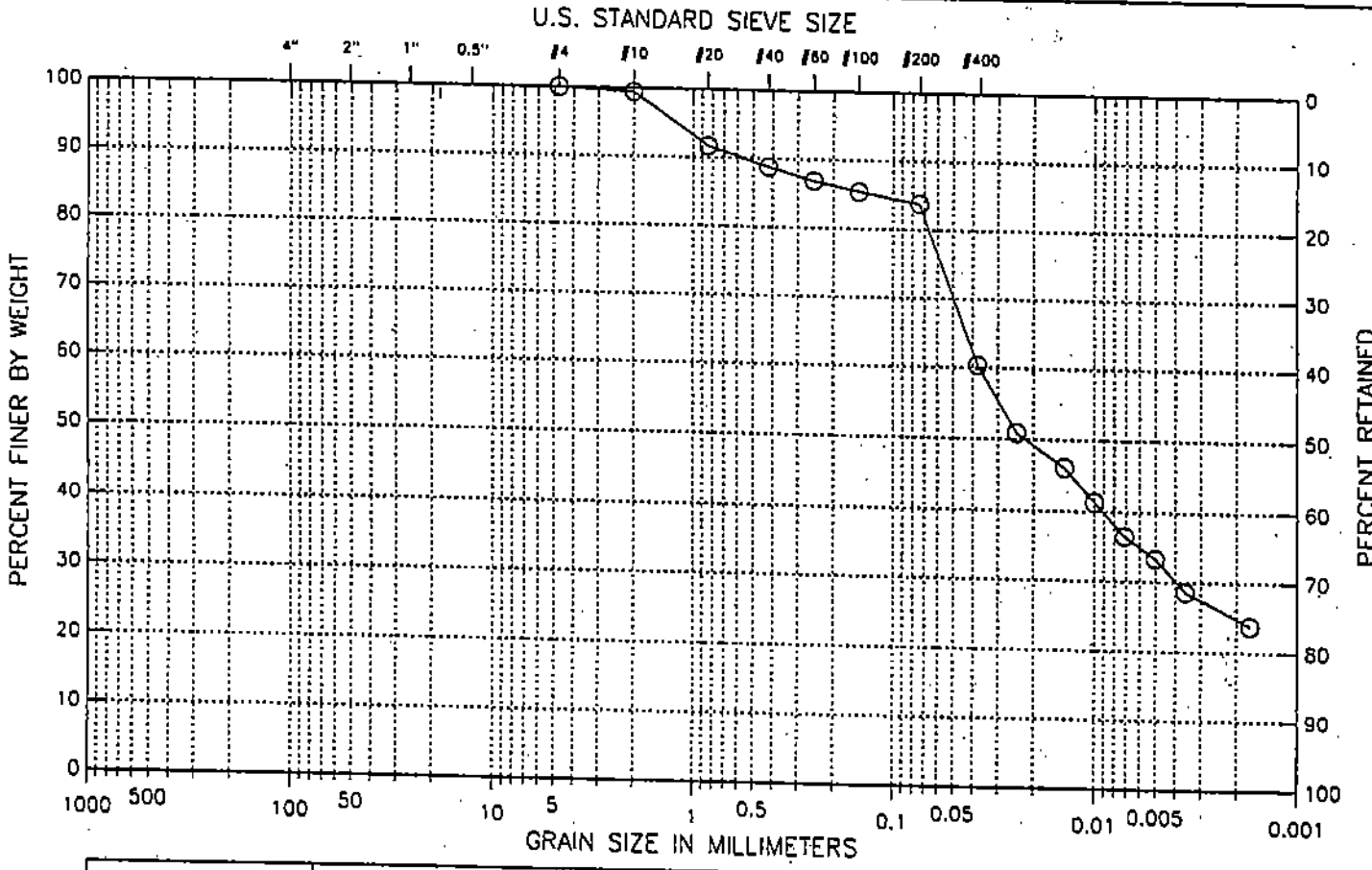
COMPACTION TEST

Mold ID :
Method Used : ASTM D698-A
Volume of Mold : 0.0333 ft^3
Mass of Mold : 5303 gm
Specific Gravity : 2.27

Moisture Content ID	Mass of Container (gm)	Mass of Container + Moist Soil (gm)	Mass of Container + Dry Soil (gm)	Mass of Mold + Specimen (gm)	Moisture Content (%)	Dry Density (pcf)
4	8.12	148.30	98.77	6427.00	54.6	48.1
5	8.14	154.09	98.99	6523.00	60.6	50.3
9	8.28	154.18	97.29	6627.00	63.9	53.5
7	8.22	109.33	68.85	6612.00	66.8	52.0
6	8.36	218.29	133.08	6584.00	68.3	50.4
8	8.20	108.60	66.32	6535.00	72.7	47.2

Optimum Dry Density = 53.5 pcf
Optimum Moisture Content = 64.3 %

	Boring No. : TPL1 Sample No: 103 (2-4) Test Method ASTM D 422 Filename : TPL1103	Project : Pownal Tannery Superfund Site Project No.: GTX-4363 Location: Pownal, VT Date : Mon Jan 06 2003



Classification :
(OH) organic silt with sand
Visual Description :
Wet, very dark grayish brown organic silt w/ sand

Remarks :

Figure 3

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GEOTECHNICAL LABORATORY TEST DATA

Project : Pownal Tannery Superfund Site
Project No. : GTX-4363
Boring No. : TPL1
Sample No. : 103 (2-4)
Location : Pownal, VT
Soil Description : Wet, very dark grayish brown organic silt w/ sand
Remarks :

Depth : 2-4 ft.
Test Date : 12/16/02
Test Method : ASTM D 422

Filename : TPL1103
Elevation : ---
Tested by : tje
Checked by : jdt

HYDROMETER

Hydrometer ID : 457488
Weight of air-dried soil = 18.68 gm
Specific Gravity = 2.35

Hydroscopic Moisture Content :
Weight of Wet Soil = 0 gm
Weight of Dry Soil = 0 gm
Moisture Content = 0

Elapsed Time (min)	Reading	Temperature (deg. C)	Corrected Reading	Particle Size (mm)	Percent Finer (%)	Adjusted Particle Size
2.00	19.00	22.00	12.67	0.038	60	0.038
5.00	17.00	22.00	10.67	0.024	51	0.024
15.00	16.00	22.00	9.67	0.014	46	0.014
30.00	15.00	22.00	8.67	0.010	41	0.010
60.00	14.00	22.00	7.67	0.007	37	0.007
120.00	13.00	22.50	7.00	0.005	33	0.005
240.00	12.00	22.50	6.00	0.004	29	0.004
1081.00	12.00	21.00	5.00	0.002	24	0.002

FINE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
#4	0.187	4.75	0.00	0.00	100
#10	0.079	2.00	0.16	0.16	99
#20	0.033	0.84	2.18	2.34	92
#40	0.017	0.42	0.85	3.19	89
#60	0.010	0.25	0.55	3.74	87
#100	0.006	0.15	0.41	4.15	85
#200	0.003	0.07	0.46	4.61	84
Pan			23.68	28.29	0

Total Dry Weight of Sample = 151.27

D85 : 0.1292 mm
D60 : 0.0371 mm
D50 : 0.0219 mm
D30 : 0.0040 mm
D15 : N/A
D10 : N/A

Soil Classification
ASTM Group Symbol : OH
ASTM Group Name : organic silt with sand
AASHTO Group Symbol : A-7-5(20)
AASHTO Group Name : Clayey Soils

ATTERBERG LIMITS

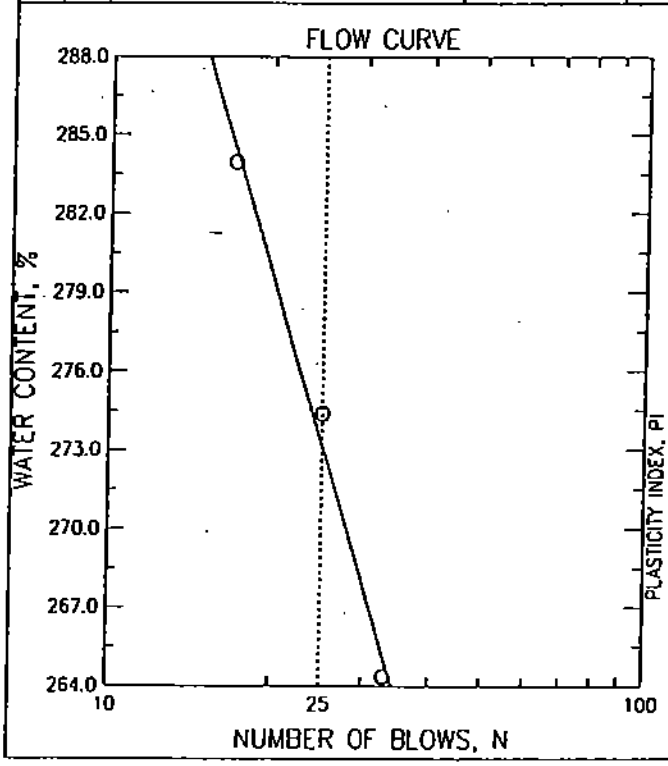
PROJECT	PROJECT NUMBER	TESTED BY	BORING NUMBER
Pownal Tannery Superfund Site	GTX-4363	tje	TPL1
LOCATION		CHECKED BY	SAMPLE NUMBER
Pownal, VT		jdl	103 (2-4)
SAMPLE DESCRIPTION		DATE	FILENAME
Wet, very dark grayish brown organic silt w/ sand		Mon Jan 06 2003	TPL1103

LIQUID LIMIT DETERMINATIONS

CONTAINER NUMBER	1	5	131		
WT. WET SOIL + TARE	23.32	23.78	19.8		
WT. DRY SOIL + TARE	17.75	17.76	14.46		
WT. WATER	5.57	6.02	5.34		
TARE WT.	15.72	15.64	12.44		
WT. DRY SOIL	2.03	2.12	2.02		
WATER CONTENT, W_N (%)	274.38	283.96	264.36		
NUMBER OF BLOWS, N	25	17	33		
ONE-POINT LIQUID LIMIT, LL	274.38	271.02	273.39		

PLASTIC LIMIT DETERMINATIONS

CONTAINER NUMBER	121	9124			
WT. WET SOIL + TARE	20.33	28.76			
WT. DRY SOIL + TARE	17.22	25.44			
WT. WATER	3.11	3.32			
TARE WT.	14.16	22.21			
WT. DRY SOIL	3.06	3.23			
WATER CONTENT (%)	101.63	102.79			



SUMMARY OF RESULTS	
NATURAL WATER CONTENT, W (%)	264.8
LIQUID LIMIT, LL	273.2
PLASTIC LIMIT, PL	102.2
PLASTICITY INDEX, PI	171.0
LIQUIDITY INDEX, LI*	0.95

*LI = (W - PL)/PI

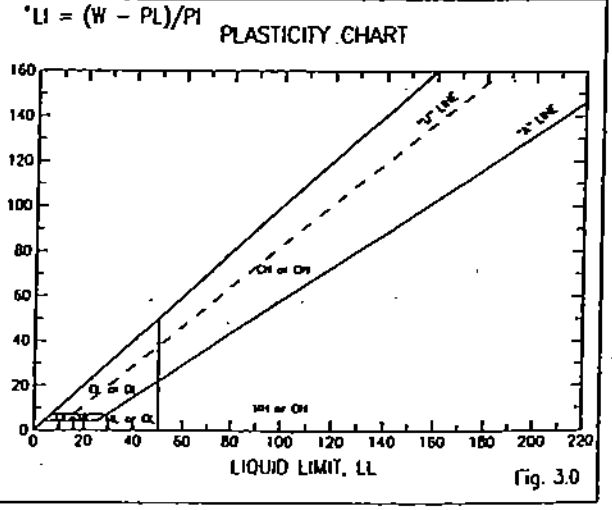
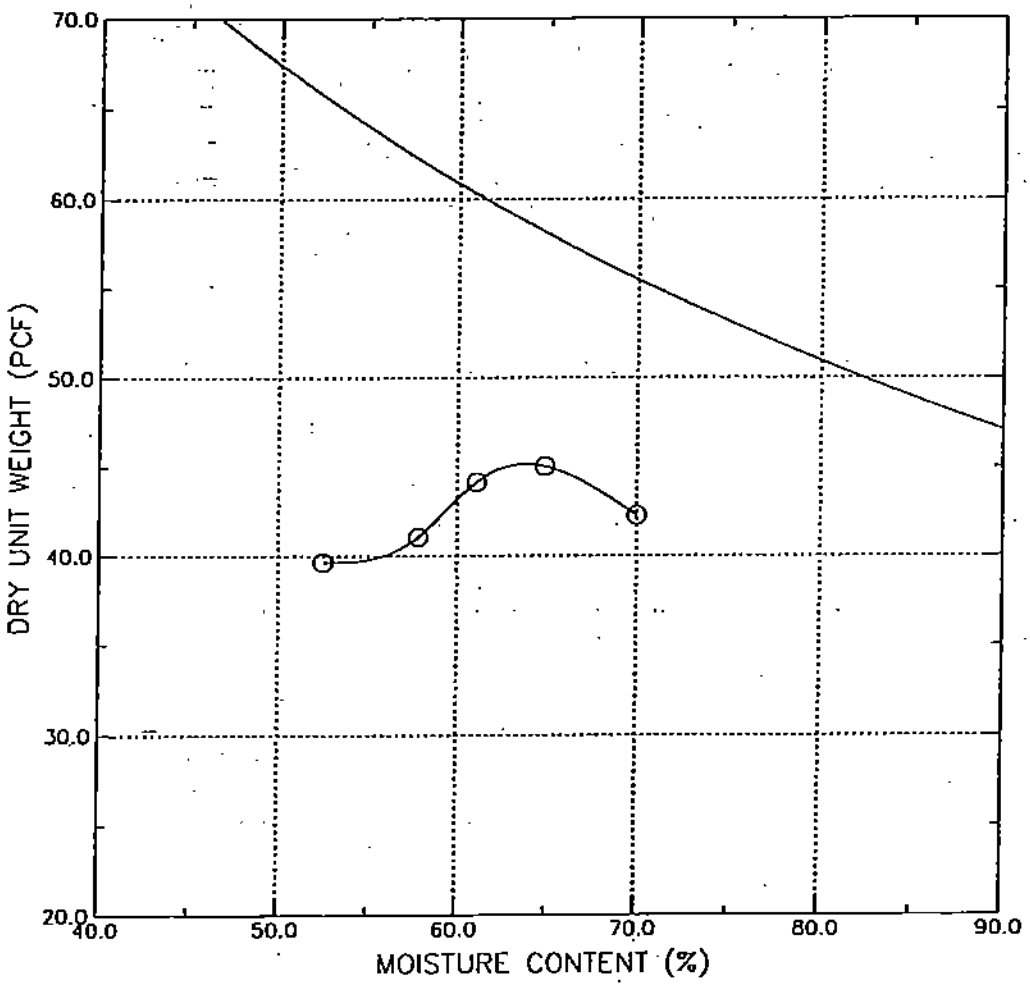


Fig. 3.0

	Boring No. : TPL1 Sample No. : 103 (2-4) Test Method : ASTM D 698 Filename : TPL1103	Project : Pownal Tannery Superfund Site Project No. : GTX-4363 Location : Pownal, VT Test Date : 12/16/02

Moisture-Density Relationship



Sample Description	: Wet, very dark grayish brown organic silt w/ sand
Compaction Test Designation	: ASTM D698-A
Maximum Dry Density	: 45.2 pcf
Optimum Moisture Content	: 63.8 %

Figure 3

GEOTECHNICAL LABORATORY TEST DATA

Project : Pownal Tannery Superfund Site
Project No. : GTX-4363 Depth : 2-4 ft. Filename : TPL2103
Boring No. : TPL1 Test Date : 12/16/02 Elevation : ---
Sample No. : 103 (2-4) Test Method : ASTM D 698 Tested by : tje
Location : Pownal, VT Checked by : jdt
Soil Description : Wet, very dark grayish brown organic silt w/ sand
Remarks :

COMPACTION TEST

Mold ID :
Method Used : ASTM D698-A
Volume of Mold : 0.0333 ft^3
Mass of Mold : 5303 gm
Specific Gravity : 2.35

Moisture Content ID	Mass of Container (gm)	Mass of Container + Moist Soil (gm)	Mass of Container + Dry Soil (gm)	Mass of Mold + Specimen (gm)	Moisture Content (%)	Dry Density (pcf)
6	8.18	74.34	51.57	6216.00	52.5	39.6
7	8.10	106.78	70.62	6282.00	57.8	41.1
5	8.21	70.47	46.87	6377.00	61.0	44.2
1	8.11	55.58	36.91	6424.00	64.8	45.0
2	8.37	71.69	45.62	6388.00	70.0	42.3

Optimum Dry Density = 45.1 pcf
Optimum Moisture Content = 63.8 %

Moisture Content of Soil by ASTM D 2216

Client:	Metcalf & Eddy	GTX #:	4363
Project Name:	Pownal Tannery Superfund Site	Test Date:	12/04/02
Project Location:	Pownal, VT	Tested By:	tje
		Checked By:	jdt

Boring #	Sample ID	Depth, ft	Visual Description	Moisture Content, %
TPL5	101	3-5	Wet, black gravelly organic silt with sand	83
TPL5	102	1-2	Wet, black organic clay	119
TPL5	103	1-3	Moist, olive brown sandy silt	51

Notes: Moisture content determined by Method A & reported as a percentage of oven-dried mass; dried to constant mass at temperature of 110 C
Ash content and organic matter determined by Method C; dried to constant mass at temperature of 440 C

Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material.

Moisture, Ash, and Organic Matter of Peat and Other Organic Soils by ASTM D 2974

Client:	Metcalf & Eddy	GTX #:	4363
Project Name:	Pownal Tannery Superfund Site	Test Date:	12/04/02
Project Location:	Pownal, VT	Tested By:	tje
		Checked By:	jdt

Boring #	Sample ID	Depth, ft	Visual Description	Moisture Content, %	Ash Content, %	Organic Matter, %
TPL5	101	3-5	Wet, black gravelly organic silt with sand	83	90.6	9.4
TPL5	102	1-2	Wet, black organic clay	119	89.7	10.3
TPL5	103	1-3	Moist, olive brown sandy silt	51	96.4	3.6

Notes: Moisture content determined by Method A & reported as a percentage of oven-dried mass; dried to constant mass at temperature of 110 C
Ash content and organic matter determined by Method C; dried to constant mass at temperature of 440 C

Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material.

Specific Gravity of Soils by ASTM D 854

Client: Metcalf & Eddy
Project Name: Pownal Tannery Superfund Site
Project Location: Pownal, VT

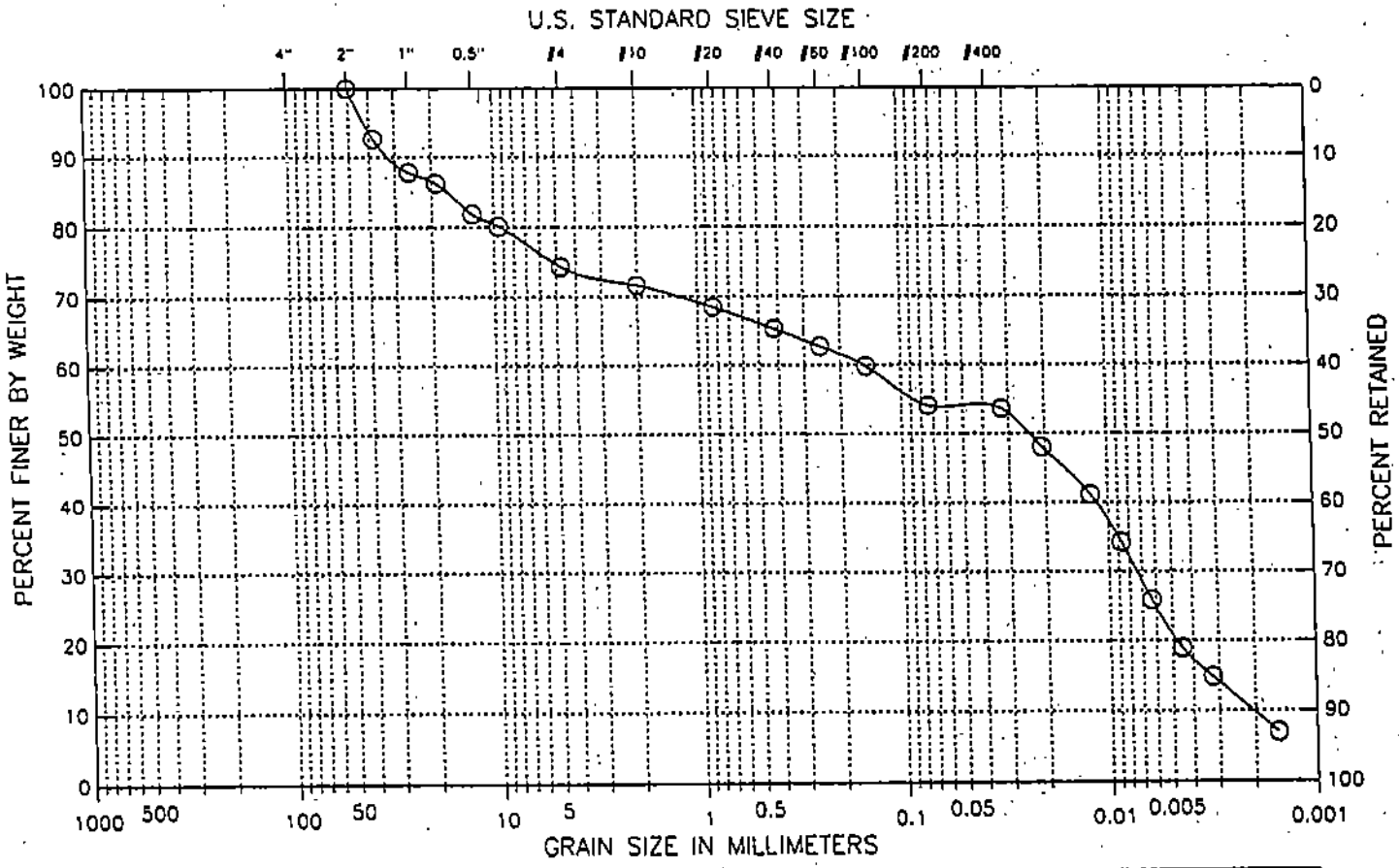
GTX #: 4363
Test Date: 12/05/02
Tested By: tje
Checked By: jdt

Boring #	Sample ID	Depth, ft	Visual Description	Specific Gravity @ 20 C
TPL5	101	3-5	Wet, black gravelly organic silt with sand	2.71
TPL5	102	1-2	Wet, black organic clay	2.51
TPL5	103	1-3	Moist, olive brown sandy silt	2.52

Notes: Specific gravity performed by using method A (oven dried specimens) of ASTM D 854

Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material.

	Boring No. : TPL5 Sample No: 101 (3-5) Test Method ASTM D 422 Filename : TPL5101	Project : Pownal Tannery Superfund Site Project No.: GTX-4363 Location: Pownal, VT Date : Mon Jan 06 2003



Classification :
(OH) Gravelly organic silt with sand
Visual Description :
Wet, black gravelly organic silt with sand

Remarks :

Figure 1

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GEOTECHNICAL LABORATORY TEST DATA

Project : Pownal Tannery Superfund Site
Project No. : GTX-4363 Depth : 3-5 ft.
Boring No. : TPLS Test Date : 12/10/02
Sample No. : 101 (3-5) Test Method : ASTM D 422
Location : Pownal, VT
Soil Description : Wet, black gravelly organic silt with sand
Remarks :

Filename : TPLS101
Elevation : ---
Tested by : tje
Checked by : jdt

HYDROMETER

Hydrometer ID : 457488
Weight of air-dried soil = 20.19 gm
Specific Gravity = 2.71

Hydroscopic Moisture Content :
Weight of Wet Soil = 0 gm
Weight of Dry Soil = 0 gm
Moisture Content = 0

Elapsed Time (min)	Reading	Temperature (deg. C)	Corrected Reading	Particle Size (mm)	Percent Finer (%)	Adjusted Particle Size
2.00	26.00	21.50	19.33	0.032	54	0.032
5.00	24.00	21.50	17.33	0.021	48	0.021
15.00	21.50	21.50	14.83	0.012	41	0.012
30.00	19.00	21.50	12.33	0.009	34	0.009
60.00	16.00	21.50	9.33	0.006	26	0.006
120.00	13.50	21.50	6.83	0.005	19	0.005
240.00	12.00	21.50	5.33	0.003	15	0.003
1079.00	9.50	21.00	2.50	0.002	7	0.002

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GEOTECHNICAL LABORATORY TEST DATA

Project : Pownal Tannery Superfund Site
Project No. : GTX-4363
Boring No. : TPLS
Sample No. : 101 (3-5)
Location : Pownal, VT
Soil Description : Wet, black gravelly organic silt with sand
Remarks :

Depth : 3-5 ft.
Test Date : 12/10/02
Test Method : ASTM D 422

Filename : TPLS101
Elevation : ---
Tested by : tje
Checked by : jdt

COARSE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
2"	2.000	50.80	0.00	0.00	100
1.5"	1.500	38.10	770.00	770.00	93
1"	1.012	25.70	505.00	1275.00	88
0.75"	0.748	19.00	165.00	1440.00	86
0.5"	0.500	12.70	453.00	1893.00	82

Total Dry Weight of Sample = 10430

FINE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
0.375"	0.374	9.51	0.63	0.63	80
#4	0.187	4.75	2.18	2.81	74
#10	0.079	2.00	1.02	3.83	72
#20	0.033	0.84	1.19	5.02	68
#40	0.017	0.42	1.17	6.19	65
#60	0.010	0.25	0.96	7.15	63
#100	0.006	0.15	1.07	8.22	60
#200	0.003	0.07	2.13	10.35	54
Pan			20.19	30.54	0

Total Dry Weight of Sample = 147.63

D85 : 17.0087 mm
D60 : 0.1539 mm
D50 : 0.0241 mm
D30 : 0.0074 mm
D15 : 0.0033 mm
D10 : 0.0021 mm

Soil Classification
ASTM Group Symbol : OH
ASTM Group Name : Gravelly organic silt with sand
AASHTO Group Symbol : A-7-5(26)
AASHTO Group Name : Clayey Soils

ATTERBERG LIMITS

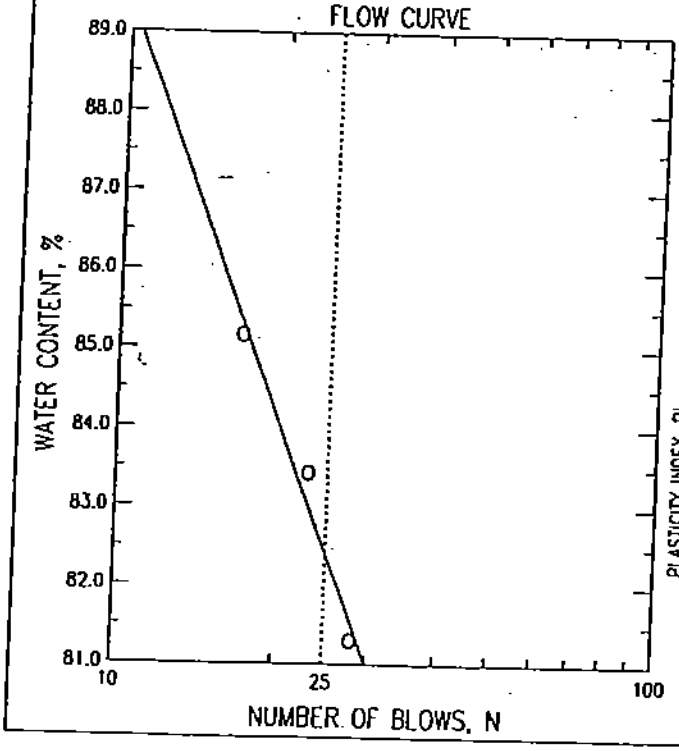
PROJECT	PROJECT NUMBER	TESTED BY	BORING NUMBER
Pownal Tannery Superfund Site	GTX-4363	tje	TPL5
LOCATION		CHECKED BY	SAMPLE NUMBER
Pownal, VT		jdt	101 (3-5)
SAMPLE DESCRIPTION		DATE	FILENAME
Wet, black gravelly organic silt with sand		Mon Jan 06 2003	TPL5101

LIQUID LIMIT DETERMINATIONS

CONTAINER NUMBER	1	129	9		
WT. WET SOIL + TARE	26.01	22.52	38.14		
WT. DRY SOIL + TARE	23.19	19	34.12		
WT. WATER	2.82	3.52	4.02		
TARE WT.	19.81	14.67	29.4		
WT. DRY SOIL	3.38	4.33	4.72		
WATER CONTENT, W_N (%)	83.43	81.29	85.17		
NUMBER OF BLOWS, N	23	28	17		
ONE-POINT LIQUID LIMIT, LL	82.59	82.42	81.29		

PLASTIC LIMIT DETERMINATIONS

CONTAINER NUMBER	1	12			
WT. WET SOIL + TARE	27.69	22.45			
WT. DRY SOIL + TARE	24.67	20.65			
WT. WATER	3.02	1.8			
TARE WT.	16.93	15.88			
WT. DRY SOIL	7.74	4.77			
WATER CONTENT (%)	39.02	37.74			



SUMMARY OF RESULTS	
NATURAL WATER CONTENT, W (%)	82.8
LIQUID LIMIT, LL	82.4
PLASTIC LIMIT, PL	38.4
PLASTICITY INDEX, PI	44.0
LIQUIDITY INDEX, LI*	1.01

*LI = (W - PL)/PI

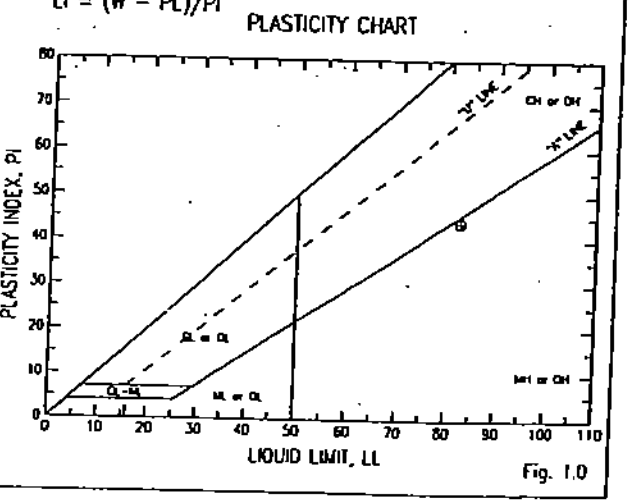
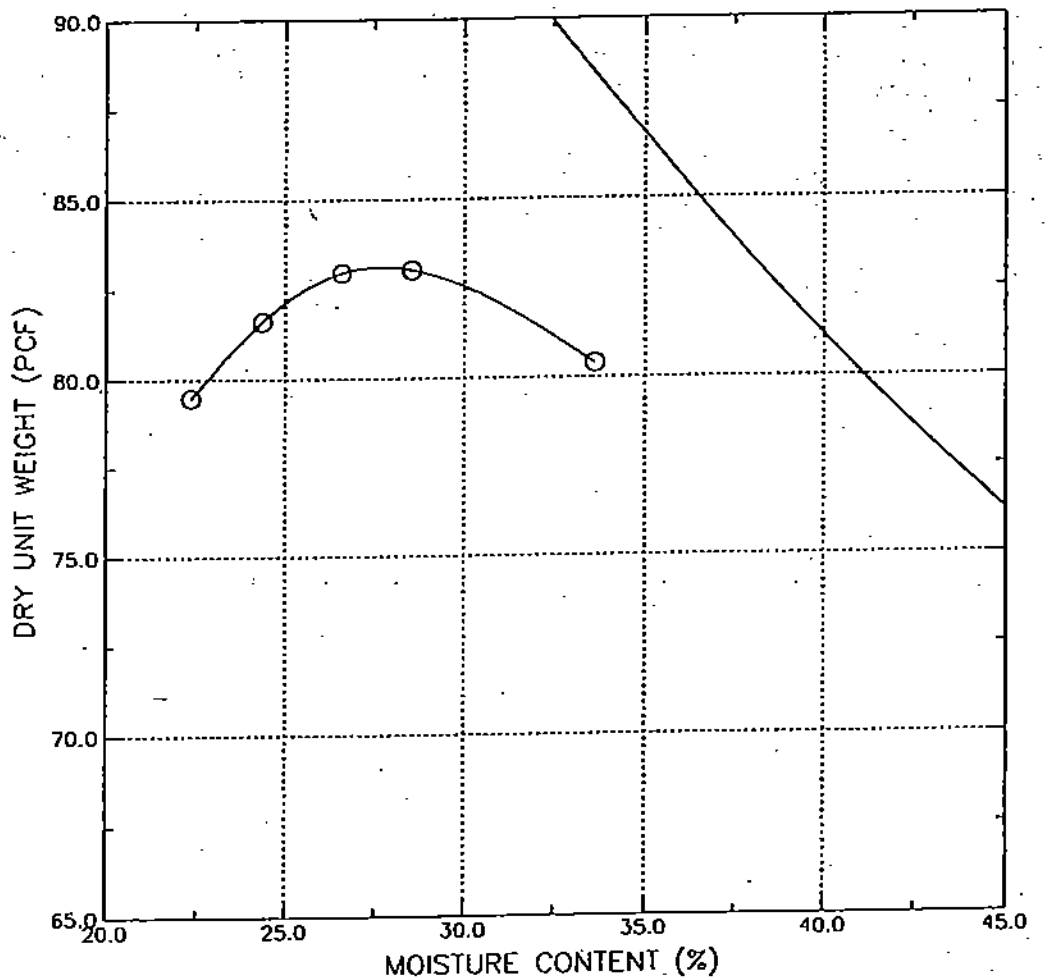


Fig. 1.0

	Boring No. : TPL5 Sample No. : 101 (3–5) Test Method : ASTM D 698 Filename : TPL5101	Project : Pownal Tannery Superfund Site Project No. : GTX-4363 Location : Pownal, VT Test Date : 12/10/02

Moisture–Density Relationship



Sample Description	: Wet, black gravelly organic silt with sand
Compaction Test Designation	: ASTM D698–C
Maximum Dry Density	: 83.1 pcf
Optimum Moisture Content	: 27.7 %

Figure 1

GEOTECHNICAL LABORATORY TEST DATA

Project : Pownal Tannery Superfund Site
Project No. : GTX-4363
Boring No. : TPL5
Sample No. : 101 (3-5)
Location : Pownal, VT
Soil Description : Wet, black gravelly organic silt with sand
Remarks :

Depth : 3-5 ft.
Test Date : 12/10/02
Test Method : ASTM D 698

Filename : TPL5101
Elevation : ---
Tested by : tje
Checked by : jdt

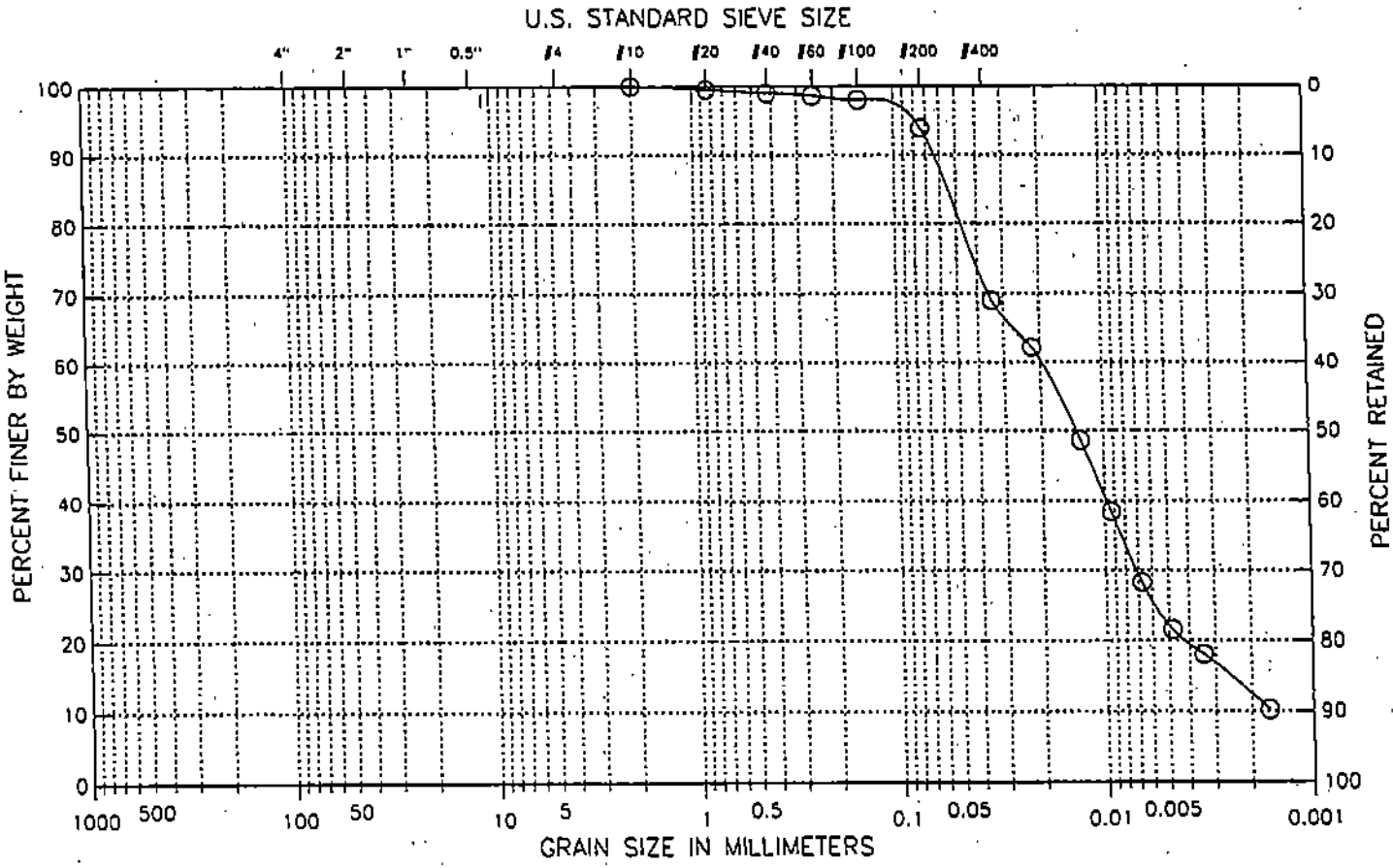
COMPACTION TEST

Mold ID :
Method Used : ASTM D698-C
Volume of Mold : 0.075 ft^3
Mass of Mold : 6052 gm
Specific Gravity : 2.71

Moisture Content ID	Mass of Container (gm)	Mass of Container + Moist Soil (gm)	Mass of Container + Dry Soil (gm)	Mass of Mold + Specimen (gm)	Moisture Content (%)	Dry Density (pcf)
1	8.14	271.33	223.26	9360.00	22.3	79.5
2	8.20	290.80	235.44	9505.00	24.4	81.6
6	8.32	329.82	262.30	9625.00	26.6	83.0
4	8.22	303.65	238.06	9683.00	28.5	83.0
5	8.19	255.10	192.95	9707.00	33.6	80.4

Optimum Dry Density = 83.1 pcf
Optimum Moisture Content = 27.7 %

	Boring No. : TPL5 Sample No: 102 (1-2) Test Method ASTM D 422 Filename : TPL5102	Project : Pownal Tannery Superfund Site Project No.: GTX-4363 Location: Pownal, VT Date : Mon Jan 06 2003



Classification :
(OH) organic clay
Visual Description :
Wet, black organic clay

Remarks :

Figure 2

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GEOTECHNICAL LABORATORY TEST DATA

Project : Pownal Tannery Superfund Site
Project No. : GTX-4363
Boring No. : TPLS
Sample No. : 102 (1-2)
Location : Pownal, VT
Soil Description : Wet, black organic clay
Remarks :

Depth : 1-2 ft.
Test Date : 12/10/02
Test Method : ASTM D 422

Filename : TPL5102
Elevation : ---
Tested by : tje
Checked by : jdt

HYDROMETER

Hydrometer ID : 457488
Weight of air-dried soil = 28.56 gm
Specific Gravity = 2.51

Hydroscopic Moisture Content :
Weight of Wet Soil = 0 gm
Weight of Dry Soil = 0 gm
Moisture Content = 0

Elapsed Time (min)	Reading	Temperature (deg. C)	Corrected Reading	Particle Size (mm)	Percent Finer (%)	Adjusted Particle Size
2.00	27.00	21.50	20.33	0.034	69	0.034
5.00	25.00	21.50	18.33	0.022	62	0.022
15.00	21.00	21.50	14.33	0.013	49	0.013
30.00	18.00	21.50	11.33	0.009	38	0.009
60.00	15.00	21.50	8.33	0.007	28	0.007
120.00	13.00	21.50	6.33	0.005	21	0.005
240.00	12.00	21.50	5.33	0.003	18	0.003
1080.00	10.00	21.00	3.00	0.002	10	0.002

FINE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
#10	0.079	2.00	0.00	0.00	100
#20	0.033	0.84	0.14	0.14	100
#40	0.017	0.42	0.15	0.29	99
#60	0.010	0.25	0.12	0.41	99
#100	0.006	0.15	0.18	0.59	98
#200	0.003	-- 0.07	1.23	1.82	94
Pan			28.56	30.38	0

Total Dry Weight of Sample = 148.69

D85 : 0.0560 mm
D60 : 0.0201 mm
D50 : 0.0137 mm
D30 : 0.0071 mm
D15 : 0.0026 mm
D10 : 0.0016 mm

Soil Classification
ASTM Group Symbol : OH
ASTM Group Name : organic clay
AASHTO Group Symbol : A-7-5(75)
AASHTO Group Name : Clayey Soils

ATTERBERG LIMITS

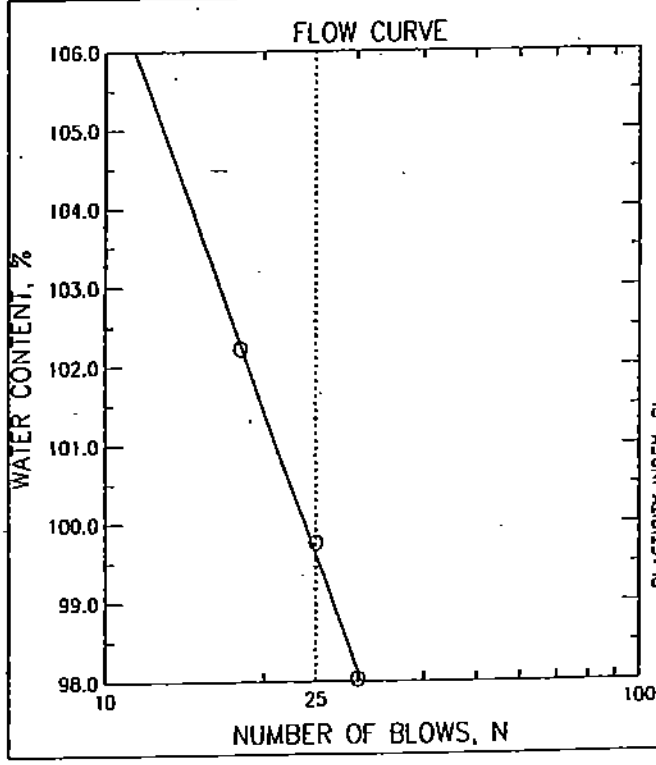
PROJECT	PROJECT NUMBER	TESTED BY	BORING NUMBER
Pownal Tannery Superfund Site	GTX-4363	tje	TPL5
LOCATION		CHECKED BY	SAMPLE NUMBER
Pownal, VT		jdl	102 (1-2)
SAMPLE DESCRIPTION		DATE	FILENAME
Wet, black organic clay		Mon Jan 06 2003	TPL5102

LIQUID LIMIT DETERMINATIONS

CONTAINER NUMBER	8	161	116		
WT. WET SOIL + TARE	39.16	19.31	23.3		
WT. DRY SOIL + TARE	34.1	15.23	18.82		
WT. WATER	5.06	4.08	4.48		
TARE WT.	29.15	11.14	14.25		
WT. DRY SOIL	4.95	4.09	4.57		
WATER CONTENT, W_N (%)	102.22	99.76	98.03		
NUMBER OF BLOWS, N	18	25	30		
ONE-POINT LIQUID LIMIT, LL	98.24	99.76	100.22		

PLASTIC LIMIT DETERMINATIONS

CONTAINER NUMBER	13	24			
WT. WET SOIL + TARE	23.03	22.88			
WT. DRY SOIL + TARE	20.96	20.8			
WT. WATER	2.07	2.08			
TARE WT.	15.8	15.75			
WT. DRY SOIL	5.16	5.05			
WATER CONTENT (%)	40.12	41.19			



SUMMARY OF RESULTS	
NATURAL WATER CONTENT, W (%)	118.7
LIQUID LIMIT, LL	99.6
PLASTIC LIMIT, PL	40.7
PLASTICITY INDEX, PI	59.0
LIQUIDITY INDEX, LI*	1.32

*LI = (W - PL)/PI

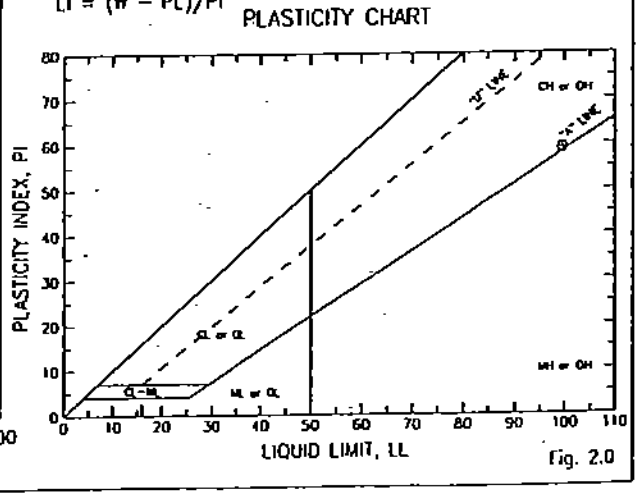
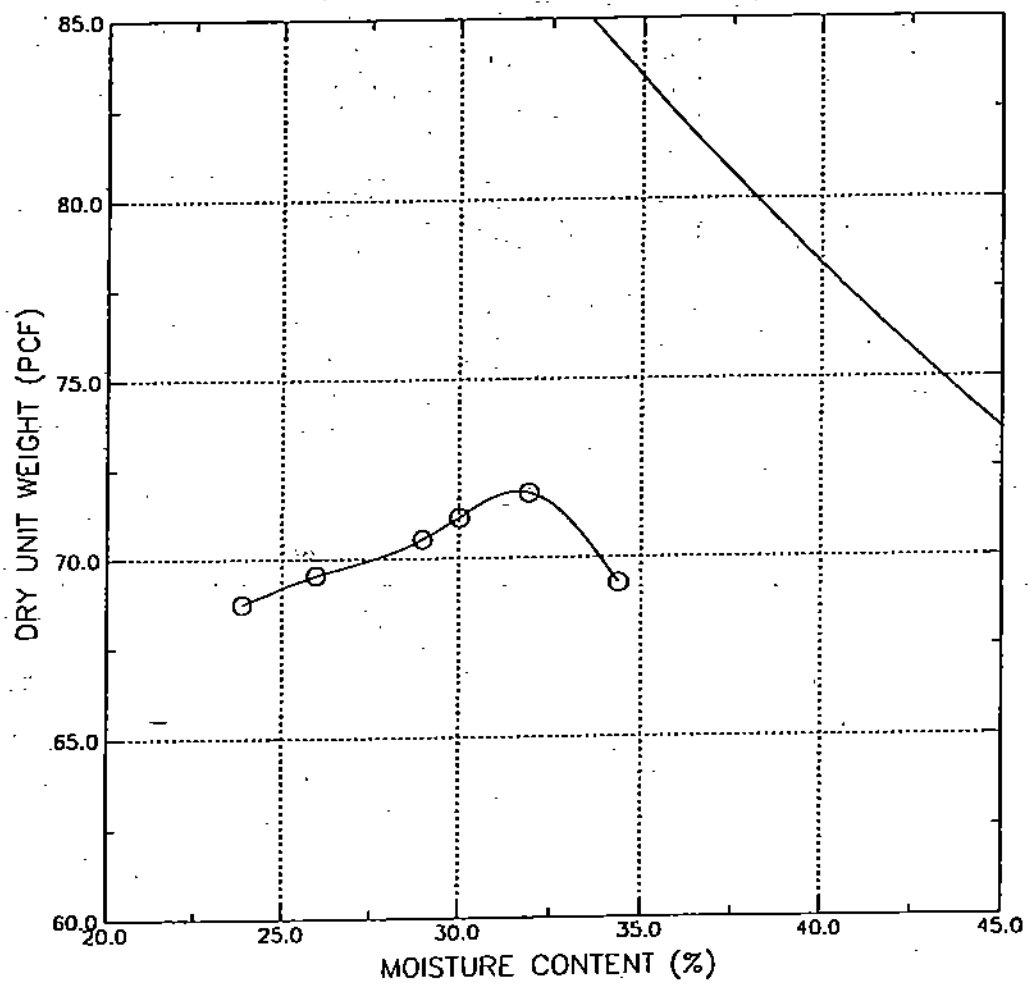


Fig. 2.0

	Boring No. : TPL5 Sample No. : 102 (1-2) Test Method : ASTM D 698 Filename : TPL5102	Project : Pownal Tannery Superfund Site Project No. : GTX-4363 Location : Pownal, VT Test Date : 12/10/02

Moisture-Density Relationship



Sample Description	: Wet, black organic clay
Compaction Test Designation	: ASTM D698-A
Maximum Dry Density	: 71.9 pcf
Optimum Moisture Content	: 31.6 %

Figure 2

GEOTECHNICAL LABORATORY TEST DATA

Project : Pownal Tannery Superfund Site
Project No. : GTX-4363
Boring No. : TPL5
Sample No. : 102 (1-2)
Location : Pownal, VT
Soil Description : Wet, black organic clay
Remarks :

Depth : 1-2 ft.
Test Date : 12/10/02
Test Method : ASTM D 698

Filename : TPL5102
Elevation : ---
Tested by : tje
Checked by : jdt

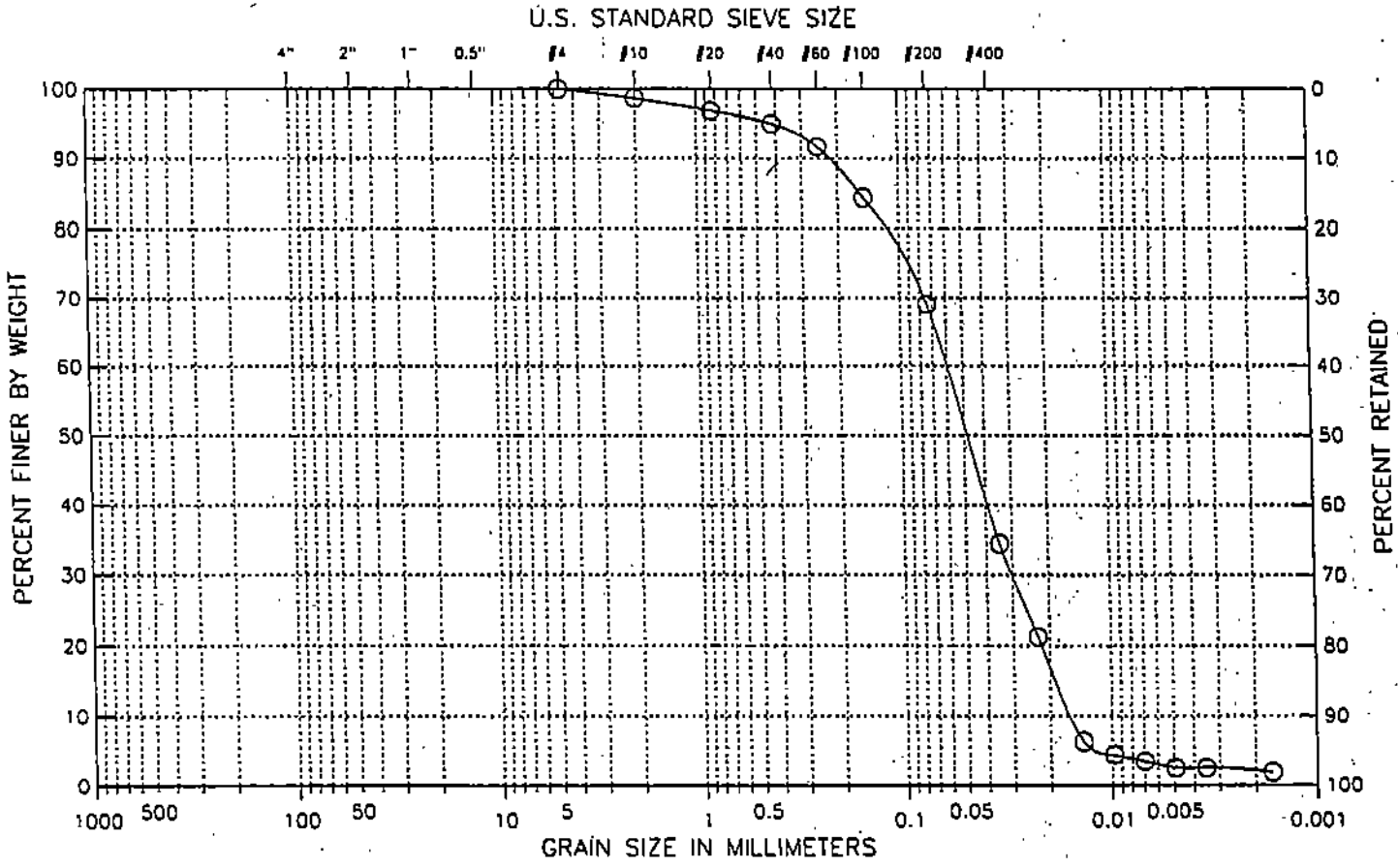
COMPACTION TEST

Mold ID :
Method Used : ASTM D698-A
Volume of Mold : 0.0333 ft^3
Mass of Mold : 5330 gm
Specific Gravity : 2.51

Moisture Content ID	Mass of Container (gm)	Mass of Container + Moist Soil (gm)	Mass of Container + Dry Soil (gm)	Mass of Mold + Specimen (gm)	Moisture Content (%)	Dry Density (pcf)
1	8.20	219.35	178.66	6616.00	23.9	68.7
4	8.17	218.64	175.27	6653.00	26.0	69.5
2	8.21	224.33	175.80	6704.00	29.0	70.5
6	8.20	228.96	178.00	6727.00	30.0	71.1
5	8.13	242.19	185.55	6761.00	31.9	71.8
3	8.12	221.33	166.79	6736.00	34.4	69.3

Optimum Dry Density = 71.9 pcf
Optimum Moisture Content = 31.6 %

	Boring No. : TPL5 Sample No: 103 (1-3) Test Method ASTM D 422 Filename : TPL5103	Project : Pownal Tannery Superfund Site Project No.: GTX-4363 Location: Pownal, VT Date : Fri Jan 03 2003



Classification :
(ML) Sandy silt
Visual Description :
Moist, olive brown sandy silt

Remarks :

Figure 3

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Fri Jan 03 15:43:04 2003

GEOTECHNICAL LABORATORY TEST DATA

Project : Poynal Tannery Superfund Site
Project No. : GTX-4363
Boring No. : TPLS
Sample No. : 103 (1-3)
Location : Poynal, VT
Soil Description : Moist, olive brown sandy silt
Remarks :

Depth : 1-3 ft.
Test Date : 12/09/02
Test Method : ASTM D 422

Filename : TPLS103
Elevation : ---
Tested by : ccp
Checked by : jdt

HYDROMETER

Hydrometer ID : 457488
Weight of air-dried soil = 37.81 gm
Specific Gravity = 2.52

Hydroscopic Moisture Content :
Weight of Wet Soil = 0 gm
Weight of Dry Soil = 0 gm
Moisture Content = 0

Elapsed Time (min)	Reading	Temperature (deg. C)	Corrected Reading	Particle Size (mm)	Percent Finer (%)	Adjusted Particle Size
2.00	25.00	21.50	18.33	0.034	34	0.034
5.00	18.00	21.50	11.33	0.023	21	0.023
15.00	10.00	21.50	3.33	0.014	6	0.014
30.00	9.00	21.50	2.33	0.010	4	0.010
60.00	8.50	21.50	1.83	0.007	3	0.007
120.00	8.00	21.50	1.33	0.005	3	0.005
240.00	8.00	21.50	1.33	0.003	3	0.003
1078.00	8.00	21.00	1.00	0.002	2	0.002

FINE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
#4	0.187	4.75	0.00	0.00	100
#10	0.079	2.00	0.71	0.71	99
#20	0.033	0.84	0.95	1.66	97
#40	0.017	0.42	1.05	2.71	95
#60	0.010	0.25	1.81	4.52	92
#100	0.006	0.15	4.04	8.56	84
#200	0.003	0.07	8.39	16.95	69
Pan			37.81	54.76	0

Total Dry Weight of Sample = 161.49

D85 : 0.1558 mm
D60 : 0.0606 mm
D50 : 0.0486 mm
D30 : 0.0300 mm
D15 : 0.0165 mm
D10 : 0.0156 mm

Soil Classification
ASTM Group Symbol : ML
ASTM Group Name : Sandy silt
AASHTO Group Symbol : A-4(5)
AASHTO Group Name : Silty Soils

ATTERBERG LIMITS

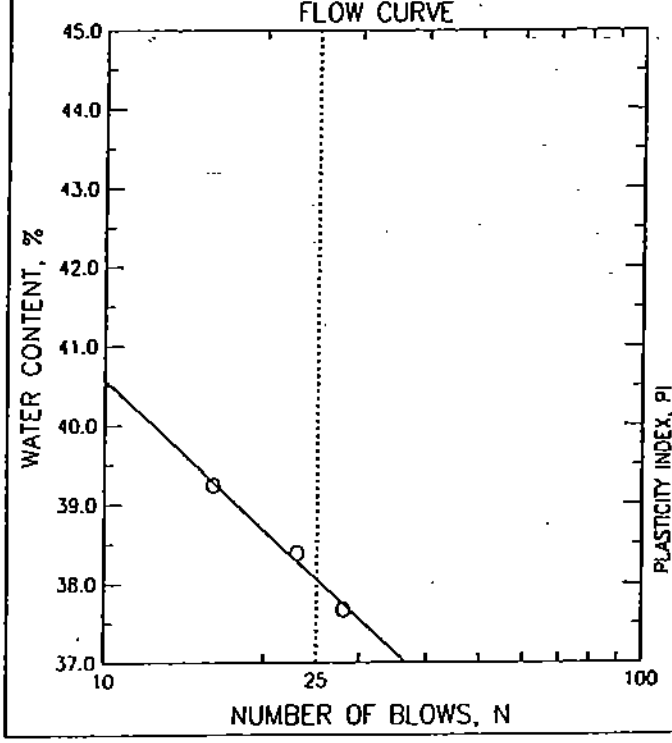
PROJECT	PROJECT NUMBER	TESTED BY	BORING NUMBER
Pownal Tonnery Superfund Site	GTX-4363	ccp	TPL5
LOCATION		CHECKED BY	SAMPLE NUMBER
Pownal, VT		jdl	103 (1-3)
SAMPLE DESCRIPTION		DATE	FILENAME
Moist, olive brown sandy silt		Fri Jan 03 2003	TPL5103

LIQUID LIMIT DETERMINATIONS

CONTAINER NUMBER	5	914	17		
WT. WET SOIL + TARE	28.24	33.2	28.59		
WT. DRY SOIL + TARE	25.03	30.34	25.16		
WT. WATER	3.21	2.86	3.43		
TARE WT.	16.51	22.89	16.42		
WT. DRY SOIL	8.52	7.45	8.74		
WATER CONTENT, W_N (%)	37.68	38.39	39.24		
NUMBER OF BLOWS, N	28	23	16		
ONE-POINT LIQUID LIMIT, LL	38.20	38.00	37.18		

PLASTIC LIMIT DETERMINATIONS

CONTAINER NUMBER	7	21			
WT. WET SOIL + TARE	25.27	22.86			
WT. DRY SOIL + TARE	23.28	21.39			
WT. WATER	1.99	1.47			
TARE WT.	16.69	16.36			
WT. DRY SOIL	6.59	5.03			
WATER CONTENT (%)	30.20	29.22			



SUMMARY OF RESULTS	
NATURAL WATER CONTENT, W (%)	50.6
LIQUID LIMIT, LL	38.1
PLASTIC LIMIT, PL	29.7
PLASTICITY INDEX, PI	8.3
LIQUIDITY INDEX, LI*	2.50

*LI = (W - PL)/PI

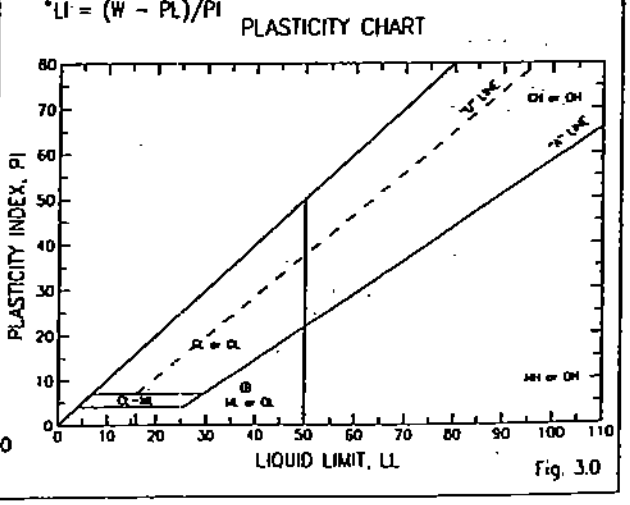
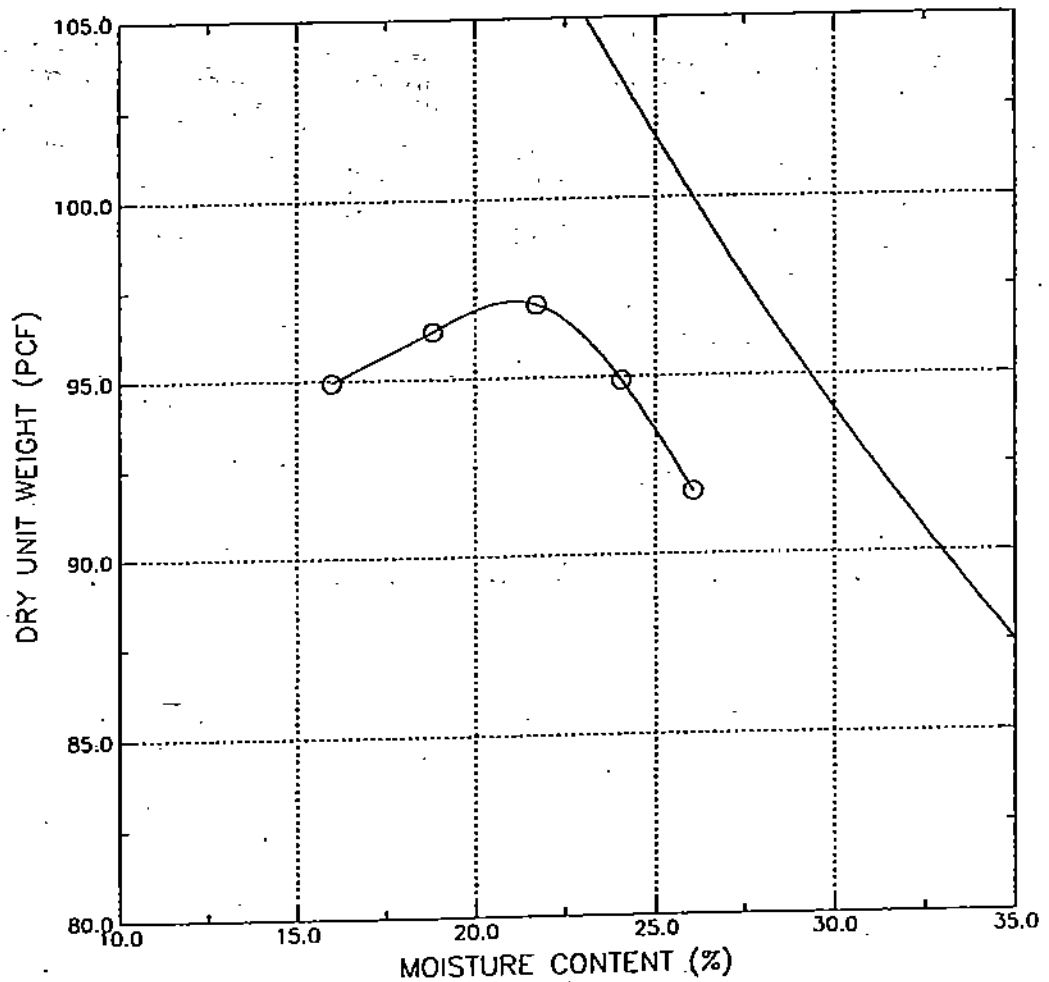


Fig. 3.0

	Boring No. : TPL5 Sample No. : 103 (1-3) Test Method : ASTM D 698 Filename : TPL5103	Project : Pownal Tannery Superfund Site Project No. : GTX-4363 Location : Pownal, VT Test Date : 12/09/02

Moisture-Density Relationship



Sample Description	: Moist, olive brown sandy silt
Compaction Test Designation	: ASTM D698-A
Maximum Dry Density	: 97.2 pcf
Optimum Moisture Content	: 21.1 %

Figure 3

GEOTECHNICAL LABORATORY TEST DATA

Project : Pownal Tannery Superfund Site
Project No. : GTX-4363
Boring No. : TPLS
Sample No. : 103 (1-3)
Location : Pownal, VT
Soil Description : Moist, olive brown sandy silt
Remarks :

Depth : 1-3 ft.
Test Date : 12/09/02
Test Method : ASTM D 698

Filename : TPLS103
Elevation : ---
Tested by : ccp
Checked by : jdt

COMPACTION TEST

Mold ID :
Method Used : ASTM D698-A
Volume of Mold : 0.0333 ft^3
Mass of Mold : 4252 gm
Specific Gravity : 2.75

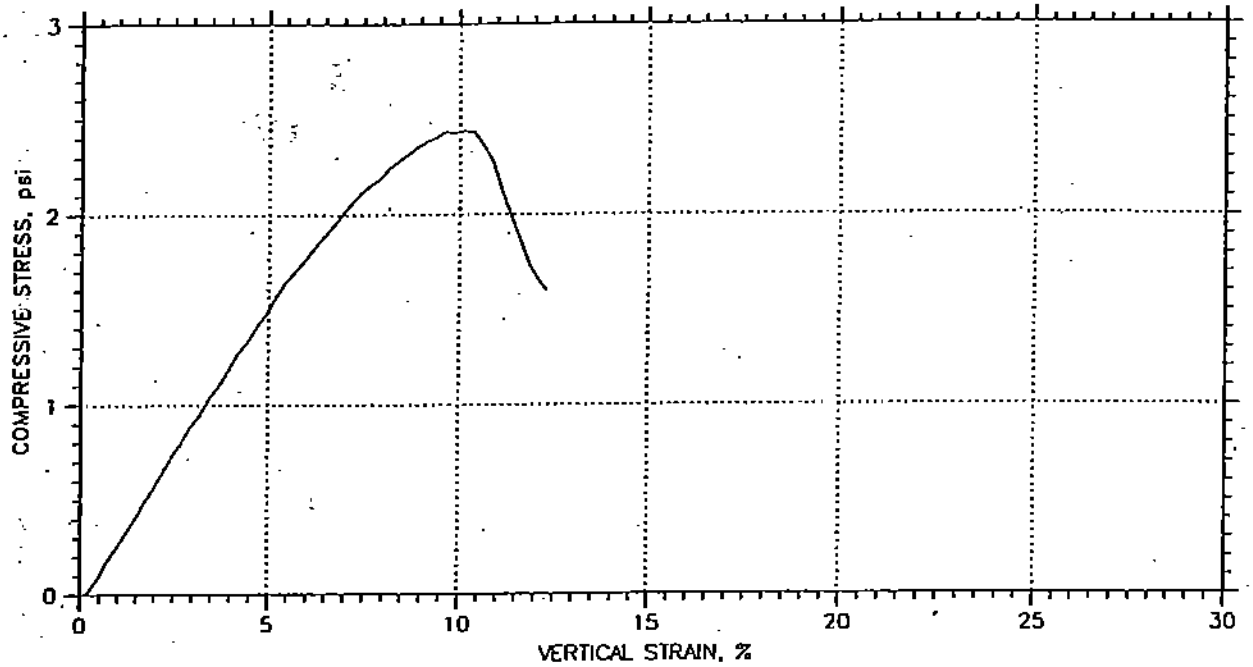
Moisture Content ID	Mass of Container (gm)	Mass of Container + Moist Soil (gm)	Mass of Container + Dry Soil (gm)	Mass of Mold + Specimen (gm)	Moisture Content (%)	Dry Density (pcf)
4	8.20	293.85	254.50	5915.00	16.0	94.9
1	8.30	310.90	262.96	5983.00	18.8	96.3
2	8.09	274.06	226.62	6036.00	21.7	97.0
3	8.16	269.10	218.51	6030.00	24.1	94.9
5	8.14	325.27	259.72	5999.00	26.1	91.8

Optimum Dry Density = 97.1 pcf
Optimum Moisture Content = 21.1 %

SECTION TWO

2

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		UC4			
Initial	Diameter, in	2.87			
	Height, in	6.2			
	Water Content, %	26.67			
	Dry Density, pcf	83.678			
	Saturation, %	69.27			
	Void Ratio	1.0666			
Unconfined Compressive Strength, psi		2.4409			
Undrained Shear Strength, psi		1.2204			
Time to Failure, min		10.25			
Strain Rate, %/min		1			
Specific Gravity		2.77			
Liquid Limit		34			
Plastic Limit		22			
Plasticity Index		13			
Failure Sketch					

Project: Pownal Tannery

Location: Pownal, VT

Project No.: GTX-4363

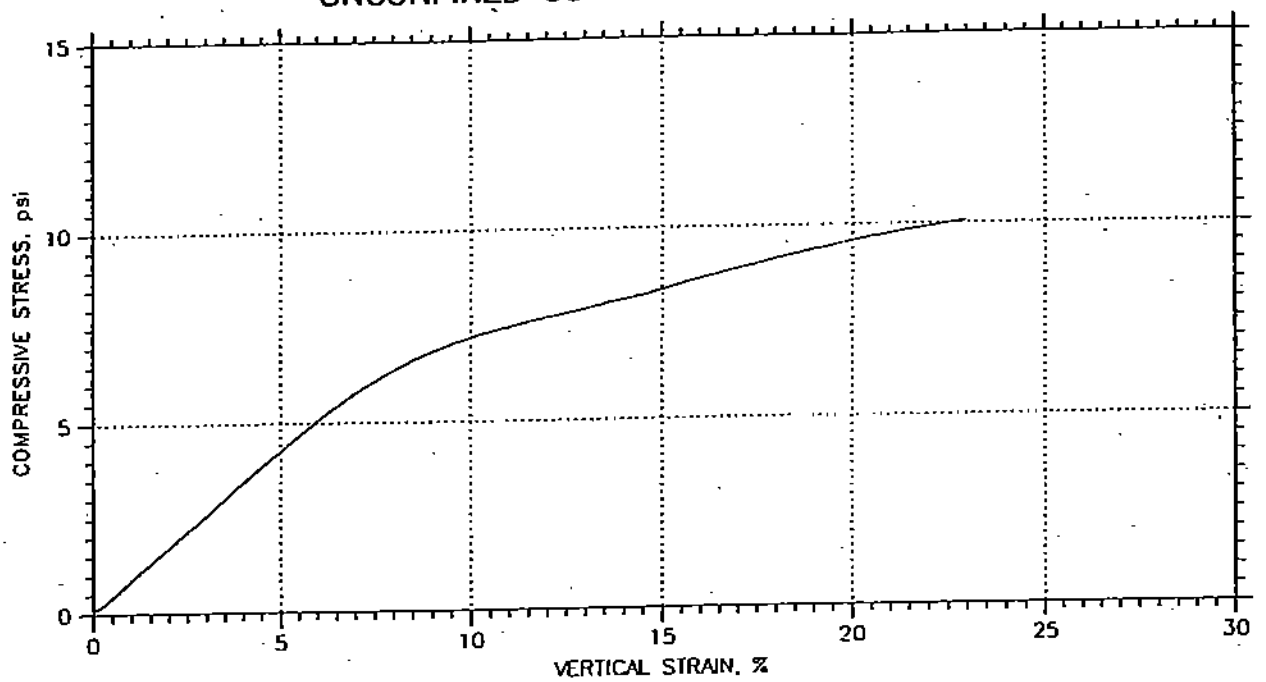
Boring No.: SBL3, 102

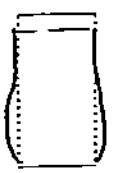
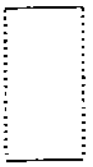
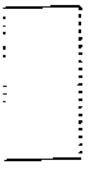
Sample Type: tube

Description: Moist, dark greenish gray clay with sand

Remarks: Depth: 6-8 ft.

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.	uc2				
Initial: Diameter, in	2.87				
Initial: Height, in	5.99				
Initial: Water Content, %	38.88				
Initial: Dry Density, pcf	81.904				
Initial: Saturation, %	95.08				
Initial: Void Ratio	1.1571				
Unconfined Compressive Strength, psi	10.051				
Undrained Shear Strength, psi	5.0256				
Time to Failure, min	6.835				
Strain Rate, %/min	1				
Specific Gravity	2.83				
Liquid Limit	49				
Plastic Limit	26				
Plasticity Index	23				
Failure Sketch					

Project: Pownal Tannery

Location: Pownal, VT

Project No.: GTX-4363

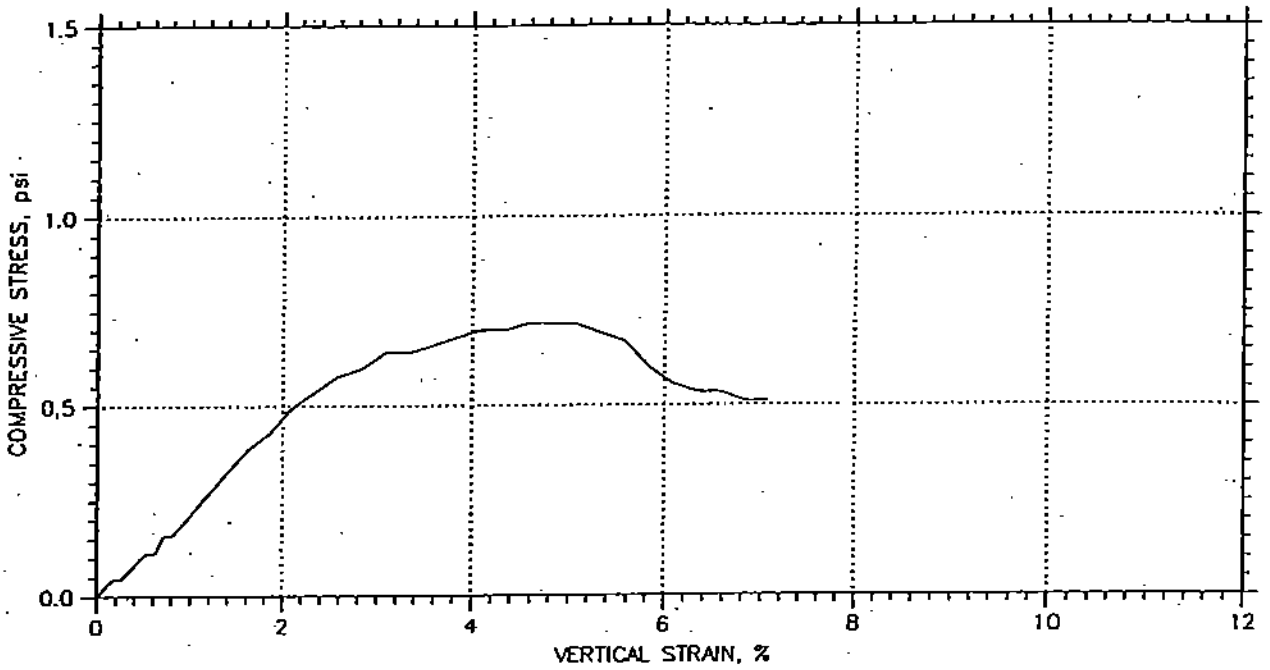
Boring No.: SBL4, 103

Sample Type: tube

Description: Moist, dark gray clay

Remarks: Depth: 25-27 ft.

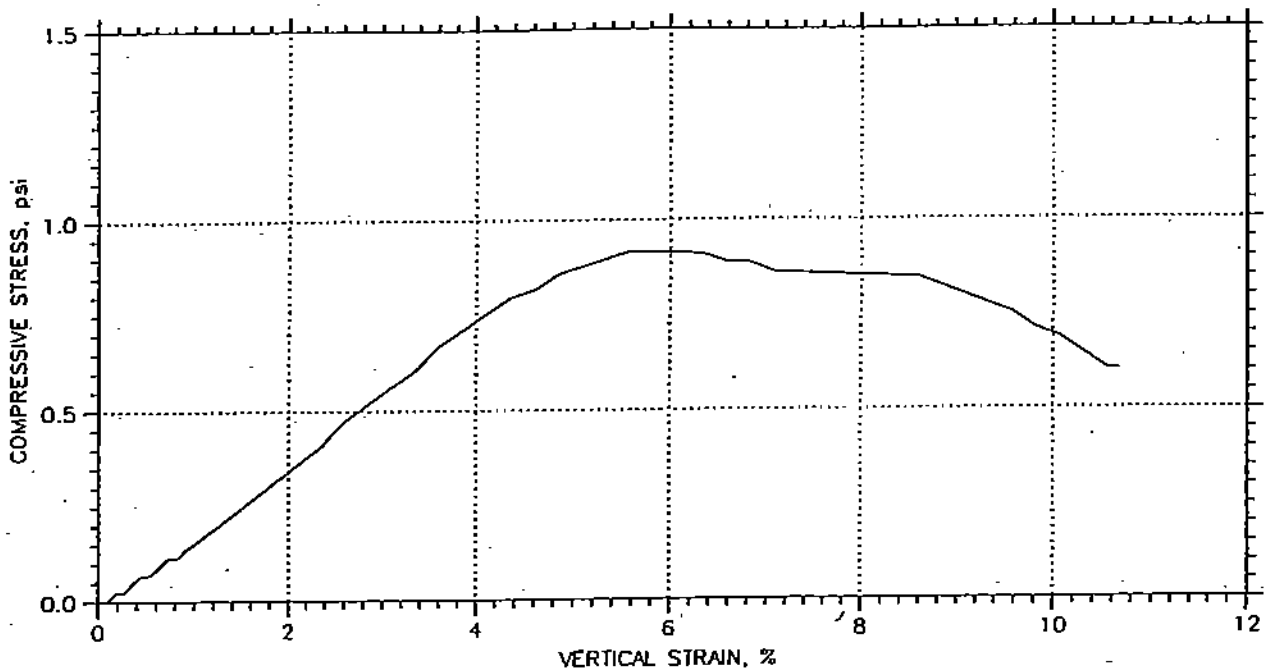
UNCONFINED COMPRESSION TEST REPORT

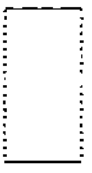
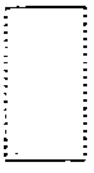
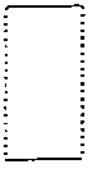


Symbol					
Test No.		UC6			
Initial	Diameter, in	2.87			
	Height, in	6.2			
	Water Content, %	91.82			
	Dry Density, pcf	37.286			
	Saturation, %	74.30			
	Void Ratio	2.8175			
Unconfined Compressive Strength, psi		0.71874			
Undrained Shear Strength, psi		0.35937			
Time to Failure, min		4.7517			
Strain Rate, %/min		1			
Specific Gravity		2.28			
Liquid Limit		112			
Plastic Limit		51			
Plasticity Index		61			
Failure Sketch					

Project: Pownal Tannery
Location: Pownal, VT
Project No.: GTX-4363
Boring No.: TPL-1, 101
Sample Type: ---
Description: Wet, very dark grayish brown organic silt with sand
Remarks: 5-7 ft; Shelby tube pushed into sample bucket; test specimen then extruded and tested

UNCONFINED COMPRESSION TEST REPORT



Symbol				
Test No.	UC3			
Initial: Diameter, in	2.85			
Initial: Height, in	5.8			
Initial: Water Content, %	194.03			
Initial: Dry Density, pcf	23.496			
Initial: Saturation, %	87.54			
Initial: Void Ratio	5.0312			
Unconfined Compressive Strength, psi	0.91785			
Undrained Shear Strength, psi	0.45892			
Time to Failure, min	5.75			
Strain Rate, %/min	1			
Specific Gravity	2.27			
Liquid Limit	199			
Plastic Limit	78			
Plasticity Index	121			
Failure Sketch				

Project: Pownal Tannery

Location: Pownal, VT

Project No.: GTX-4363

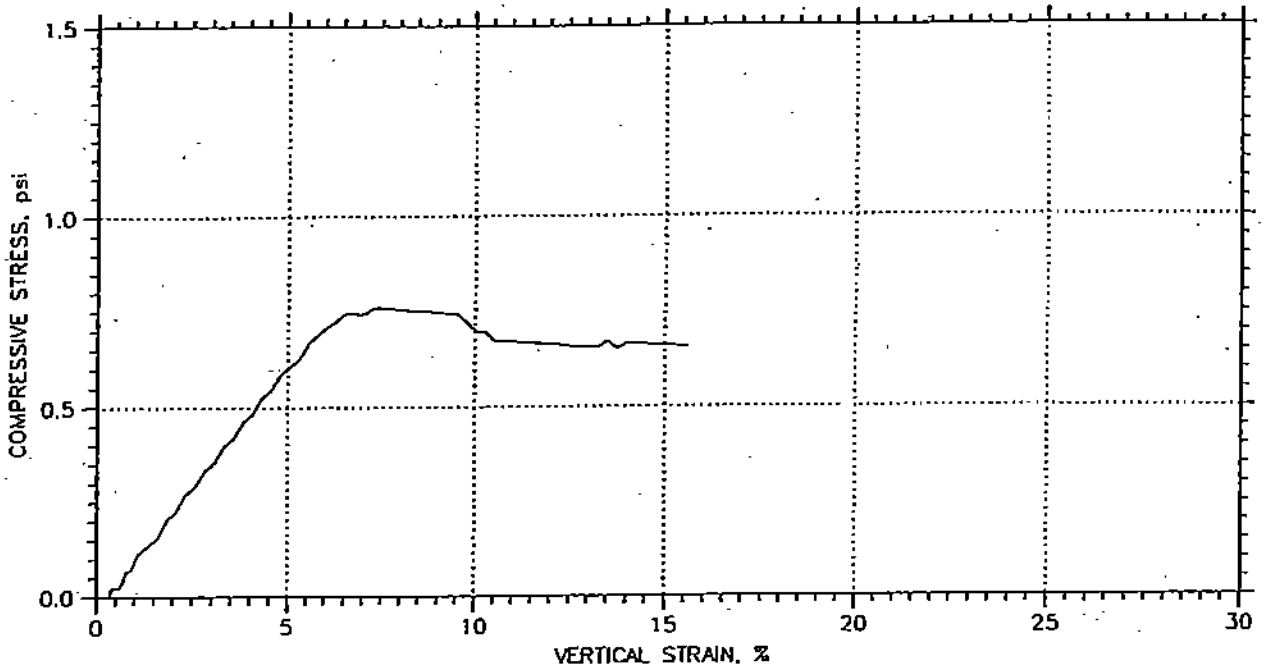
Boring No.: TPL-1, 102

Sample Type: tube

Description: Wet, very dark grayish brown organic silt

Remarks: Depth: 2-4 ft.

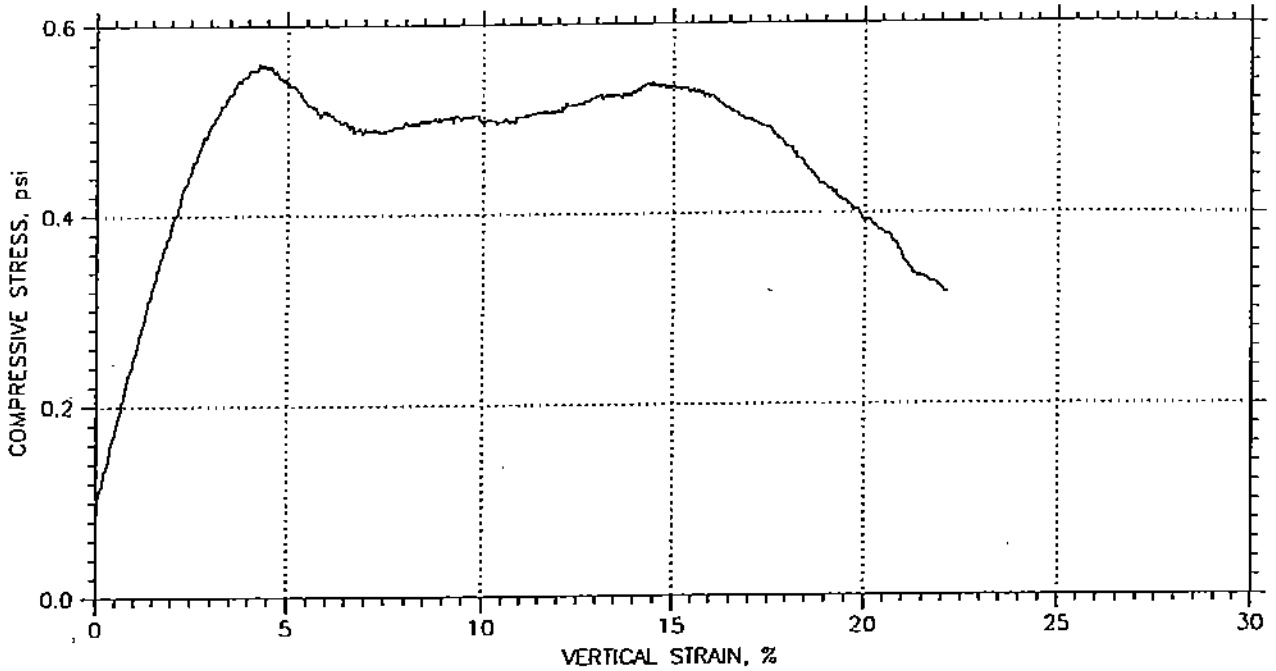
UNCONFINED COMPRESSION TEST REPORT

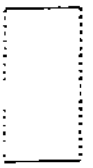


Symbol				
Test No.	UC5			
Initial: Diameter, in	2.87			
Initial: Height, in	6.21			
Initial: Water Content, %	191.46			
Initial: Dry Density, pcf	21.734			
Initial: Saturation, %	78.25			
Initial: Void Ratio	5.7502			
Unconfined Compressive Strength, psi	0.76177			
Undrained Shear Strength, psi	0.38088			
Time to Failure, min	7.5006			
Strain Rate, %/min	1			
Specific Gravity	2.35			
Liquid Limit	273			
Plastic Limit	102			
Plasticity Index	171			
Failure Sketch				

Project: Pownal Tannery
Location: Pownal, VT
Project No.: GTX-4363
Boring No.: TPL-1, 103
Sample Type: ---
Description: Wet, very dark grayish brown organic silt with sand
Remarks: 2-4 ft; Shelby tube pushed into sample bucket; test specimen then extruded and tested

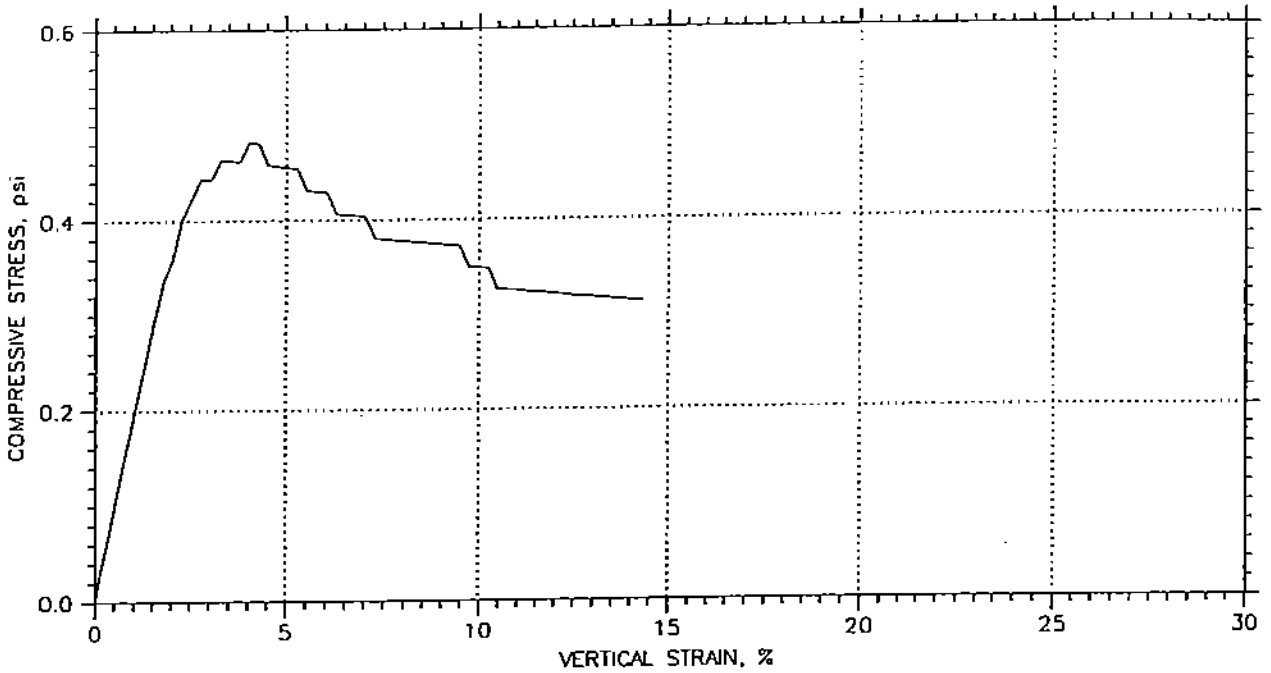
UNCONFINED COMPRESSION TEST REPORT

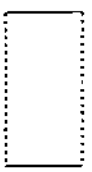
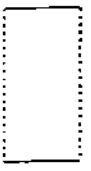


Symbol					
Test No.		uc1			
Initial	Diameter, in	2.87			
	Height, in	6.2			
	Water Content, %	101.35			
	Dry Density, pcf	41.887			
	Saturation, %	92.82			
	Void Ratio	2.7408			
Unconfined Compressive Strength, psi		0.56063			
Undrained Shear Strength, psi		0.28032			
Time to Failure, min		1.3104			
Strain Rate, %/min		1			
Specific Gravity		2.51			
Liquid Limit		100			
Plastic Limit		41			
Plasticity Index		59			
Failure Sketch					

Project: Pownal Tannery
Location: Pownal, VT
Project No.: GTX-4363
Boring No.: TPL5-102
Sample Type: ---
Description: Wet, black organic clay
Remarks: Depth 1-2 ft.; Shelby tube pushed into sample bucket; test specimen then extruded and tested

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		UC8			
Initial	Diameter, in	2.87			
	Height, in	6.2			
	Water Content, %	51.48			
	Dry Density, pcf	70.415			
	Saturation, %	99.46			
	Void Ratio	1.4026			
Unconfined Compressive Strength, psi		0.48196			
Undrained Shear Strength, psi		0.24098			
Time to Failure, min		4.0992			
Strain Rate, %/min		1			
Specific Gravity		2.71			
Liquid Limit		82			
Plastic Limit		38			
Plasticity Index		44			
Failure Sketch					

Project: Pownal Tannery

Location: Pownal, VT

Project No.: GTX-4363

Boring No.: TPL-5, 101

Sample Type: -

Description: Wet, black gravelly organic silt with sand

Remarks: 3-5 ft; Shelby tube pushed into sample bucket; test specimen then extruded and tested

Unconfined Compressive Strength of Soil by ASTM D 2166

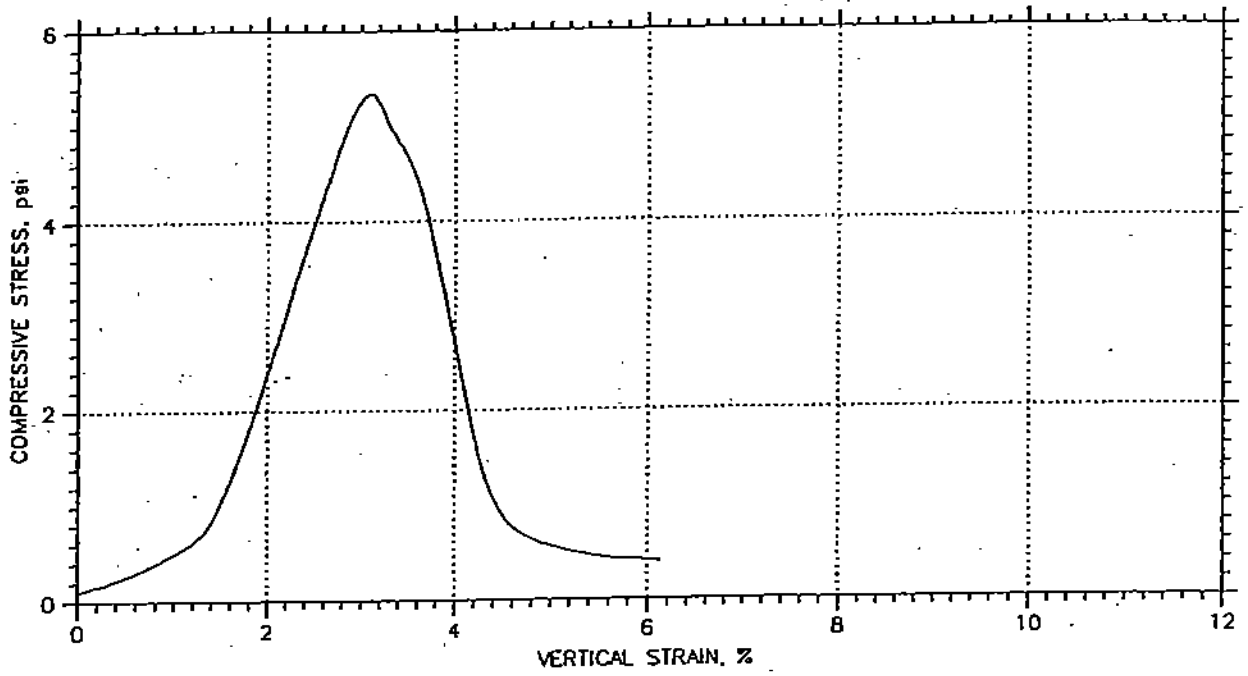
Client:	Metcalf & Eddy	GTX #:	4363
Project Name:	Pownal Tannery Superfund Site	Report Date:	01/02/03
Project Location:	Pownal, VT	Tested By:	md
		Checked By:	jdt

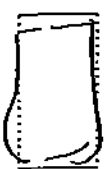
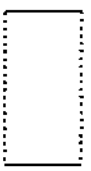
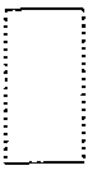
Sample ID	Water Content, %	Dry Density, pcf	Unconfined Compressive Strength, psi
TPL5-102 1-2 ft.	32	64.3	5.3
TPL5-102 1-2 ft.	40	65.1	6.0
TPL5-102 1-2 ft.	49	65.2	6.4
TPL5-102 1-2 ft.	60	Sample collapsed under its own weight	
TPL5-102 1-2 ft.	80	Sample collapsed under its own weight	

Notes: Moisture Contents determined by ASTM D 2216 at 60 Celsius.
See attached Unconfined Compression Test Reports for sample dimensions and Stress vs. Strain plots

Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material.

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		uc3			
Initial	Diameter, in	2.87			
	Height, in	6.05			
	Water Content, %	31.55			
	Dry Density, pcf	64.294			
	Saturation, %	55.10			
	Void Ratio	1.4371			
Unconfined Compressive Strength, psi		5.3443			
Undrained Shear Strength, psi		2.6722			
Time to Failure, min		0.92233			
Strain Rate, %/min		1			
Specific Gravity		2.51			
Liquid Limit		100			
Plastic Limit		41			
Plasticity Index		59			
Failure Sketch					

Project: Pownal Tannery Superfund

Location: Pownal, VT

Project No.: GTX-4363

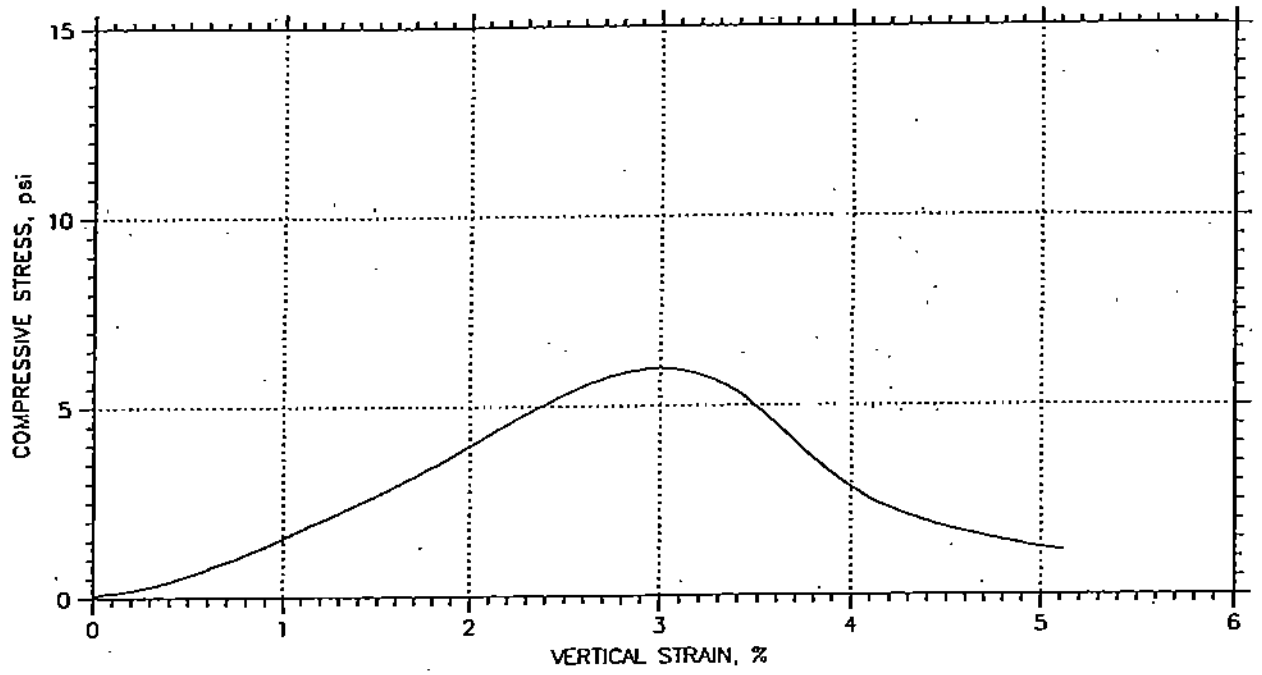
Boring No.: TPL-5 102

Sample Type: remolded

Description: Moist, black organic clay

Remarks: Depth: 1-2 ft.; Compacted to 90% of 71.9 pcf at 32% Moisture Content

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		uc4			
Initial	Diameter, in	2.87			
	Height, in	6			
	Water Content, %	40.22			
	Dry Density, pcf	65.096			
	Saturation, %	71.74			
	Void Ratio	1.4071			
Unconfined Compressive Strength, psi		5.9909			
Undrained Shear Strength, psi		2.9954			
Time to Failure, min		0.9305			
Strain Rate, %/min		1			
Specific Gravity		2.51			
Liquid Limit		100			
Plastic Limit		41			
Plasticity Index		59			
Failure Sketch					

Project: Pownal Tannery Superfund

Location: Pownal, VT

Project No.: GTX-4363

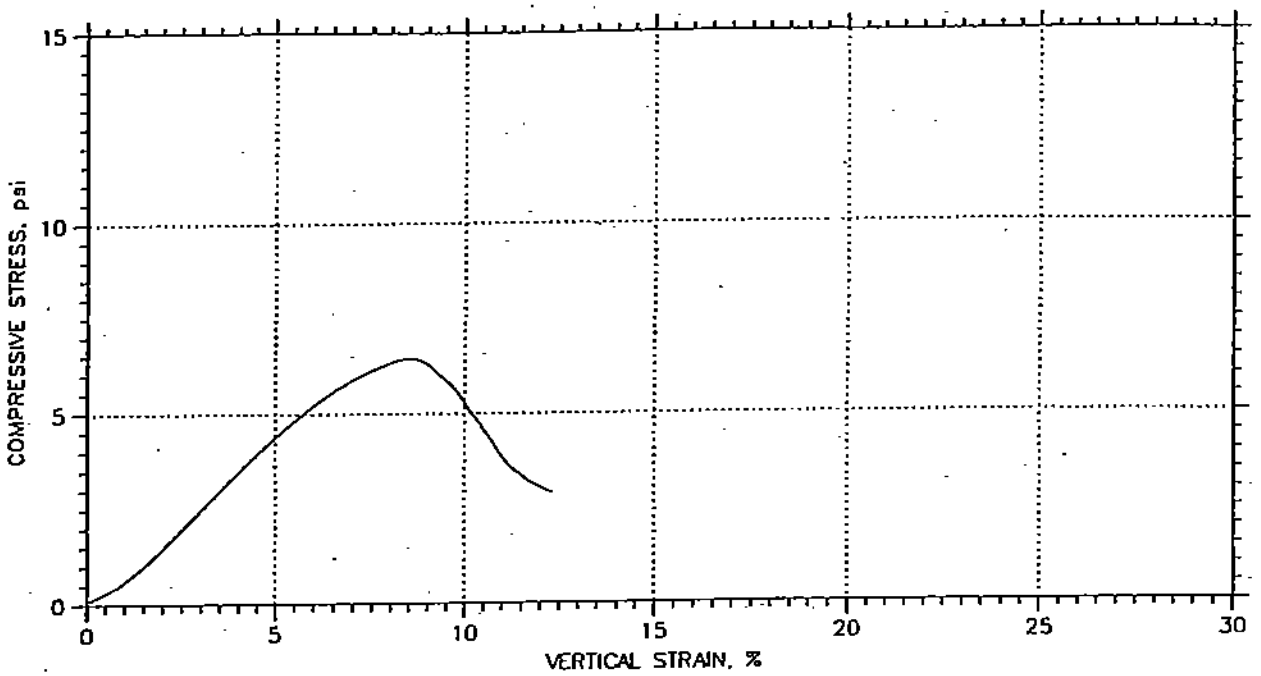
Boring No.: TPL-5 102

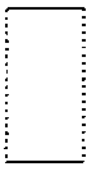
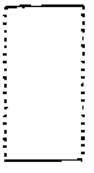
Sample Type: remolded

Description: Moist, black organic clay

Remarks: Depth: 1-2 ft.; Compacted 90% of 71.9 pcf at 41% Moisture Content.

UNCONFINED COMPRESSION TEST REPORT



Symbol				
Test No.	uc5			
Initial — Diameter, in	2.87			
Initial — Height, in	5.99			
Initial — Water Content, %	49.20			
Initial — Dry Density, pcf	65.168			
Initial — Saturation, %	87.92			
Initial — Void Ratio	1.4045			
Unconfined Compressive Strength, psi	6.4391			
Undrained Shear Strength, psi	3.2196			
Time to Failure, min	2.5665			
Strain Rate, %/min	1			
Specific Gravity	2.51			
Liquid Limit	100			
Plastic Limit	41			
Plasticity Index	59			
Failure Sketch				

Project: Pownal Tannery Superfund

Location: Pownal, VT

Project No.: GTX-4363

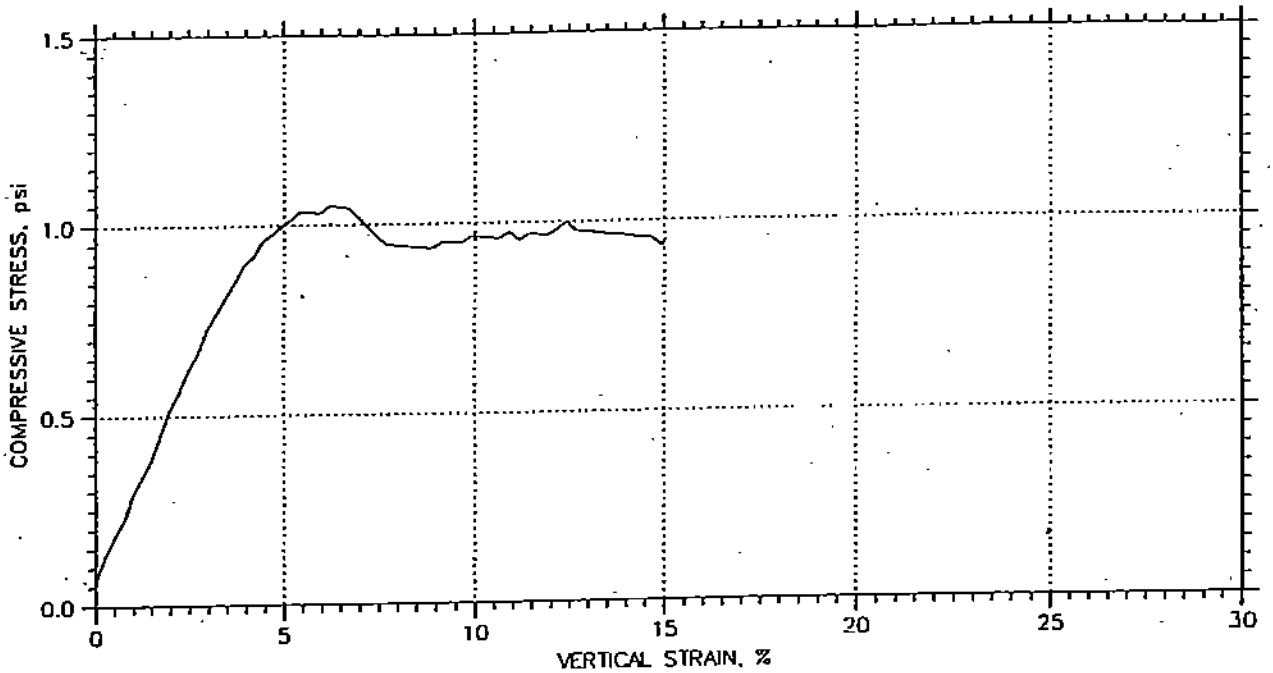
Boring No.: TPL-5 102

Sample Type: remolded

Description: Moist, gray clay

Remarks: Depth: 1-2 ft.; COmpacted to 90% of 71.9 pcf at 50% Moisture Content

UNCONFINED COMPRESSION TEST REPORT



Symbol				
Test No.	UC7			
Initial: Diameter, in	2.87			
Initial: Height, in	6.2			
Initial: Water Content, %	42.48			
Initial: Dry Density, pcf	74.262			
Initial: Saturation, %	95.71			
Initial: Void Ratio	1.1184			
Unconfined Compressive Strength, psi	1.0492			
Undrained Shear Strength, psi	0.52459			
Time to Failure, min	6.2494			
Strain Rate, %/min	1			
Specific Gravity	2.52			
Liquid Limit	38			
Plastic Limit	30			
Plasticity Index	8			
Failure Sketch				

Project: Pownal Tannery

Location: Pownal, VT

Project No.: GTX-4363

Boring No.: TPL-5 , T03

Sample Type: -

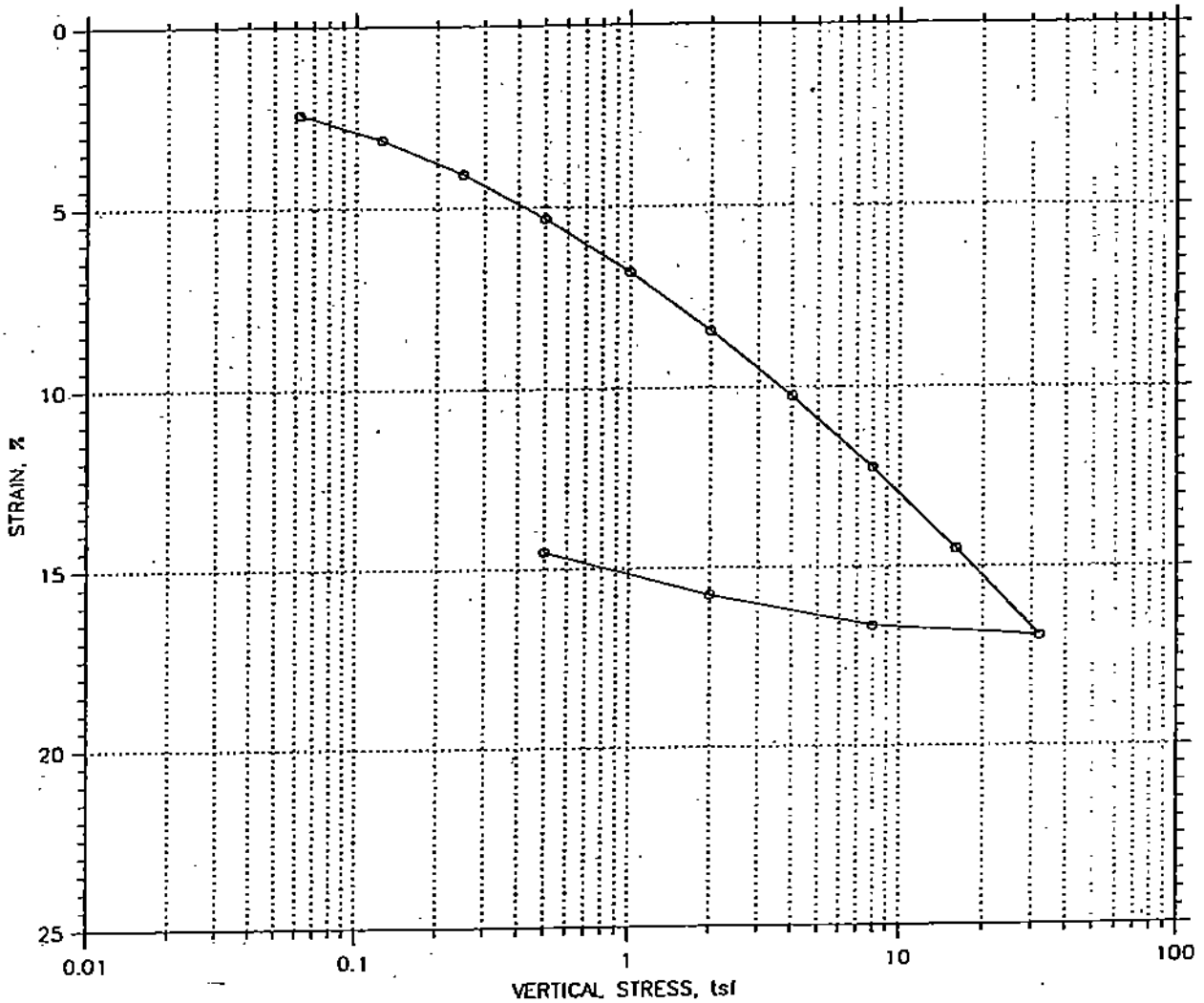
Description: Moist, olive brown sandy silt

Remarks: 1-3 ft; Shelby tube pushed into sample bucket; test specimen then extruded and tested

SECTION
THREE

3

CONSOLIDATION TEST DATA
SUMMARY REPORT



				Before Test	After Test
Overburden Pressure, tsf:				Water Content, %	26.51	17.62
Preconsolidation Pressure, tsf:				Dry Unit Weight, pcf	99.239	116.11
Compression Index:				Saturation, %	98.91	99.75
Diameter: 2.504 in		Height: 1.01 in		Void Ratio	0.74	0.49
LL: 34	PL: 22	PI: 13	GS: 2.77			

Project: Pownal Tannery	Location: Pownal, VT	Project No.: GTX-4363
Boring No.: SBL-3	Tested By: fy	Checked By: jdl
Sample No.: 102	Test Date: 12/17/02	Depth: 6-8 ft
Test No.: C3	Sample Type: Tube	Elevation: ---

Description: Moist, dark greenish gray clay with sand

Remarks: ---

CONSOLIDATION TEST DATA

Project: Pownal Tannery	Location: Pownal, VT	Project No.: GTX-4363
Boring No.: SBL-3	Tested By: fy	Checked By: jdt
Sample No.: 102	Test Date: 12/17/02	Depth: 6-8 ft
Test No.: C3	Sample Type: Tube	Elevation: ---

Soil Description: Moist, dark greenish gray clay with sand
Remarks: ---

Specific Gravity: 2.77	Liquid Limit: 34	Initial Height: 1.01 in
Initial Void Ratio: 0.74	Plastic Limit: 22	Specimen Diameter: 2.50 in
Final Void Ratio: 0.49	Plasticity Index: 13	

	Before Consolidation		After Consolidation	
	Trimmings	Specimen+Ring	Specimen+Ring	Trimmings
Container ID	pf12	RING		winch
Wt. Container + Wet Soil, gm	135.64	375.03	363.51	160.47
Wt. Container + Dry Soil, gm	106.65	340.68	340.68	137.7
Wt. Container, gm	8.18	211.13	211.13	8.48
Wt. Dry Soil, gm	98.47	129.55	129.55	129.22
Water Content, %	29.44	26.51	17.62	17.62
Void Ratio	---	0.74	0.49	---
Degree of Saturation, %	---	98.91	99.75	---
Dry Unit Weight, pcf	---	99.239	116.11	---

CONSOLIDATION TEST DATA

Project: Pownal Tannery
Boring No.: SBL-3
Sample No.: I02
Test No.: C3

Location: Pownal, VT
Tested By: fy
Test Date: 12/17/02
Sample Type: Tube

Project No.: GTX-4363
Checked By: jdt
Depth: 6-8 ft
Elevation: ---

Soil Description: Moist, dark greenish gray clay with sand
Remarks: ---

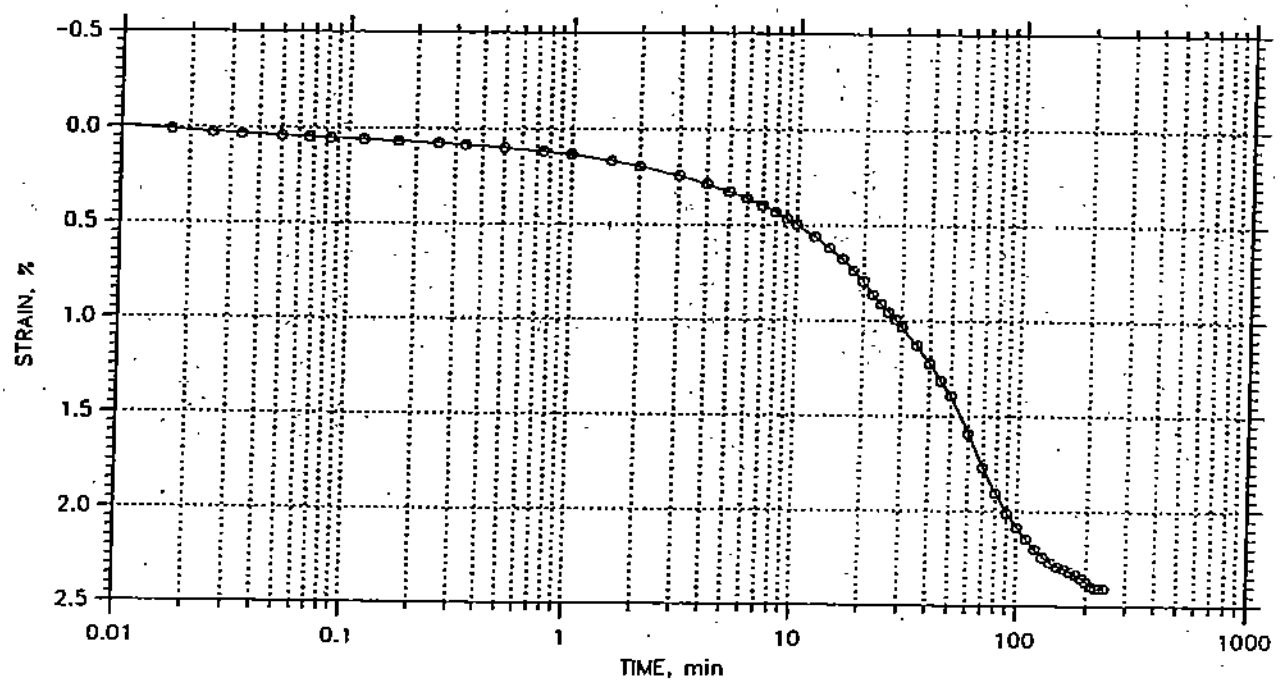
	Applied Stress tsf	Final Displacement in	Void Ratio	Strain at End %	T50 Fitting Sq.Rt. min	T50 Fitting Log min	Coefficient of Consolidation Sq.Rt. in^2/sec	Coefficient of Consolidation Log in^2/sec	Coefficient of Consolidation Ave in^2/sec
1	0.0625	0.02429	0.701	2.41	43.8	0.0	1.87e-005	0.00e+000	1.87e-005
2	0.125	0.03141	0.688	3.11	15.1	14.0	5.25e-005	5.68e-005	5.45e-005
3	0.25	0.04107	0.672	4.07	5.8	10.3	1.35e-004	7.58e-005	9.71e-005
4	0.5	0.05374	0.650	5.32	3.4	4.2	2.22e-004	1.80e-004	1.99e-004
5	1	0.06882	0.624	6.81	2.2	2.9	3.42e-004	2.57e-004	2.93e-004
6	2	0.08518	0.596	8.43	1.2	0.0	6.05e-004	0.00e+000	6.05e-004
7	4	0.1035	0.564	10.25	0.9	0.0	7.50e-004	0.00e+000	7.50e-004
8	8	0.1237	0.529	12.25	0.5	0.5	1.43e-003	1.21e-003	1.31e-003
9	16	0.1465	0.490	14.50	0.4	0.4	1.77e-003	1.63e-003	1.70e-003
10	32	0.1709	0.448	16.92	0.2	0.2	2.51e-003	2.69e-003	2.60e-003
11	8	0.1681	0.453	16.64	0.0	0.0	6.12e-002	0.00e+000	6.12e-002
12	2	0.1591	0.468	15.76	0.2	0.0	2.67e-003	0.00e+000	2.67e-003
13	0.5	0.1467	0.489	14.53	1.8	0.0	3.28e-004	0.00e+000	3.28e-004

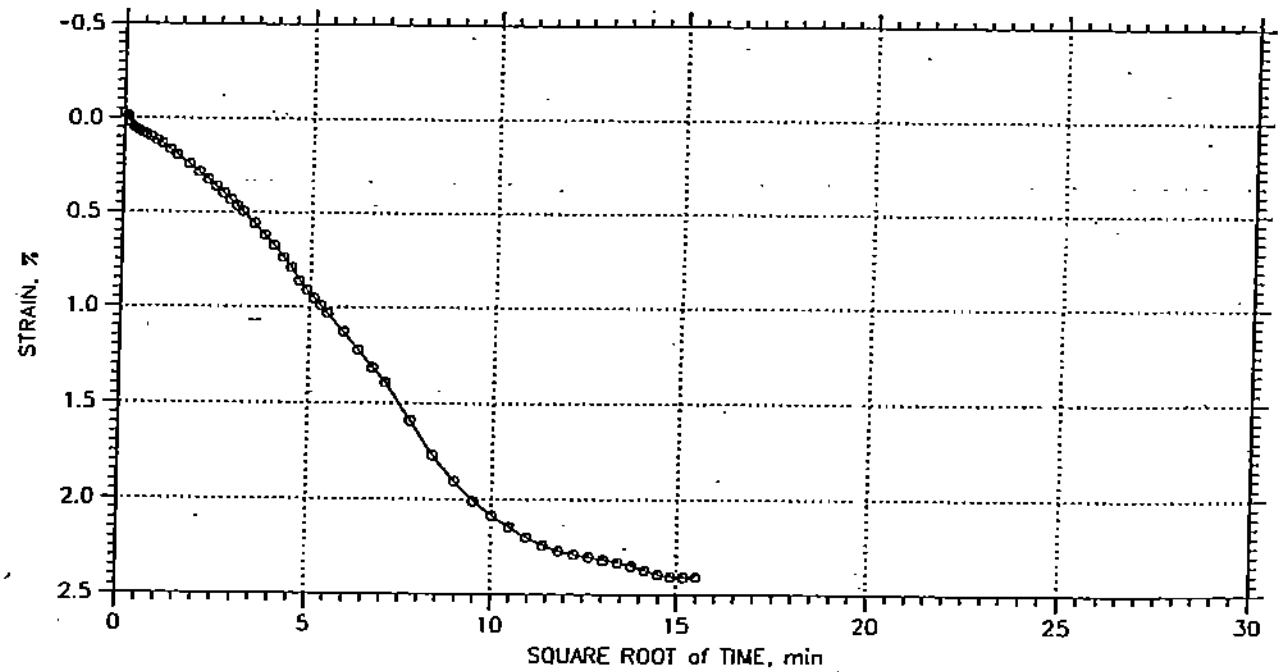
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 1 of 13

Stress: 6.25e-002 tsf





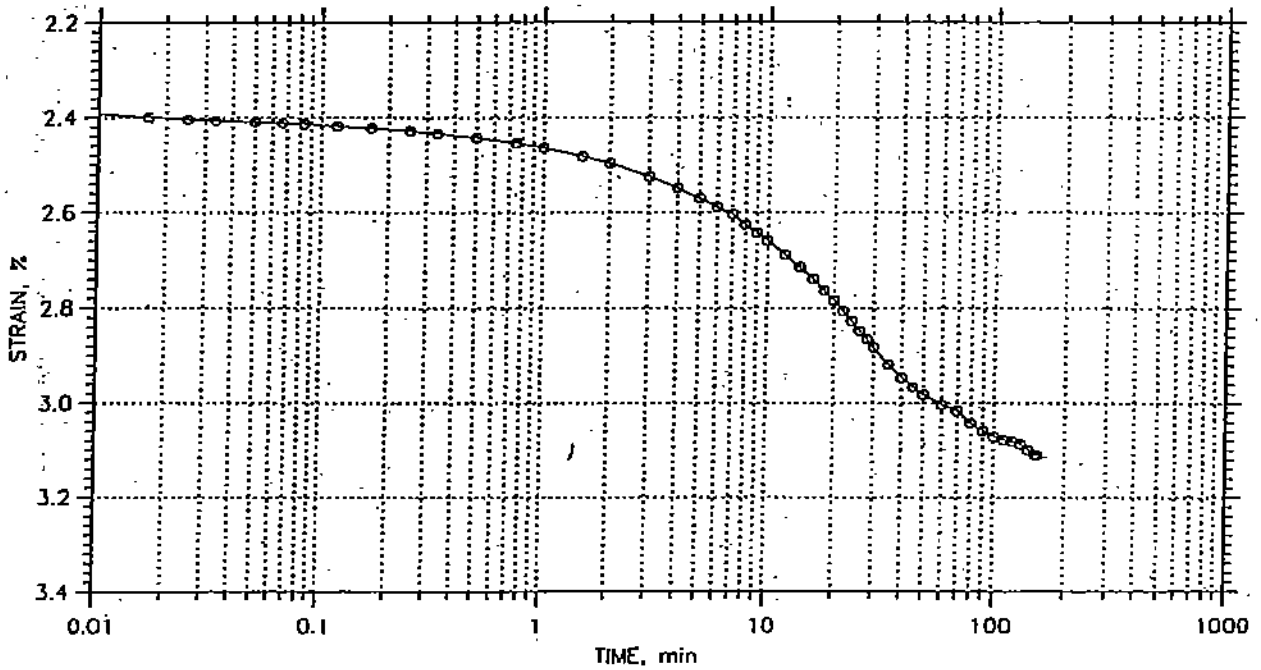
Project: Pownal Tannery	Location: Pownal, VT	Project No.: GTX-4363
Boring No.: SBL-3	Tested By: ly	Checked By: jdl
Sample No.: 102	Test Date: 12/17/02	Depth: 6-8 ft
Test No.: C3	Sample Type: Tube	Elevation: ---
Description: Moist, dark greenish gray clay with sand		
Remarks: ---		

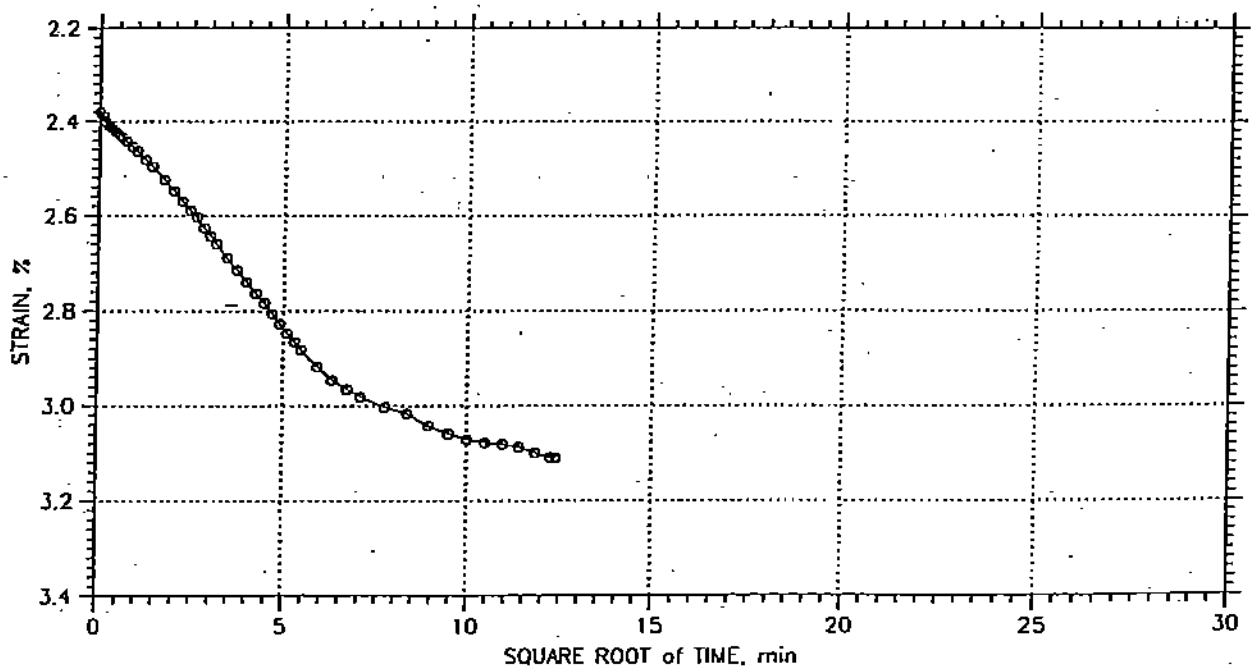
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 2 of 13

Stress: 0.125 tsf





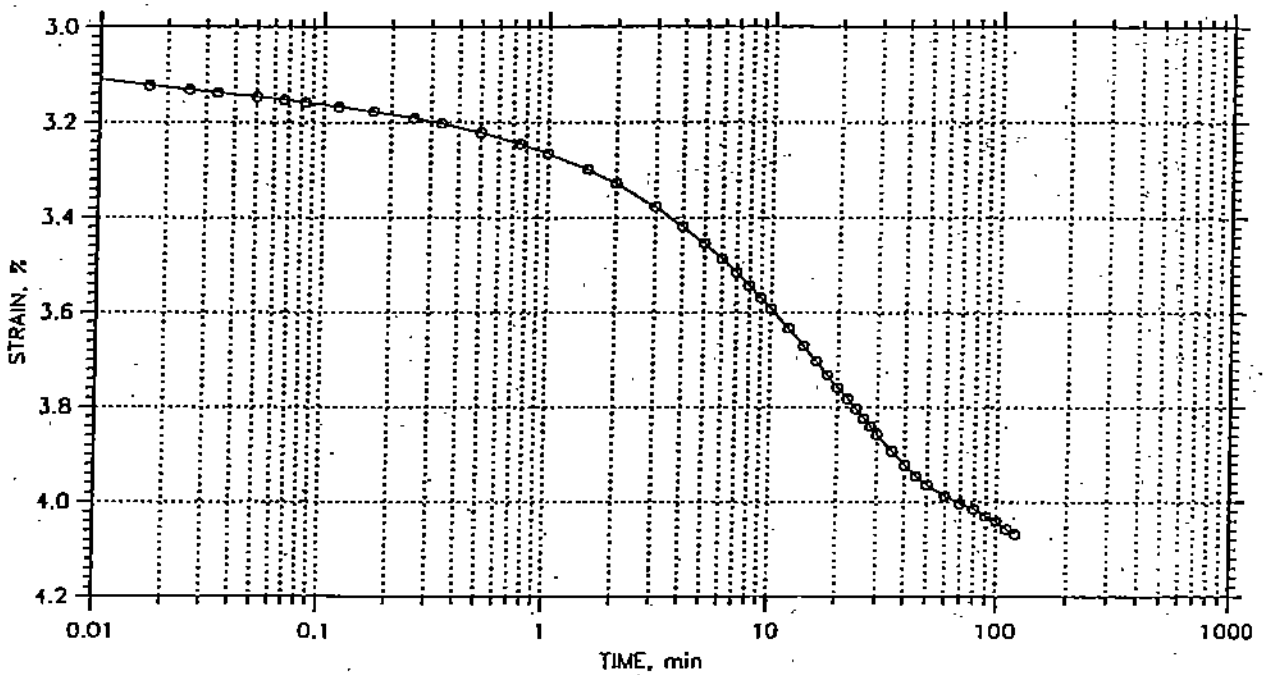
Project: Pownal Tannery	Location: Pownal, VT	Project No.: GTX-4363
Boring No.: SBL-3	Tested By: fy	Checked By: jdt
Sample No.: 102	Test Date: 12/17/02	Depth: 6-8 ft
Test No.: C3	Sample Type: Tube	Elevation: ---
Description: Moist, dark greenish gray clay with sand		
Remarks: ---		

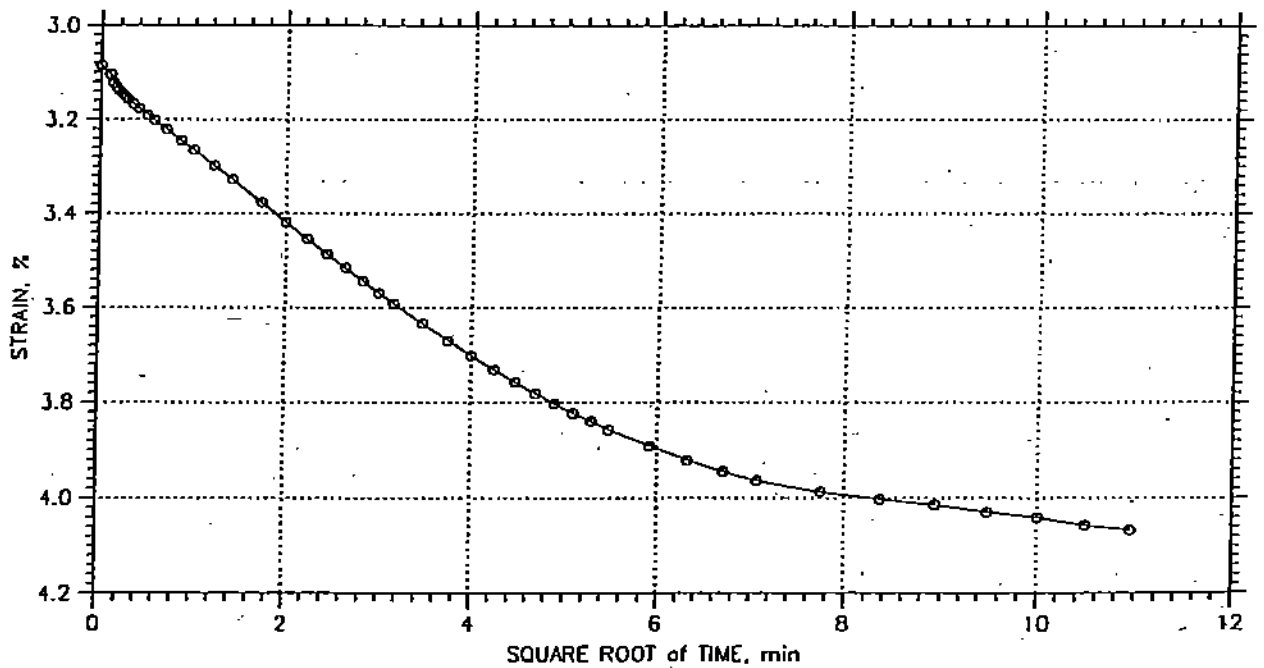
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 3 of 13

Stress: 0.25 tsf





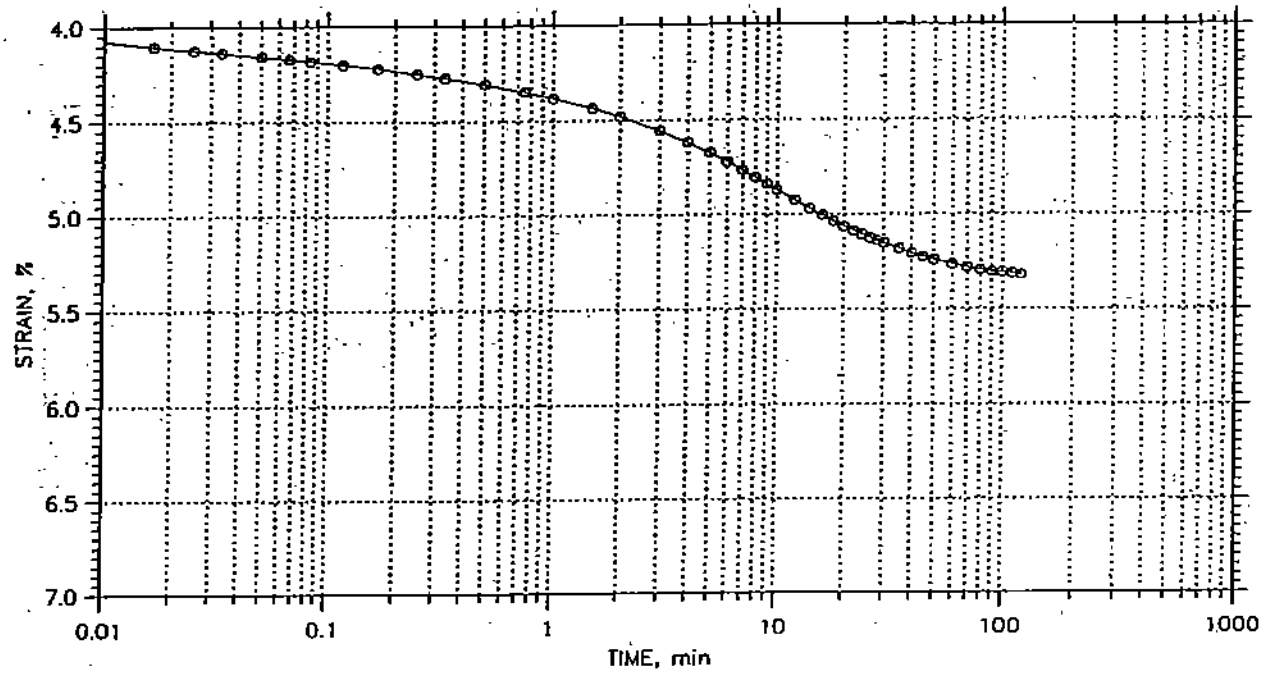
Project: Pownal Tannery	Location: Pownal, VT	Project No.: GTX-4363
Boring No.: SBL-3	Tested By: fy	Checked By: jdt
Sample No.: 102	Test Date: 12/17/02	Depth: 6-8 ft
Test No.: C3	Sample Type: Tube	Elevation: ---
Description: Moist, dark greenish gray clay with sand		
Remarks: ---		

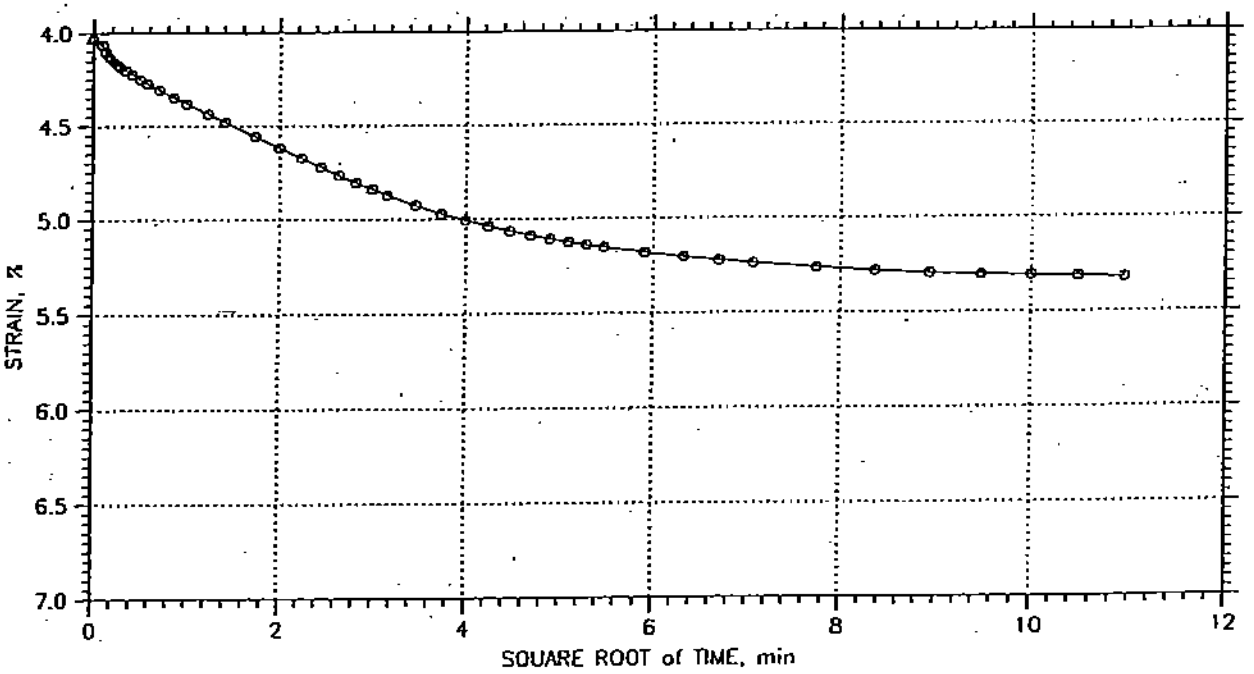
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 4 of 13

Stress: 0.5 tsf





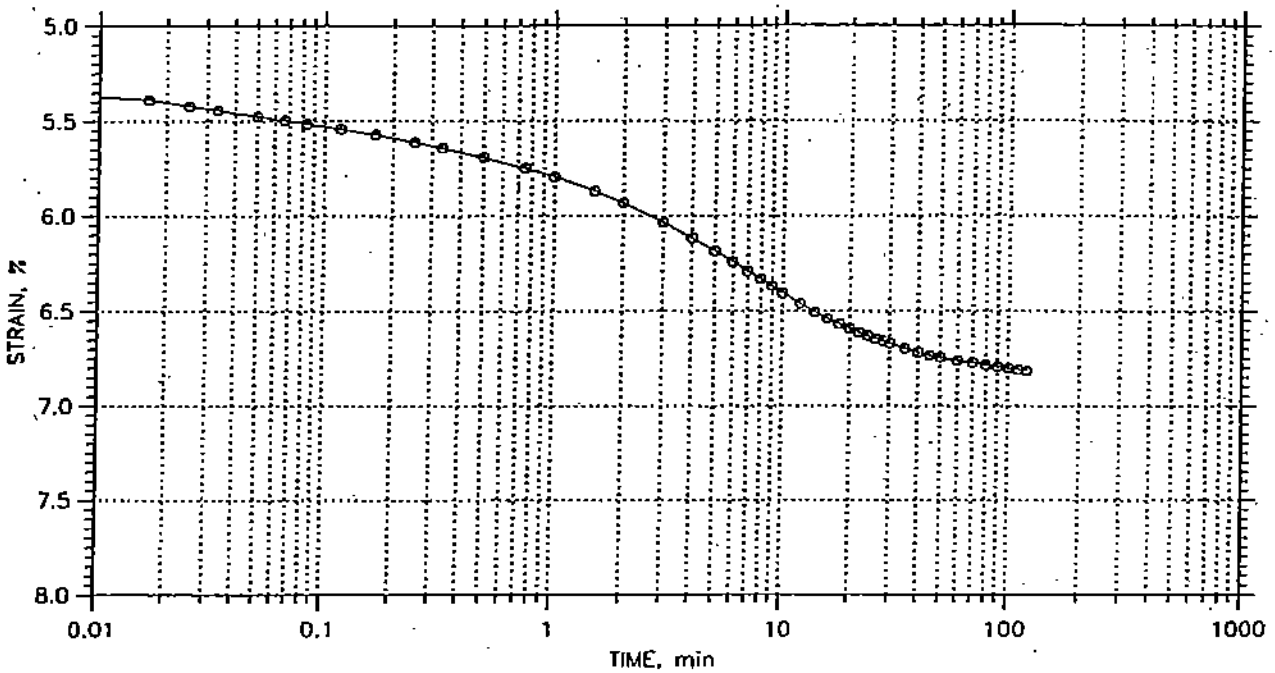
Project: Pownal Tannery	Location: Pownal, VT	Project No.: GTX-4363
Boring No.: SBL-3	Tested By: fy	Checked By: jdt
Sample No.: 102	Test Date: 12/17/02	Depth: 6-8 ft
Test No.: C3	Sample Type: Tube	Elevation: ---
Description: Moist, dark greenish gray clay with sand		
Remarks: ---		

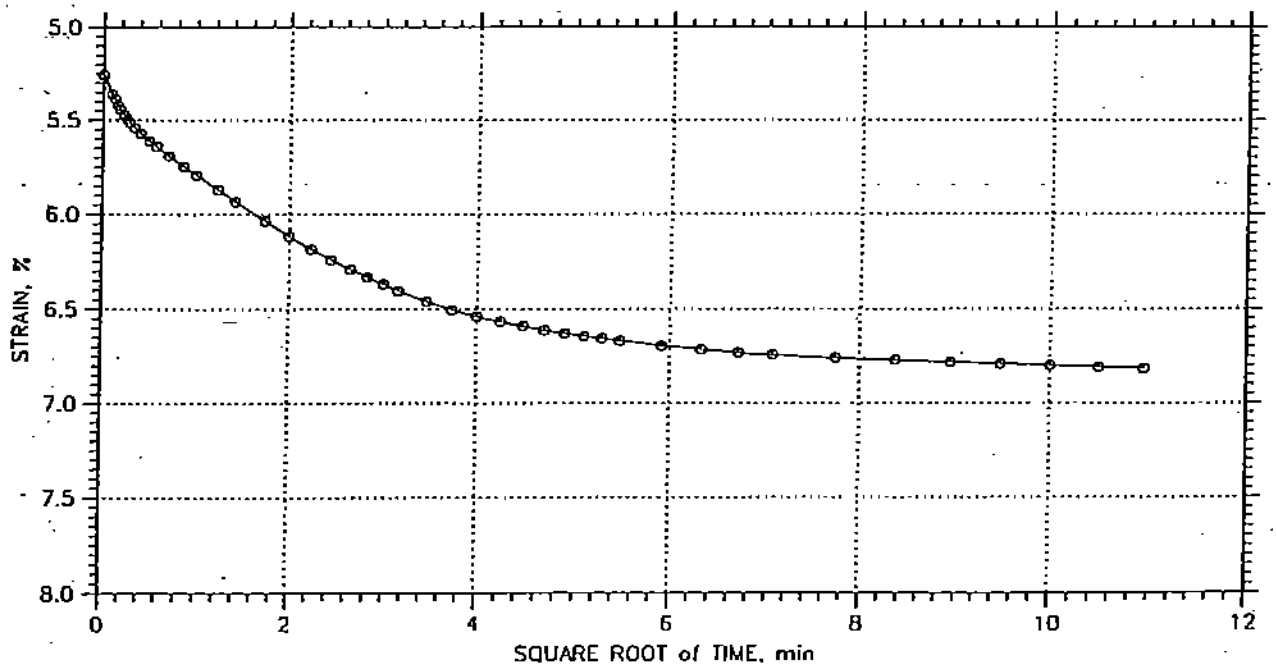
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 5 of 13

Stress: 1. tsf





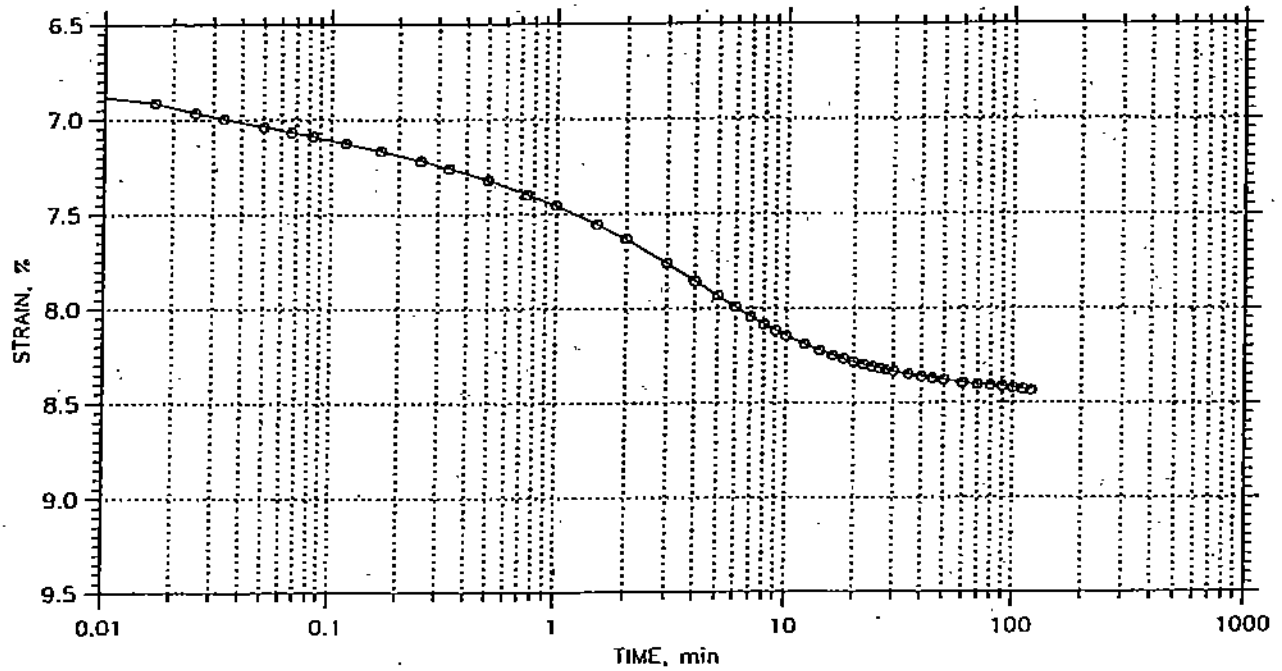
Project: Pownal Tannery	Location: Pownal, VT	Project No.: GTX-4363
Boring No.: SBL-3	Tested By: fy	Checked By: jdt
Sample No.: 102	Test Date: 12/17/02	Depth: 6-8 ft
Test No.: C3	Sample Type: Tube	Elevation: ---
Description: Moist, dark greenish gray clay with sand		
Remarks: ---		

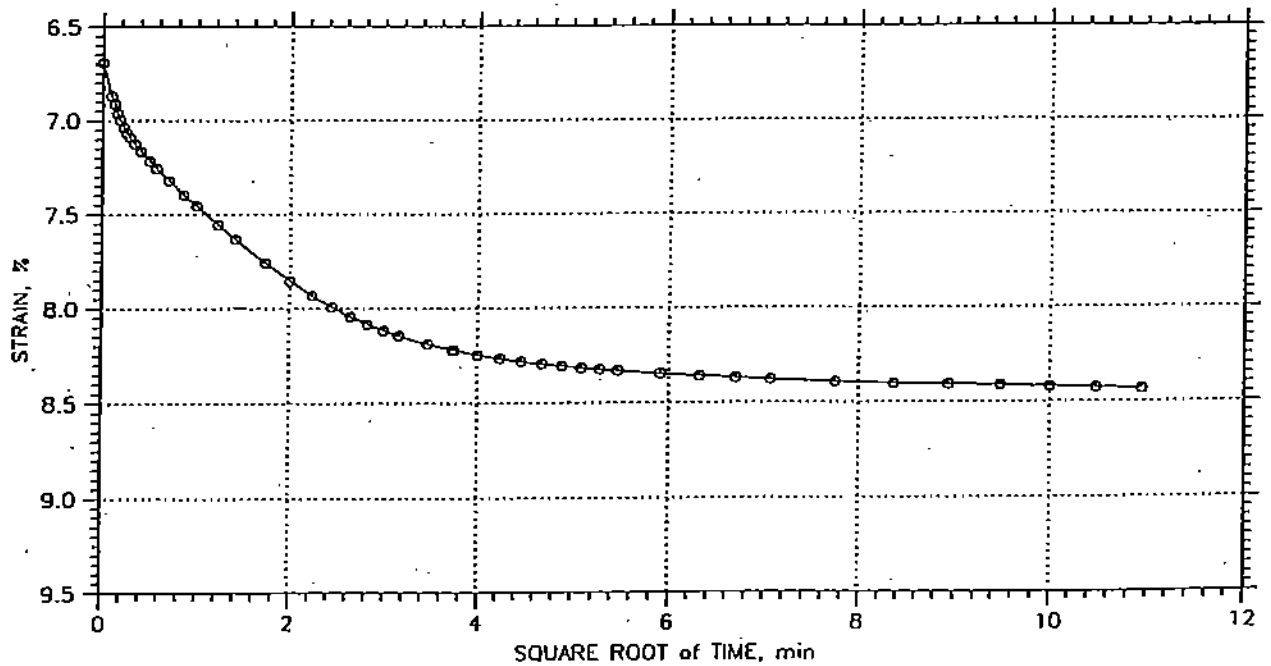
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 6 of 13

Stress: 2. tsf





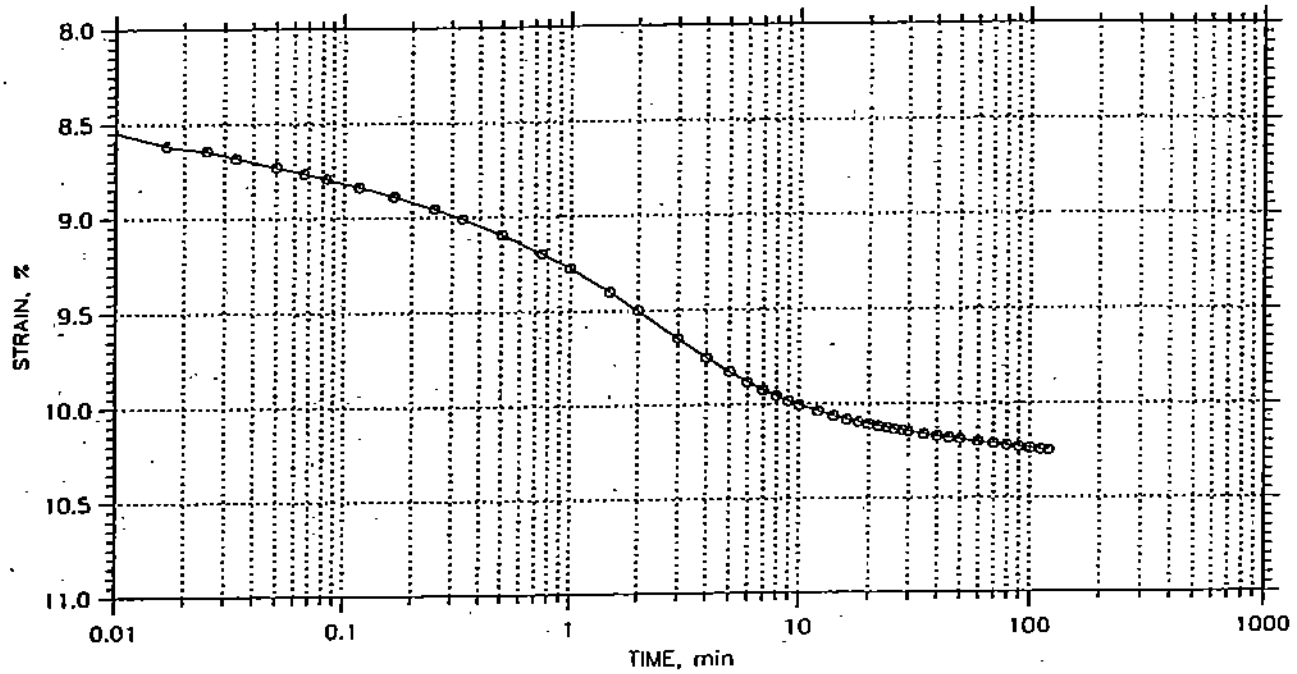
Project: Pownal Tannery	Location: Pownal, VT	Project No.: GTX-4363
Boring No.: SBL-3	Tested By: fy	Checked By: jdt
Sample No.: 102	Test Date: 12/17/02	Depth: 6-8 ft
est No.: C3	Sample Type: Tube	Elevation: ---
Description: Moist, dark greenish gray clay with sand		
Remarks: ---		

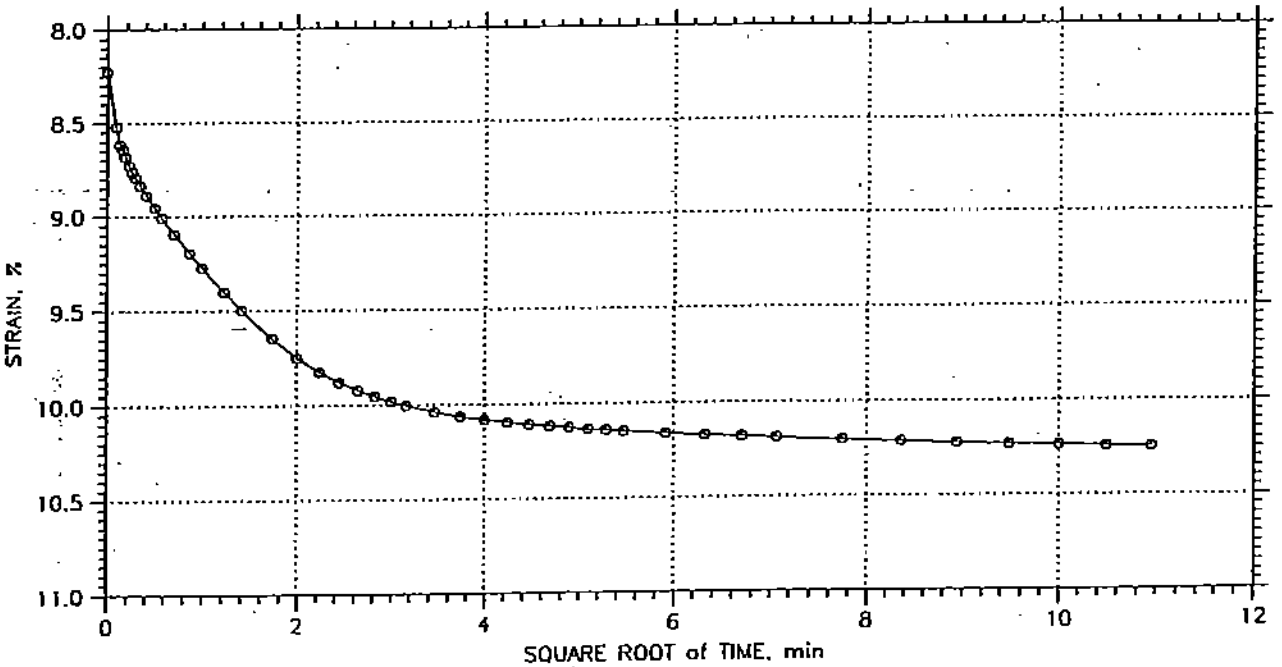
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 7 of 13

Stress: 4. tsf





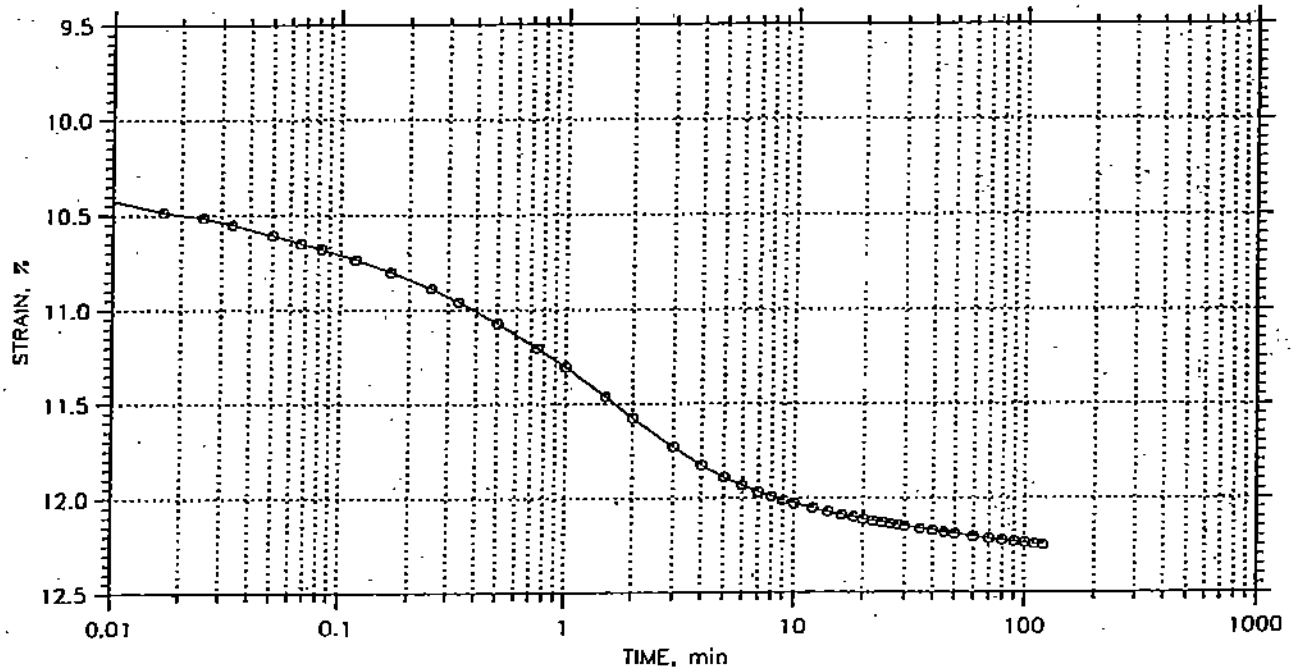
Project: Pownal Tannery	Location: Pownal, VT	Project No.: GTX-4363
Boring No.: SBL-3	Tested By: fy	Checked By: jdl
Sample No.: 102	Test Date: 12/17/02	Depth: 6-8 ft
Test No.: C3	Sample Type: Tube	Elevation: ---
Description: Moist, dark greenish gray clay with sand		
Remarks: ---		

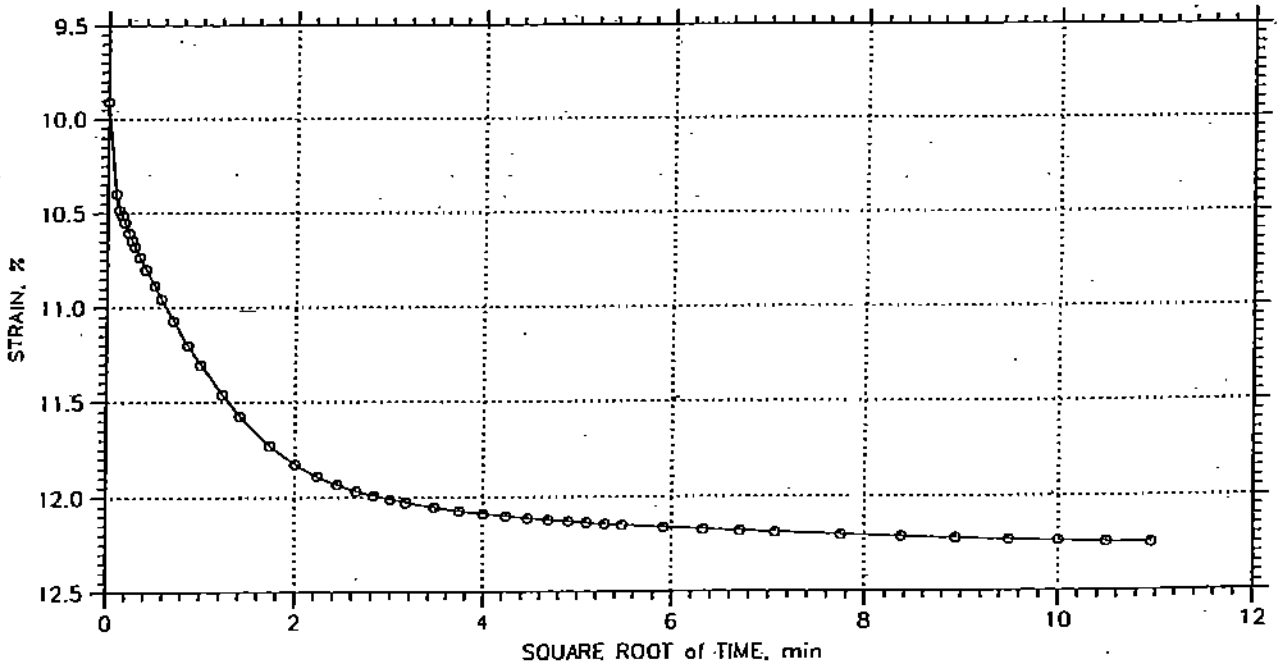
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 8 of 13

Stress: 8. tsf





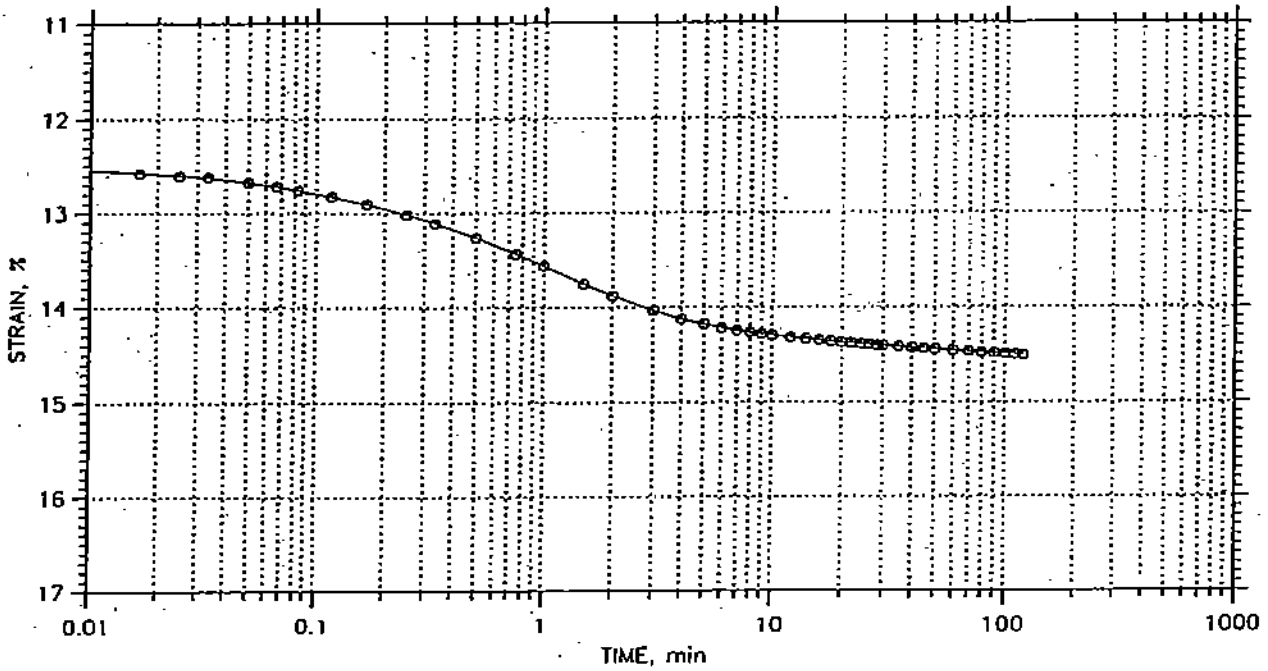
Project: Pownal Tannery	Location: Pownal, VT	Project No.: GTX-4363
Boring No.: SBL-3	Tested By: fy	Checked By: jdl
Sample No.: 102	Test Date: 12/17/02	Depth: 6-8 ft
Test No.: C3	Sample Type: Tube	Elevation: ---
Description: Moist, dark greenish gray clay with sand		
Remarks: ---		

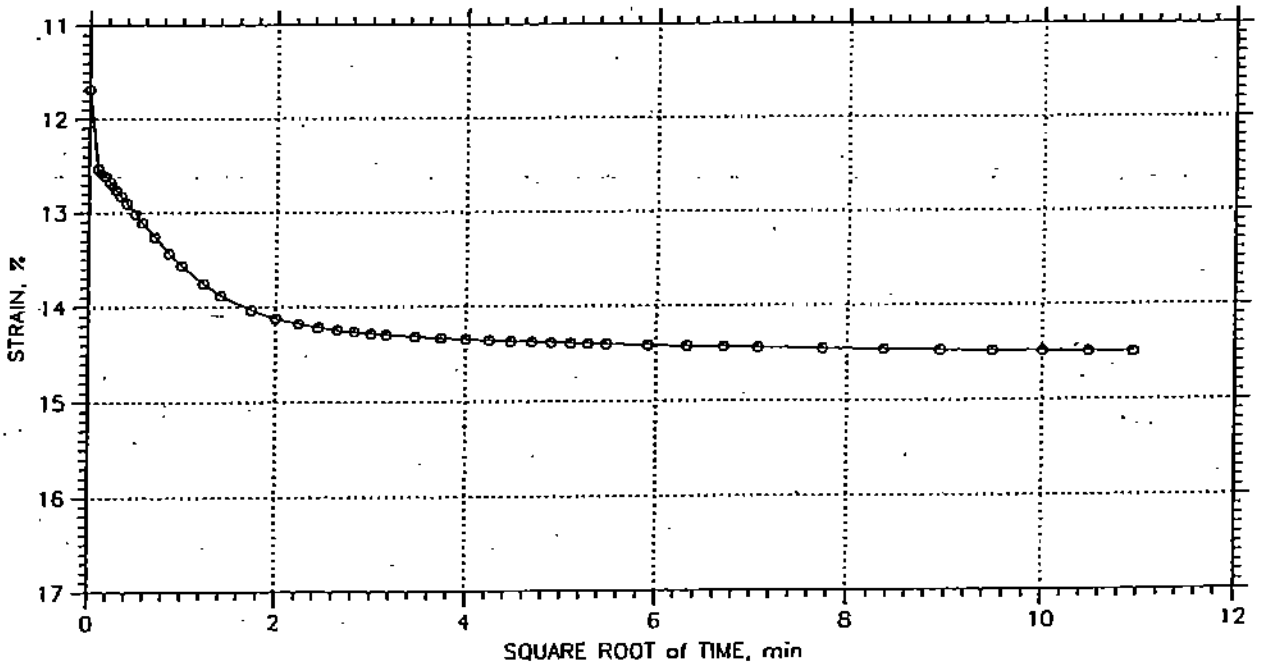
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 9 of 13

Stress: 16. tsf





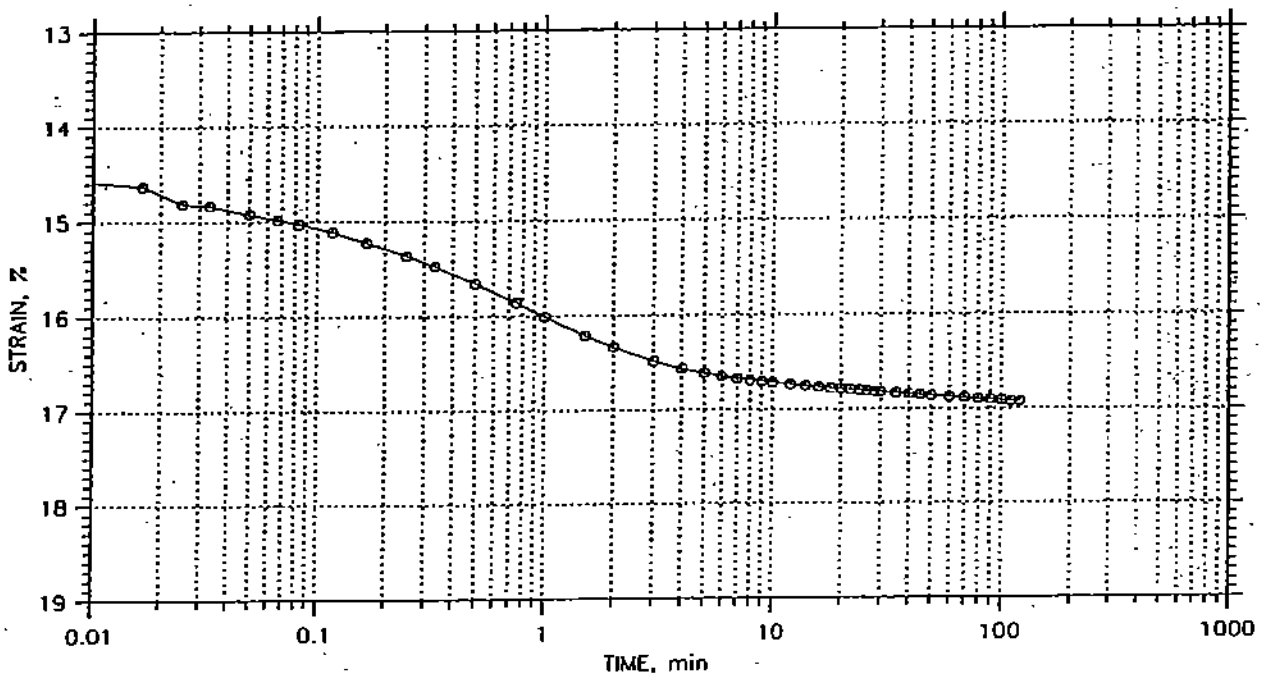
Project: Pownal Tannery	Location: Pownal, VT	Project No.: GTX-4363
Boring No.: SBL-3	Tested By: fy	Checked By: jdt
Sample No.: 102	Test Date: 12/17/02	Depth: 6-8 ft
Test No.: C3	Sample Type: Tube	Elevation: ---
Description: Moist, dark greenish gray clay with sand		
Remarks: ---		

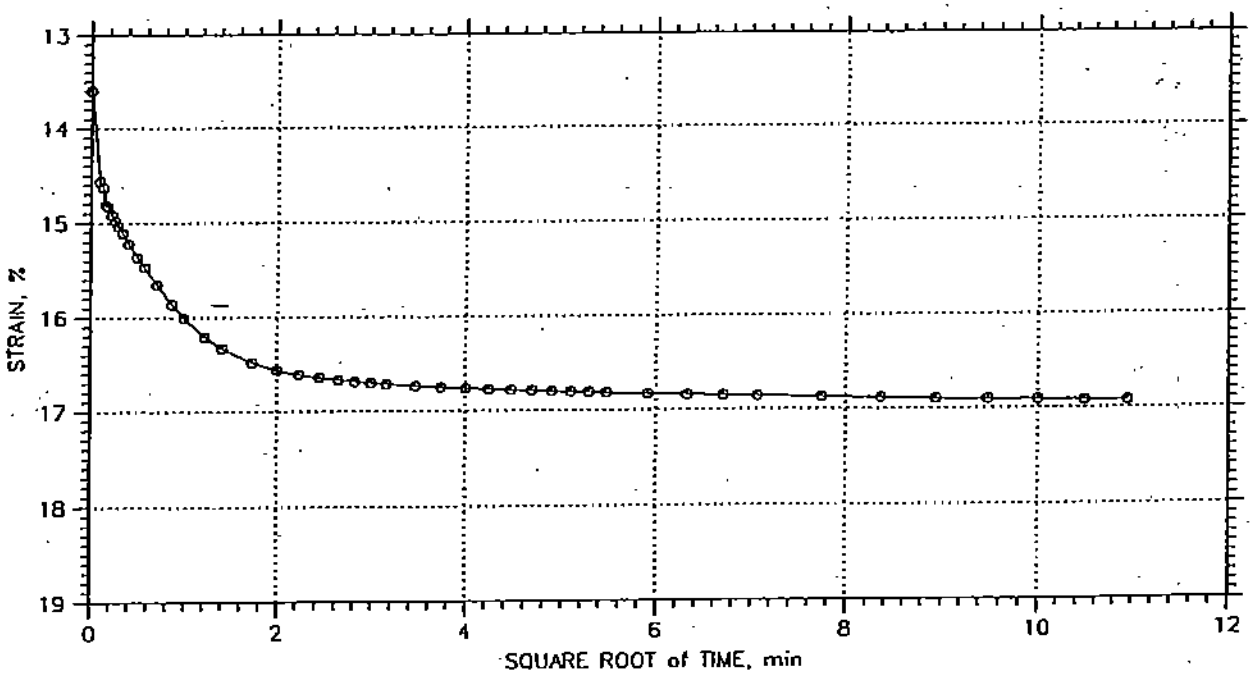
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 10 of 13

Stress: 32. tsf





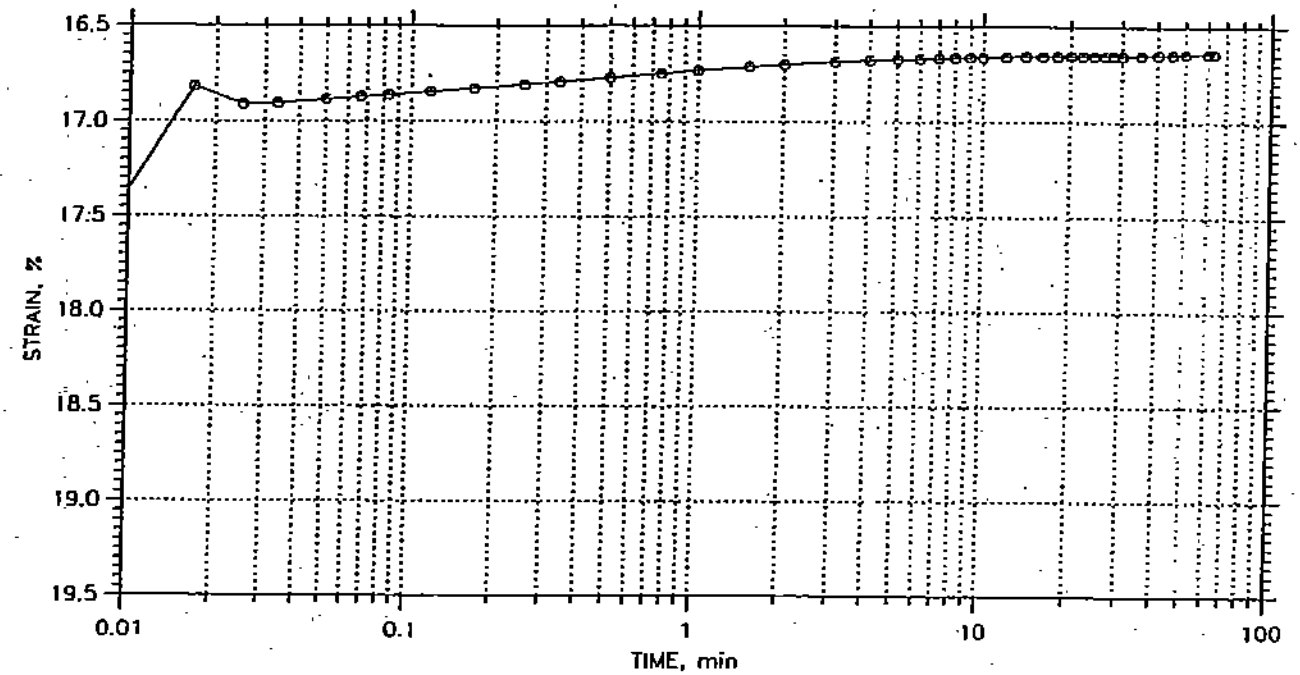
Project: Pownal Tannery	Location: Pownal, VT	Project No.: GTX-4363
Boring No.: SBL-3	Tested By: fy	Checked By: jdl
Sample No.: 102	Test Date: 12/17/02	Depth: 6-8 ft
Test No.: C3	Sample Type: Tube	Elevation: ---
Description: Moist, dark greenish gray clay with sand		
Remarks: ---		

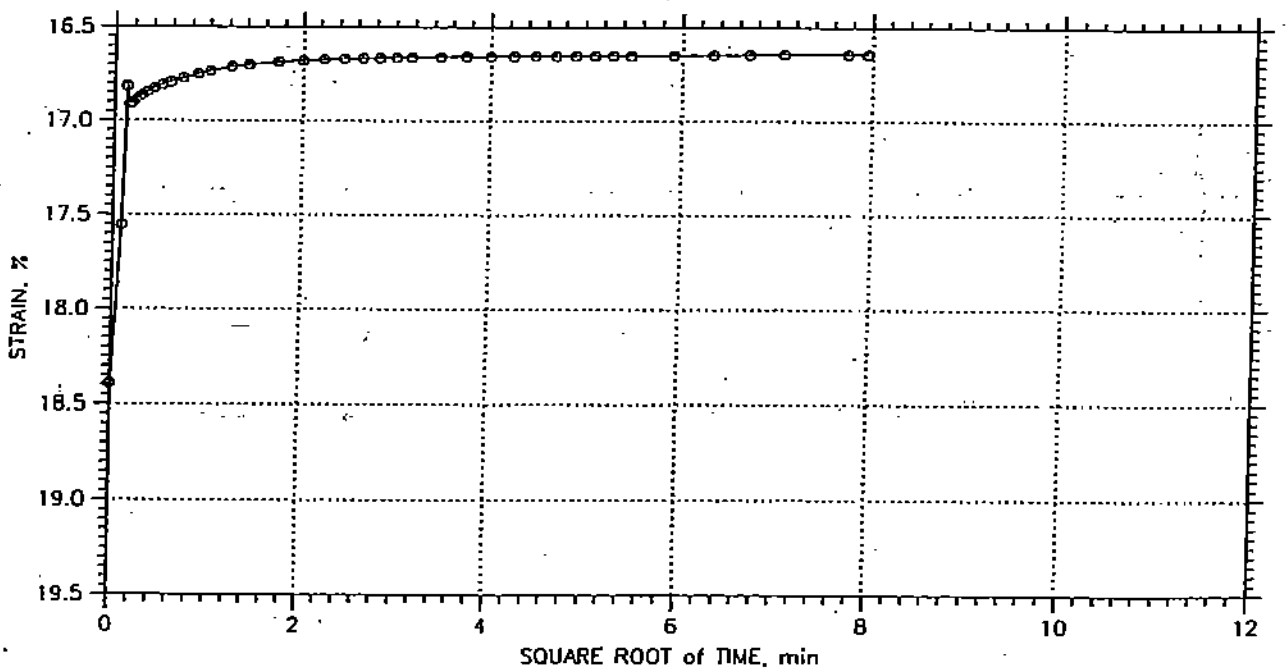
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 11 of 13

Stress: 8. tsf





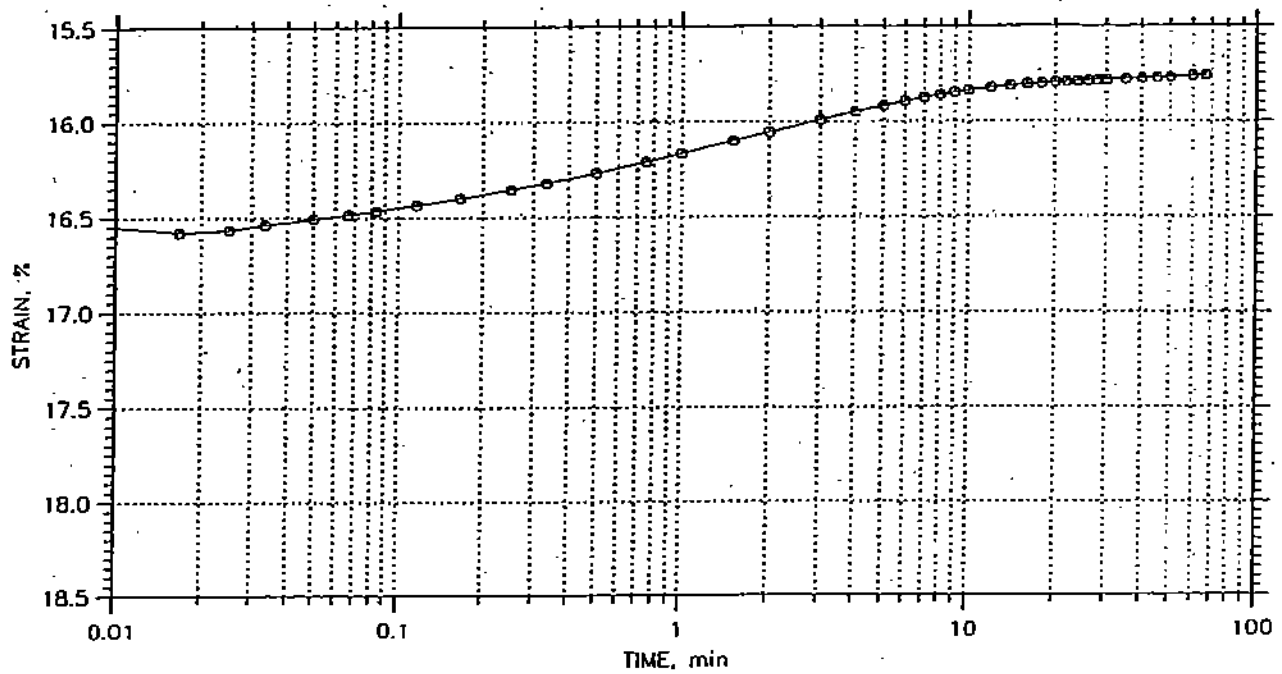
Project: Pownal Tannery	Location: Pownal, VT	Project No.: GTX-4363
Boring No.: SBL-3	Tested By: fy	Checked By: jdt
Sample No.: 102	Test Date: 12/17/02	Depth: 6-8 ft
Test No.: C3	Sample Type: Tube	Elevation: ---
Description: Moist, dark greenish gray clay with sand		
Remarks: ---		

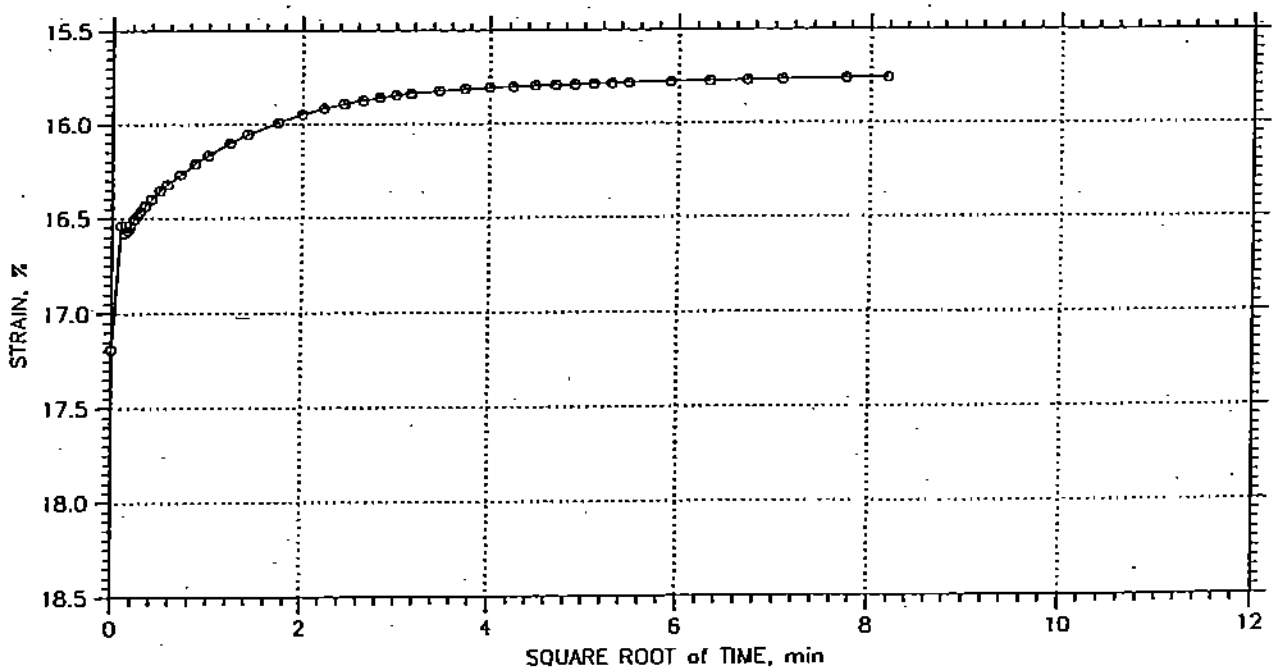
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 12 of 13

Stress: 2. tsf





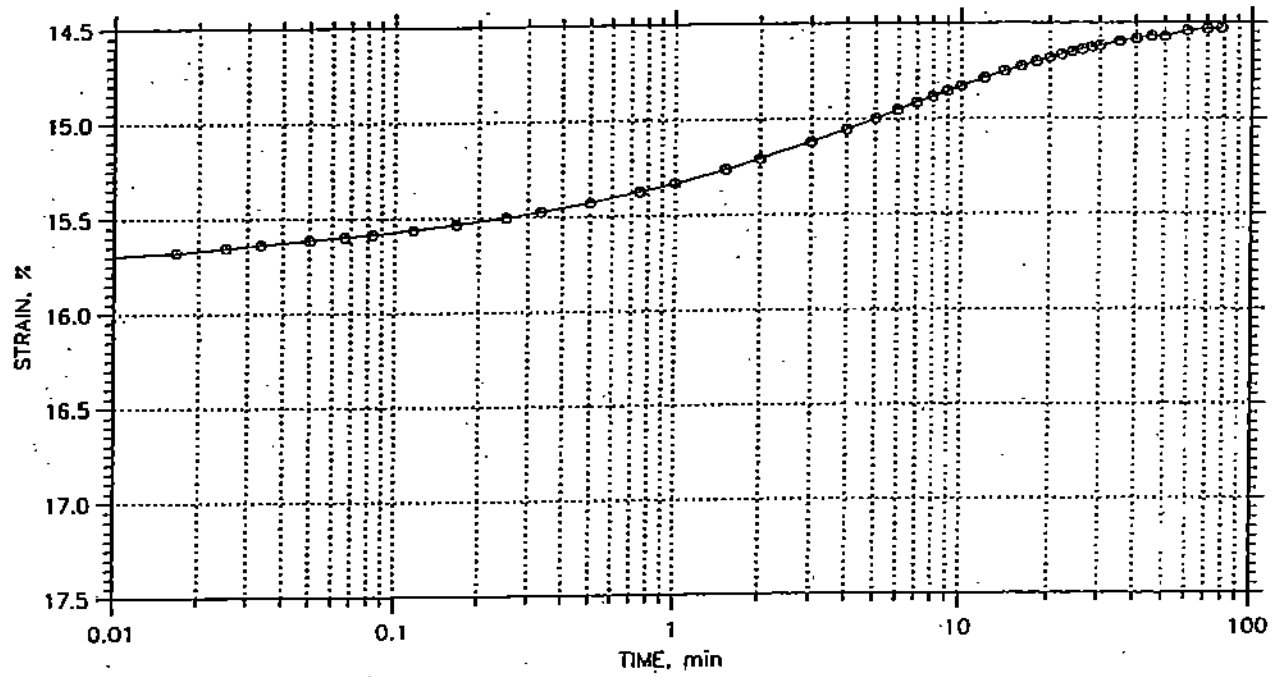
Project: Pownal Tannery	Location: Pownal, VT	Project No.: GTX-4363
Boring No.: SBL-3	Tested By: fy	Checked By: jdt
Sample No.: 102	Test Date: 12/17/02	Depth: 6-8 ft
Test No.: C3	Sample Type: Tube	Elevation: ---
Description: Moist, dark greenish gray clay with sand		
Remarks: ---		

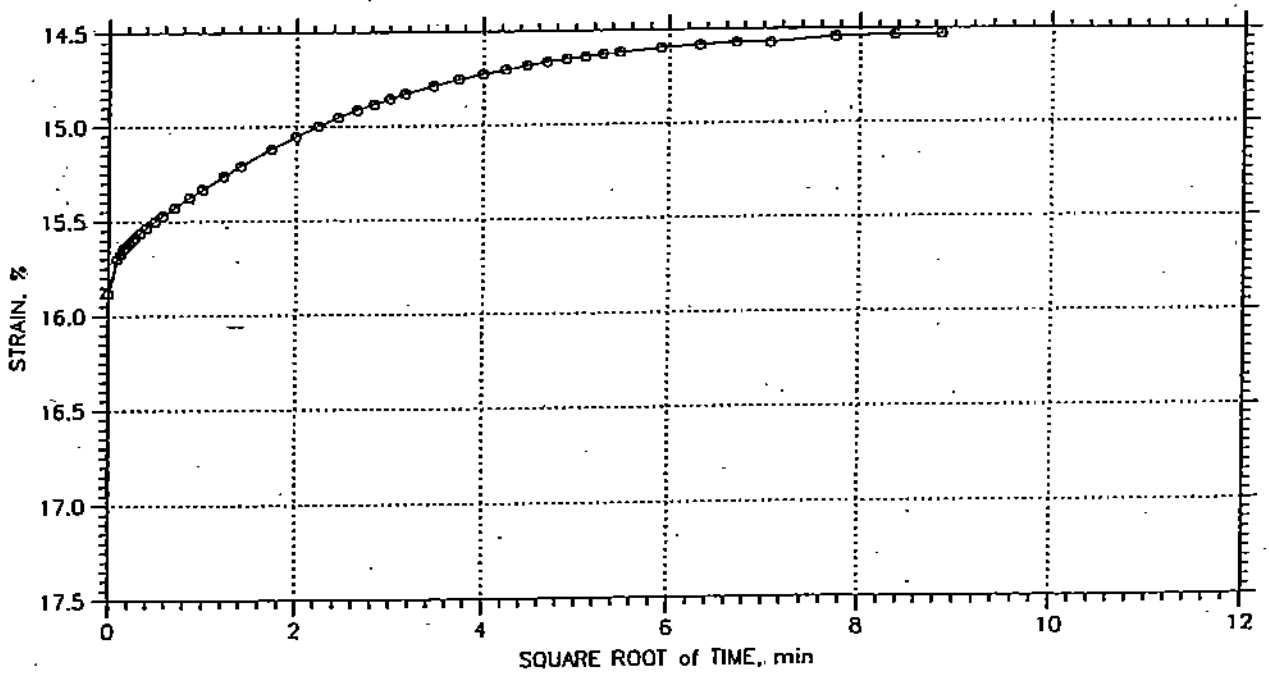
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 13 of 13

Stress: 0.5 tsf

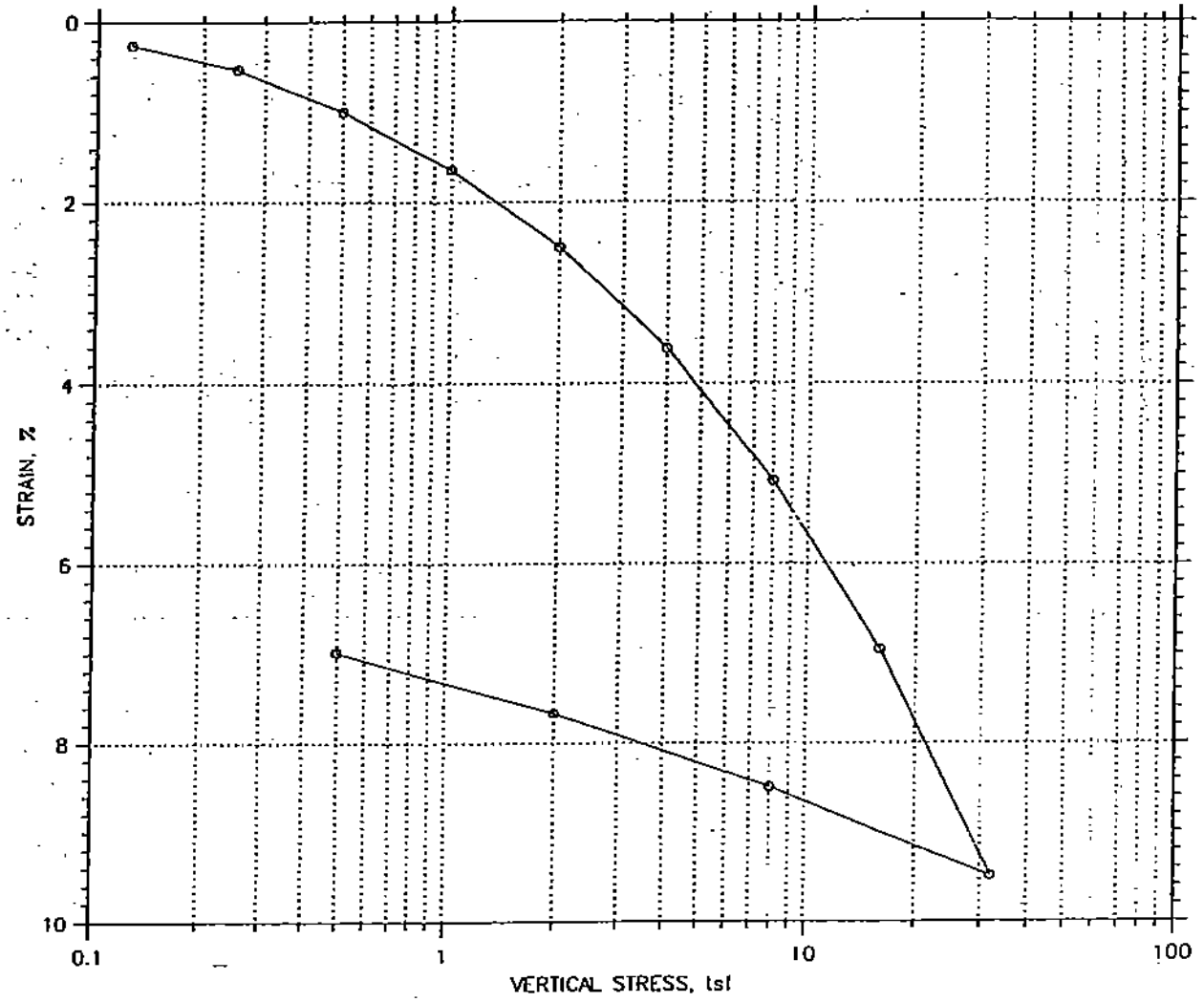




Project: Pownal Tannery	Location: Pownal, VT	Project No.: GTX-4363
Boring No.: SBL-3	Tested By: ly	Checked By: jdl
Sample No.: 102	Test Date: 12/17/02	Depth: 6-8 ft
Test No.: C3	Sample Type: Tube	Elevation: ---
Description: Moist, dark greenish gray clay with sand		
Remarks: ---		

CONSOLIDATION TEST DATA

SUMMARY REPORT



				Before Test	After Test
Overburden Pressure, tsf:				Water Content, %	23.99	20.73
Preconsolidation Pressure, tsf:				Dry Unit Weight, pcf	102.38	110.06
Compression Index:				Saturation, %	96.02	100.00
Diameter: 2.5 in		Height: 1 in		Void Ratio	0.69	0.58
LL: 0	PL: 0	PI: 0	GS: 2.78			

Project: Pownal Tannery	Location: Pownal, VT	Project No.: GTX-4363
Boring No.: SBL4	Tested By: fy	Checked By: jdl
Sample No.: 101	Test Date: 12/17/02	Depth: 8-10 ft
Test No.: C2	Sample Type: Tube	Elevation: ---

Description: Moist, dark greenish gray silty sand

Remarks: Sample determined to be Non-Plastic

CONSOLIDATION TEST DATA

Project: Pownal Tannery
Boring No.: SBL4
Sample No.: 101
Test No.: C2

Location: Pownal, VT
Tested By: fy
Test Date: 12/17/02
Sample Type: Tube

Project No.: GTX-4363
Checked By: jdt
Depth: 8-10 ft
Elevation: ---

Soil Description: Moist, dark greenish gray silty sand
Remarks: Sample determined to be Non-Plastic

Specific Gravity: 2.78
Initial Void Ratio: 0.69
Final Void Ratio: 0.58

Liquid Limit: 0
Plastic Limit: 0
Plasticity Index: 0

Initial Height: 1.00 in
Specimen Diameter: 2.50 in

	Before Consolidation		After Consolidation	
	Trimmings	Specimen+Ring	Specimen+Ring	Trimmings
Container ID	orb	RING		stash
Wt. Container + Wet Soil, gm	284.05	378.31	374.01	167.14
Wt. Container + Dry Soil, gm	233.58	346.66	346.66	139.84
Wt. Container, gm	8.21	214.74	214.74	8.16
Wt. Dry Soil, gm	225.37	131.92	131.92	131.68
Water Content, %	22.39	23.99	20.73	20.73
Void Ratio	---	0.69	0.58	---
Degree of Saturation, %	---	96.02	100.00	---
Dry Unit Weight, pcf	---	102.38	110.06	---

CONSOLIDATION TEST DATA

Project: Pownal Tannery
Boring No.: SBL4
Sample No.: 101
Test No.: C2

Location: Pownal, VT
Tested By: fy
Test Date: 12/17/02
Sample Type: Tube

Project No.: GTX-4363
Checked By: jdt
Depth: 8-10 ft
Elevation: ---

Soil Description: Moist, dark greenish gray silty sand
Remarks: Sample determined to be Non-Plastic

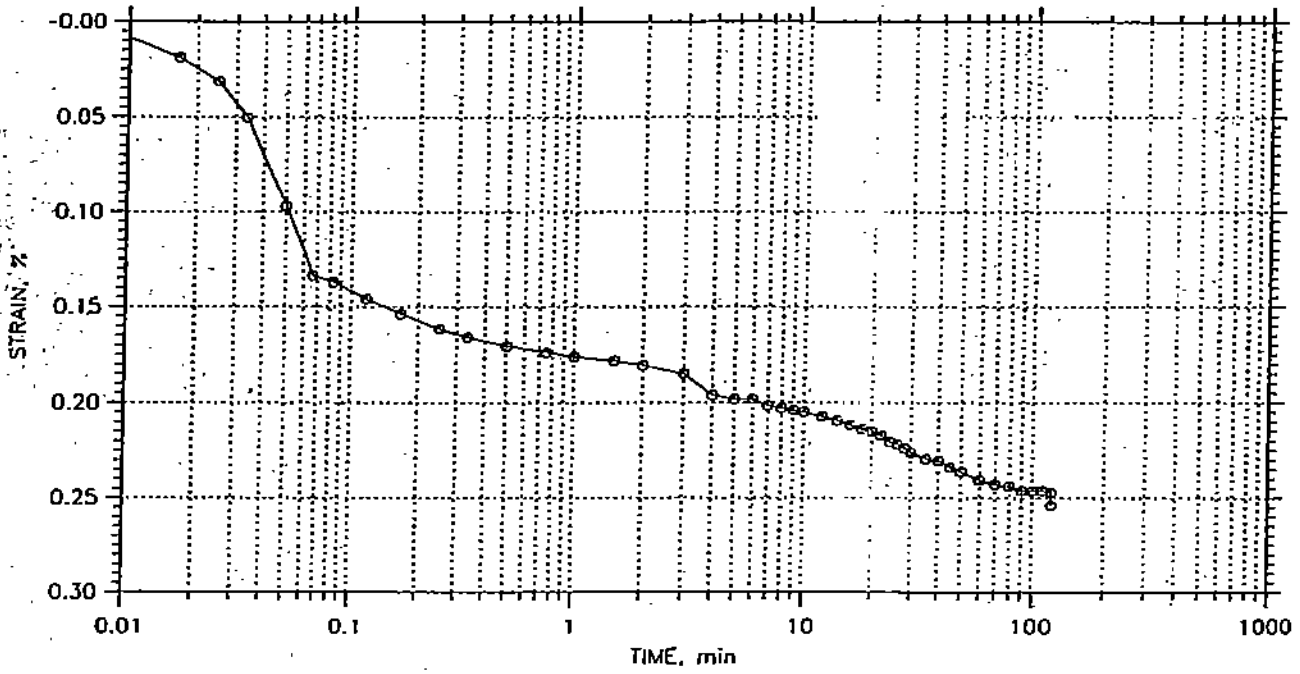
	Applied Stress tsf	Final Displacement in	Void Ratio	Strain at End %	T50 Fitting Sq.Rt. min	T50 Fitting Log min	Coefficient of Consolidation Sq.Rt. in^2/sec	Coefficient of Consolidation Log in^2/sec	Coefficient of Consolidation Ave in^2/sec
1	0.125	0.00254	0.690	0.25	0.3	0.1	3.19e-003	1.62e-002	5.32e-00
2	0.25	0.005247	0.685	0.52	0.1	0.1	8.64e-003	1.63e-002	1.13e-00
3	0.5	0.009937	0.677	0.99	0.0	0.0	1.80e-002	1.97e-002	1.88e-00
4	1	0.01643	0.666	1.64	0.0	0.0	2.29e-002	2.27e-002	2.28e-00
5	2	0.02503	0.652	2.50	0.0	0.0	3.49e-002	3.25e-002	3.37e-00
6	4	0.03614	0.633	3.61	0.0	0.0	2.95e-002	3.91e-002	3.36e-00
7	8	0.05081	0.608	5.08	0.0	0.0	2.41e-002	4.63e-002	3.17e-00
8	16	0.06949	0.577	6.95	0.0	0.0	5.04e-002	5.67e-002	5.33e-00
9	32	0.09491	0.533	9.49	0.0	0.0	6.58e-002	6.09e-002	6.33e-00
10	8	0.08495	0.550	8.50	0.0	0.0	0.00e+000	0.00e+000	0.00e+00
11	2	0.07667	0.564	7.67	0.0	0.0	6.38e-002	0.00e+000	6.38e-00
12	0.5	0.06978	0.576	6.98	0.0	0.0	4.19e-002	3.22e-002	3.64e-00

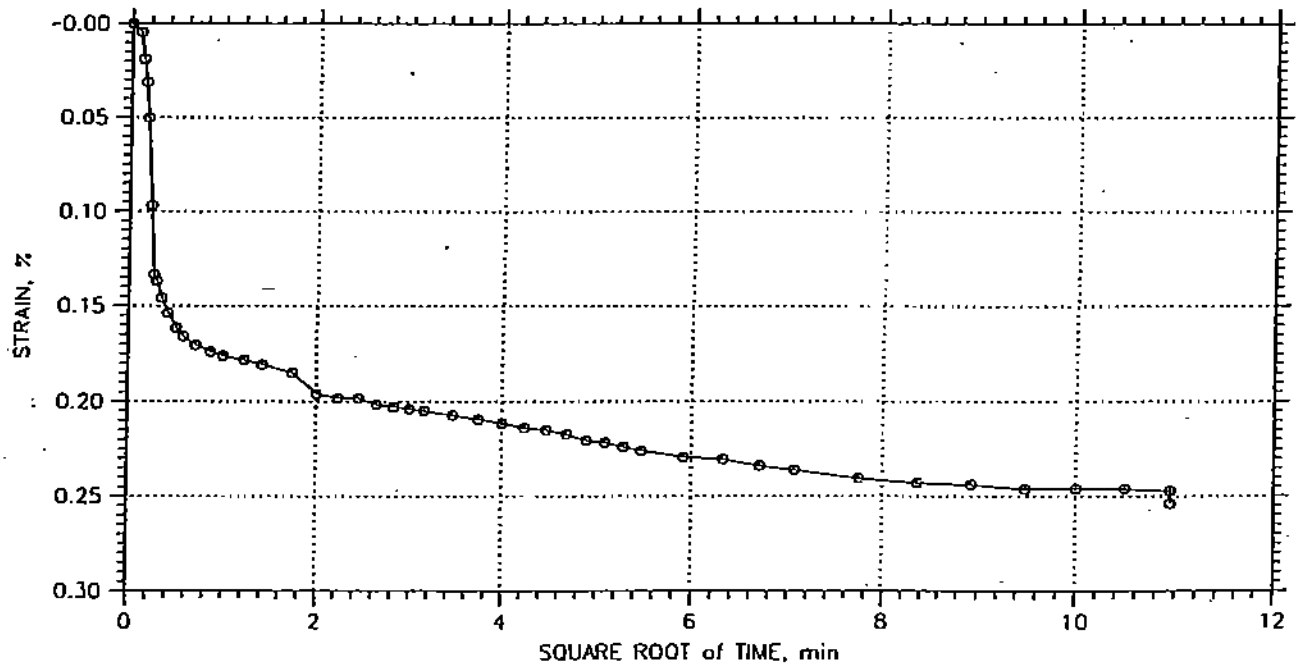
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 1 of 12

Stress: 0.125 tsf





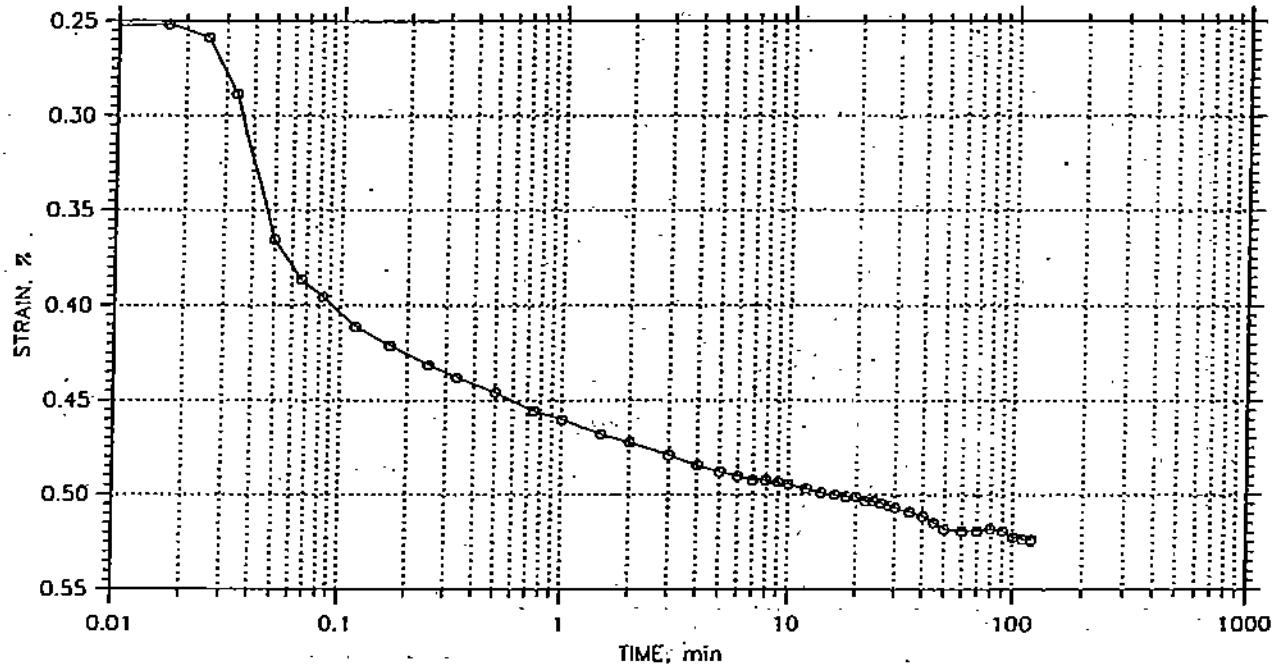
Project: Pownal Tannery	Location: Pownal, VT	Project No.: GTX-4363
Boring No.: SBL4	Tested By: fy	Checked By: jdt
Sample No.: 101	Test Date: 12/17/02	Depth: 8-10 ft
Test No.: C2	Sample Type: Tube	Elevation: ---
Description: Moist, dark greenish gray silty sand		
Remarks: Sample determined to be Non-Plastic		

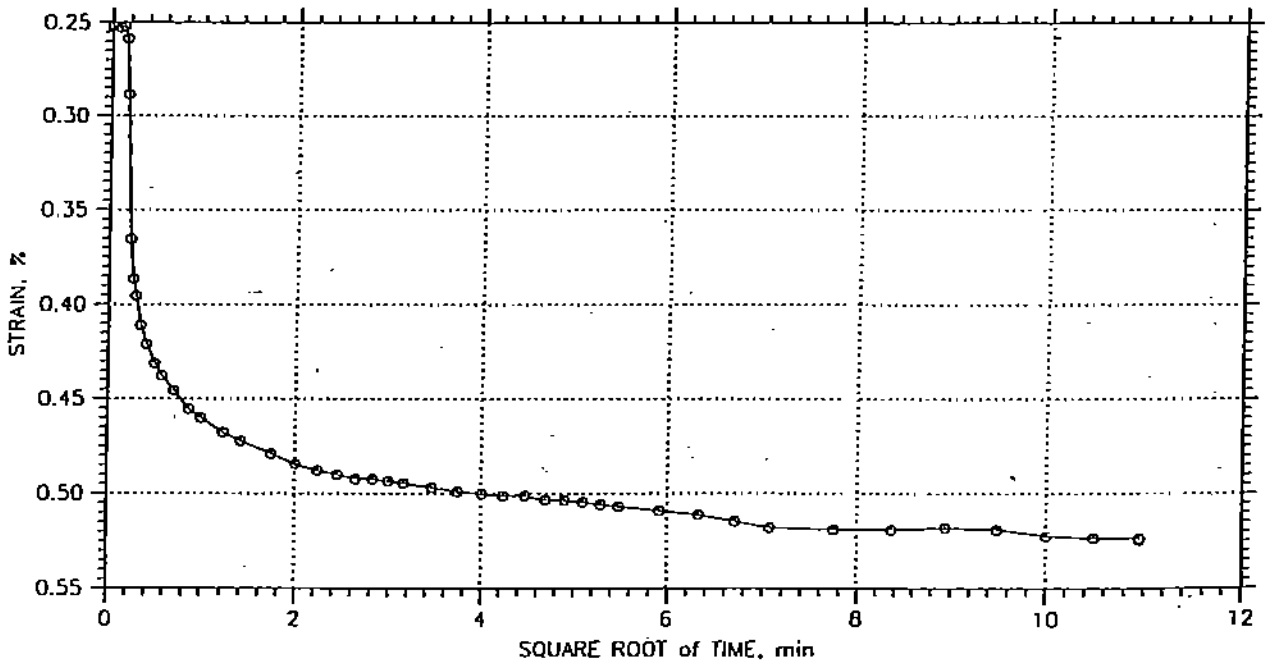
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 2 of 12

Stress: 0.25 tsf





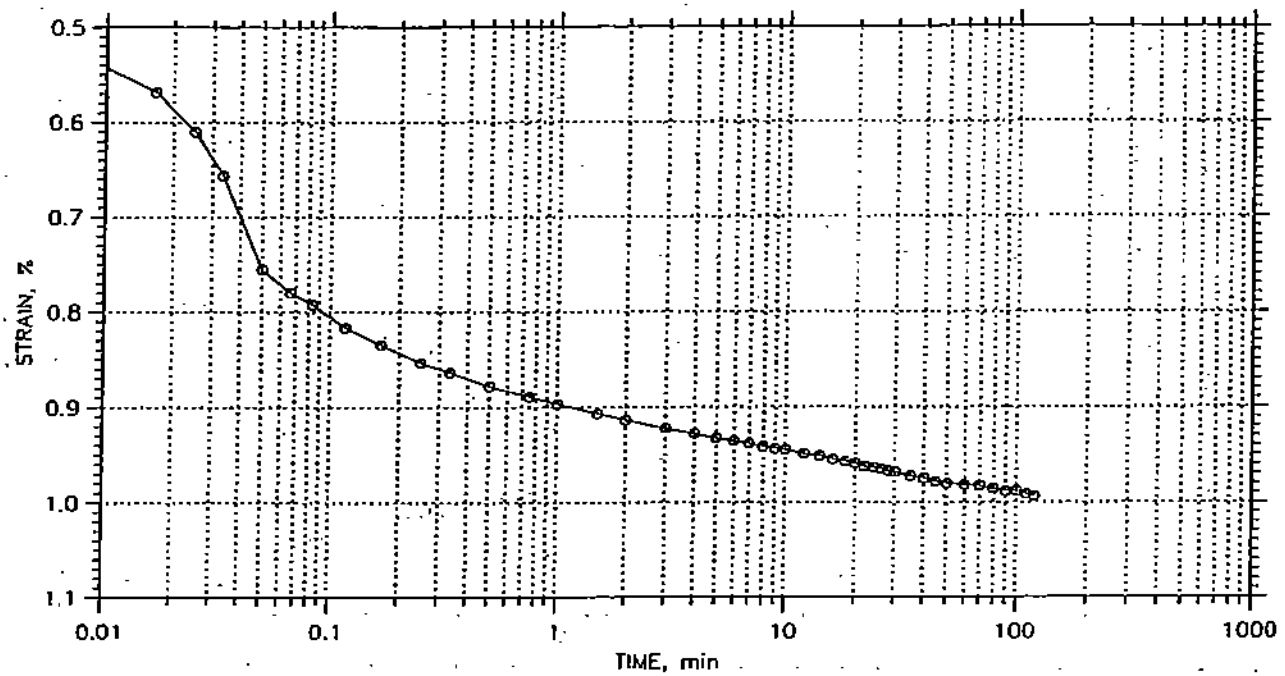
Project: Pownal Tannery	Location: Pownal, VT	Project No.: GTX-4363
Boring No.: SBL4	Tested By: fy	Checked By: jdt
Sample No.: 101	Test Date: 12/17/02	Depth: 8-10 ft
Test No.: C2	Sample Type: Tube	Elevation: ---
Description: Moist, dark greenish gray silty sand		
Remarks: Sample determined to be Non-Plastic		

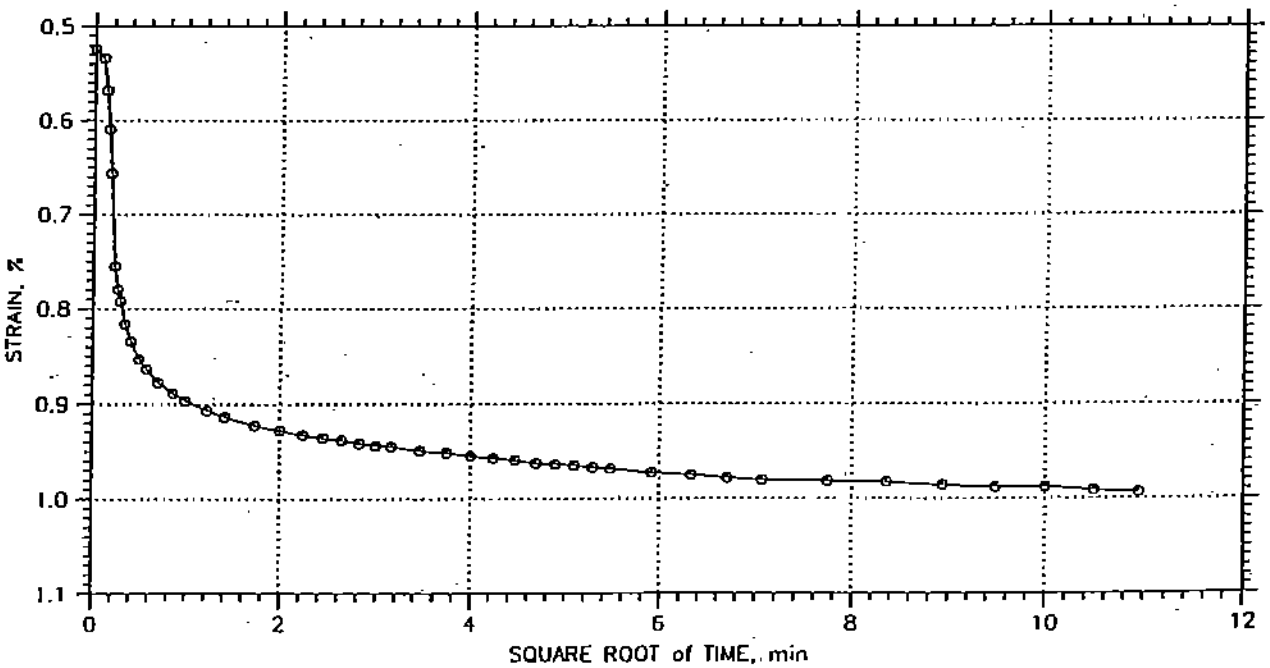
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 3 of 12

Stress: 0.5 tsf





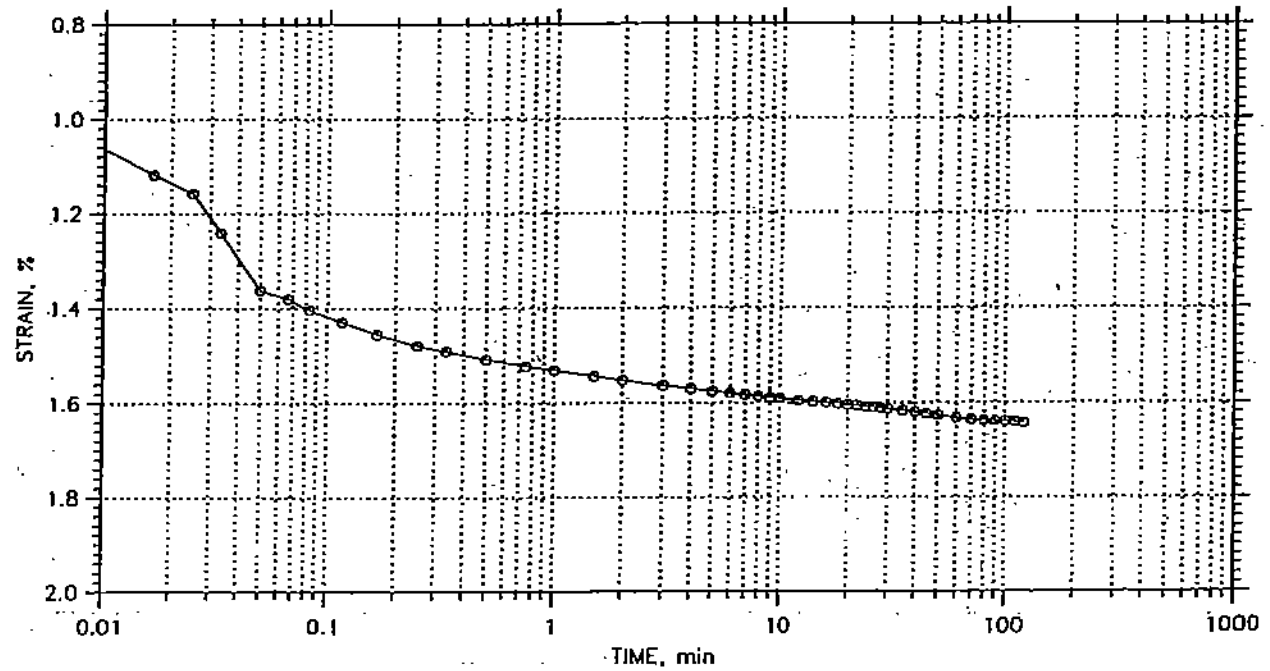
Project: Pownal Tannery	Location: Pownal, VT	Project No.: GTX-4363
Boring No.: SBL4	Tested By: fy	Checked By: jdt
Sample No.: 101	Test Date: 12/17/02	Depth: 8-10 ft
Test No.: C2	Sample Type: Tube	Elevation: ---
Description: Moist, dark greenish gray silty sand		
Remarks: Sample determined to be Non-Plastic		

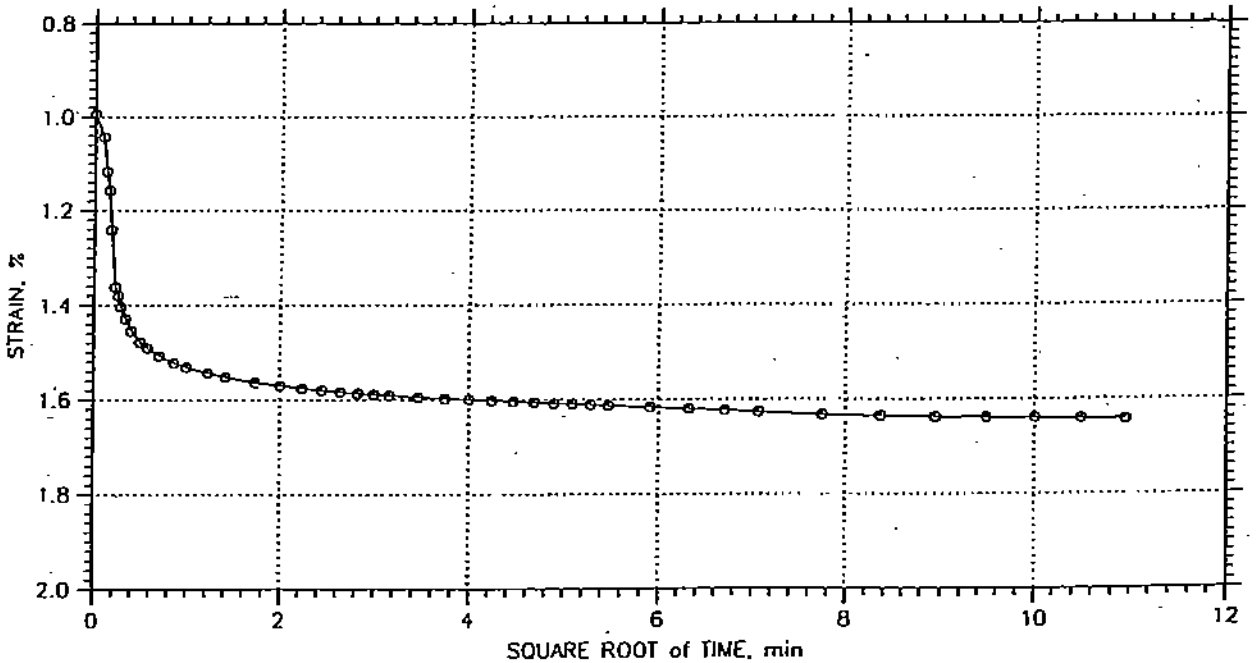
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 4 of 12

Stress: 1. tsf





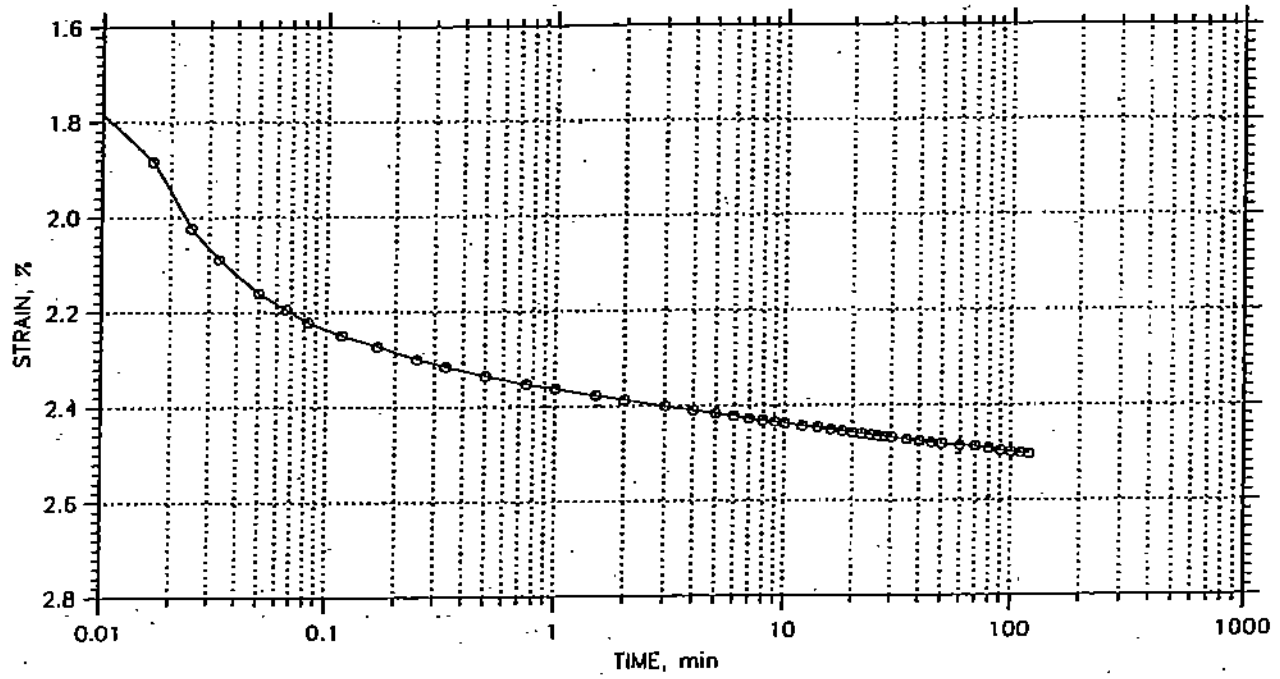
Project: Pownal Tannery	Location: Pownal, VT	Project No.: GTX-4363
Boring No.: SBL4	Tested By: fy	Checked By: jdt
Sample No.: 101	Test Date: 12/17/02	Depth: 8-10 ft
Test No.: C2	Sample Type: Tube	Elevation: ---
Description: Moist, dark greenish gray silty sand		
Remarks: Sample determined to be Non-Plastic		

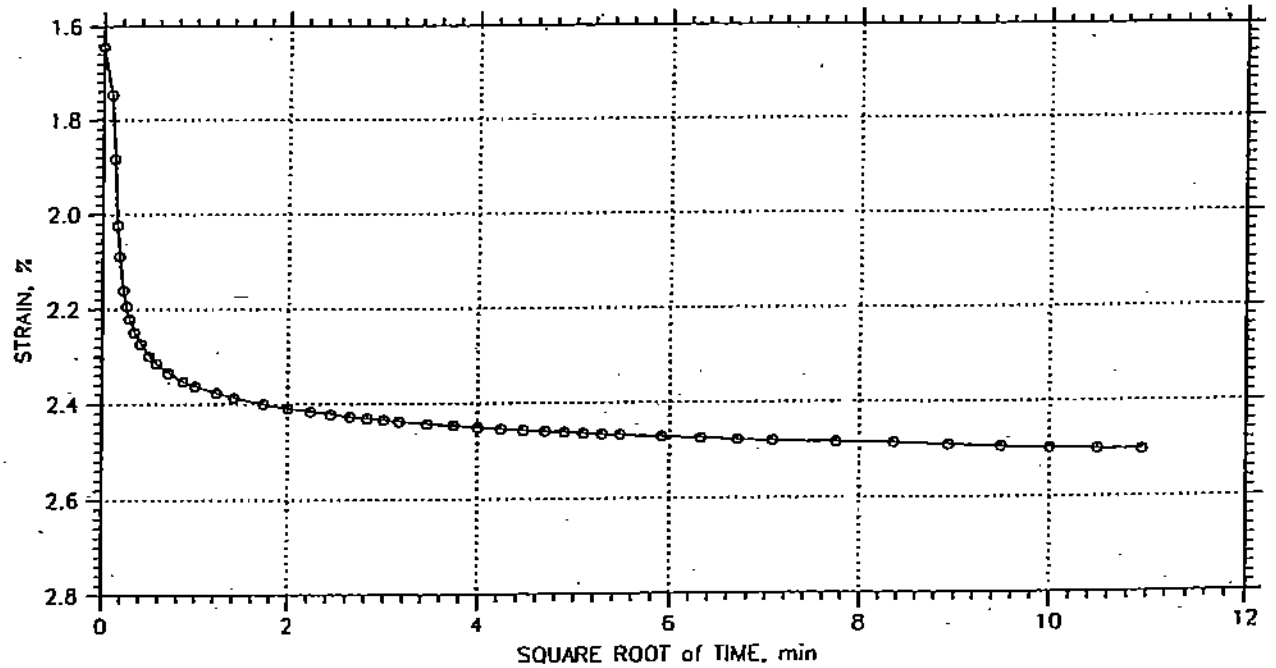
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 5 of 12

Stress: 2. tsf





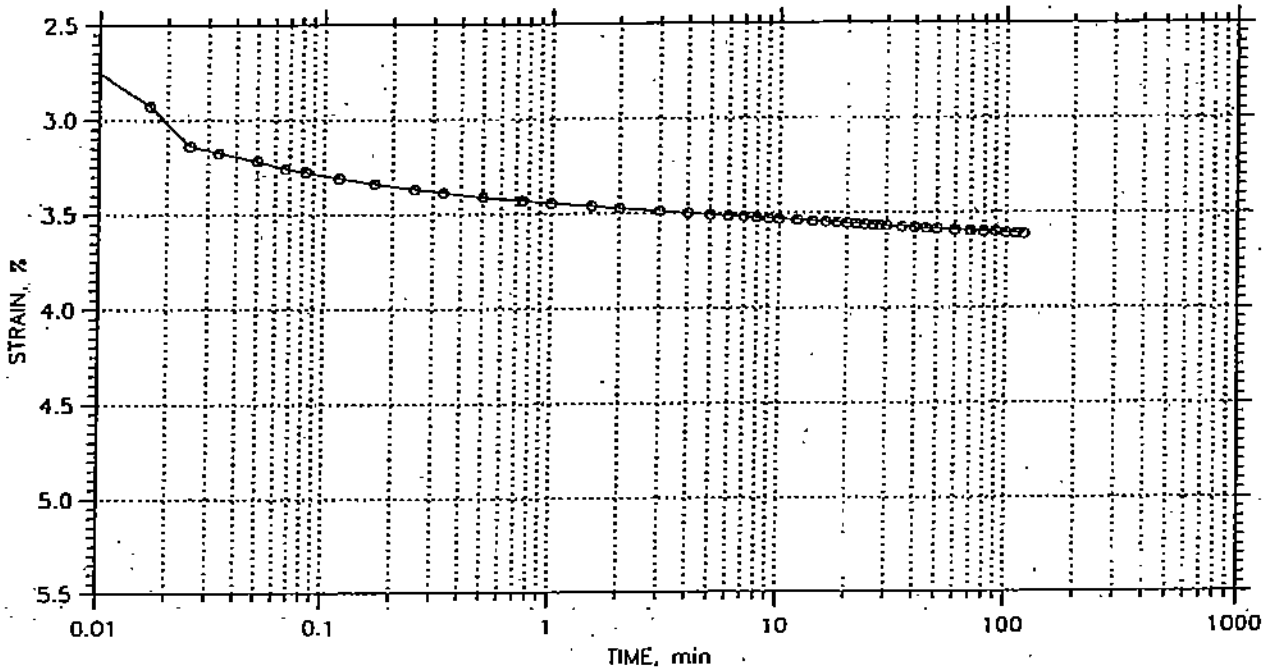
Project: Pownal Tannery	Location: Pownal, VT	Project No.: GTX-4363
Boring No.: SBL4	Tested By: fy	Checked By: jdt
Sample No.: 101	Test Date: 12/17/02	Depth: 8-10 ft
Test No.: C2	Sample Type: Tube	Elevation: ---
Description: Moist, dark greenish gray silty sand		
Remarks: Sample determined to be Non-Plastic		

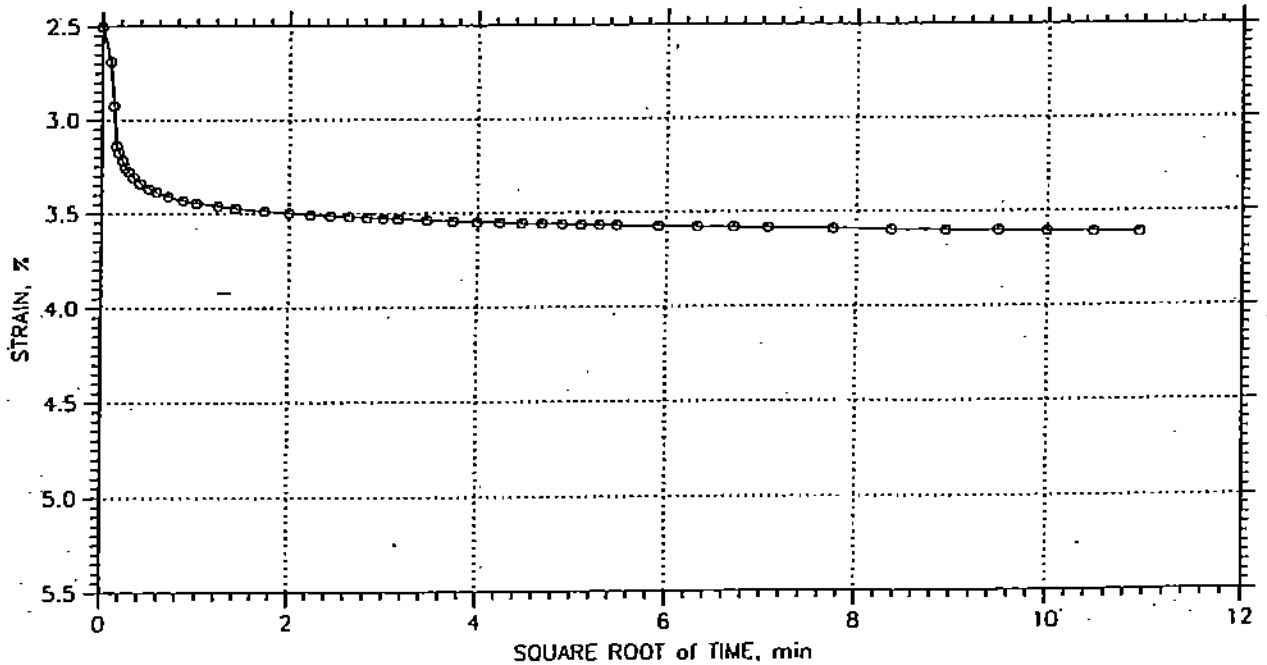
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 6 of 12

Stress: 4. tsf





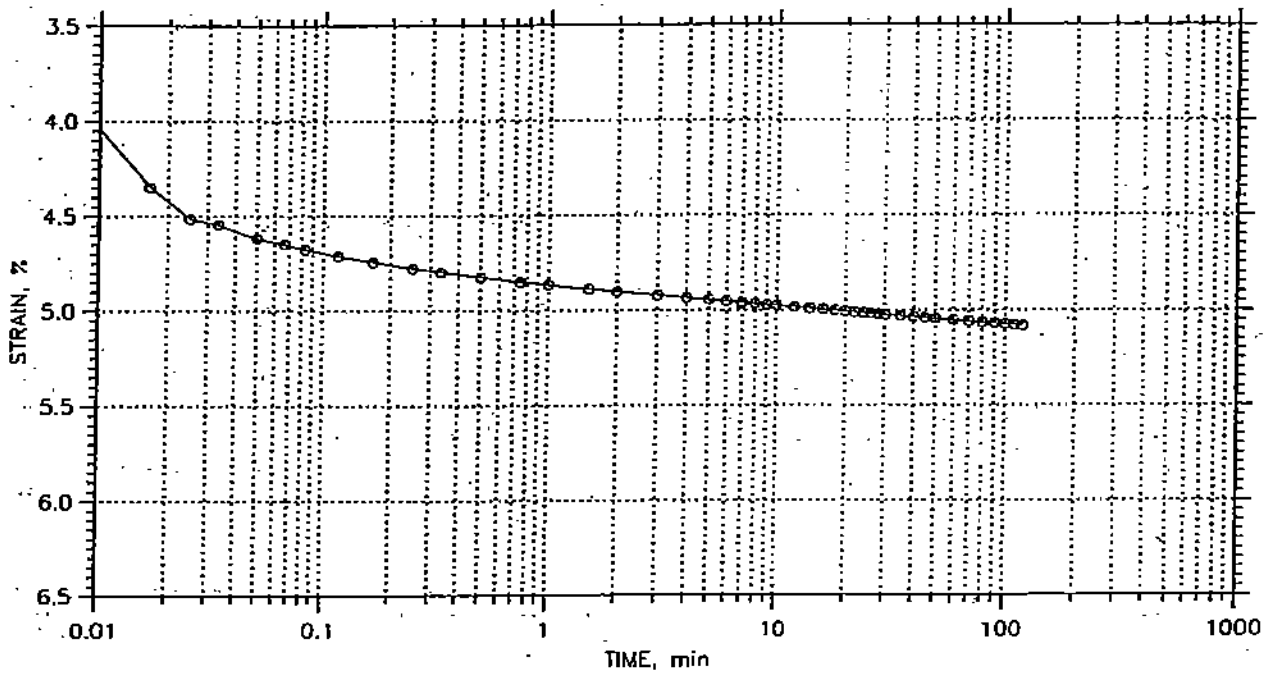
Project: Pownal Tannery	Location: Pownal, VT	Project No.: GTX-4363
Boring No.: SBL4	Tested By: fy	Checked By: jdt
Sample No.: 101	Test Date: 12/17/02	Depth: 8-10 ft
Test No.: C2	Sample Type: Tube	Elevation: ---
Description: Moist, dark greenish gray silty sand		
Remarks: Sample determined to be Non-Plastic		

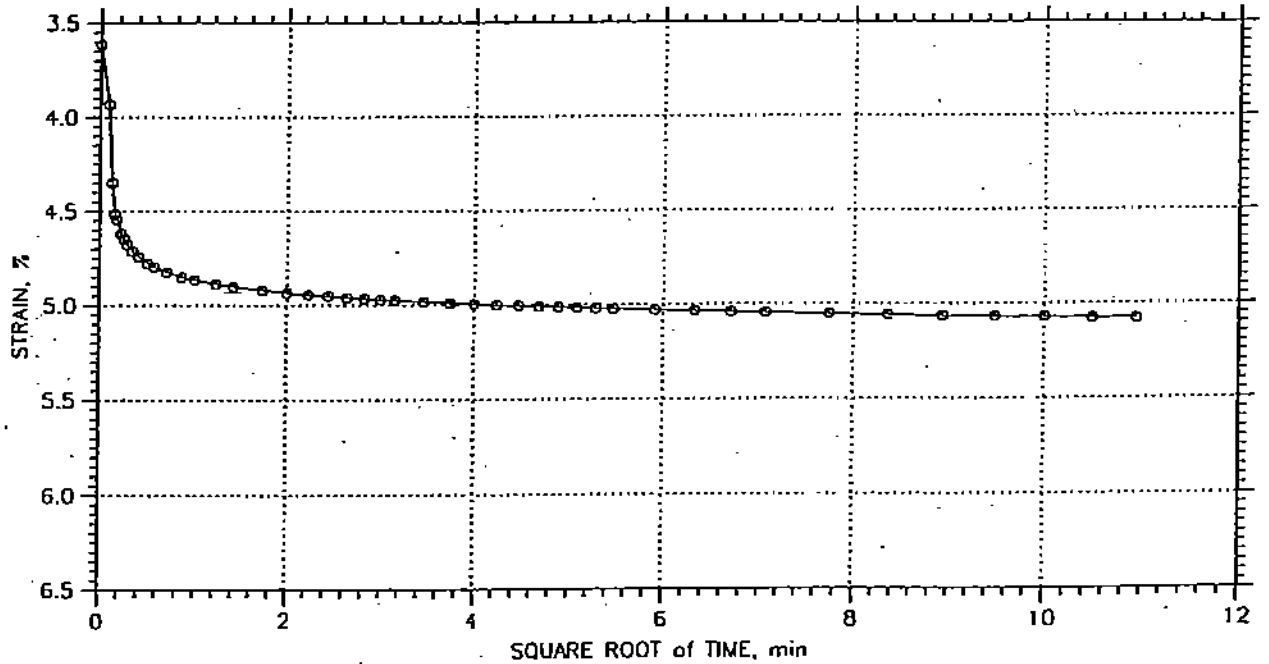
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 7 of 12

Stress: 8. tsf





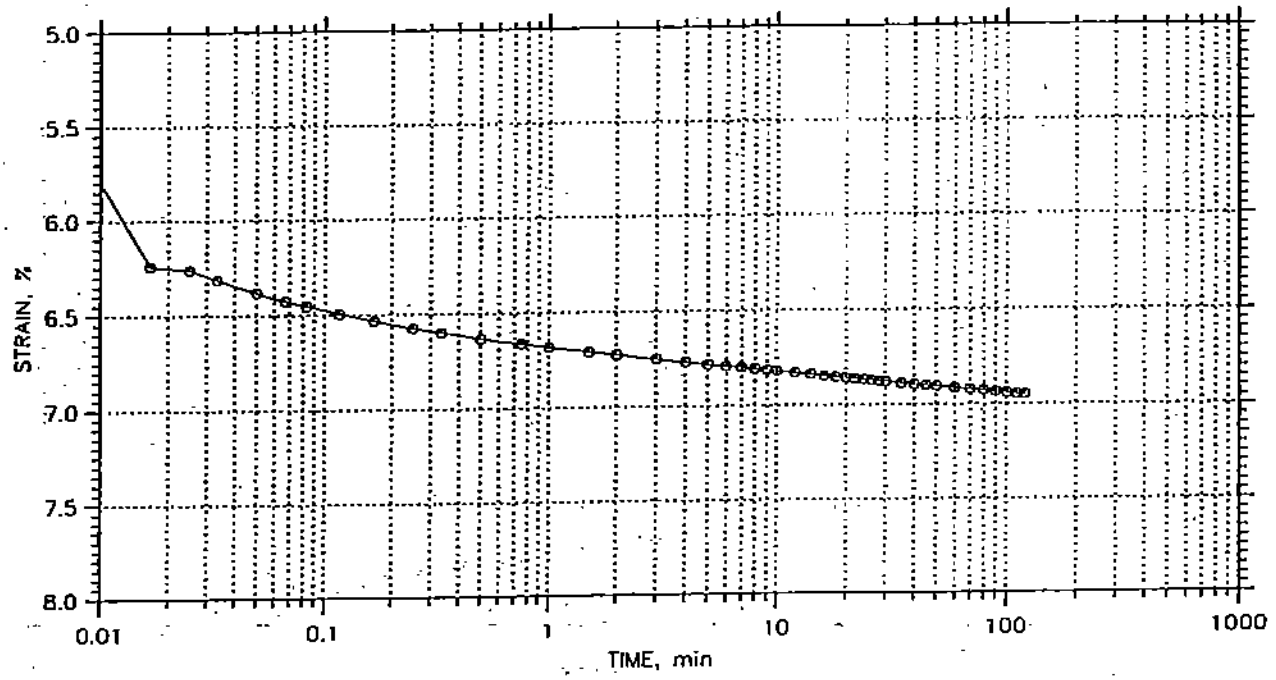
Project: Pownal Tannery	Location: Pownal, VT	Project No.: GTX-4363
Boring No.: SBL4	Tested By: fy	Checked By: jdl
Sample No.: 101	Test Date: 12/17/02	Depth: 8-10 ft
Test No.: C2	Sample Type: Tube	Elevation: ---
Description: Moist, dark greenish gray silty sand		
Remarks: Sample determined to be Non-Plastic		

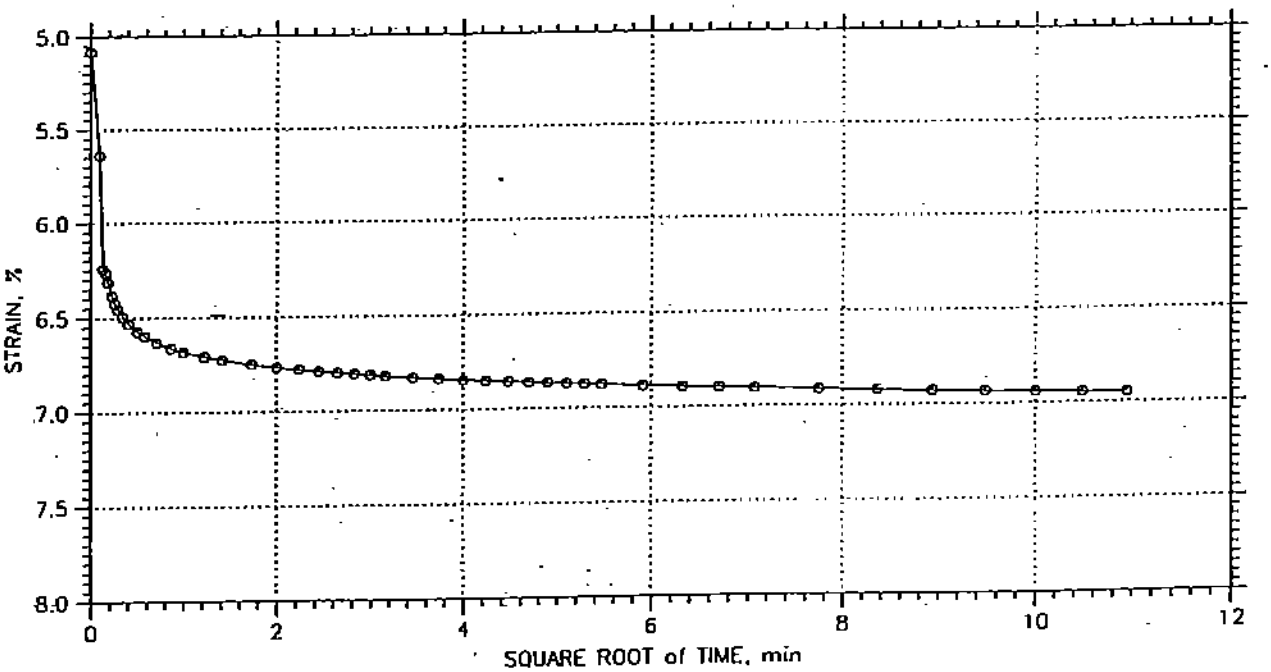
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 8 of 12

Stress: 16. tsf





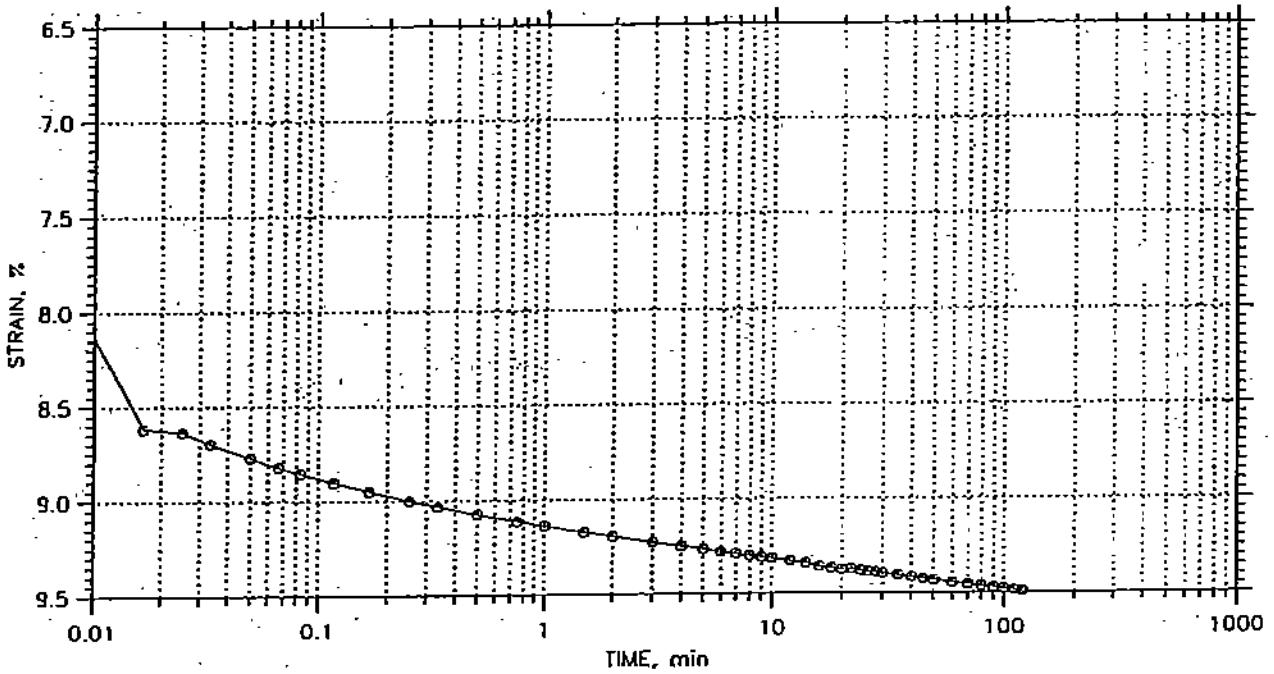
Project: Pownal Tannery	Location: Pownal, VT	Project No.: GTX-4363
Boring No.: SBL4	Tested By: fy	Checked By: jdl
Sample No.: 101	Test Date: 12/17/02	Depth: 8-10 ft
Test No.: C2	Sample Type: Tube	Elevation: ---
Description: Moist, dark greenish gray silty sand		
Remarks: Sample determined to be Non-Plastic		

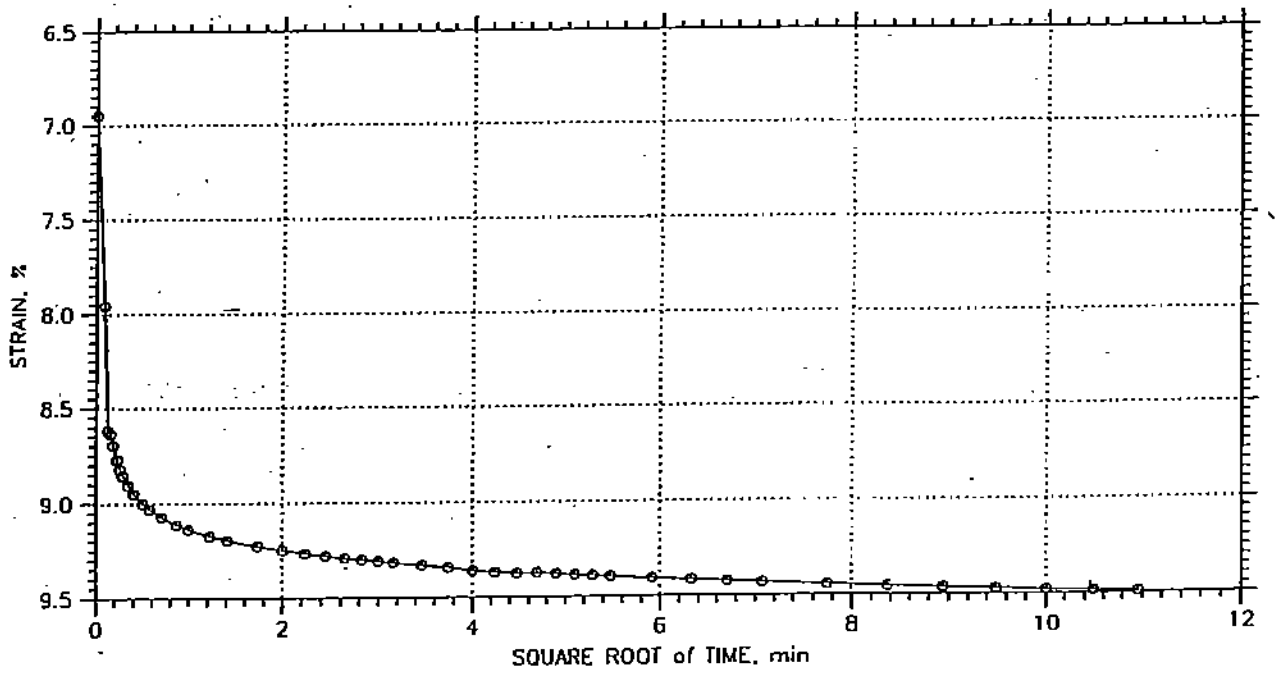
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 9 of 12

Stress: 32. tsf





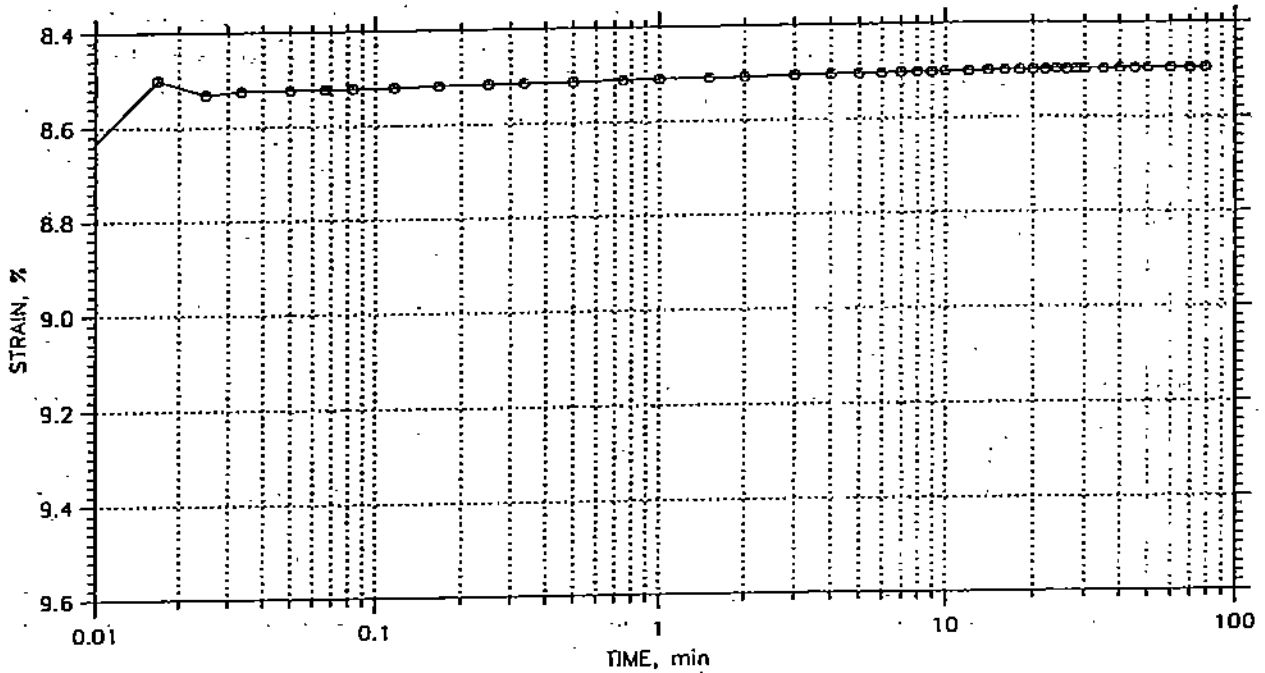
Project: Pownal Tannery	Location: Pownal, VT	Project No.: GTX-4363
Boring No.: SBL4	Tested By: fy	Checked By: jdl
Sample No.: 101	Test Date: 12/17/02	Depth: 8-10 ft
Test No.: C2	Sample Type: Tube	Elevation: ---
Description: Moist, dark greenish gray silty sand		
Remarks: Sample determined to be Non-Plastic		

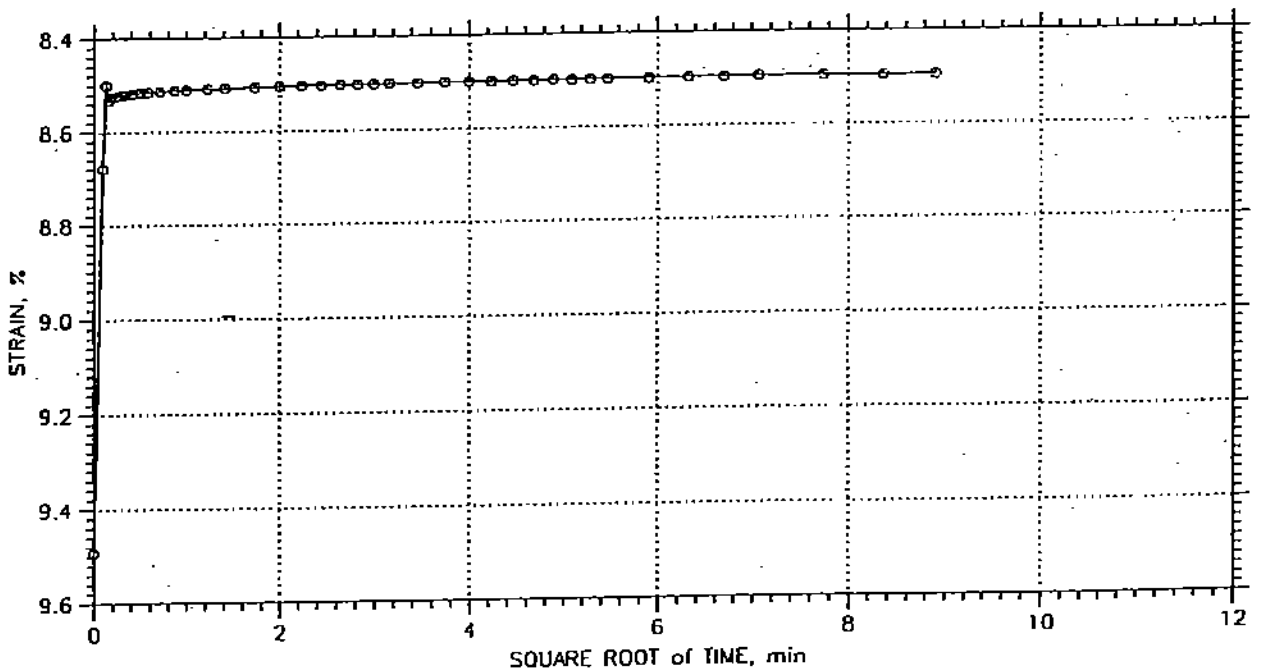
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 10 of 12

Stress: 8. tsf





Project: Pownal Tannery	Location: Pownal, VT	Project No.: GTX-4363
Boring No.: SBL4	Tested By: fy	Checked By: jdt
Sample No.: 101	Test Date: 12/17/02	Depth: 8-10 ft
Test No.: C2	Sample Type: Tube	Elevation: ---
Description: Moist, dark greenish gray silty sand		
Remarks: Sample determined to be Non-Plastic		

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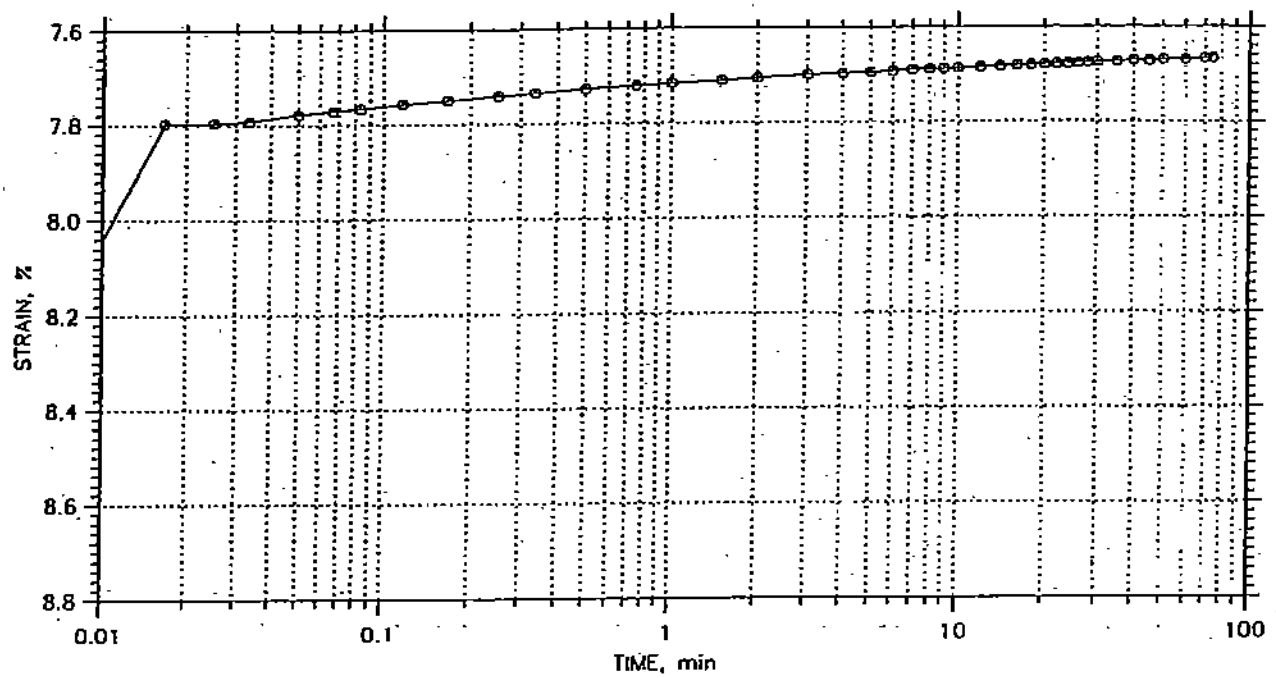
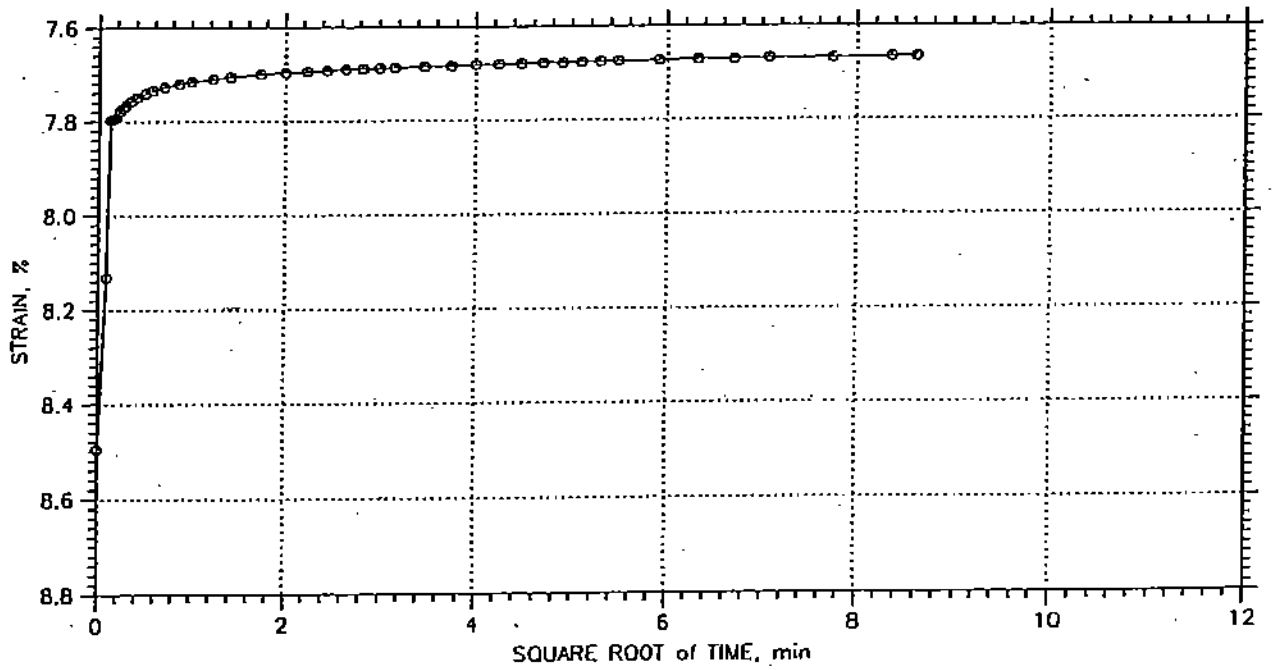
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 11 of 12

Stress: 2. tsf





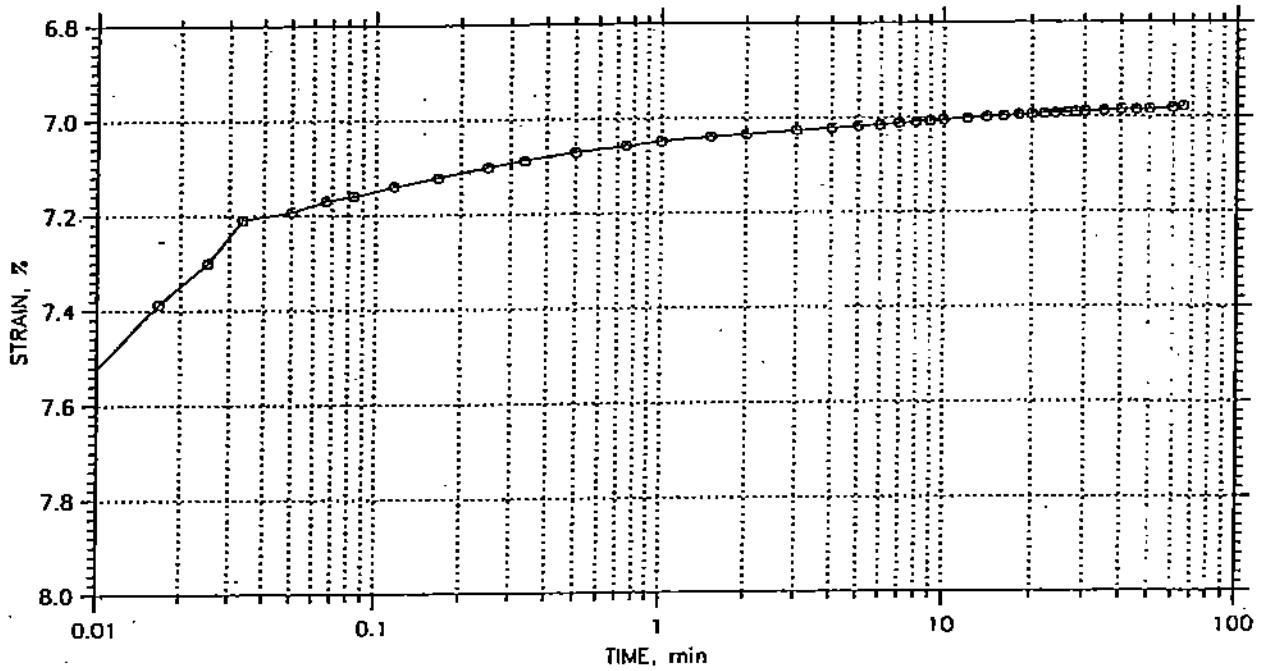
Project: Pownal Tannery	Location: Pownal, VT	Project No.: GTX-4363
Boring No.: SBL4	Tested By: fy	Checked By: jdl
Sample No.: 101	Test Date: 12/17/02	Depth: 8-10 ft
Test No.: C2	Sample Type: Tube	Elevation: ---
Description: Moist, dark greenish gray silty sand		
Remarks: Sample determined to be Non-Plastic		

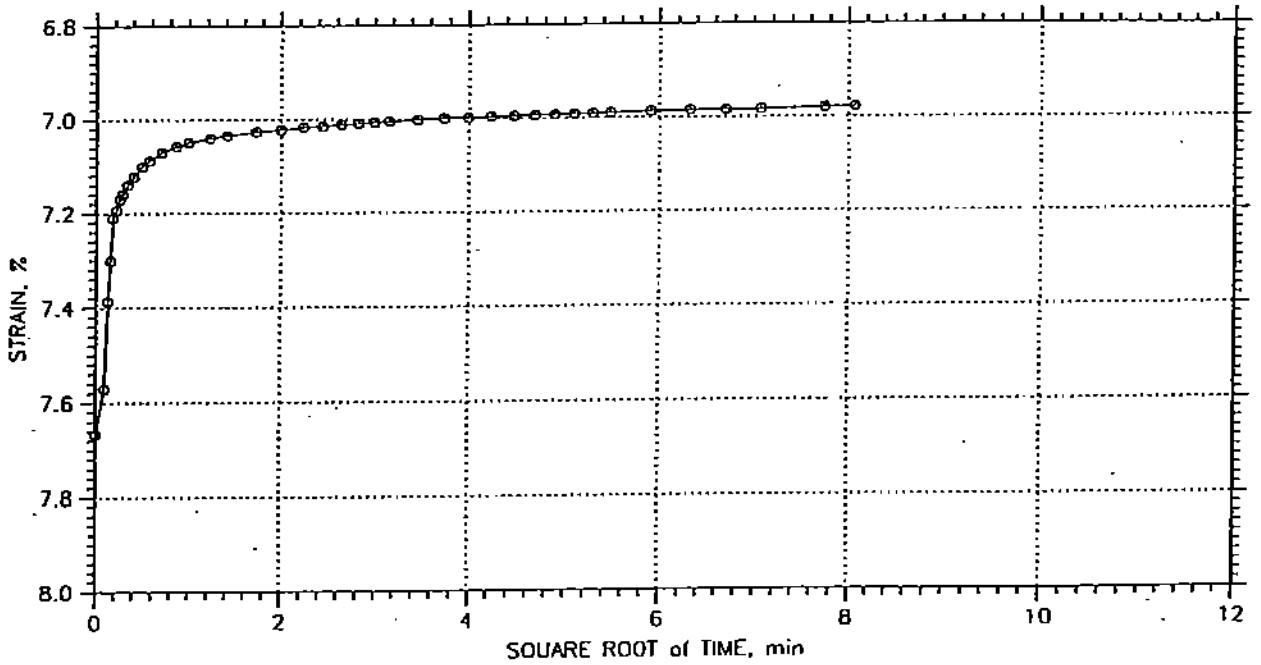
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 12 of 12

Stress: 0.5 tsf





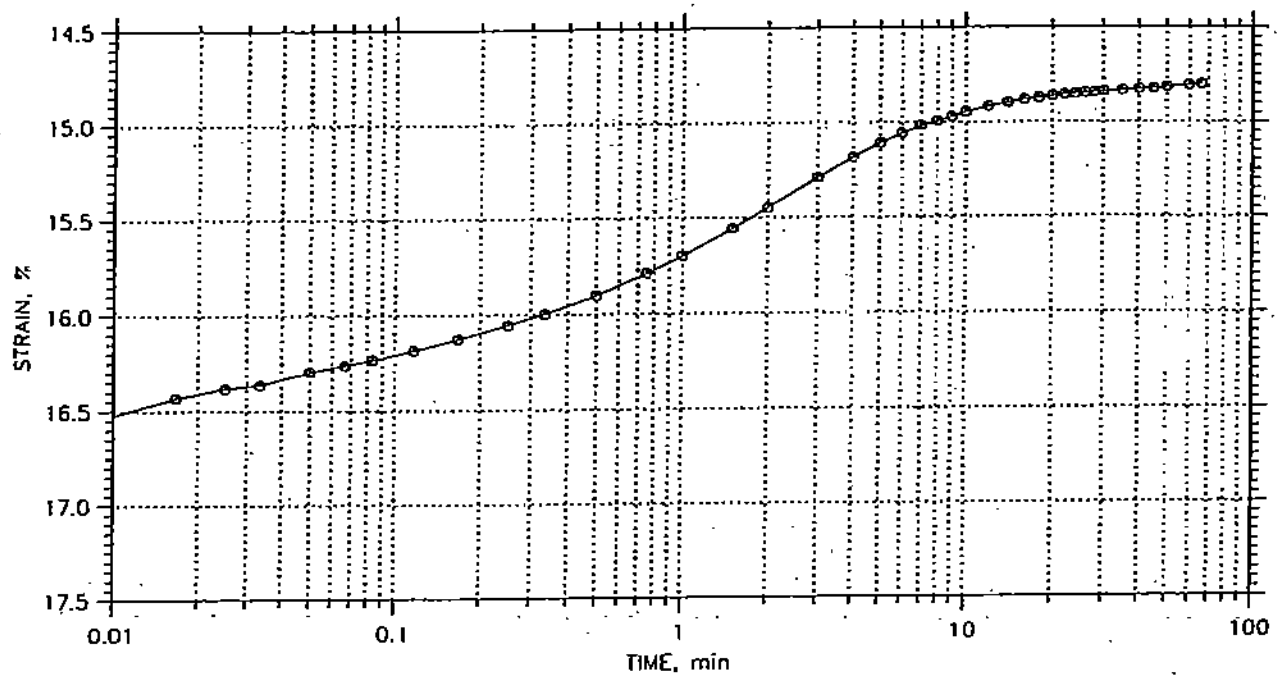
Project: Pownal Tannery	Location: Pownal, VT	Project No.: GTX-4363
Boring No.: SBL4	Tested By: fy	Checked By: jdl
Sample No.: 101	Test Date: 12/17/02	Depth: 8-10 ft
Test No.: C2	Sample Type: Tube	Elevation: ---
Description: Moist, dark greenish gray silty sand		
Remarks: Sample determined to be Non-Plastic		

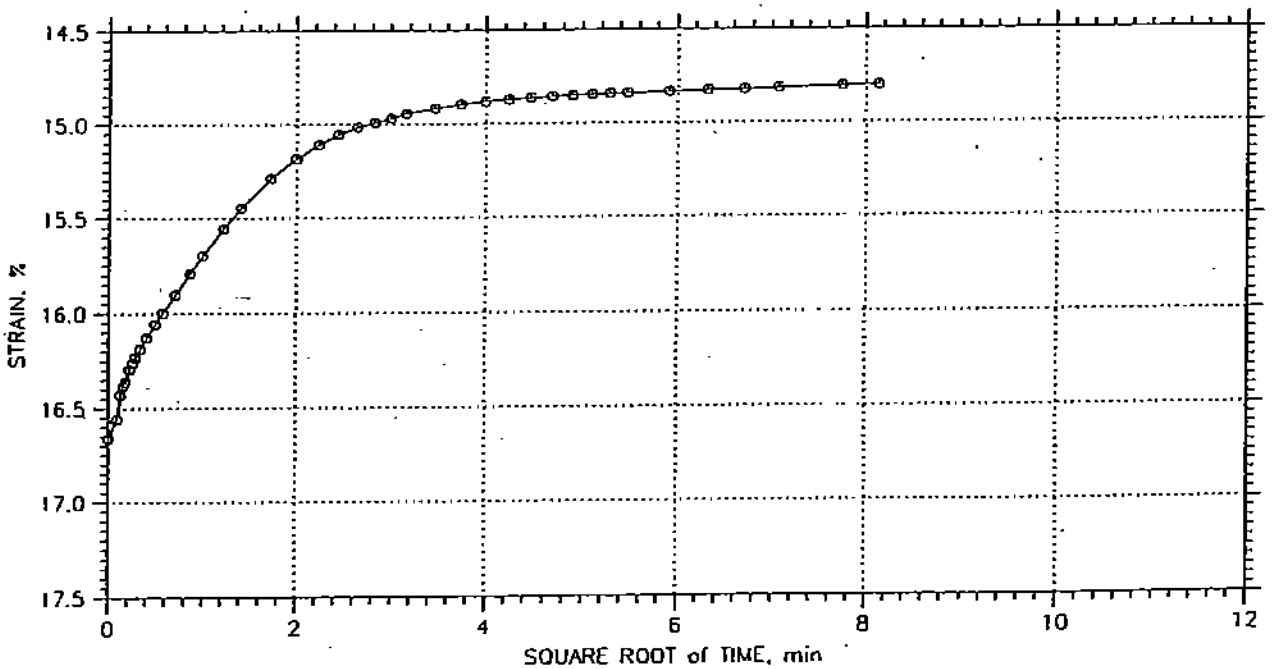
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 12 of 12

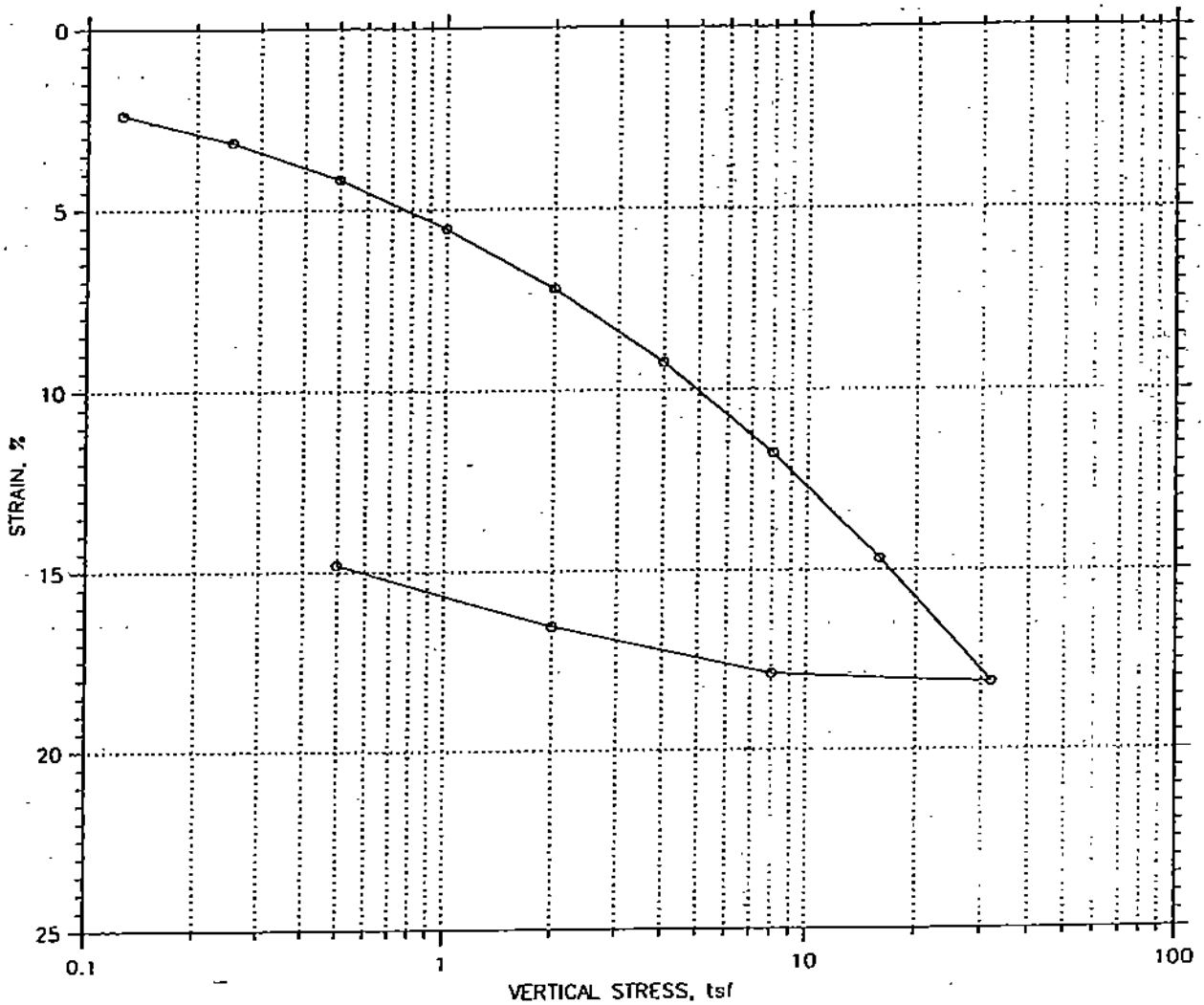
Stress: 0.5 tsf





Project: Pownal Tannery Superfund	Location: ---	Project No.: GTX-4363
Boring No.: SBL4	Tested By: fy	Checked By: jdl
Sample No.: 103	Test Date: 12/02/02	Depth: 25-27 ft
Test No.: C1	Sample Type: Tube	Elevation: ---
Description: Moist, dark gray clay		
Remarks: ---		

CONSOLIDATION TEST DATA
SUMMARY REPORT



					Before Test	After Test
Overburden Pressure, tsf:				Water Content, %	35.62	25.18
Preconsolidation Pressure, tsf:				Dry Unit Weight, pcf	87.891	103.16
Compression Index:				Saturation, %	99.79	99.99
Diameter: 2.489 in		Height: 1 in		Void Ratio	1.01	0.71
LL: 49	PL: 26	PI: 23	GS: 2.83			

Project: Pownal Tannery Superfund	Location: ---	Project No.: GTX-4363
Boring No.: SBL4	Tested By: fy	Checked By: jdl
Sample No.: 103	Test Date: 12/02/02	Depth: 25-27 ft
Test No.: C1	Sample Type: Tube	Elevation: ---
Description: Moist, dark gray clay		
Remarks: ---		

CONSOLIDATION TEST DATA

Project: Pownal Tannery Superfund
Boring No.: SBL4
Sample No.: 103
Test No.: C1

Location: ---
Tested By: fy
Test Date: 12/02/02
Sample Type: Tube

Project No.: GTX-4363
Checked By: jdt
Depth: 25-27 ft
Elevation: ---

Soil Description: Moist, dark gray clay
Remarks: ---

Specific Gravity: 2.83
Initial Void Ratio: 1.01
Final Void Ratio: 0.71

Liquid Limit: 49
Plastic Limit: 26
Plasticity Index: 23

Initial Height: 1.00 in
Specimen Diameter: 2.49 in

	Before Consolidation		After Consolidation	
	Trimmings	Specimen+Ring	Specimen+Ring	Trimmings
Container ID	P	RING		
Wt. Container + Wet Soil, gm	220.86	368.83	357.11	148.32
Wt. Container + Dry Soil, gm	164.82	328.85	328.85	120.14
Wt. Container, gm	8.11	216.59	216.59	8.22
Wt. Dry Soil, gm	156.71	112.26	112.26	111.92
Water Content, %	35.76	35.62	25.18	25.18
Void Ratio	---	1.01	0.71	---
Degree of Saturation, %	---	99.79	99.99	---
Dry Unit Weight, pcf	---	87.891	103.16	---

CONSOLIDATION TEST DATA

Project: Pownal Tannery Superfund
Boring No.: SBL4
Sample No.: 103
Test No.: C1

Location: ---
Tested By: fy
Test Date: 12/02/02
Sample Type: Tube

Project No.: GTX-4363
Checked By: jdt
Depth: 25-27 ft
Elevation: ---

Soil Description: Moist, dark gray clay
Remarks: ---

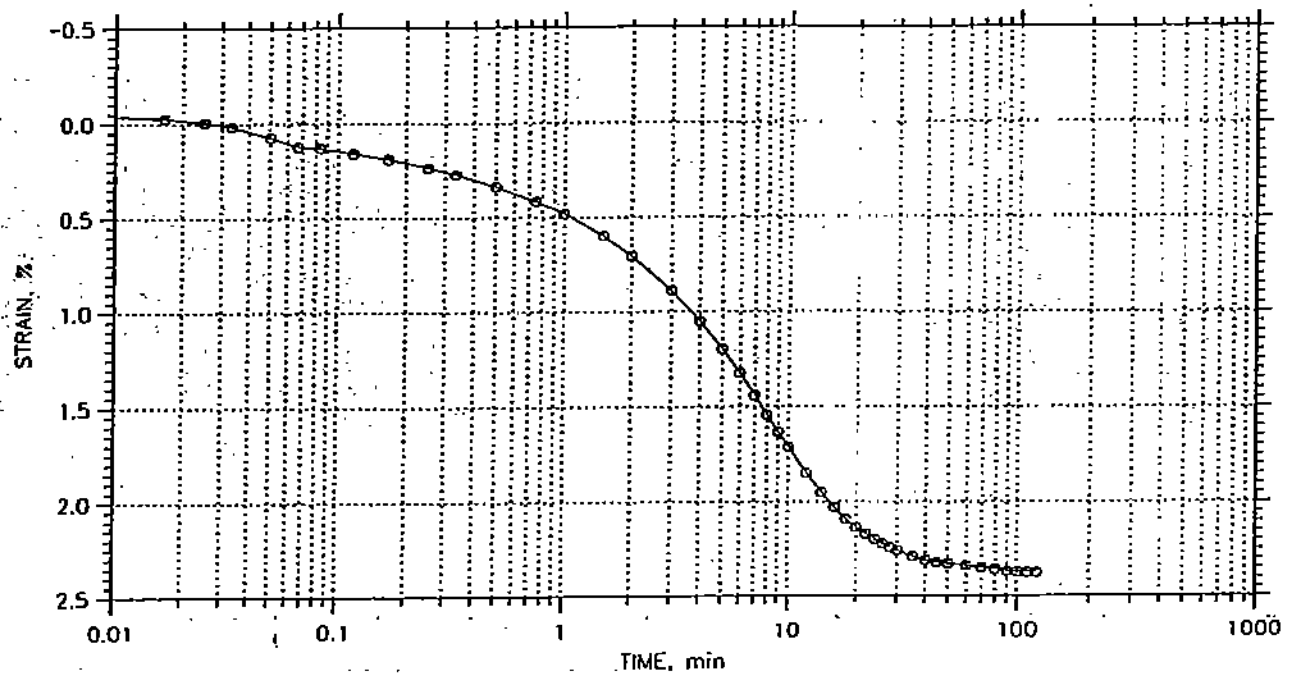
	Applied Stress tsf	Final Displacement in	Void Ratio	Strain at End %	T50 Fitting Sq.Rt. min	T50 Fitting Log min	Coefficient of Consolidation Sq.Rt. in^2/sec	Coefficient of Consolidation Log in^2/sec	Coefficient of Consolidation Ave in^2/sec
1	0.125	0.02375	0.962	2.37	4.7	4.3	1.70e-004	1.72e-004	1.71e-004
2	0.25	0.03127	0.947	3.13	1.9	2.6	4.17e-004	3.01e-004	3.49e-004
3	0.5	0.04166	0.926	4.17	1.2	1.3	6.57e-004	5.89e-004	6.21e-004
4	1	0.05522	0.899	5.52	0.7	0.8	1.06e-003	9.06e-004	9.77e-004
5	2	0.07213	0.865	7.21	0.3	0.4	2.06e-003	1.85e-003	1.95e-003
6	4	0.09249	0.824	9.25	0.2	0.3	3.10e-003	2.59e-003	2.82e-003
7	8	0.1175	0.774	11.75	0.2	0.1	4.00e-003	5.25e-003	4.54e-003
8	16	0.1468	0.715	14.68	0.1	0.1	5.71e-003	6.57e-003	6.11e-003
9	32	0.1811	0.646	18.11	0.1	0.1	7.99e-003	9.46e-003	8.66e-003
10	8	0.1786	0.651	17.86	0.0	0.0	5.56e-002	0.00e+000	5.56e-002
11	2	0.1654	0.678	16.54	0.2	0.0	2.99e-003	0.00e+000	2.99e-003
12	0.5	0.148	0.713	14.80	0.7	0.0	8.38e-004	0.00e+000	8.38e-004

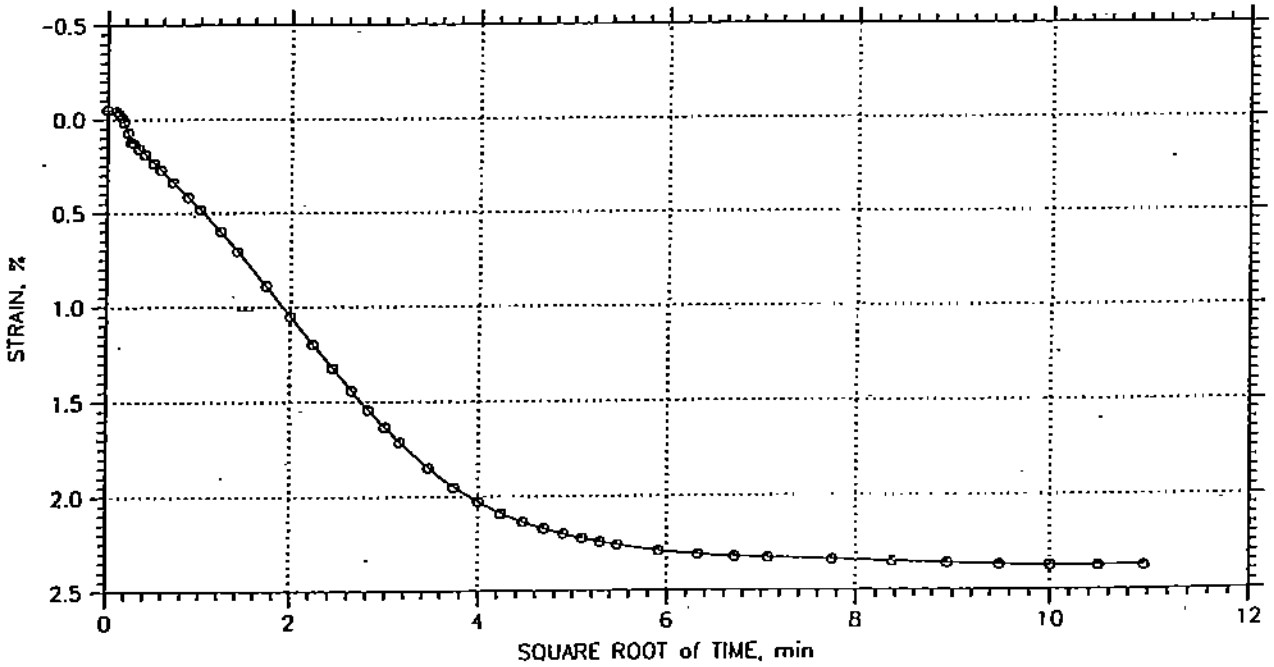
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 1 of 12

Stress: 0.125 tsf





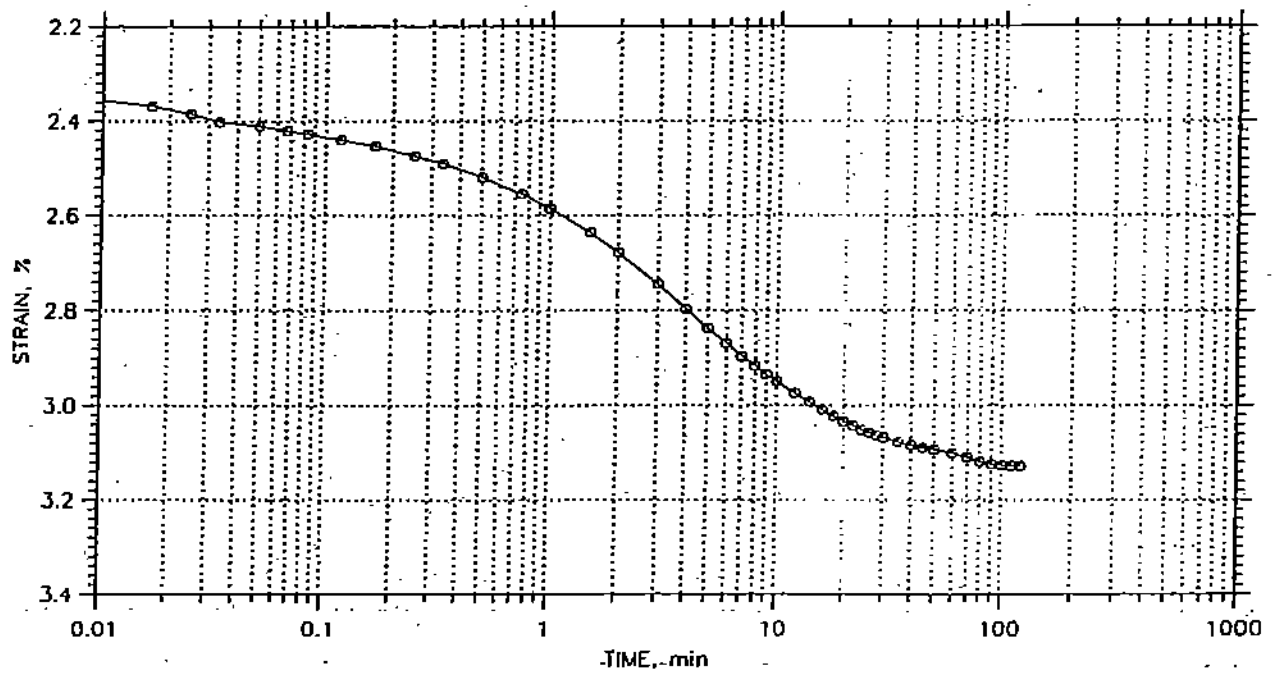
Project: Pownal Tannery Superfund	Location: ---	Project No.: GTX-4363
Boring No.: SBL4	Tested By: ly	Checked By: jdt
Sample No.: 103	Test Date: 12/02/02	Depth: 25-27 ft
Test No.: C1	Sample Type: Tube	Elevation: ---
Description: Moist, dark gray clay		
Remarks: ---		

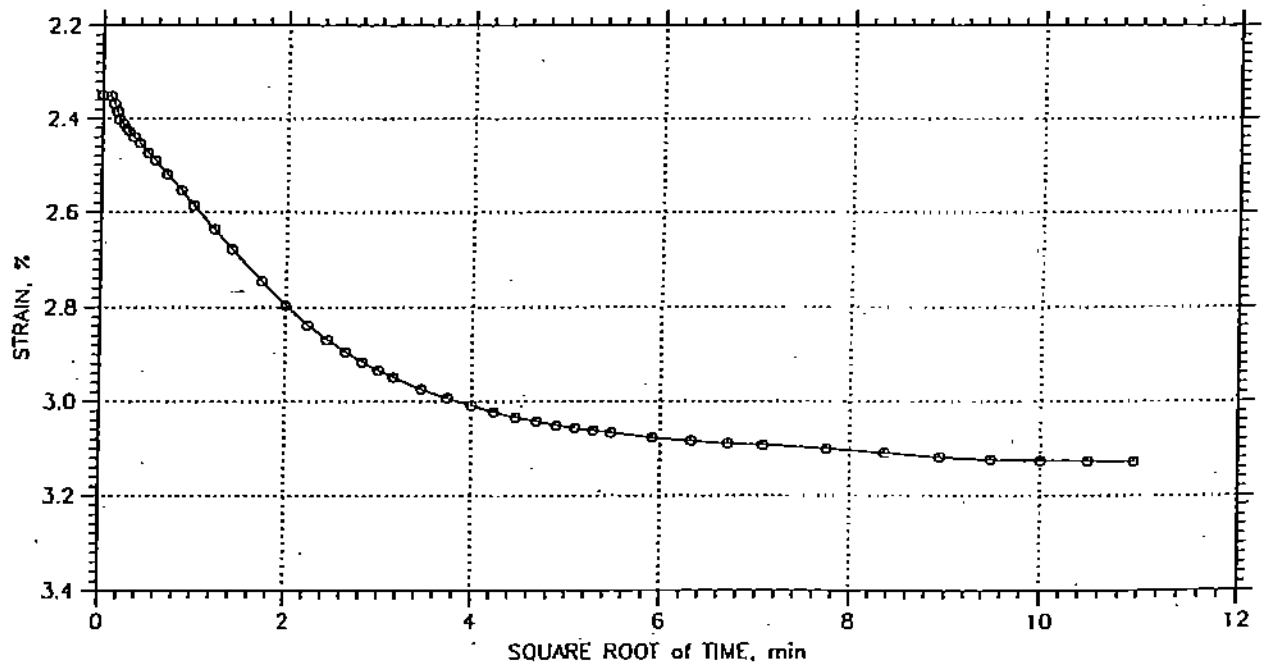
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 2 of 12

Stress: 0.25 tsf





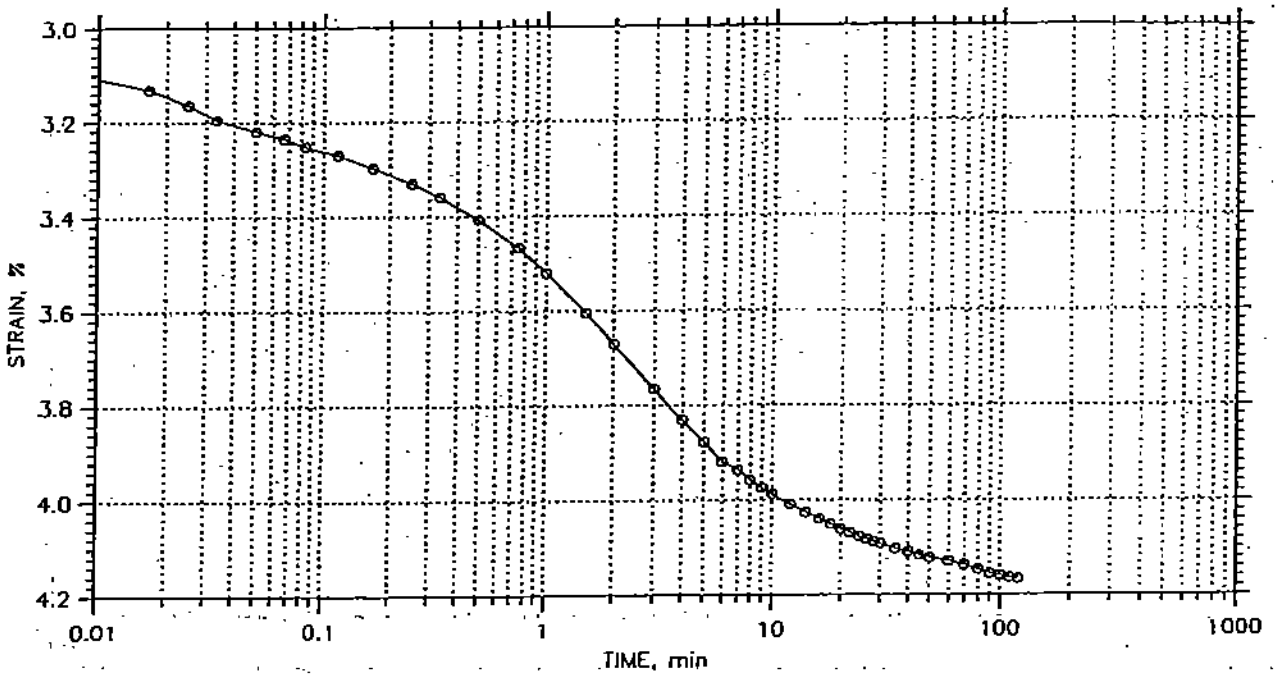
Project: Pownal Tannery Superfund	Location: ---	Project No.: GTX-4363
Boring No.: SBL4	Tested By: fy	Checked By: jdt
Sample No.: 103	Test Date: 12/02/02	Depth: 25-27 ft
Test No.: C1	Sample Type: Tube	Elevation: ---
Description: Moist, dark gray clay		
Remarks: ---		

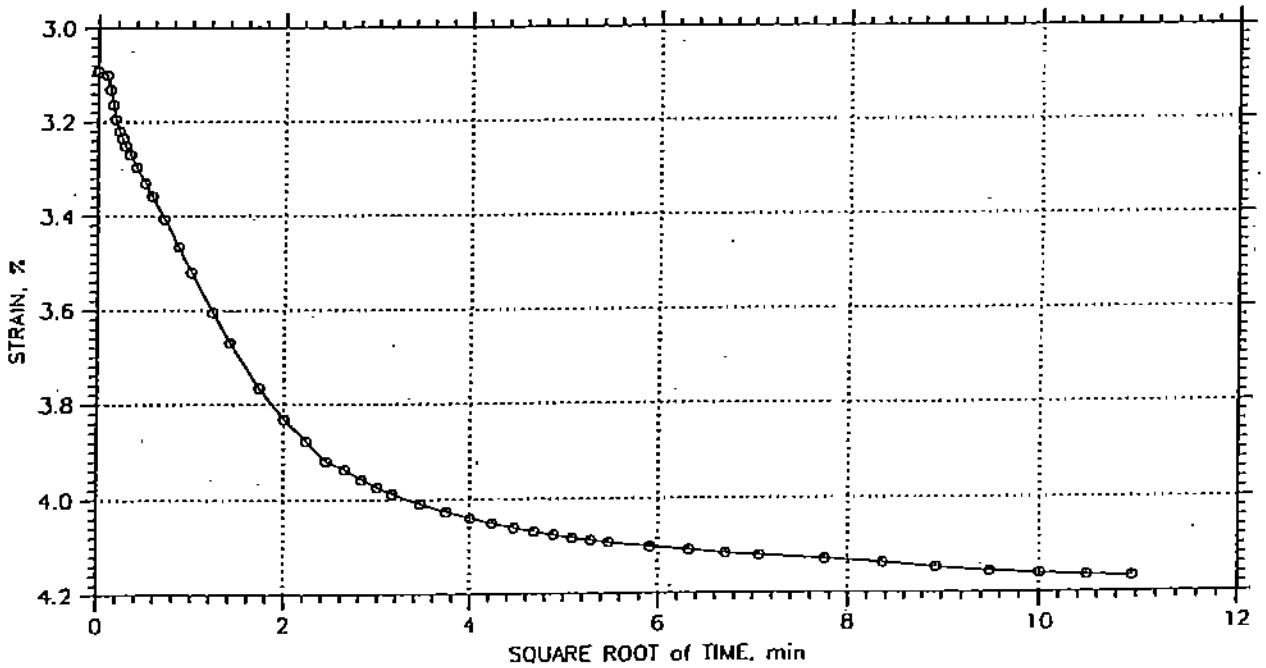
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 3 of 12

Stress: 0.5 tsf





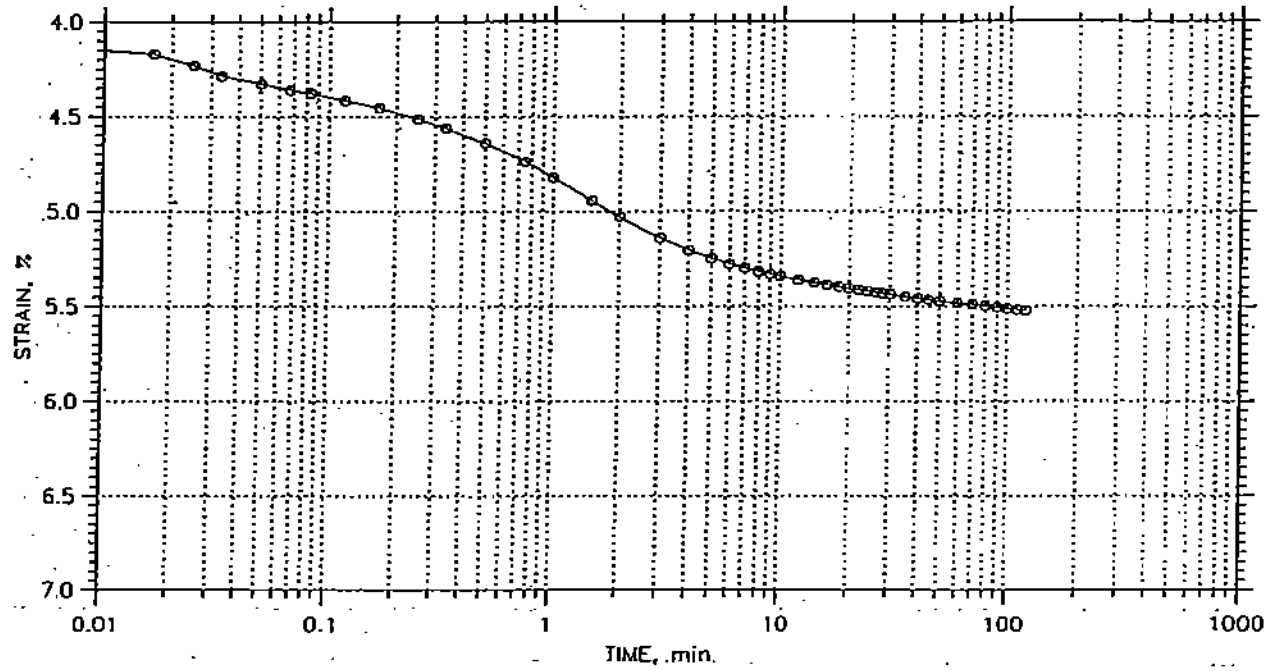
Project: Pownal Tannery Superfund	Location: ---	Project No.: GTX-4363
Boring No.: SBL4	Tested By: fy	Checked By: jdt
Sample No.: 103	Test Date: 12/02/02	Depth: 25-27 ft
Test No.: C1	Sample Type: Tube	Elevation: ---
Description: Moist, dark gray clay		
Remarks: ---		

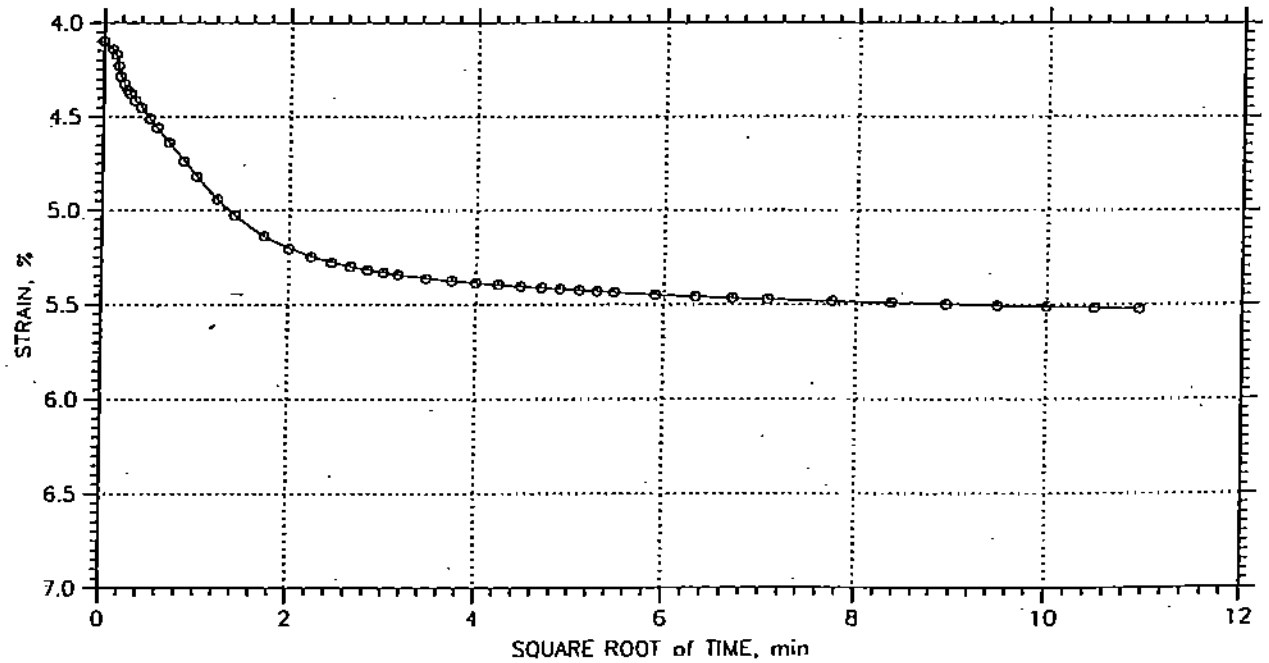
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 4 of 12

Stress: 1. tsf





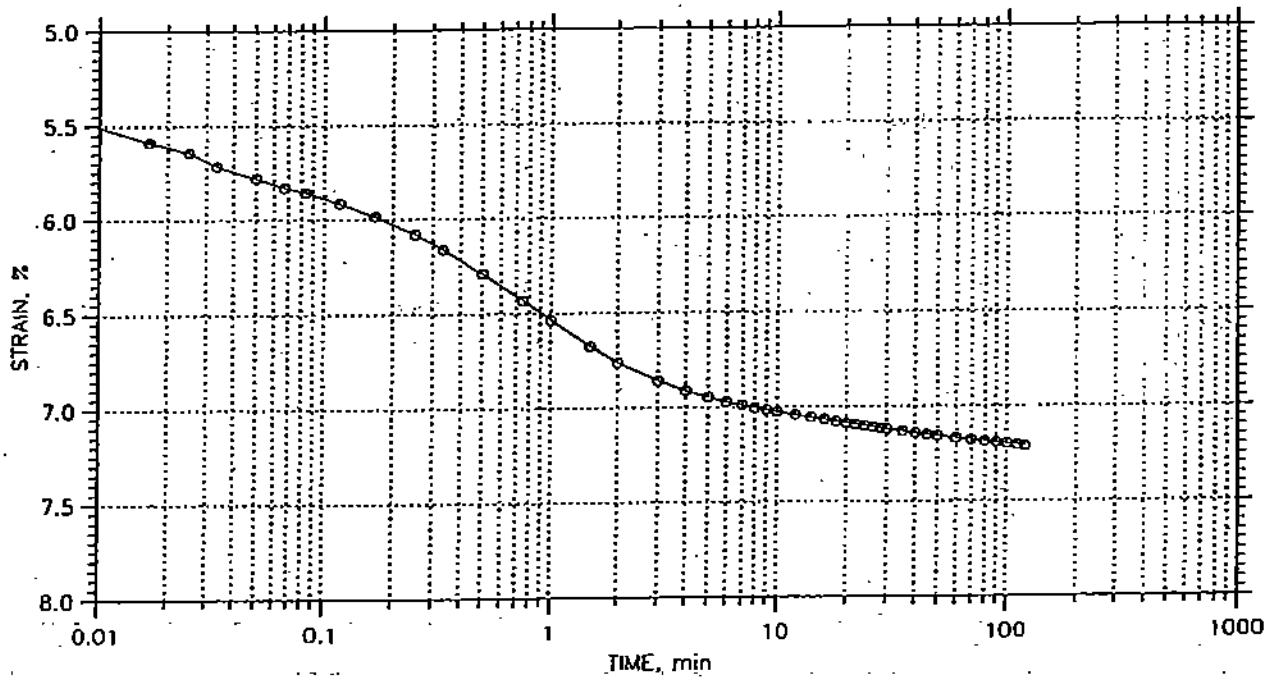
Project: Pownal Tannery Superfund	Location: ---	Project No.: GTX-4363
Boring No.: SBL4	Tested By: fy	Checked By: jdt
Sample No.: 103	Test Date: 12/02/02	Depth: 25-27 ft
Test No.: C1	Sample Type: Tube	Elevation: ---
Description: Moist, dark gray clay		
Remarks: ---		

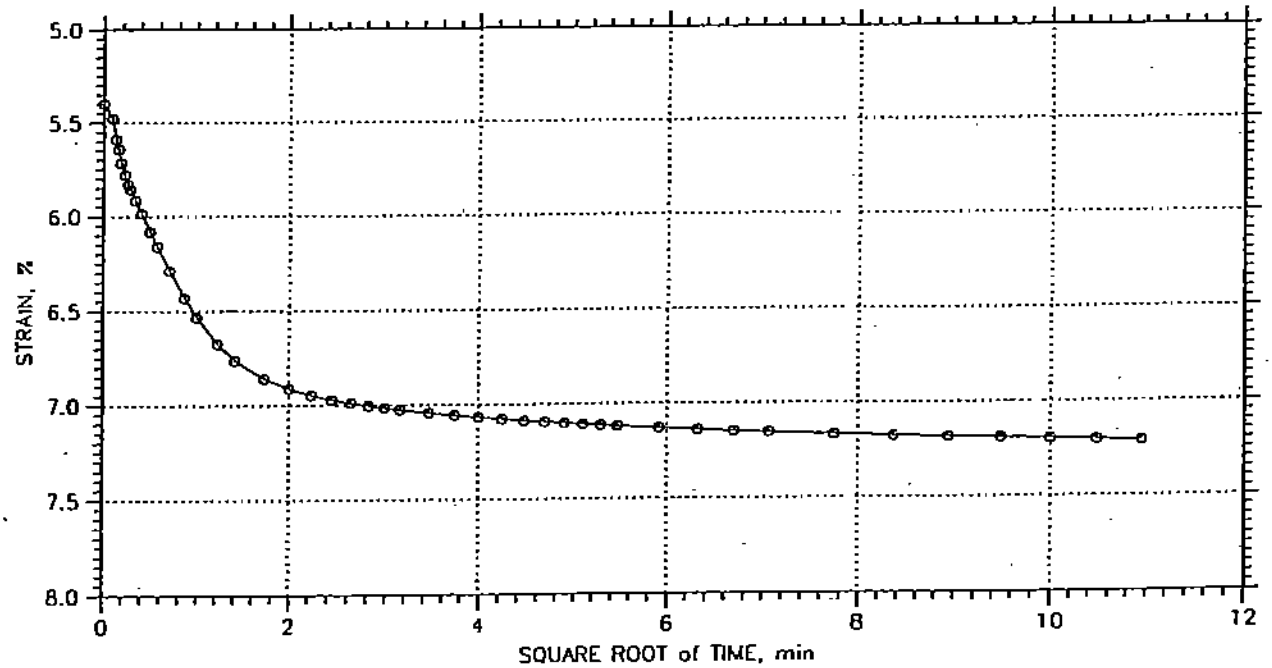
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 5 of 12

Stress: 2. tsf





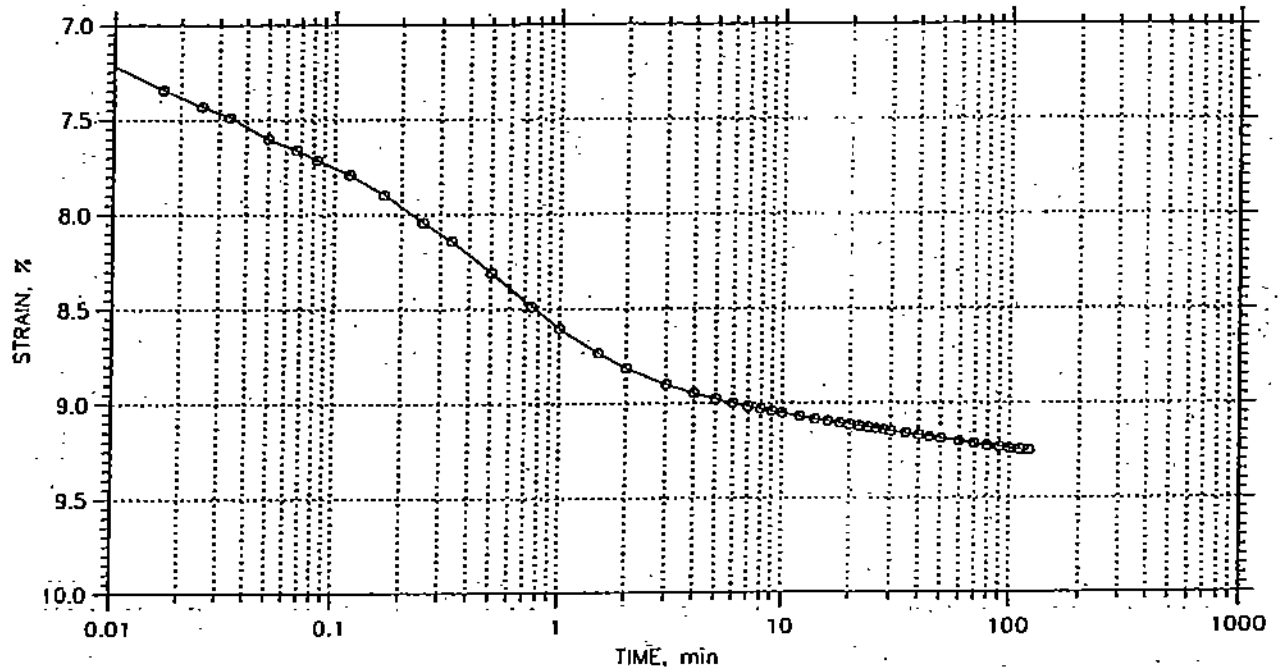
Project: Pownal Tannery Superfund	Location: ---	Project No.: GTX-4363
Boring No.: SBL4	Tested By: fy	Checked By: jdl
Sample No.: 103	Test Date: 12/02/02	Depth: 25-27 ft
Test No.: C1	Sample Type: Tube	Elevation: ---
Description: Moist, dark gray clay		
Remarks: ---		

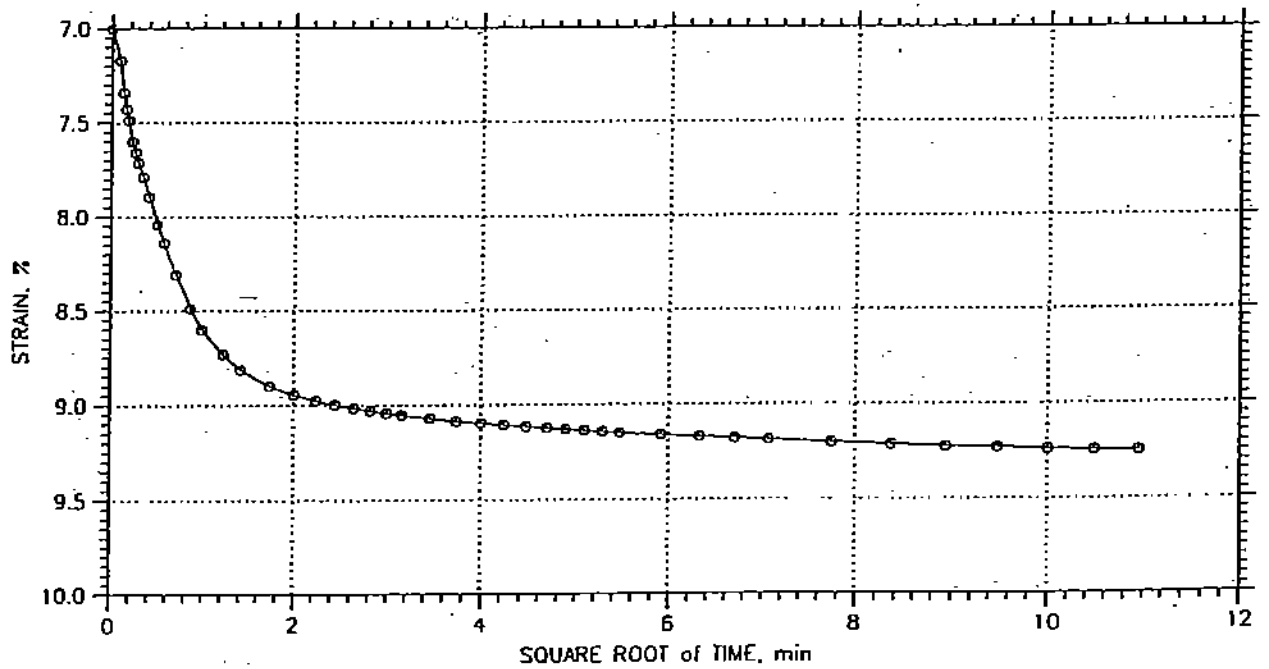
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 6 of 12

Stress: 4. tsf





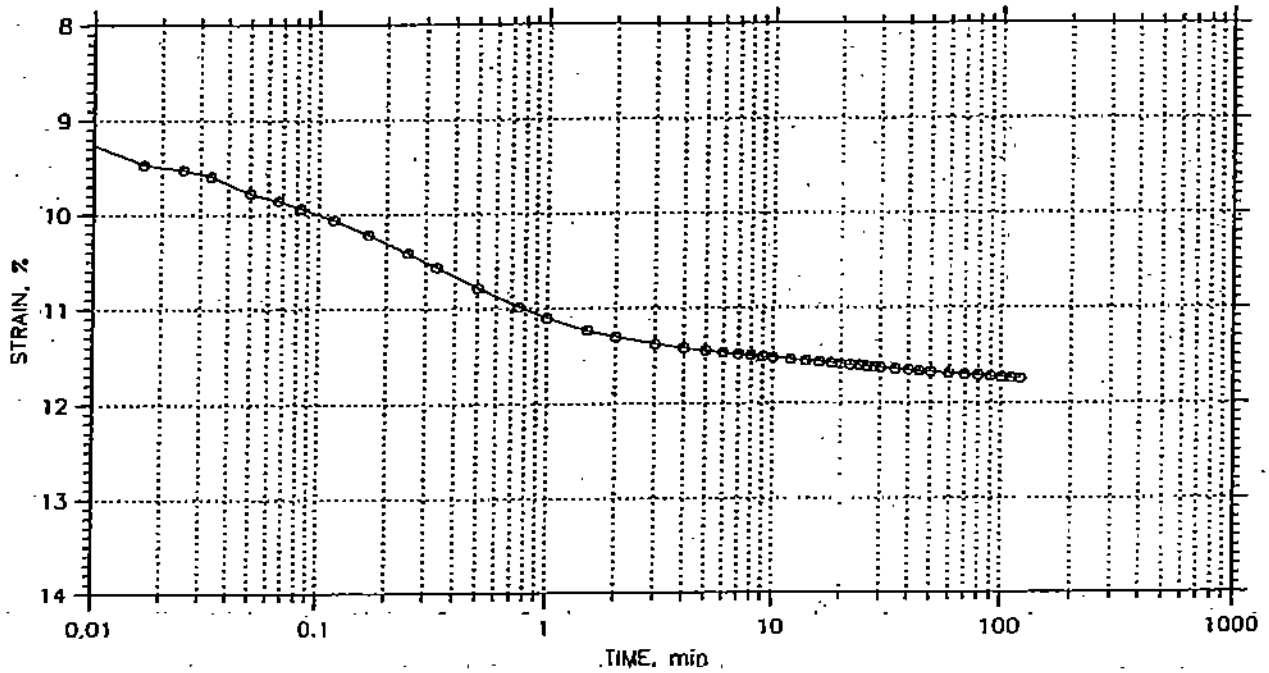
Project: Pownal Tannery Superfund	Location: ---	Project No.: GTX-4363
Boring No.: SBL4	Tested By: fy	Checked By: jdt
Sample No.: 103	Test Date: 12/02/02	Depth: 25-27 ft
Test No.: C1	Sample Type: Tube	Elevation: ---
Description: Moist, dark gray clay		
Remarks: ---		

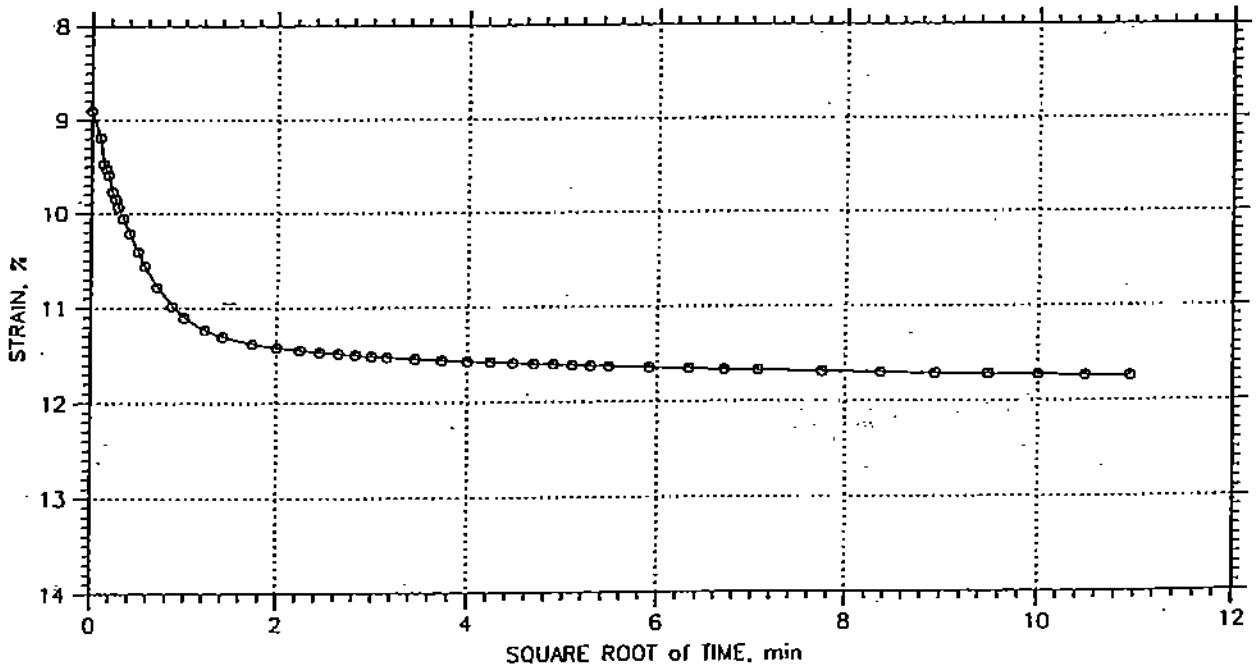
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 7 of 12

Stress: 8. tsf





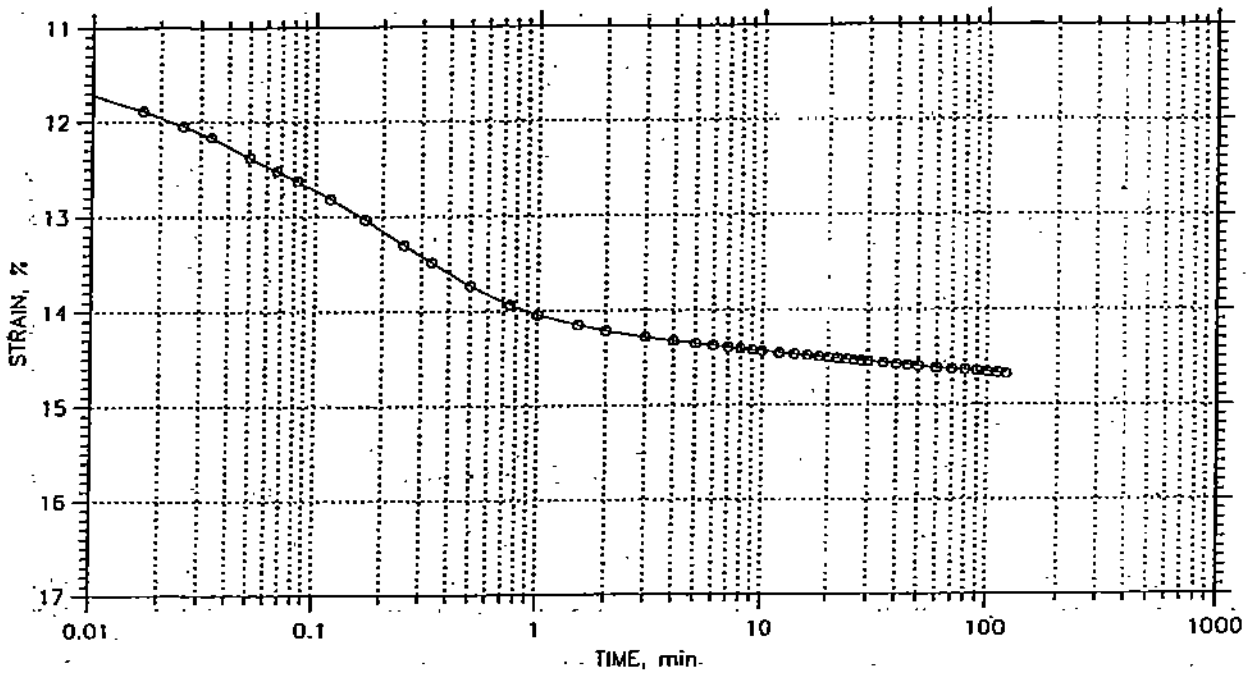
Project: Pownal Tannery Superfund	Location: ---	Project No.: GTX-4363
Boring No.: SBL4	Tested By: fy	Checked By: jdt
Sample No.: 103	Test Date: 12/02/02	Depth: 25-27 ft
Test No.: C1	Sample Type: Tube	Elevation: ---
Description: Moist, dark gray clay		
Remarks: ---		

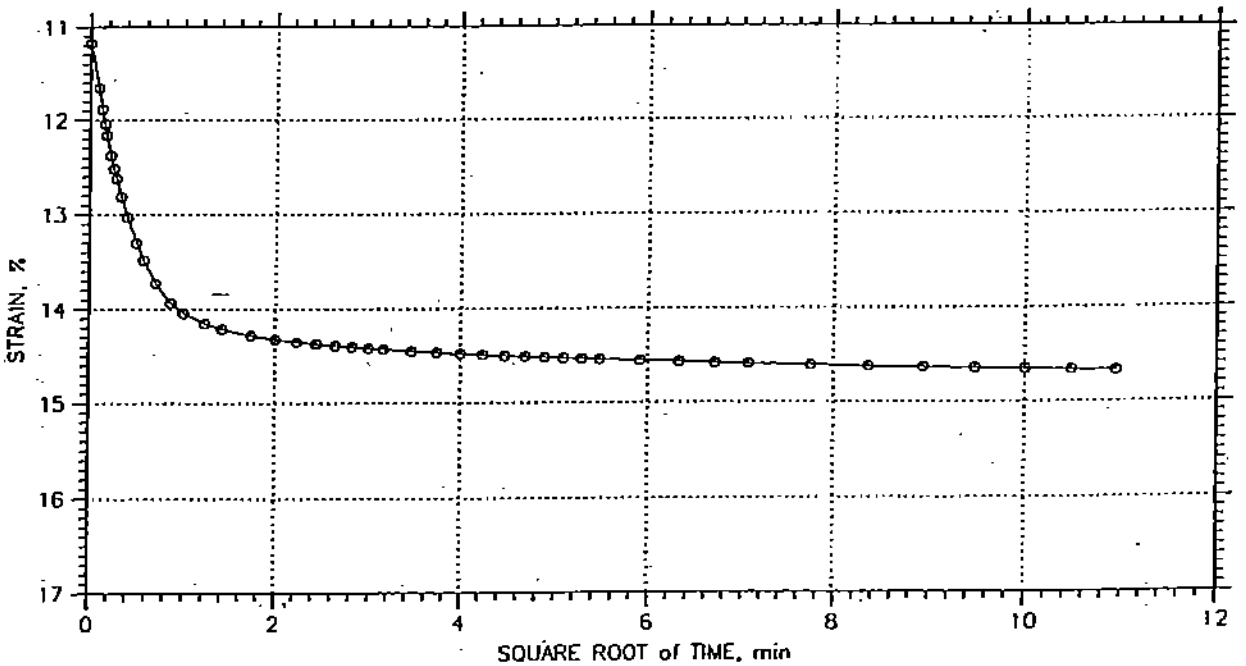
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 8 of 12

Stress: 16. tsf





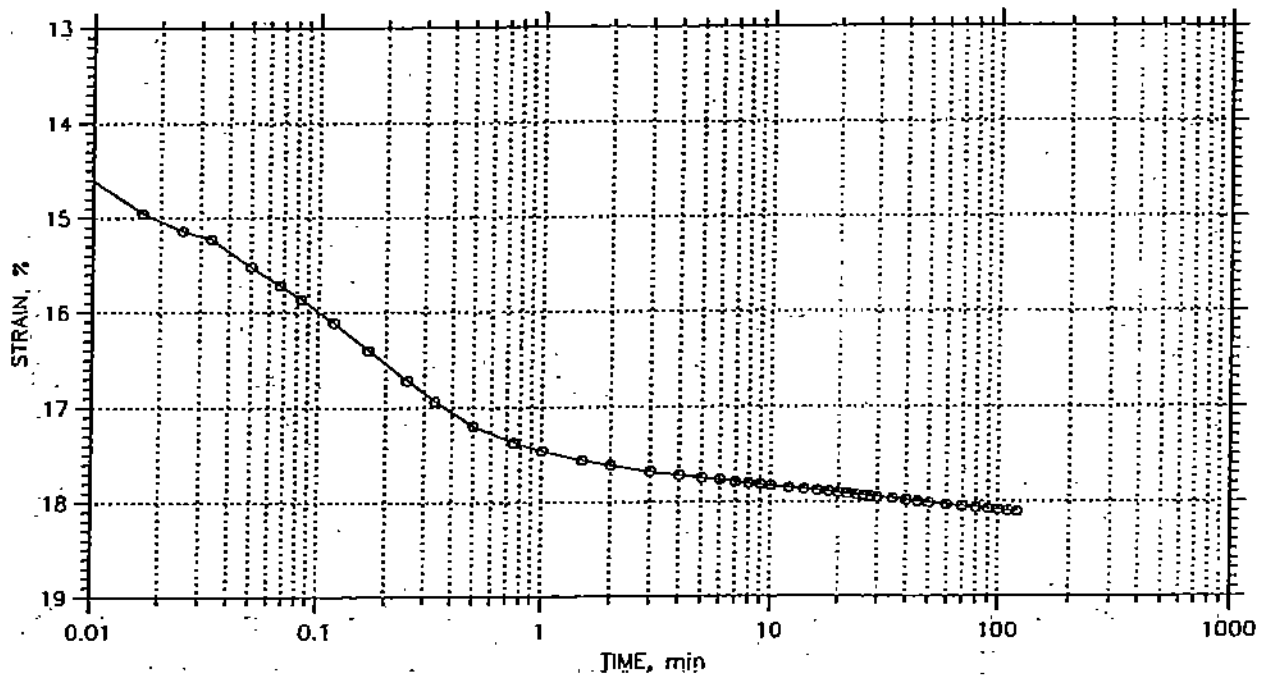
Project: Pownal Tannery Superfund	Location: ---	Project No.: GTX-4363
Boring No.: SBL4	Tested By: fy	Checked By: jdl
Sample No.: 103	Test Date: 12/02/02	Depth: 25-27 ft
Test No.: C1	Sample Type: Tube	Elevation: ---
Description: Moist, dark gray clay.		
Remarks: ---		

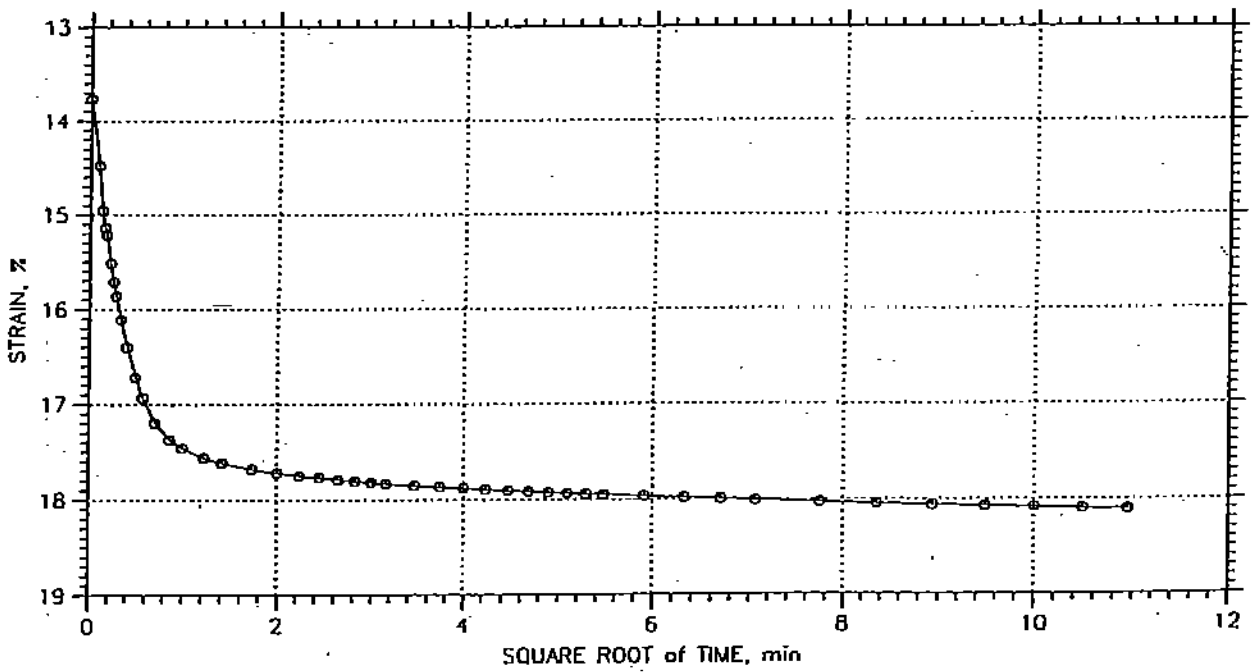
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 9 of 12

Stress: 32. tsf





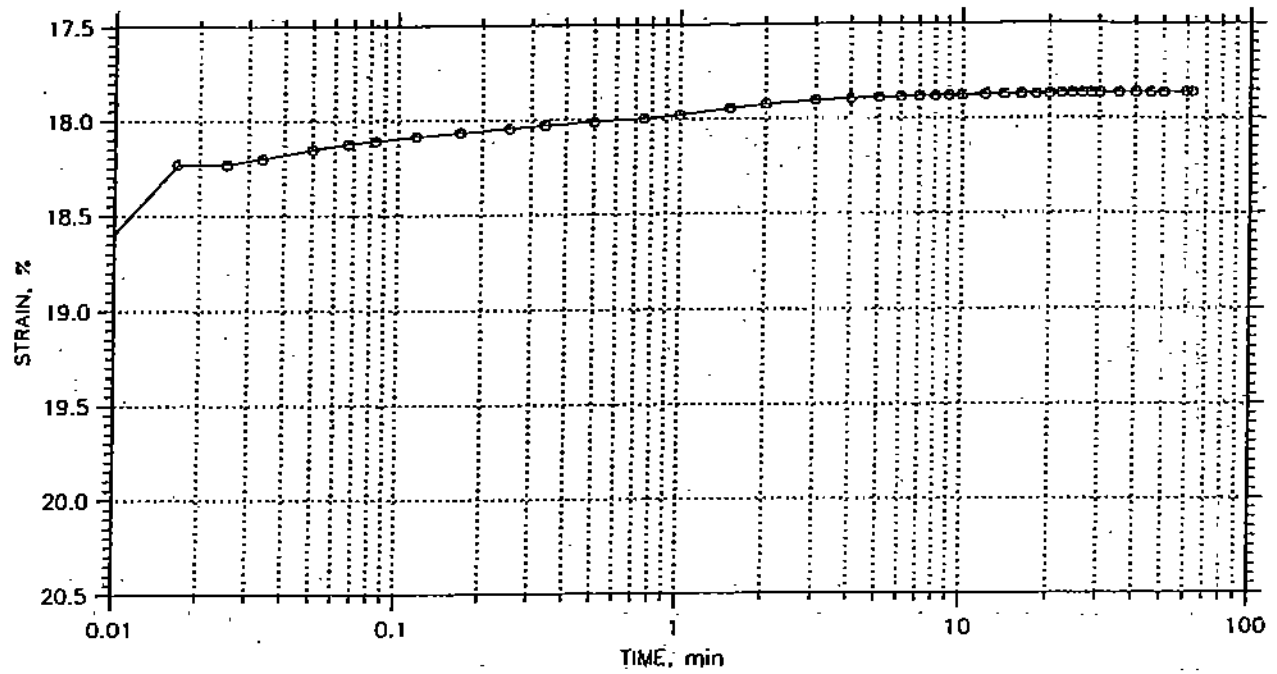
Project: Pownal Tannery Superfund	Location: ---	Project No.: GTX-4363
Boring No.: SBL4	Tested By: fy	Checked By: jdt
Sample No.: 103	Test Date: 12/02/02	Depth: 25-27 ft
Test No.: C1	Sample Type: Tube	Elevation: ---
Description: Moist, dark gray clay		
Remarks: ---		

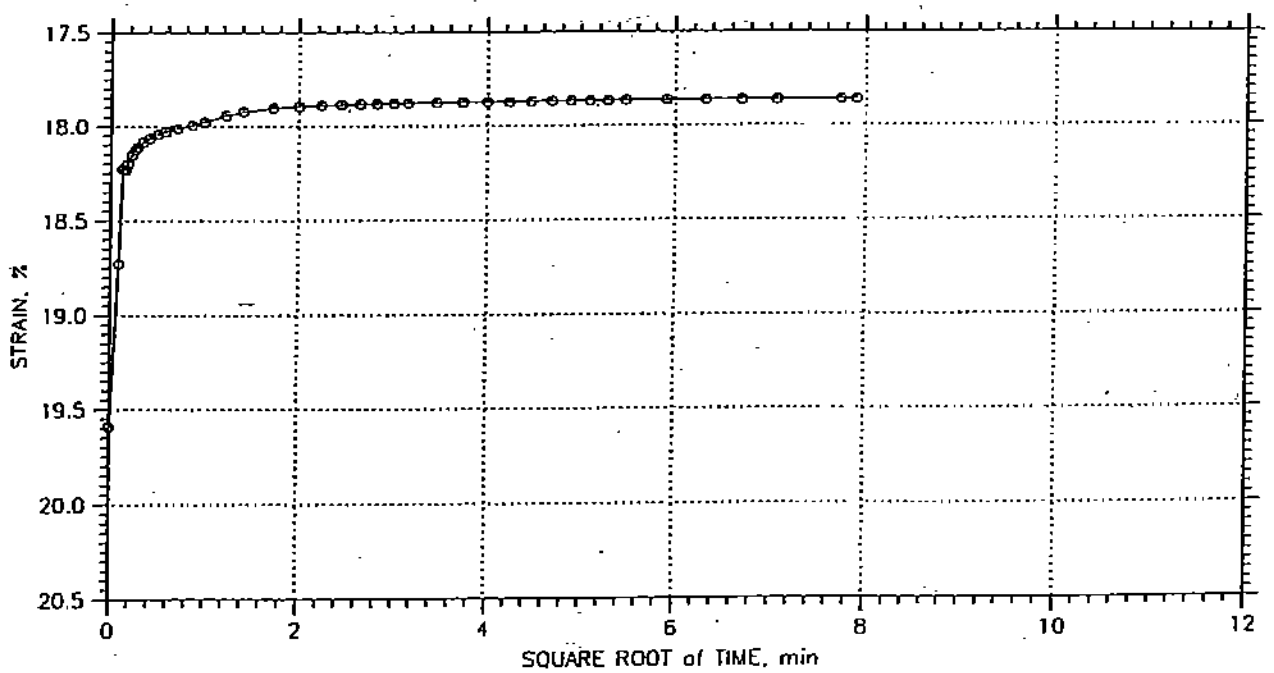
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 10 of 12

Stress: 8. tsf





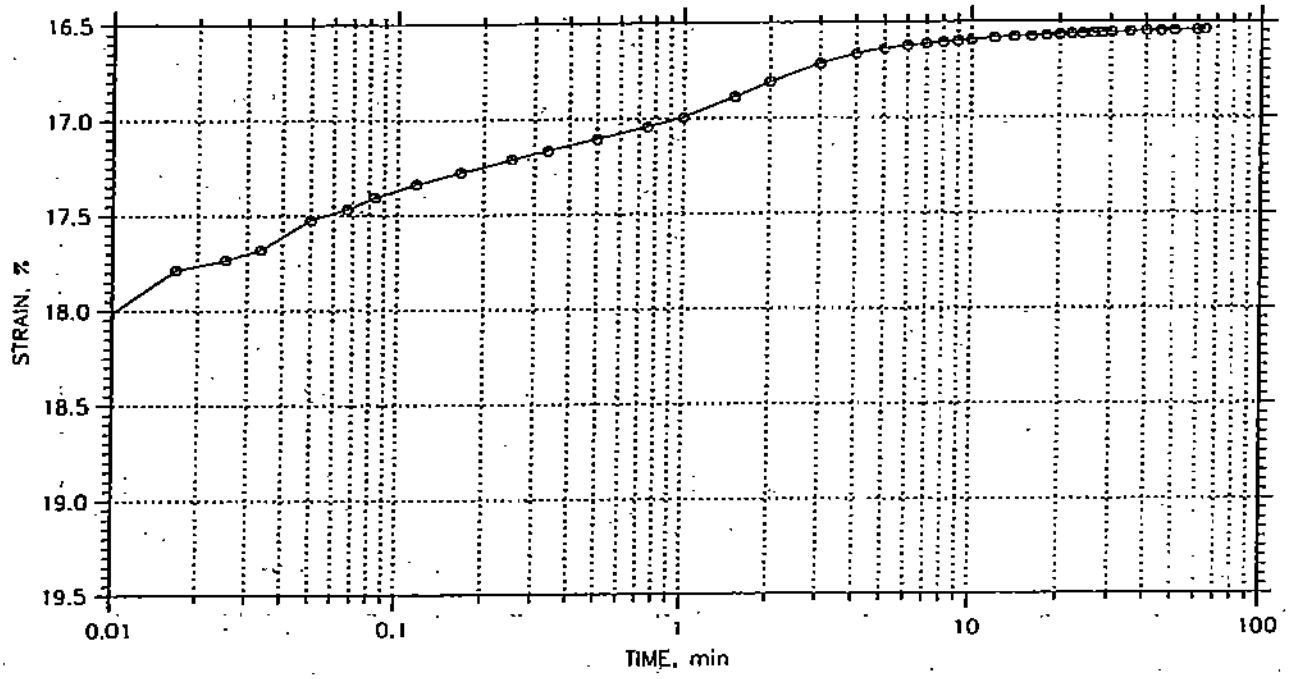
Project: Pownal Tannery Superfund	Location: ---	Project No.: GTX-4363
Boring No.: SBL4	Tested By: fy	Checked By: jdt
Sample No.: 103	Test Date: 12/02/02	Depth: 25-27 ft
Test No.: C1	Sample Type: Tube	Elevation: ---
Description: Moist, dark gray clay		
Remarks: ---		

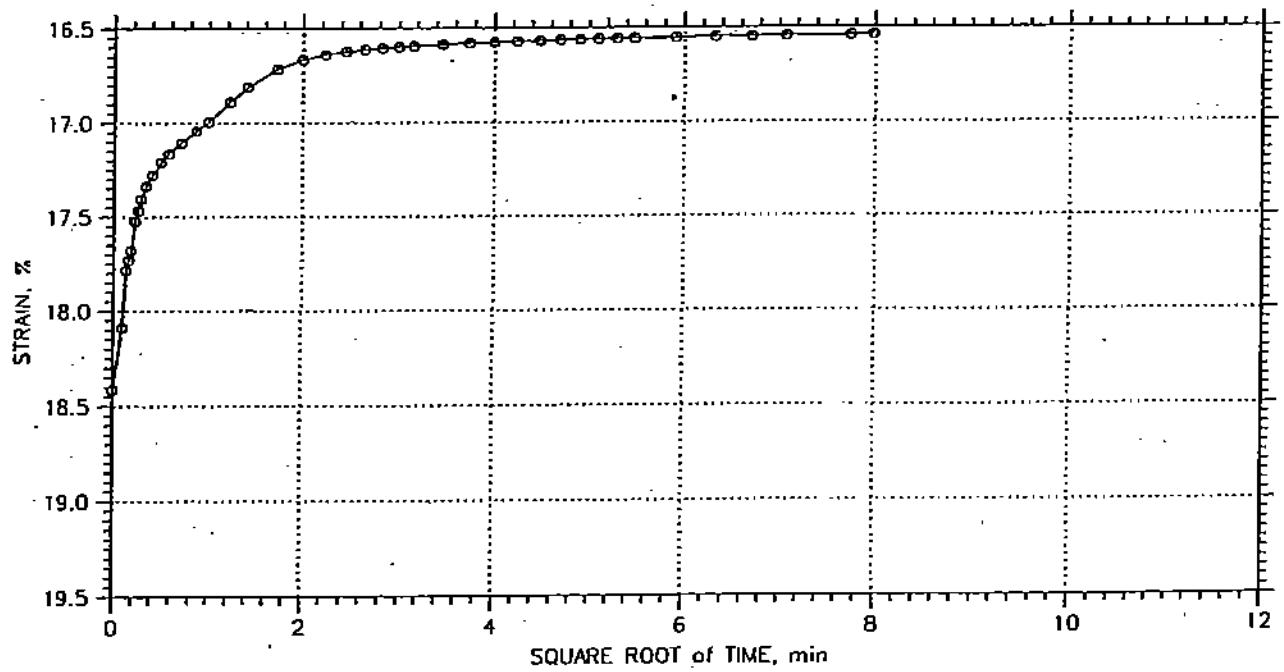
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 11 of 12

Stress: 2. tsf





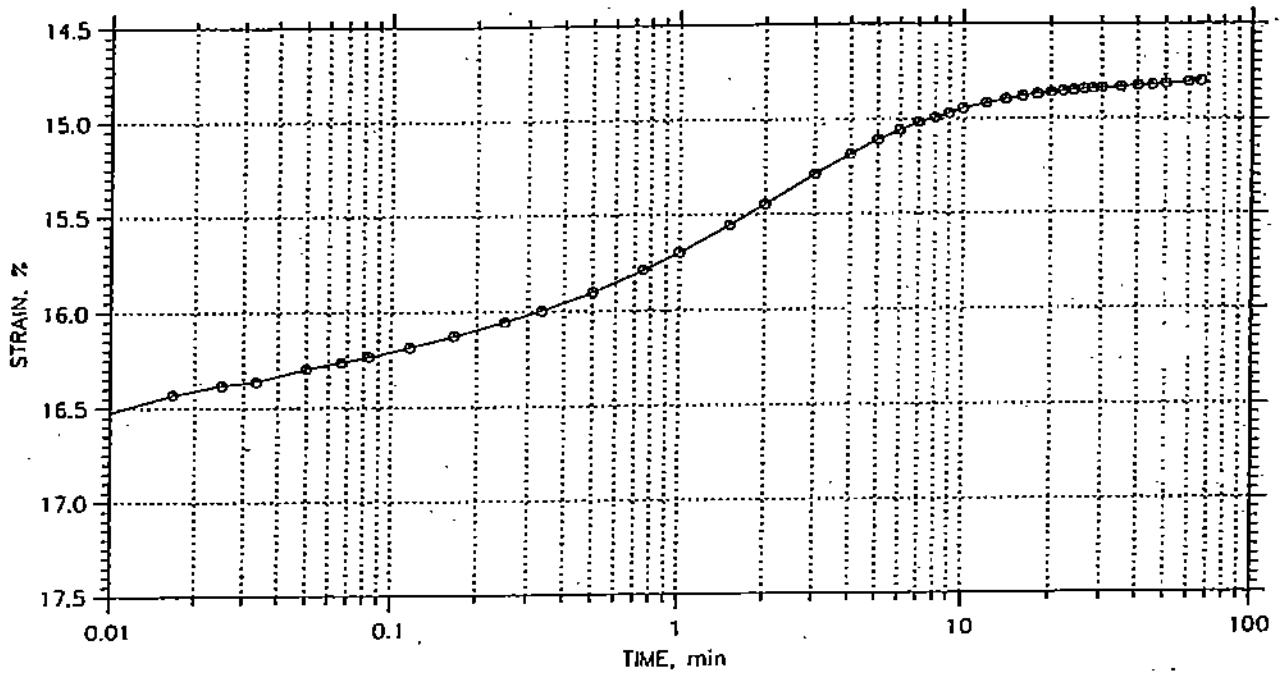
Project: Pownal Tannery Superfund	Location: ---	Project No.: GTX-4363
Boring No.: SBL4	Tested By: fy	Checked By: jdl
Sample No.: 103	Test Date: 12/02/02	Depth: 25-27 ft
Test No.: C1	Sample Type: Tube	Elevation: ---
Description: Moist, dark gray clay		
Remarks: ---		

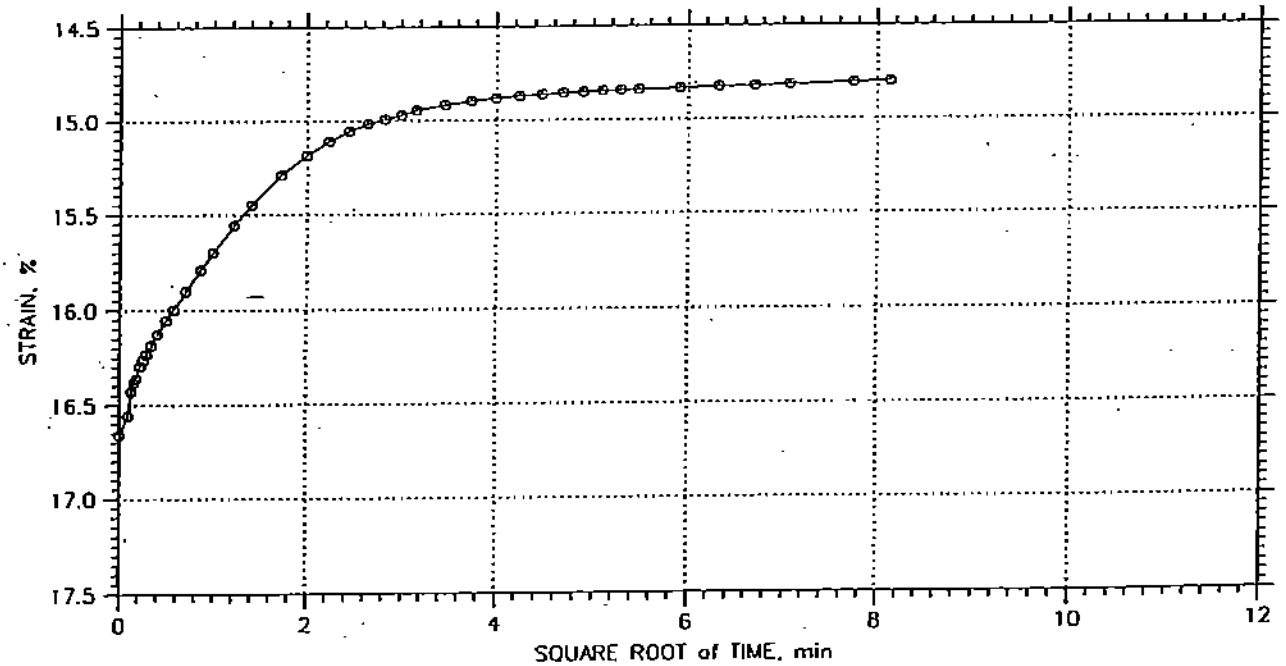
CONSOLIDATION TEST DATA

TIME CURVES

Constant Load Step: 12 of 12

Stress: 0.5 tsf

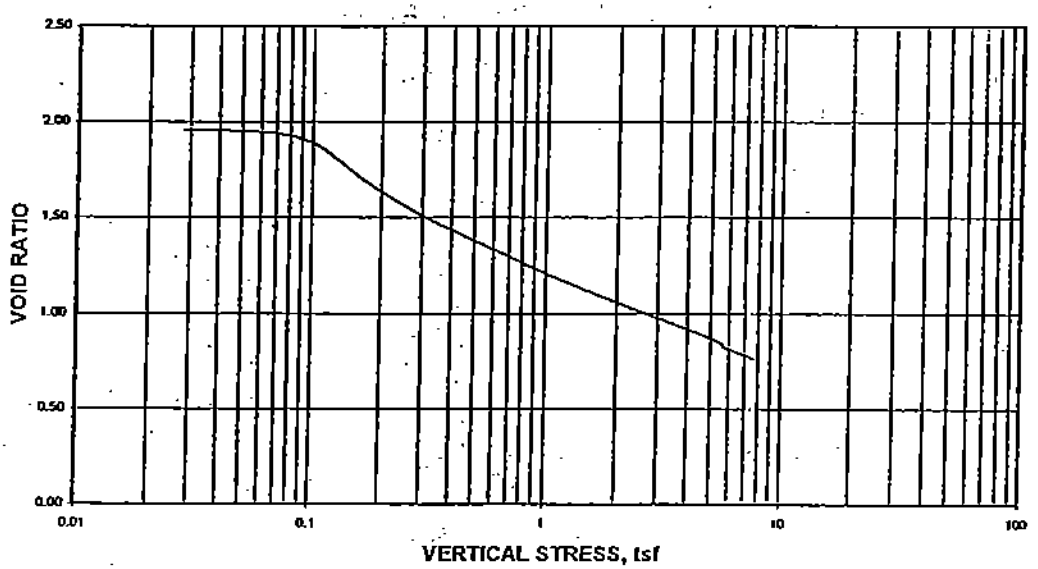




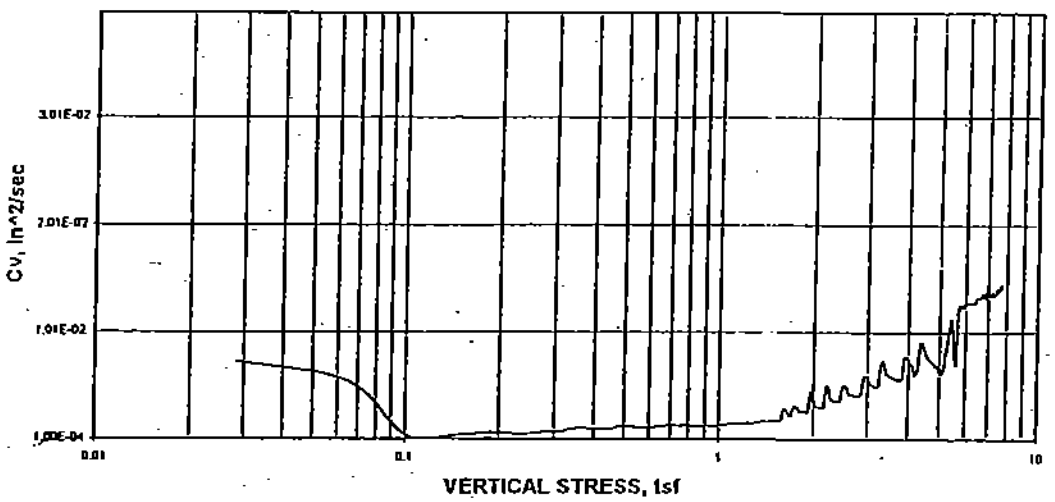
Project: Pownal Tannery Superfund	Location: ---	Project No.: GTX-4363
Boring No.: SBL4	Tested By: fy	Checked By: jdl
Sample No.: 103	Test Date: 12/02/02	Depth: 25-27 ft
Test No.: C1	Sample Type: Tube	Elevation: ---
Description: Moist, dark gray clay		
Remarks: ---		

One-Dimensional Consolidation Properties of Soils Using Controlled-Strain Loading by ASTM D 4186

Void Ratio vs. Vertical Stress



Cv vs. Vertical Stress



Project:	Pownal Tannery Superfund Site	Location:	Pownal, VT	Project No.:	GTX-4363
Boring No.:	TPL5	Tested By:	fy	Checked By:	jdt
Sample No.:	101/102/103	Test Date:	jdt	Depth:	1-5 ft.
Test No.:	CRC-1	Sample Type:	remolded	Elevation:	---
Description:	Wet, black organic sandy, silty clay with some gravel				
marks:	Composite sample of TPL5 101 (3-5), TPL5 102 (1-2), and TPL5 103 (1-3). Equal proportions of each based on wet mass. Test sample compacted with moderate effort at the as-received moisture of each sample.				

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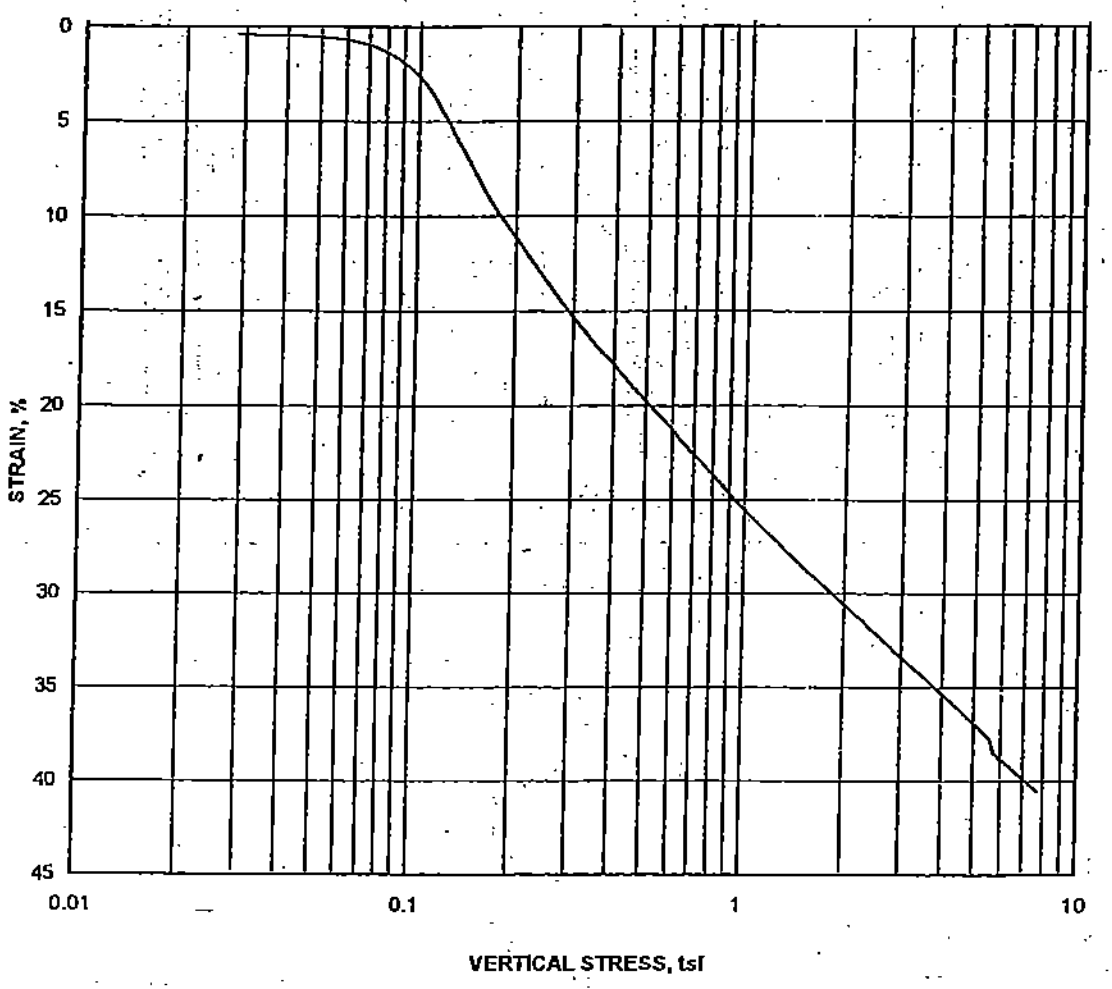
One-Dimensional Consolidation Properties of Soils Using Controlled-Strain Loading by ASTM D 4186

STRAIN vs. VERTICAL STRESS



					Before Test	After Test
Overburden Pressure, tsf:	---			Water Content, %	51.0	27.7
Preconsolidation Pressure, tsf:	---			Dry Unit Weight, pcf	58.1	93.3
Compression Index:	---			Saturation, %	74.3	97.9
Diameter, in:	11.05	Height, in:	4.8	Void Ratio	1.77	0.73
LL: ---	PL: ---	PI: ---	Specific Gravity: 2.58			

Project:	Pownal Tannery Superfund Site	Location:	Pownal, VT	Project No.:	GTX-4363
Boring No.:	TPL5	Tested By:	fy	Checked By:	jdt
Sample No.:	101/102/103	Test Date:	jdt	Depth:	1-5 ft.
Test No.:	CRC-1	Sample Type:	remolded	Elevation:	---
Description:	Wet, black organic sandy, silty clay with some gravel				
emarks:	Composite sample of TPL5 101 (3-5), TPL5 102 (1-2), and TPL5 103 (1-3). Equal proportions of each based on wet mass. Test sample compacted with moderate effort at the as-received moisture of each sample.				

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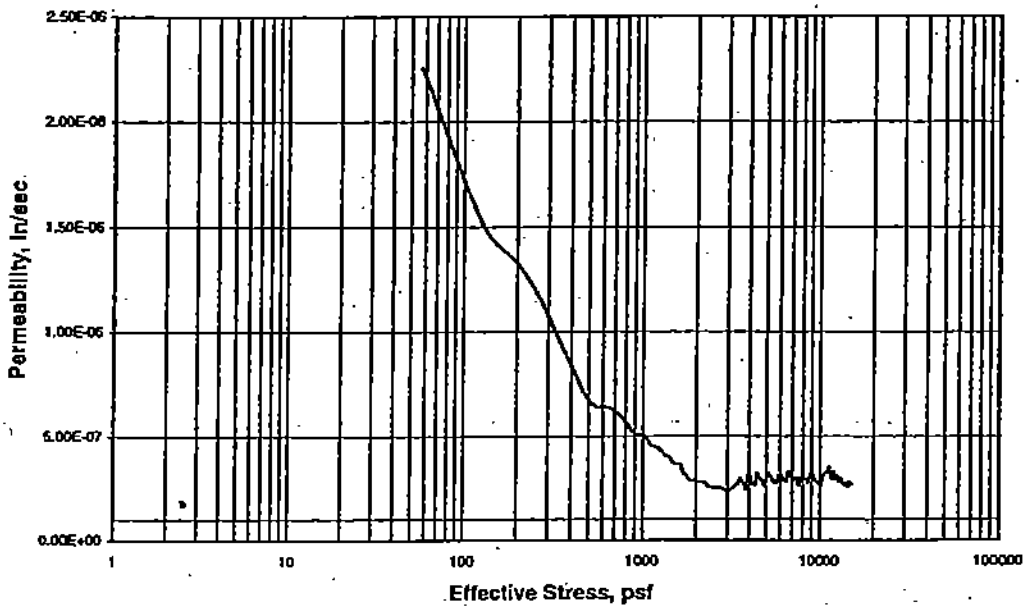
One-Dimensional Consolidation Properties of Soils Using Controlled-Strain Loading by ASTM D 4186

Permeability vs. Vertical Stress



Project:	Pownal Tannery Superfund Site	Location:	Pownal, VT	Project No.:	GTX-4363
Boring No.:	TPL5	Tested By:	fy	Checked By:	jdt
Sample No.:	101/102/103	Test Date:	jdt	Depth:	1-5 ft.
Test No.:	CRC-1	Sample Type:	remolded	Elevation:	---
Description:	Wet, black organic sandy, silty clay with some gravel				
emarks:	Composite sample of TPL5 101 (3-5), TPL5 102 (1-2), and TPL5 103 (1-3). Equal proportions of each based on wet mass. Test sample compacted with moderate effort at the as-received moisture of each sample.				

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GeoTesting Express
1145 Mass Avenue - Boxborough, MA 01719
(978) 635-0424 - Fax (978) 635-0266

LETTER OF TRANSMITTAL

TO:

Mr. Don Dwight
Metcalf & Eddy
30 Harvard Mill Square
Wakefield, MA 01888

DATE: 04/21/03	GTX NO: 4363
RE: Pownal Tannery Superfund Site Project	
Pages (excluding transmittal): 2	

We are sending you ☑ Attached ☐ Under separate cover via _____ the following items:
☑ Test results ☐ Proposal ☑ Report ☐ Samples ☐ Specifications ☐ Invoice
☐ Copy of letter ☐ Change order
☐ Other

COPIES	DATE	DESCRIPTION
1	04/21/03	**April 2003 Laboratory Test Reports**
		1 Unconfined Compressive Strength of Molded Soil-Cement Cylinders (ASTM D 1633)

THESE ITEMS ARE TRANSMITTED as checked below:
☐ For approval ☐ Approved as submitted ☐ Resubmit _____ Copies for approval
☑ For your use ☐ Approved as noted ☐ Submit _____ Copies for distribution
☑ As requested ☐ Returned for corrections ☐ Return
☐ For review and comment
☐ For bids due _____, 20
☐ _____

REMARKS

COPY TO Mr. Greg Mischel
TRC Environmental
Foot of John Street
Lowell, MA 01852

SIGNED Joe Tomei

Joseph Tomei - Laboratory Manager

Geotechnical Test Report

Pownal Tannery Superfund Site

Pownal, VT

Prepared for:

Wakefield, MA

Prepared by:

GeoTesting Express, Inc.

Boxborough, MA

April 4, 2003

ASTM D 1633 - Compressive Strength of Molded Soil-Cement Cylinders

Client:	Metcalf & Eddy	GTX No.:	4363
Project Name:	Pownal Tannery Superfund Site	Report Date:	04/04/03
Project Location:	Pownal, VT	Tested by:	tje/md
		Checked By:	jdt

Unconfined Compressive Strength, psi

Sample ID	1-day cure	3-day cure	7-day cure	23-day cure
TPL-1 102 3% QuickLime	2.3	3.4	5.6	—
TPL-1 102 5% QuickLime	3.8	5.5	8.7	—
TPL-1 102 7% QuickLime	4.8	5.7	8.0	13.9

Notes:

See attached Unconfined Compression Test Reports for sample dimensions and Stress vs. Strain plots

Initial Moisture Content of TPL-1 102 material used was 198%.

Specimens prepared in general accordance with ASTM D 1633 Method B.

Percentage of QuickLime was added by wet sludge weight.

Mixes were prepared by mixing QuickLime into wet soil sample and mixing with a spoon.

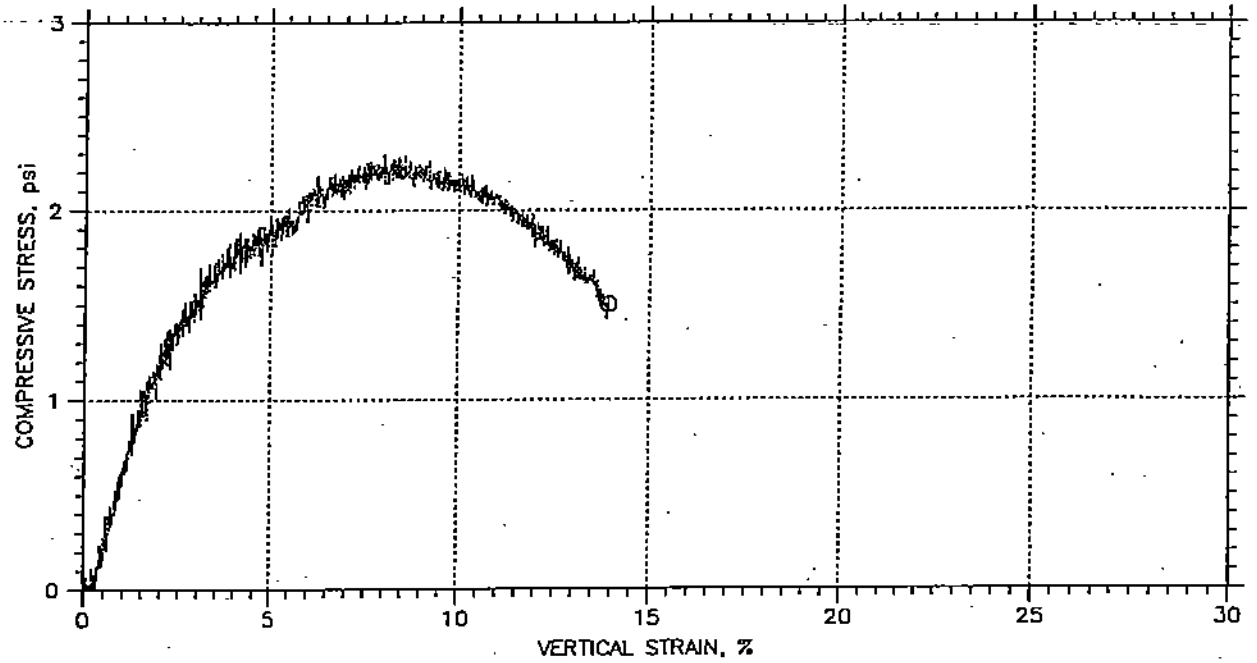
Approximately 180 passes with the spoon were required to mix the 3% QuickLime into the soil until individual pieces were not visible.

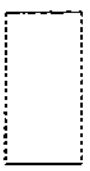
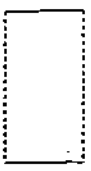
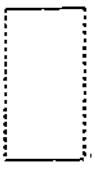
Approximately 220 passes with the spoon were required to mix the 5% QuickLime into the soil until individual pieces were not visible.

Approximately 330 passes with the spoon were required to mix the 7% QuickLime into the soil until individual pieces were not visible.

Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material.

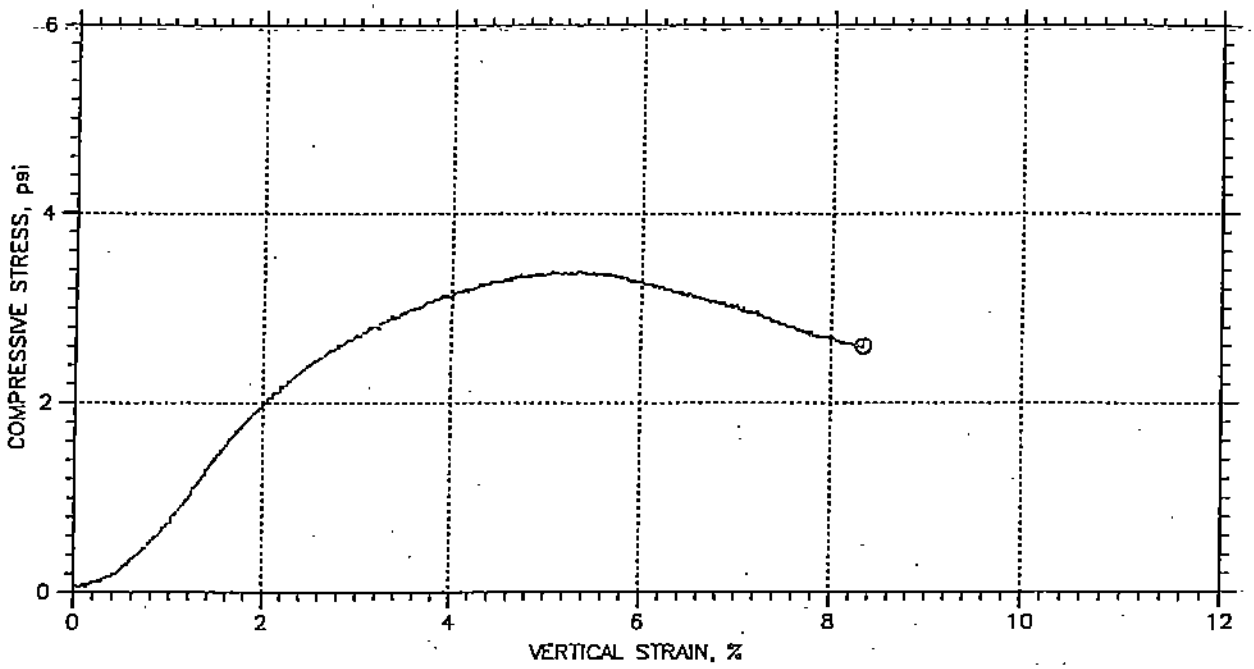
UNCONFINED COMPRESSION TEST REPORT

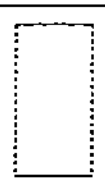
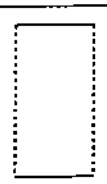
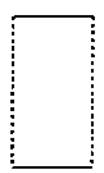


Symbol		⊙			
Test No.		4363-uc1			
Initial	Diameter, in	3			
	Height, in	5.9			
	Water Content, %	168.63			
	Dry Density, pcf	27.883			
	Saturation, %	90.59			
	Void Ratio	4.9331			
Unconfined Compressive Strength, psi		2.2986			
Undrained Shear Strength, psi		1.1493			
Time to Failure, min		7.6074			
Strain Rate, %/min		1			
Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: Pownal Tannery
Location: Pownal VT
Project No.: GTX-4363
Boring No.: TPL-1 102
Sample Type: Remolded
Description: Moist, brown silt with 3 % lime
Remarks: 3% Quicklime; 1-day curing period

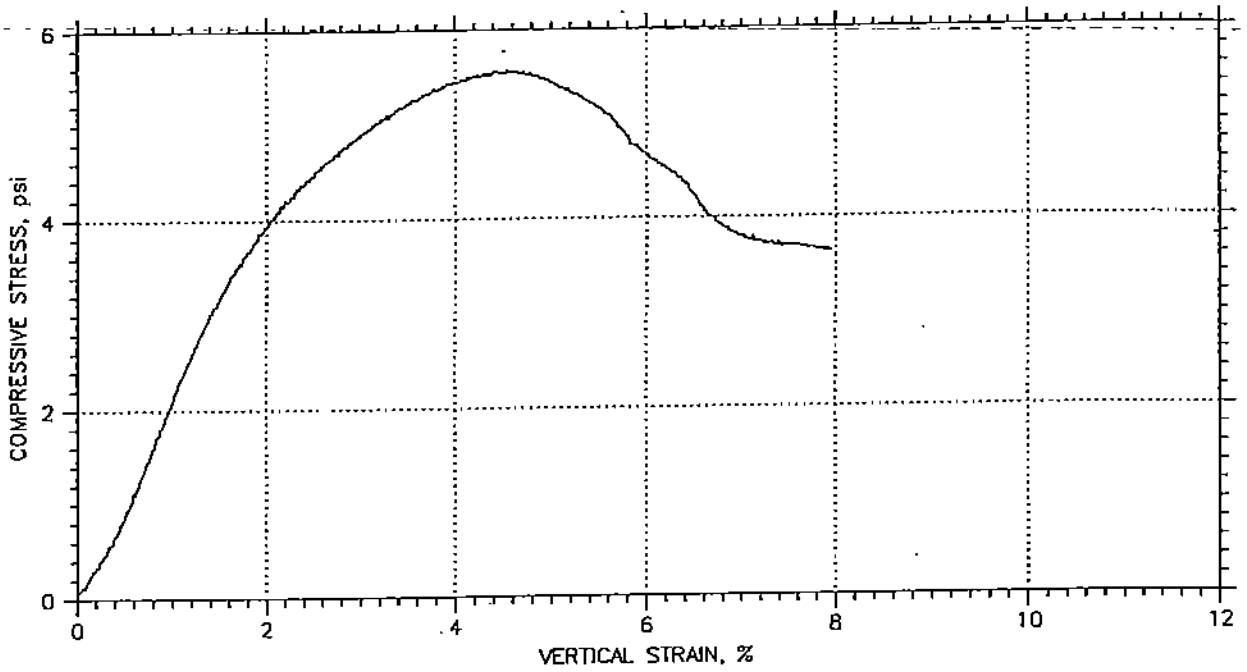
UNCONFINED COMPRESSION TEST REPORT

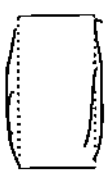
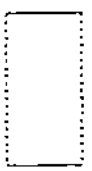
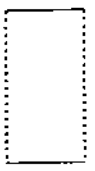
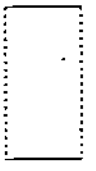


Symbol		⊙			
Test No.		4363-uc4			
Initial	Diameter, in	3			
	Height, in	5.89			
	Water Content, %	170.17			
	Dry Density, pcf	27.501			
	Saturation, %	89.91			
	Void Ratio	5.0156			
Unconfined Compressive Strength, psi		3.395			
Undrained Shear Strength, psi		1.6975			
Time to Failure, min		5.0242			
Strain Rate, %/min		1			
Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: Pownal Tannery
Location: Pownal VT
Project No.: GTX-4363
Boring No.: TPL-1 102
Sample Type: Remolded
Description: Moist, brown silt with 3% lime
Remarks: 3% Quicklime; 3-day curing period

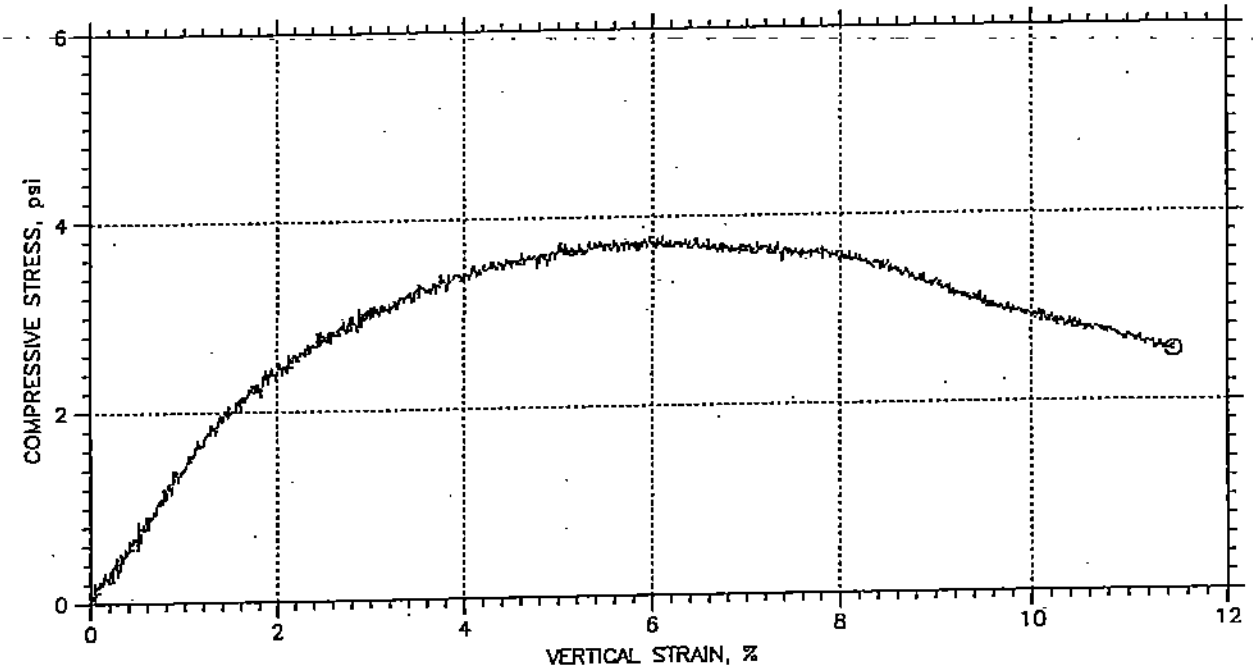
UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		4363-uc7			
Initial	Diameter, in	3			
	Height, in	5.95			
	Water Content, %	168.65			
	Dry Density, pcf	28.052			
	Saturation, %	91.26			
	Void Ratio	4.8973			
Unconfined Compressive Strength, psi		5.5813			
Undrained Shear Strength, psi		2.7907			
Time to Failure, min		4.2356			
Strain Rate, %/min		1			
Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: Pownal Tannery
Location: Pownal VT
Project No.: GTX-4363
Boring No.: TPL-1 102
Sample Type: Remolded
Description: Moist, dark gray silt with 3% lime
Remarks: 3% Quicklime; 7-day curing period

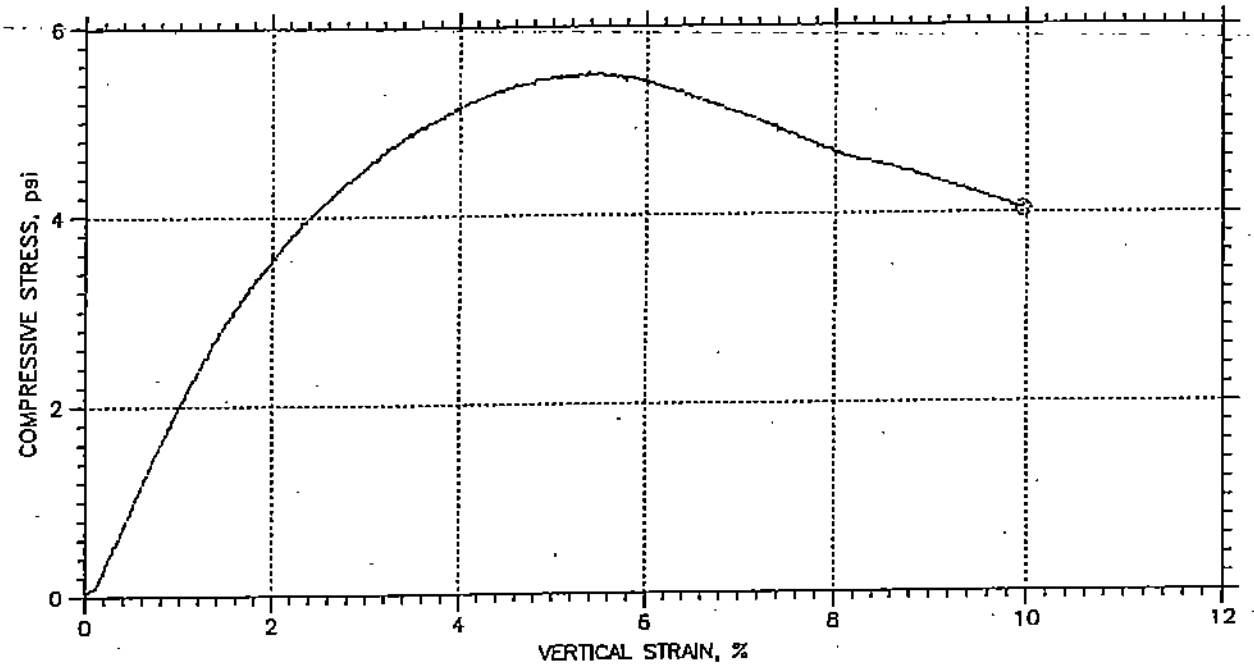
UNCONFINED COMPRESSION TEST REPORT

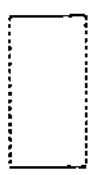
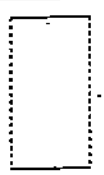
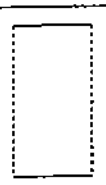


Symbol		⊙			
Test No.		4363-uc2			
Initial	Diameter, in	3			
	Height, in	5.9			
	Water Content, %	152.62			
	Dry Density, pcf	30.302			
	Saturation, %	90.69			
	Void Ratio	4.4594			
Unconfined Compressive Strength, psi		3.7921			
Undrained Shear Strength, psi		1.896			
Time to Failure, min		5.6917			
Strain Rate, %/min		1			
Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: Pownal Tannery
Location: Pownal VT
Project No.: GTX-4363
Boring No.: TPL-1 102
Sample Type: Remolded
Description: Moist, brown silt with 5 % lime
Remarks: 5% Quicklime; 1-day curing period

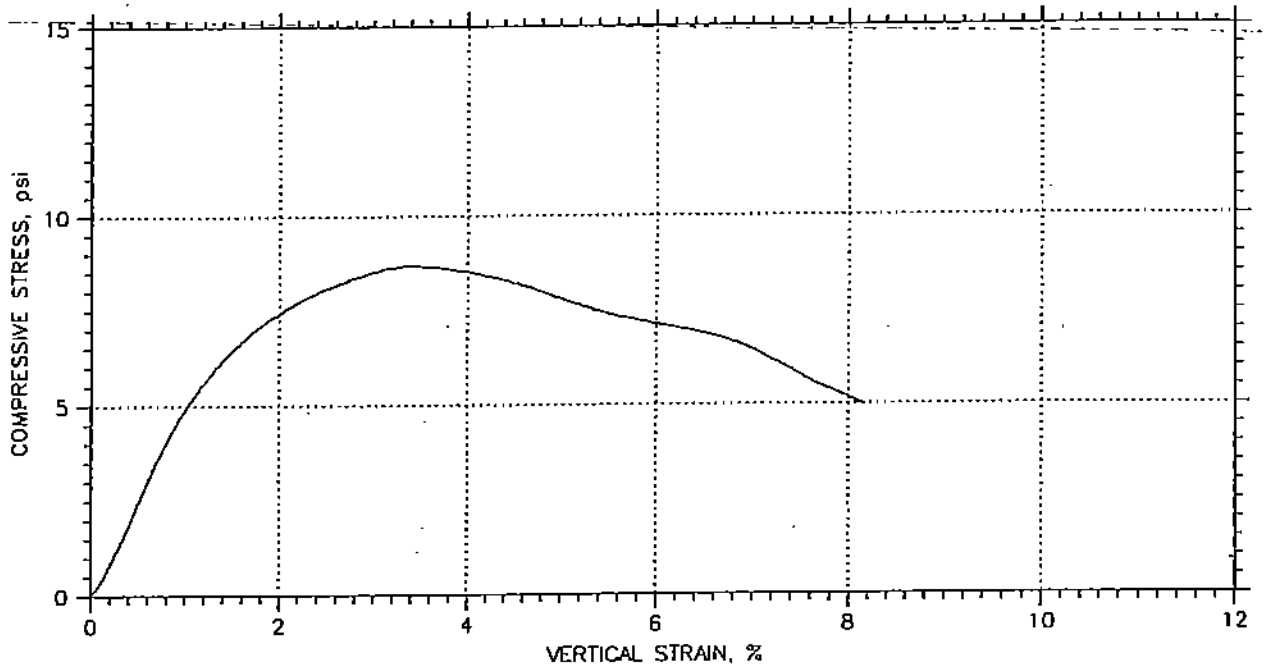
UNCONFINED COMPRESSION TEST REPORT

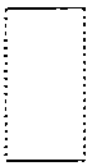
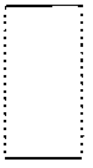


Symbol		⊙			
Test No.		4363-uc5			
Initial	Diameter, in	3			
	Height, in	5.9			
	Water Content, %	153.73			
	Dry Density, pcf	29.917			
	Saturation, %	89.94			
	Void Ratio	4.5298			
Unconfined Compressive Strength, psi		5.5171			
Undrained Shear Strength, psi		2.7586			
Time to Failure, min		5.0323			
Strain Rate, %/min		1			
Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: Pownal Tannery
Location: Pownal VT
Project No.: GTX-4363
Boring No.: S-2
Sample Type: Remolded
Description: Moist, brown silt with 5% lime
Remarks: 5% Quicklime; 3-day curing period

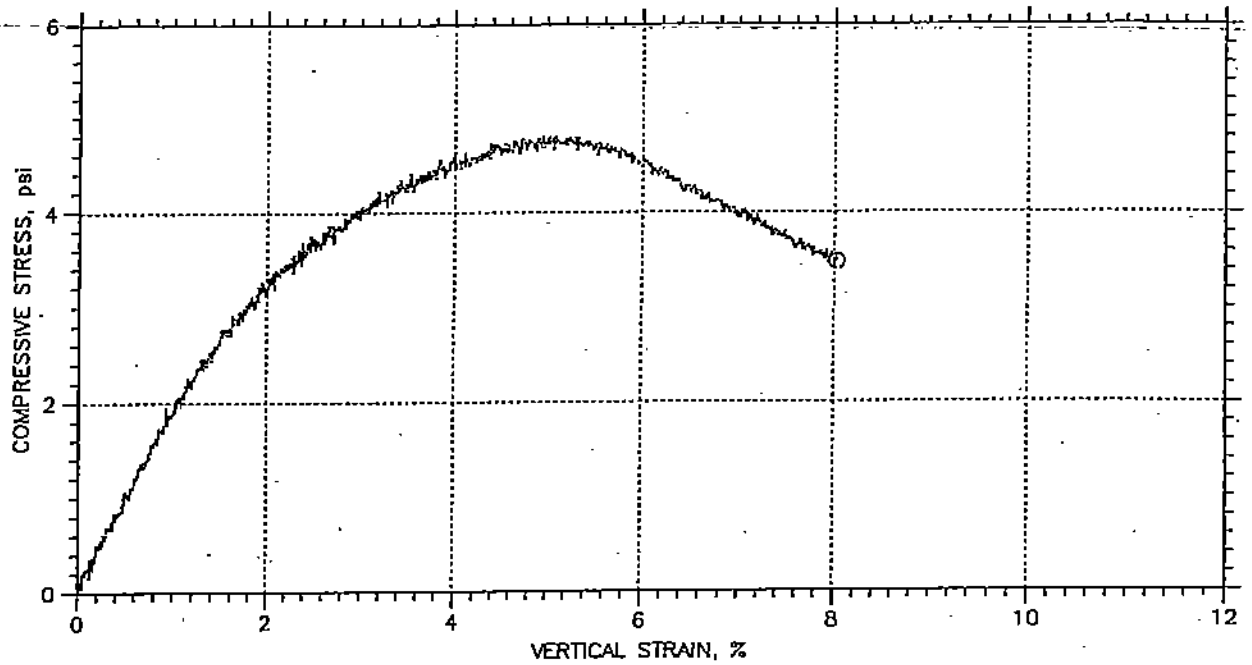
UNCONFINED COMPRESSION TEST REPORT

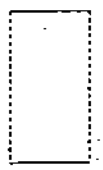
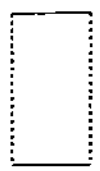


Symbol					
Test No.		4363-uc8			
Initial	Diameter, in	3			
	Height, in	5.9			
	Water Content, %	157.39			
	Dry Density, pcf	29.705			
	Saturation, %	91.28			
	Void Ratio	4.5693			
Unconfined Compressive Strength, psi		8.7074			
Undrained Shear Strength, psi		4.3537			
Time to Failure, min		3.1883			
Strain Rate, %/min		1			
Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: Pownal Tannery
Location: Pownal VT
Project No.: GTX-4363
Boring No.: TPL-1 102
Sample Type: Remolded
Description: Moist, dark gray silt with 5% lime
Remarks: 5% Quicklime; 7-day curing period

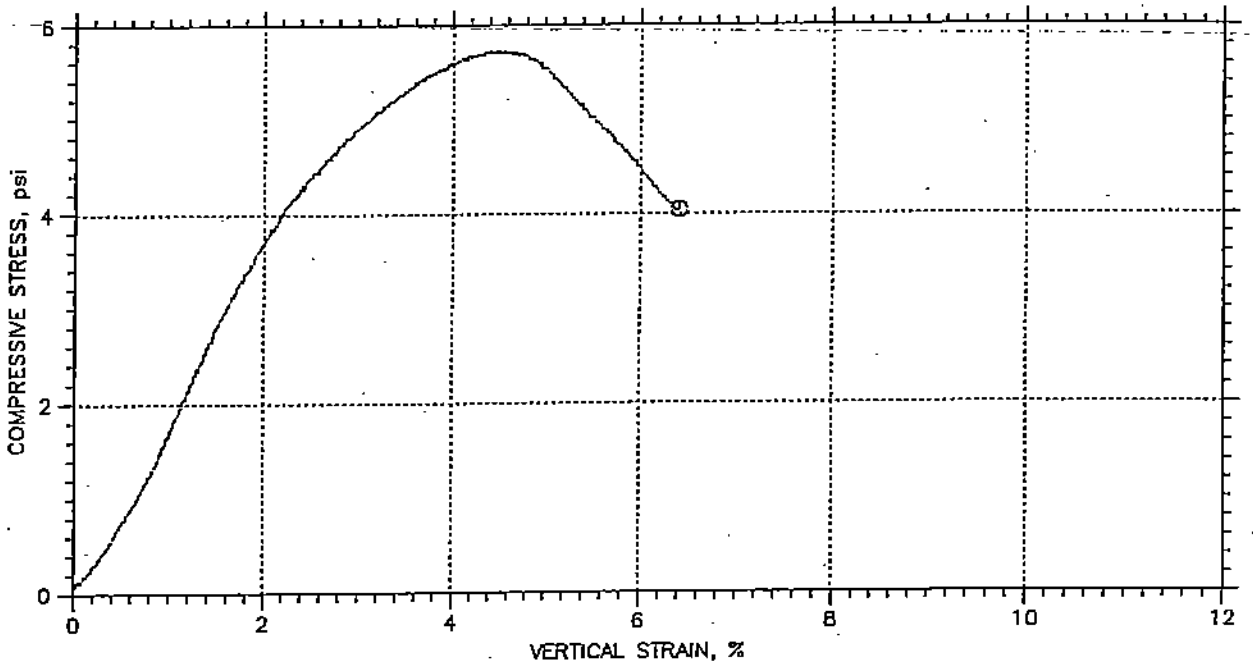
UNCONFINED COMPRESSION TEST REPORT



Symbol		⊙			
Test No.		4363-uc3			
Initial	Diameter, in	3			
	Height, in	5.91			
	Water Content, %	135.00			
	Dry Density, pcf	33.14			
	Saturation, %	89.62			
	Void Ratio	3.992			
Unconfined Compressive Strength, psi		4.8136			
Undrained Shear Strength, psi		2.4068			
Time to Failure, min		4.824			
Strain Rate, %/min		1			
Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: Pownal Tannery
Location: Pownal VT
Project No.: GTX-4363
Boring No.: TPL-1 102
Sample Type: Remolded
Description: Moist, brown silt with 7 % lime
Remarks: 7% Quicklime; 1-day curing period

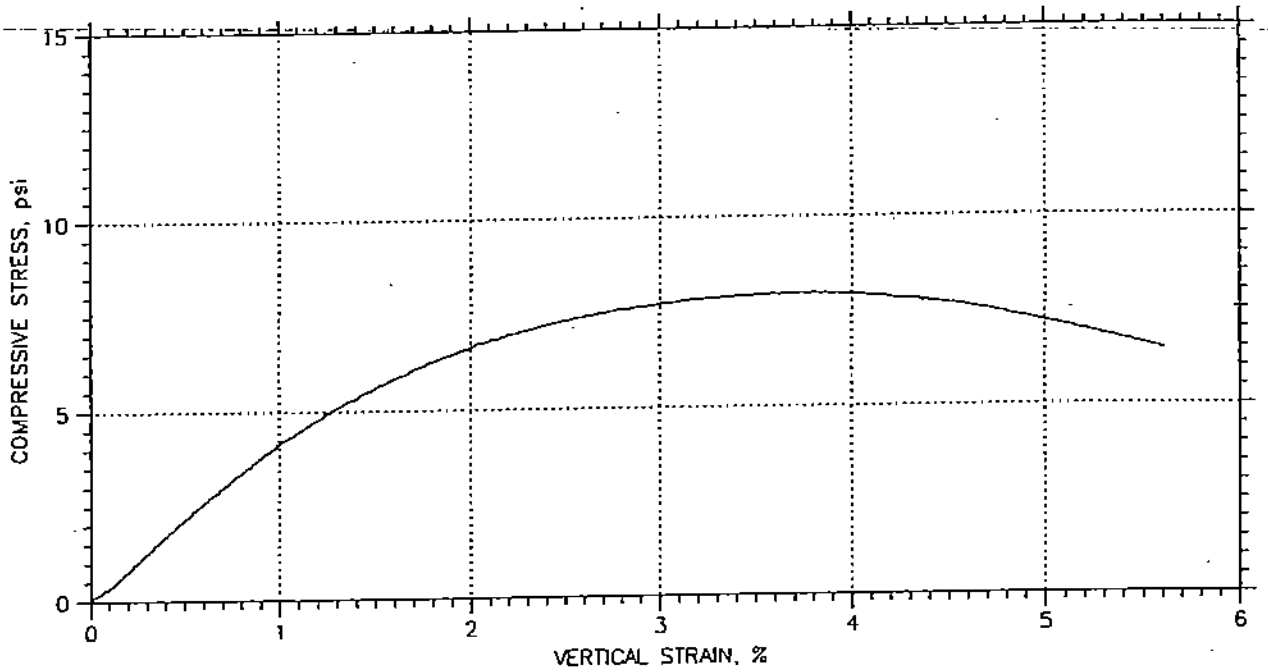
UNCONFINED COMPRESSION TEST REPORT

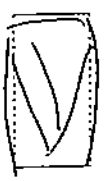
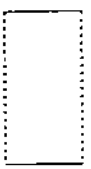
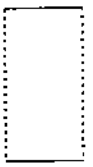
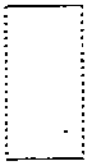


Symbol		⊙			
Test No.		4363-uc6			
Initial	Diameter, in	3			
	Height, in	5.91			
	Water Content, %	154.88			
	Dry Density, pcf	30.126			
	Saturation, %	91.38			
	Void Ratio	4.4914			
Unconfined Compressive Strength, psi		5.7314			
Undrained Shear Strength, psi		2.8657			
Time to Failure, min		4.1645			
Strain Rate, %/min		1			
Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: Pownal Tannery
Location: Pownal VT
Project No.: GTX-4363
Boring No.: TPL-1 102
Sample Type: Remolded
Description: Moist, brown silt with 7% lime
Remarks: 7% Quicklime; 3-day curing period

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		4363-uc9			
Initial	Diameter, in	3			
	Height, in	5.91			
	Water Content, %	161.40			
	Dry Density, pcf	29.164			
	Saturation, %	91.54			
	Void Ratio	4.6724			
Unconfined Compressive Strength, psi		7.9814			
Undrained Shear Strength, psi		3.9907			
Time to Failure, min		3.6177			
Strain Rate, %/min		1			
Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: Pownal Tannery

Location: Pownal VT

Project No.: GTX-4363

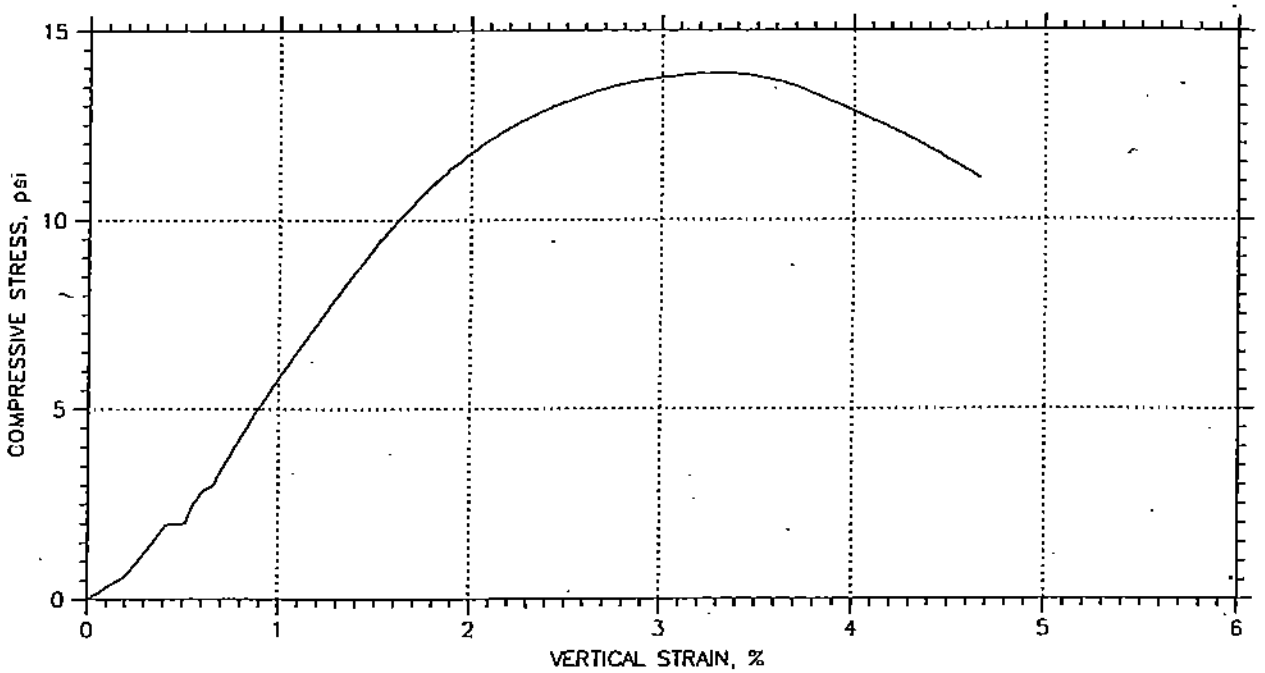
Boring No.: TPL-1 102

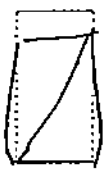
Sample Type: Remolded

Description: Moist, dark gray silt with 7% lime

Remarks: 7% Quicklime; 7-day curing period

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		4363uc11			
Initial	Diameter, in	3			
	Height, in	5.95			
	Water Content, %	340.32			
	Dry Density, pcf	17.649			
	Saturation, %	107.46			
	Void Ratio	8.5505			
Unconfined Compressive Strength, psi		13.863			
Undrained Shear Strength, psi		6.9315			
Time to Failure, min		3.2547			
Strain Rate, %/min		1			
Specific Gravity		2.70			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: Pownal Tannery Superfund
Location: Pownal, VT
Project No.: GTX-4363
Boring No.: TPL-1 102
Sample Type: remolded
Description: Moist, dark gray silt with 7% lime
Remarks: 7% Quicklime; 23-day curing period

GeoTesting Express
1145 Mass Avenue - Boxborough, MA 01719
(978) 635-0424 - Fax (978) 635-0266

LETTER OF TRANSMITTAL

D:

Mr. Don Dwight
Metcalf & Eddy
30 Harvard Mill Square
Wakefield, MA 01888

DATE: 06/03/03	GTX NO: 4363
RE: Pownal Tannery Superfund Site Project	
Pages (excluding transmittal): 8	

/e are sending you ☐ Attached ☐ Under separate cover via _____ the following items:
☐ Test results ☐ Proposal ☐ Report ☐ Samples ☐ Specifications ☐ Invoice
☐ Copy of letter ☐ Change order
☐ Other

COPIES	DATE	DESCRIPTION
1	06/03/03	**May 2003 Laboratory Test Reports**
		7 Unconfined Compressive Strength Tests (ASTM D 2166)

'HESE ITEMS ARE TRANSMITTED as checked below:
☐ For approval ☐ Approved as submitted ☐ Resubmit _____ Copies for approval
☐ For your use ☐ Approved as noted ☐ Submit _____ Copies for distribution
☐ As requested ☐ Returned for corrections ☐ Return
☐ For review and comment
☐ For bids due _____, 20
☐ _____

REMARKS

COPY TO Mr. Greg Mischel
TRC Environmental
Foot of John Street
Lowell, MA 01852

SIGNED _____
Joseph Tomei - Laboratory Manager

Geotechnical Test Report

Pownal Tannery Superfund Site
Pownal, VT

Prepared for:

Wakefield, MA

Prepared by:

Boxborough, MA

June 3, 2003

Unconfined Compressive Strength of Soil by ASTM D 2166

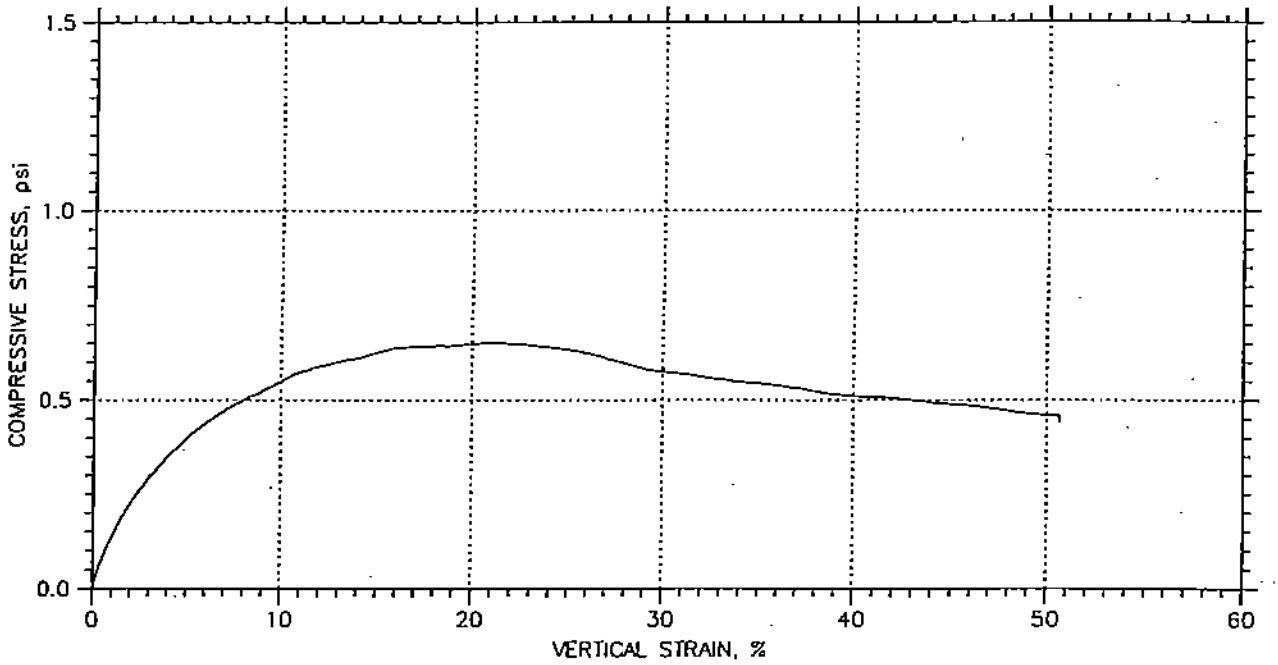
Client:	Metcalf & Eddy	GTX #:	4363
Project Name:	Pownal Tannery Superfund Site	Report Date:	05/23/03
Project Location:	Pownal, VT	Tested By:	rbd
		Checked By:	jdt

Sample ID	% Portland Cement	Moisture Content, %	Bulk Density, pcf	Unconfined Compressive Strength, psi: 1 day cure	Unconfined Compressive Strength, psi: 7 day cure
TPL1-103	1	249	65.5	0.65	—
TPL1-103	3	222	66.9	1.18	---
TPL1-103	3	214	69.1	---	1.15
TPL1-103	5	201	66.8	1.62	---
TPL5-102	1	136	85.9	Sample collapsed under its own weight	—
TPL5-102	3	126	81.1	0.43	—
TPL5-102	5	124	78.2	1.24	—
TPL5-102	5	128	81.5	---	1.30

Notes: Moisture Contents determined by ASTM D 2216 at 60 Celsius.
See attached Unconfined Compression Test Reports for sample dimensions and Stress vs. Strain plots

Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material.

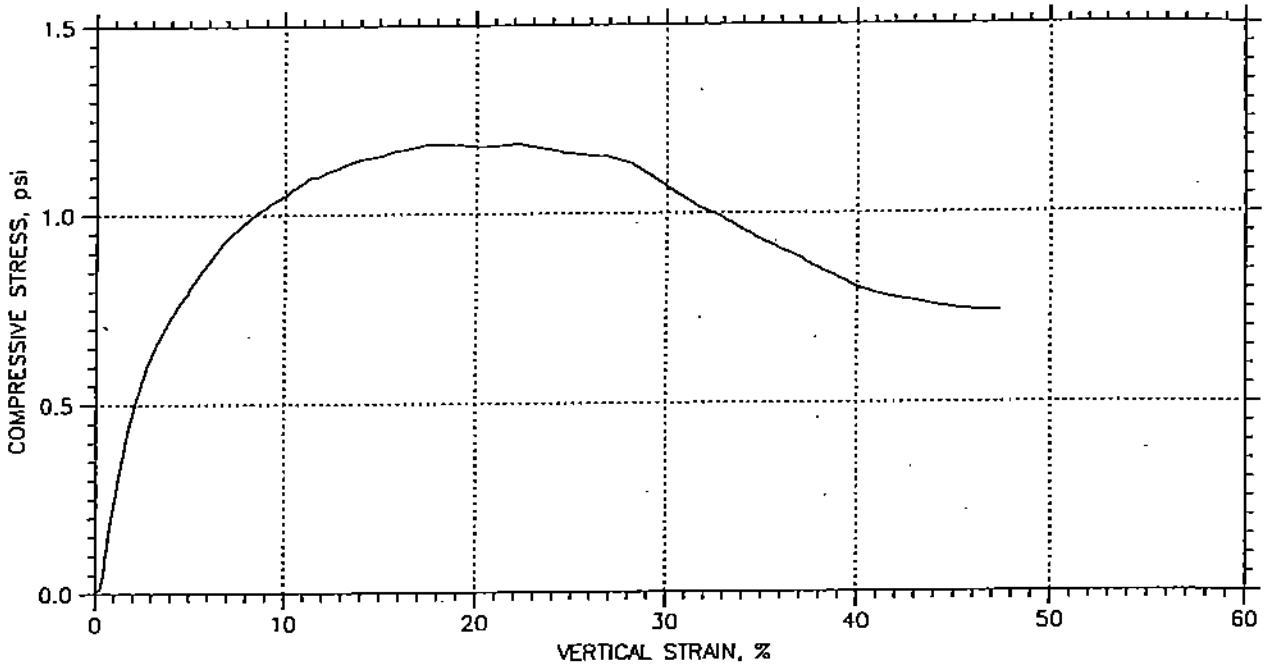
UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		4363uc7			
Initial	Diameter, in	2			
	Height, in	4			
	Water Content, %	248.62			
	Dry Density, pcf	18.845			
	Saturation, %	84.50			
	Void Ratio	7.9442			
Unconfined Compressive Strength, psi		0.65199			
Undrained Shear Strength, psi		0.326			
Time to Failure, min		4.9199			
Strain Rate, %/min		8			
Specific Gravity		2.70			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: Pownal Tannery
Location: Pownal, VT
Project No.: GTX-4363
Boring No.: TPL1-103
Sample Type: remolded
Description: Wet, black organic silt
Remarks: TPL1-103 with 1% Portland Cement added. 1-day curing period.

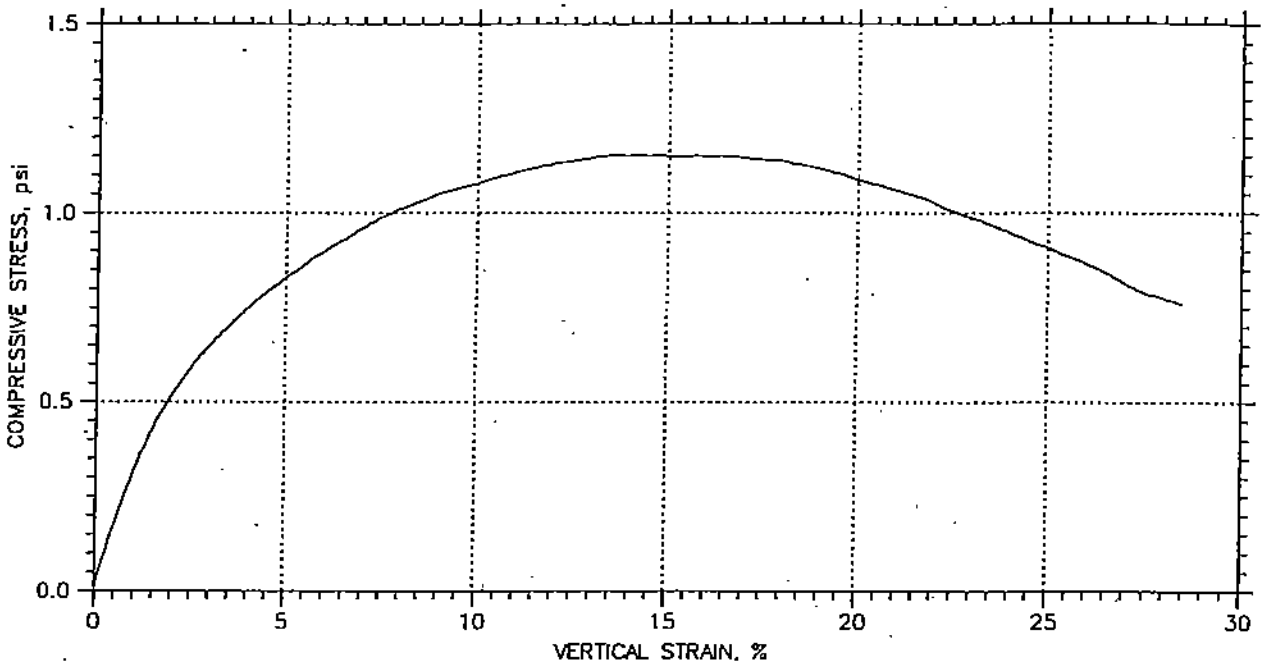
UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		4363uc8			
Initial	Diameter, in	2			
	Height, in	4			
	Water Content, %	221.73			
	Dry Density, pcf	20.768			
	Saturation, %	84.13			
	Void Ratio	7.1162			
Unconfined Compressive Strength, psi		1.1846			
Undrained Shear Strength, psi		0.59232			
Time to Failure, min		4.0851			
Strain Rate, %/min		4			
Specific Gravity		2.70			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: Pownal Tannery
Location: Pownal, VT
Project No.: GTX-4363
Boring No.: TPL1-103
Sample Type: remolded
Description: Wet, black organic silt
Remarks: TPL1-103 with 3% Portland Cement added. 1-day curing period

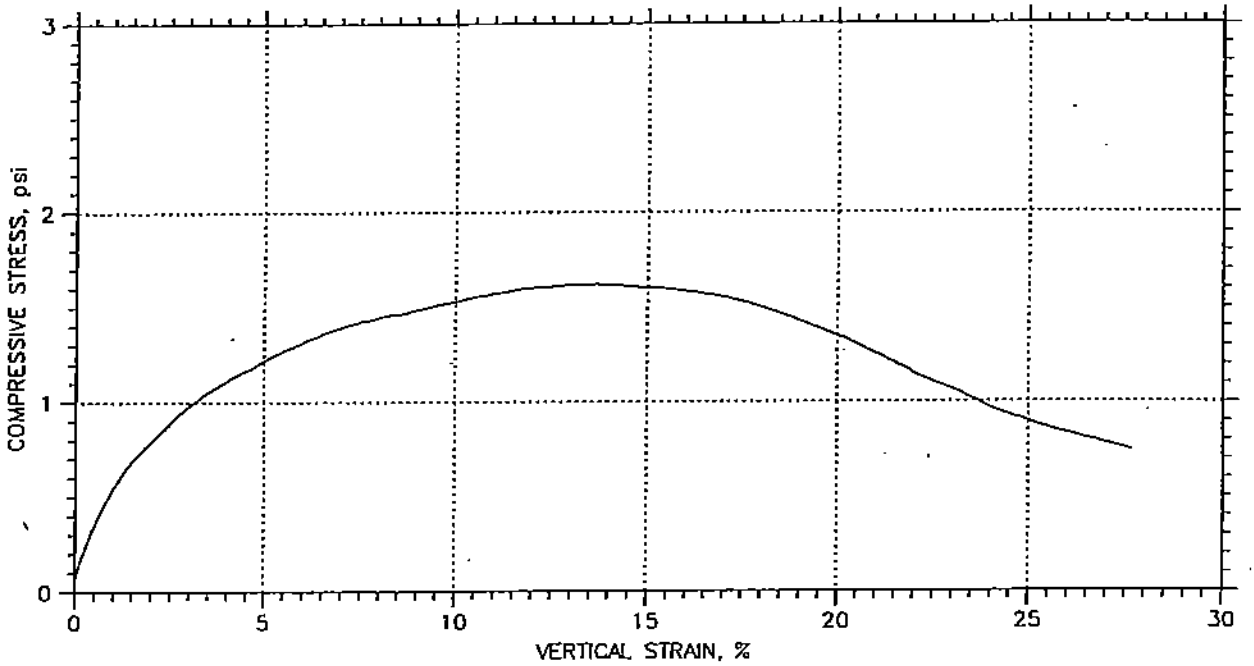
UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		4363uc10			
Initial	Diameter, in	2			
	Height, in	4			
	Water Content, %	214.16			
	Dry Density, pcf	22.021			
	Saturation, %	86.90			
	Void Ratio	6.6544			
Unconfined Compressive Strength, psi		1.1522			
Undrained Shear Strength, psi		0.57608			
Time to Failure, min		3.3508			
Strain Rate, %/min		4			
Specific Gravity		2.70			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: Pownal Tannery
Location: Pownal, VT
Project No.: GTX-4363
Boring No.: TPL1-103
Sample Type: remolded
Description: Wet, black organic silt
Remarks: TPL1-103 with 3% Portland Cement added. 7-day curing period.

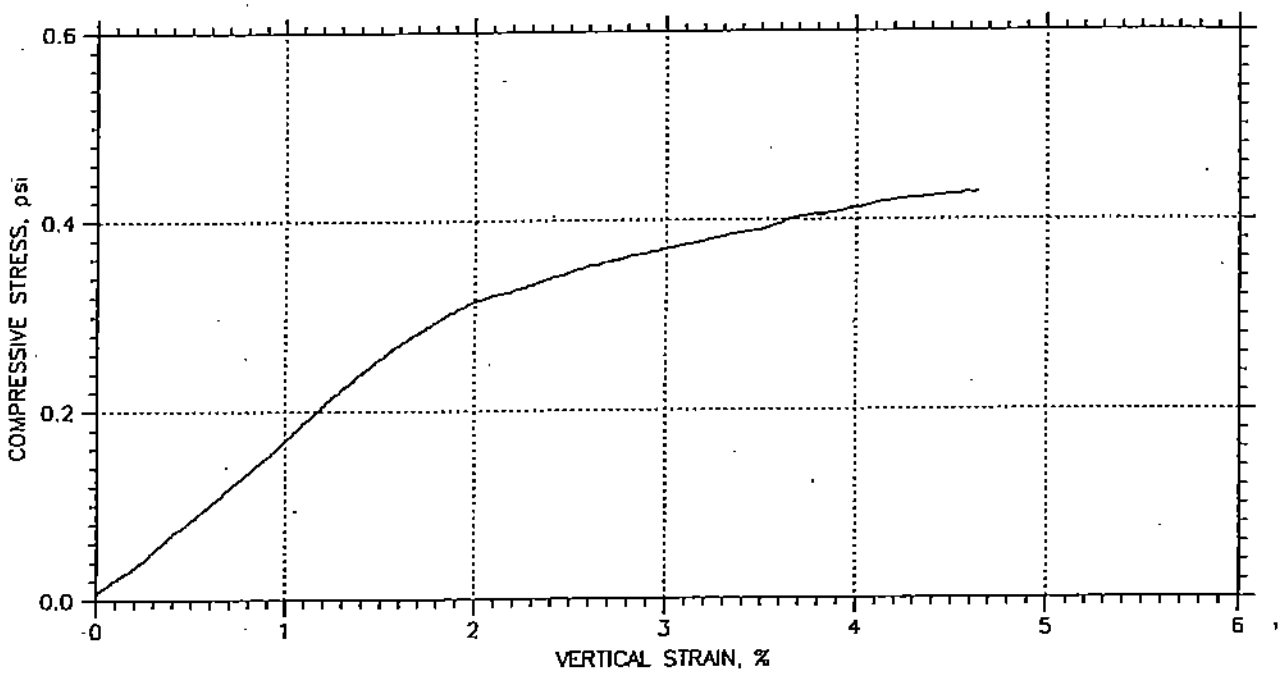
UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		4363uc9			
Initial	Diameter, in	2			
	Height, in	4			
	Water Content, %	201.07			
	Dry Density, pcf	22.213			
	Saturation, %	82.40			
	Void Ratio	6.5881			
Unconfined Compressive Strength, psi		1.6199			
Undrained Shear Strength, psi		0.80995			
Time to Failure, min		1.5856			
Strain Rate, %/min		8			
Specific Gravity		2.70			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: Pownal Tannery
Location: Pownal, VT
Project No.: GTX-4363
Boring No.: TPL1-103
Sample Type: remolded
Description: Wet, black organic silt
Remarks: TPL1-103 with 5% Portland Cement added. 1-day curing period

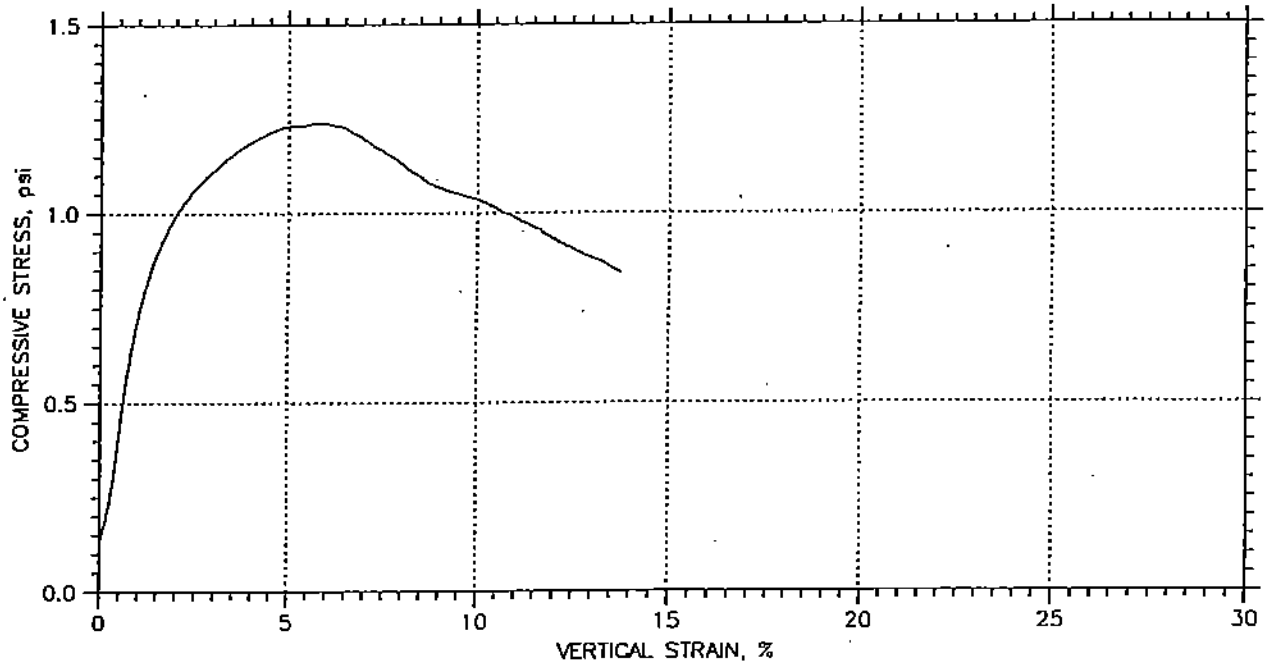
UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		4363uc2			
Initial	Diameter, in	2			
	Height, in	3.95			
	Water Content, %	125.69			
	Dry Density, pcf	35.87			
	Saturation, %	91.74			
	Void Ratio	3.699			
Unconfined Compressive Strength, psi		0.42911			
Undrained Shear Strength, psi		0.21456			
Time to Failure, min		16.851			
Strain Rate, %/min		0.5			
Specific Gravity		2.70			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: Pownal Tannery
Location: Pownal, VT
Project No.: GTX-4363
Boring No.: TPL5-102
Sample Type: remolded
Description: Wet, black organic silt
Remarks: TPL5-102 with 3% Portland Cement added, 1-day curing period

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		4363uc3			
Initial	Diameter, in	2			
	Height, in	4			
	Water Content, %	123.52			
	Dry Density, pcf	34.897			
	Saturation, %	87.08			
	Void Ratio	3.8301			
Unconfined Compressive Strength, psi		1.2397			
Undrained Shear Strength, psi		0.61984			
Time to Failure, min		5.5041			
Strain Rate, %/min		2			
Specific Gravity		2.70			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: Pownal Tannery

Location: Pownal, VT

Project No.: GTX-4363

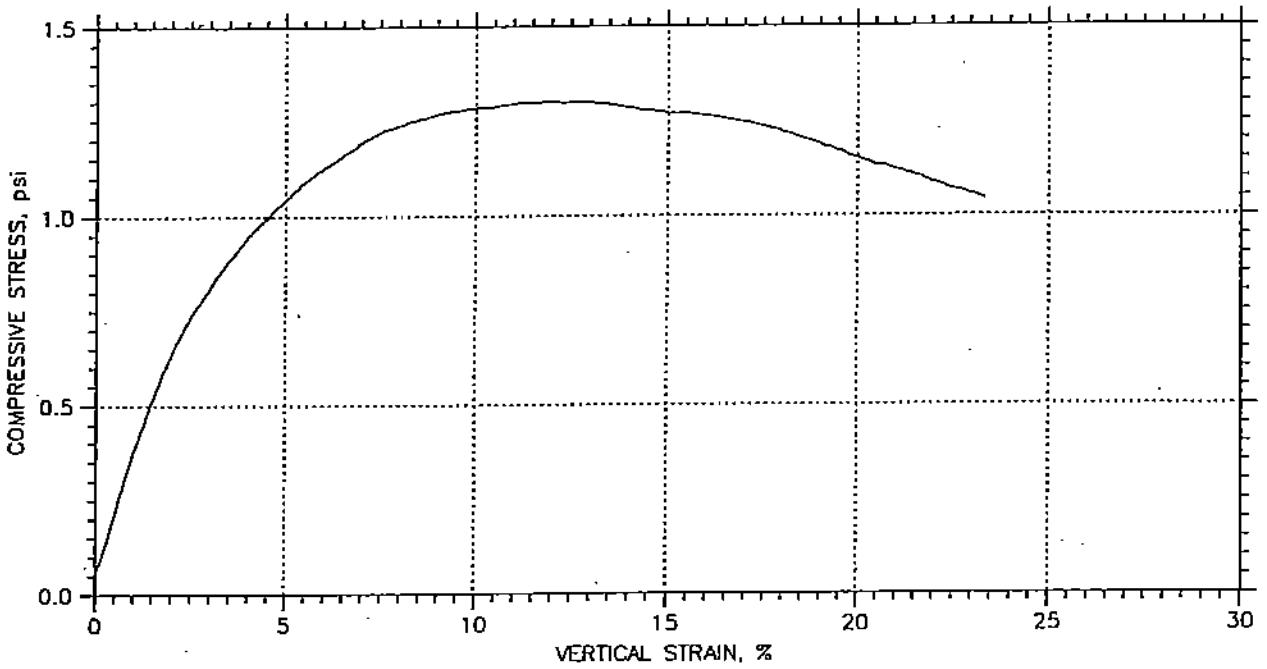
Boring No.: TPL5-102

Sample Type: remolded

Description: Wet, black organic silt

Remarks: TPL5-102 with 5% Portland Cement added. 1-day curing period

UNCONFINED COMPRESSION TEST REPORT



Symbol				
Test No.	4363uc11			
Initial — Diameter, in	2			
Initial — Height, in	4			
Initial — Water Content, %	127.75			
Initial — Dry Density, pcf	35.753			
Initial — Saturation, %	92.86			
Initial — Void Ratio	3.7145			
Unconfined Compressive Strength, psi	1.3006			
Undrained Shear Strength, psi	0.6503			
Time to Failure, min	2.6371			
Strain Rate, %/min	4			
Specific Gravity	2.70			
Liquid Limit	0			
Plastic Limit	0			
Plasticity Index	0			
Failure Sketch				

Project: Pownal Tannery
Location: Pownal, VT
Project No.: GTX-4363
Boring No.: TPL5-102
Sample Type: remolded
Description: Wet, black organic silt
Remarks: TPL5-102 with 3% Portland Cement added. 7-day curing period

GeoTesting Express
1145 Mass Avenue - Boxborough, MA 01719
(978) 635-0424 - Fax (978) 635-0266

LETTER OF TRANSMITTAL

):

Mr. Don Dwight
Metcalf & Eddy
30 Harvard Mill Square
Wakefield, MA 01888

DATE: 06/12/03	GTX NO: 4363
RE: Pownal Tannery Superfund Site Project	
Pages (excluding transmittal): 12	

e are sending you ☑ Attached ☐ Under separate cover via _____ the following items:
☑ Test results ☐ Proposal ☑ Report ☐ Samples ☐ Specifications ☐ Invoice
☐ Copy of letter ☐ Change order
☐ Other

COPIES	DATE	DESCRIPTION
1	06/12/03	**June 2003 Laboratory Test Reports**
		11 Unconfined Compressive Strength Tests (ASTM D 2166)

HESE ITEMS ARE TRANSMITTED as checked below:
☐ For approval ☐ Approved as submitted ☐ Resubmit _____ Copies for approval
☑ For your use ☐ Approved as noted ☐ Submit _____ Copies for distribution
☑ As requested ☐ Returned for corrections ☐ Return
☐ For review and comment
☐ For bids due _____, 20
☐ _____

EMARKS

COPY TO Mr. Greg Mischel
TRC Environmental
Foot of John Street
Lowell, MA 01852

SIGNED _____
Joseph Tomei – Laboratory Manager

Unconfined Compressive Strength of Soil by ASTM D 2166

Client: Metcalf & Eddy
Project Name: Pownal Tannery Superfund Site
Project Location: Pownal, VT

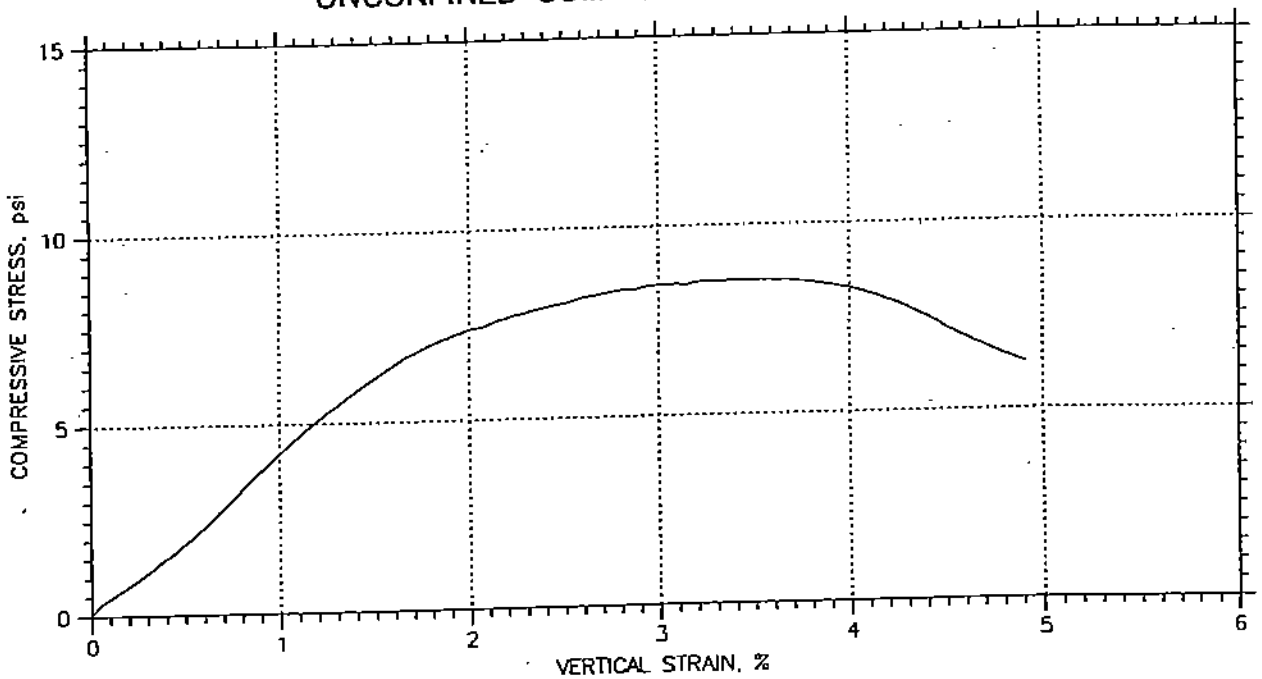
GTX #: 4363
Report Date: 06/12/03
Tested By: rbd
Checked By: jdt

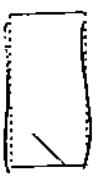
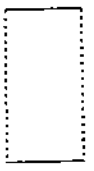
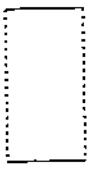
Sample ID	% Portland Cement	% Quicklime	Moisture Content, %	Bulk Density, pcf	Unconfined Compressive Strength, psi 3 day cure	7 day cure
TPL1-101 (5-7 ft.)	9 (DRY)	0	69	90.5	8.5	—
TPL1-101 (5-7 ft.)	9 (SLURRY)	0	55	91.0	4.7	—
TPL1-101 (5-7 ft.)	11	0	62	93.9	11.2	—
TPL1-101 (5-7 ft.)	13	0	63	94.6	11.1	—
TPL1-101 (5-7 ft.)	0	13 (DRY)	42	95.4	9.2	—
TPL1-101 (5-7 ft.)	0	13 (DRY)	43	89.1	—	9.1
TPL1-101 (5-7 ft.)	0	11 (DRY)	45	92.9	9.7	—
TPL1-101 (5-7 ft.)	0	11 (DRY)	47	92.2	—	7.2
TPL1-101 (5-7 ft.)	2	10	64	91.8	5.6	—
TPL1-101 (5-7 ft.)	4	8	58	90.4	12.1	—
TPL1-101 (5-7 ft.)	6	6	63	89.8	10.1	—

Notes: Moisture Contents determined by ASTM D 2216 at 60 Celsius.
See attached Unconfined Compression Test Reports for sample dimensions and Stress vs. Strain plots

Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material.

UNCONFINED COMPRESSION TEST REPORT



Symbol				
Test No.	4363uc12			
Initial: Diameter, in	2			
Initial: Height, in	4			
Initial: Water Content, %	69.44			
Initial: Dry Density, pcf	53.421			
Initial: Saturation, %	86.99			
Initial: Void Ratio	2.1552			
Unconfined Compressive Strength, psi	8.537			
Undrained Shear Strength, psi	4.2685			
Time to Failure, min	1.67			
Strain Rate, %/min	2			
Specific Gravity	2.70			
Liquid Limit	0			
Plastic Limit	0			
Plasticity Index	0			
Failure Sketch				

Project: Pownal Superfund Site

Location: Pownal, VT

Project No.: GTX-4363

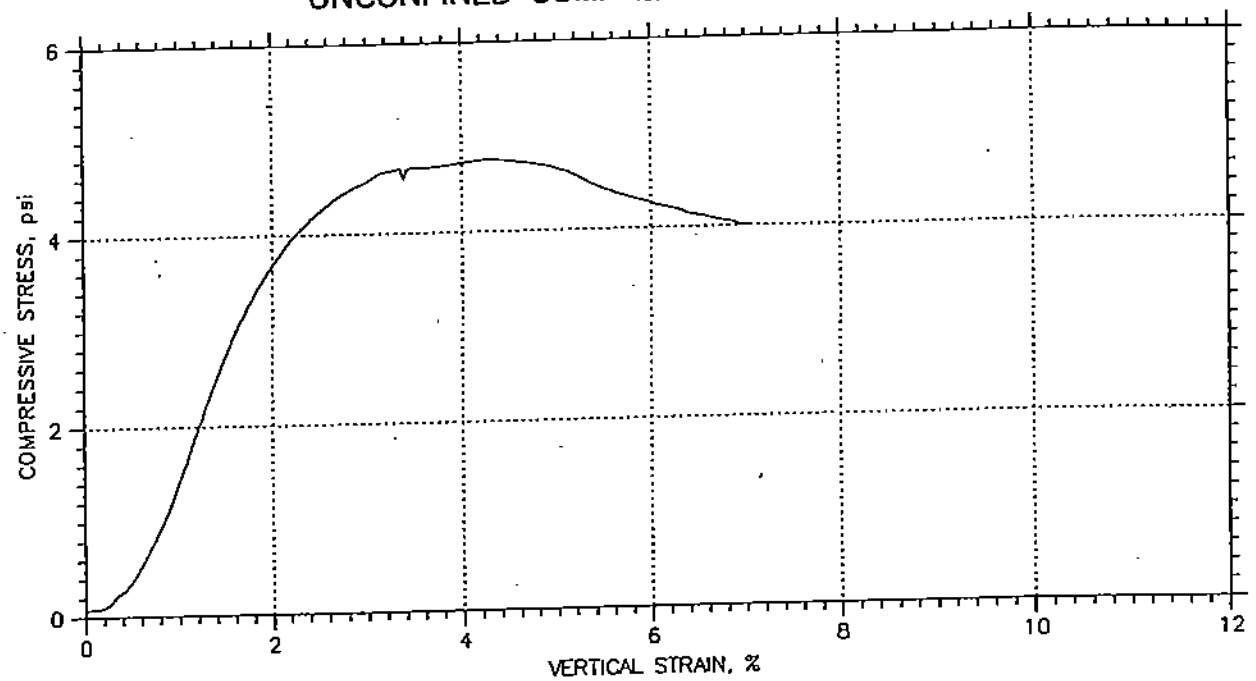
Boring No.: 9% Portland

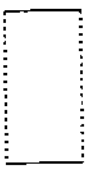
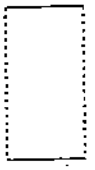
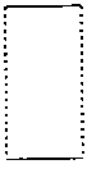
Sample Type: remolded

Description: Wet, black silt and organics with 9% Portland Cement DRY

Remarks: Sample ID: TPL1-101 (5-7 ft.) with 9% Portland Cement added DRY. 3-day curing period.

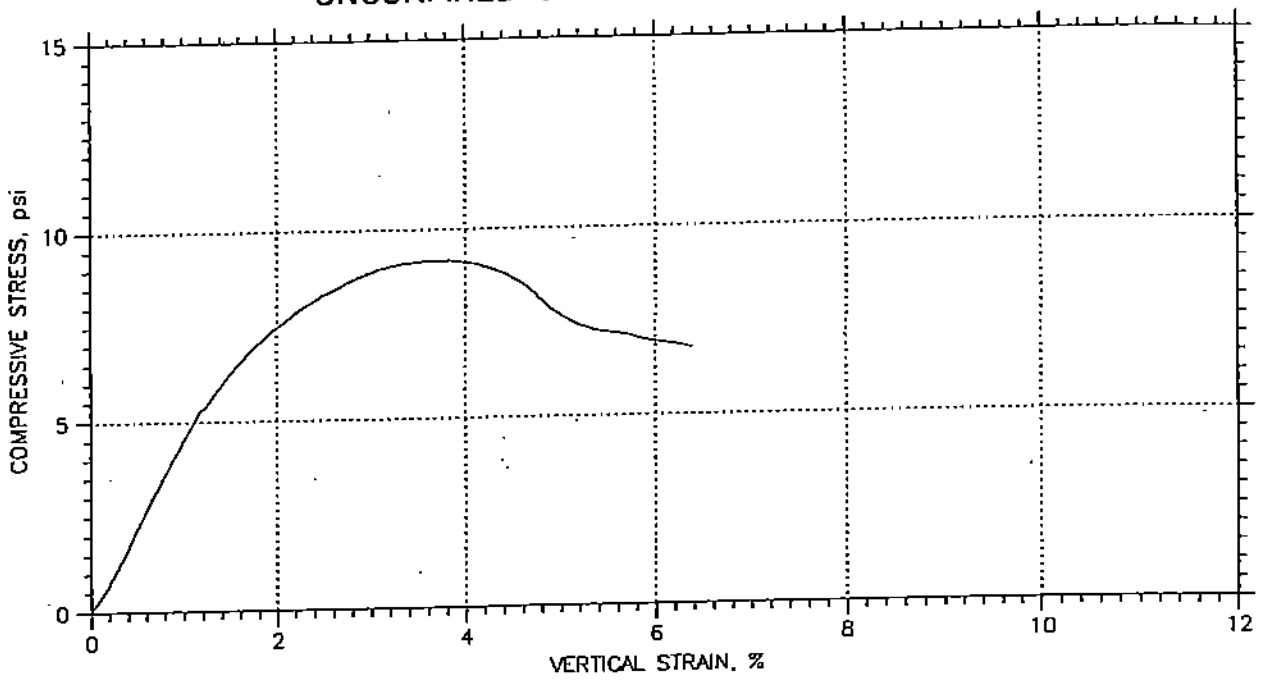
UNCONFINED COMPRESSION TEST REPORT

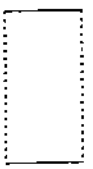
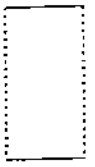
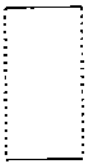


Symbol				
Test No.	4363uc13			
Initial: Diameter, in	2			
Initial: Height, in	3.95			
Initial: Water Content, %	55.35			
Initial: Dry Density, pcf	58.582			
Initial: Saturation, %	79.60			
Initial: Void Ratio	1.8772			
Unconfined Compressive Strength, psi	4.7622			
Undrained Shear Strength, psi	2.3811			
Time to Failure, min	2.0851			
Strain Rate, %/min	2			
Specific Gravity	2.70			
Liquid Limit	0			
Plastic Limit	0			
Plasticity Index	0			
Failure Sketch				

Project: Pownal Superfund Site
Location: Pownal, VT
Project No.: GTX-4363
Boring No.: 9% Portland
Sample Type: remolded
Description: Wet, black silt and organics with 9% Portland Cement SLURRY
Remarks: Sample ID: TPL1-101 (5-7 ft.) with 9% Portland Cement added in SLURRY. 3-day curing period.

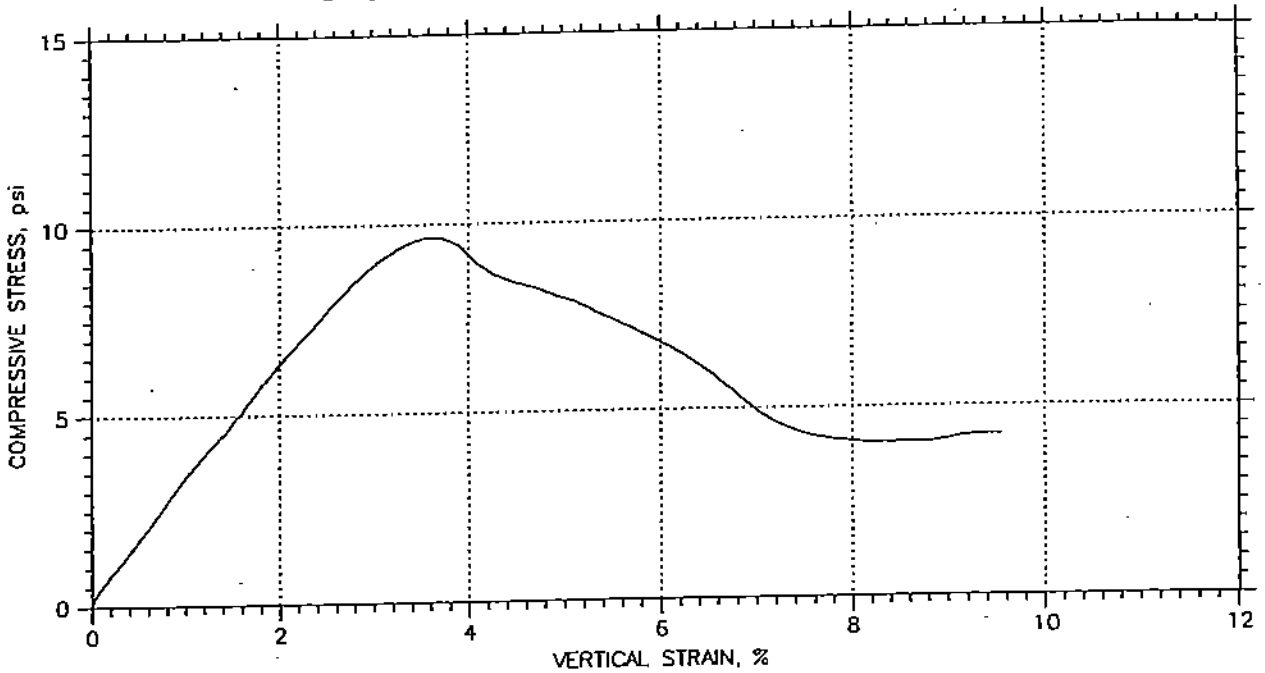
UNCONFINED COMPRESSION TEST REPORT

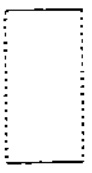
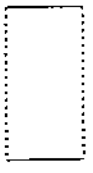
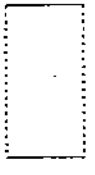


Symbol					
Test No.		4363uc14			
Initial	Diameter, in	2			
	Height, in	4			
	Water Content, %	42.11			
	Dry Density, pcf	67.129			
	Saturation, %	75.24			
	Void Ratio	1.5109			
Unconfined Compressive Strength, psi		9.1709			
Undrained Shear Strength, psi		4.5854			
Time to Failure, min		1.7869			
Strain Rate, %/min		2			
Specific Gravity		2.70			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: Pownal Superfund Site
Location: Pownal, VT
Project No.: GTX-4363
Boring No.: 13% Lime
Sample Type: remolded
Description: Wet, black silt and organics with 13% Quicklime DRY
Remarks: Sample ID: TPL1-101 (5-7 ft.) with 13% Quicklime added DRY. 3-day curing period.

UNCONFINED COMPRESSION TEST REPORT



Symbol				
Test No.	4363uc15			
Initial: Diameter, in	2			
Initial: Height, in	3.7			
Initial: Water Content, %	44.52			
Initial: Dry Density, pcf	64.274			
Initial: Saturation, %	74.08			
Initial: Void Ratio	1.6224			
Unconfined Compressive Strength, psi	9.6566			
Undrained Shear Strength, psi	4.8283			
Time to Failure, min	1.7193			
Strain Rate, %/min	2			
Specific Gravity	2.70			
Liquid Limit	0			
Plastic Limit	0			
Plasticity Index	0			
Failure Sketch				

Project: Pownal Superfund Site

Location: Pownal, VT

Project No.: GTX-4363

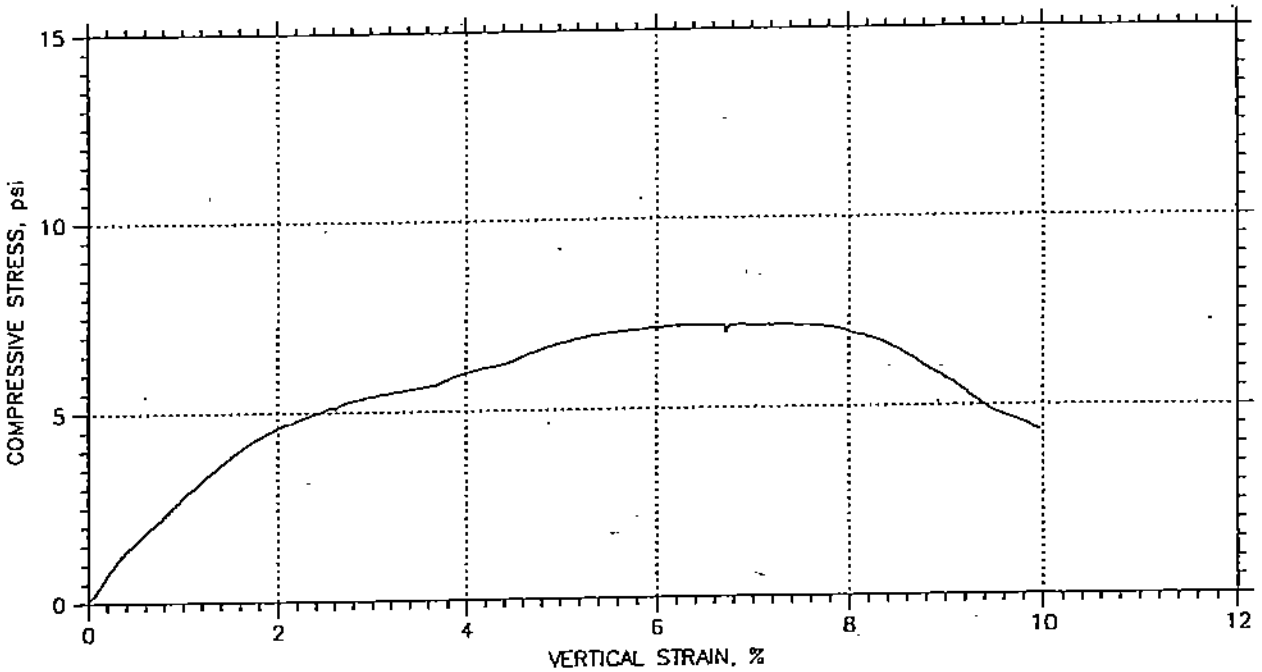
Boring No.: 11% Lime

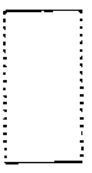
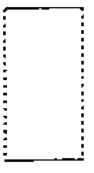
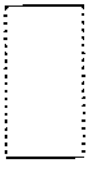
Sample Type: --

Description: Wet, black silt and organics with 11% Quicklime DRY

Remarks: Sample ID: TPL1-101 (5-7 ft.) with 11% Quicklime added DRY. 3-day curing period.

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		4363uc16			
Initial	Diameter, in	2.01			
	Height, in	3.97			
	Water Content, %	47.26			
	Dry Density, pcf	62.636			
	Saturation, %	75.46			
	Void Ratio	1.691			
Unconfined Compressive Strength, psi		7.164			
Undrained Shear Strength, psi		3.582			
Time to Failure, min		5.9836			
Strain Rate, %/min		1			
Specific Gravity		2.70			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: Pownal Superfund Site

Location: Pownal, VT

Project No.: GTX-4363

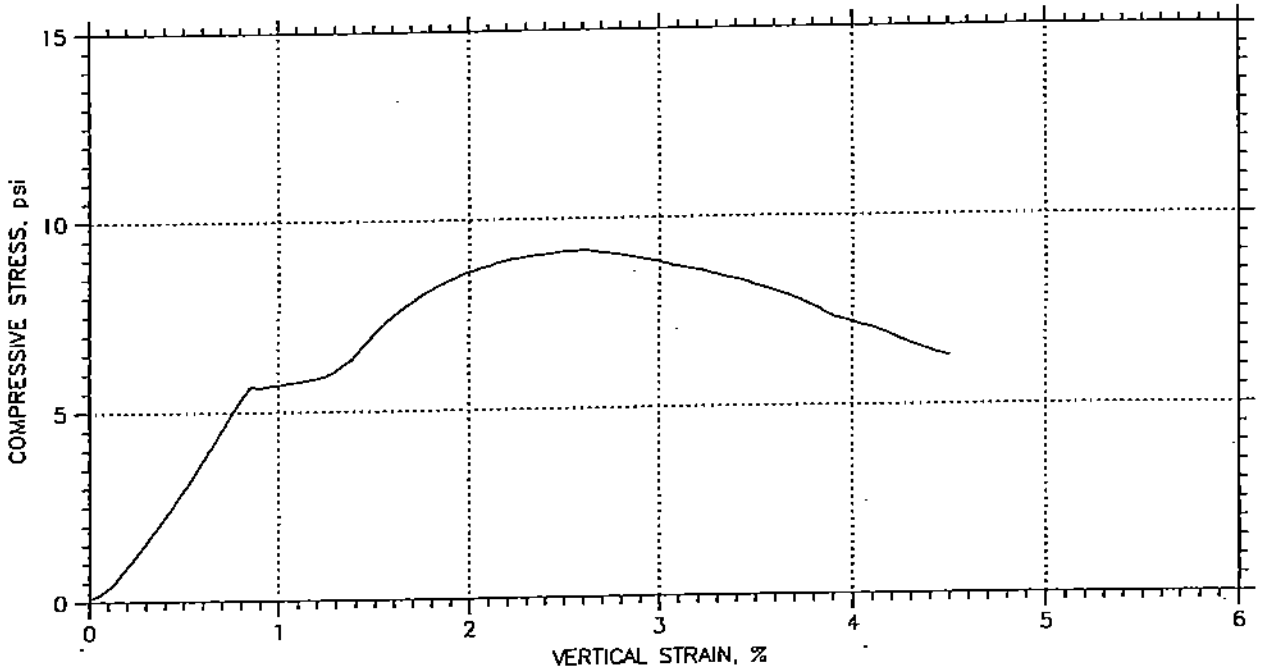
Boring No.: 11% Lime

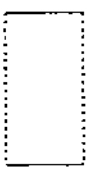
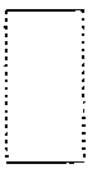
Sample Type: remolded

Description: Wet, black silt and organics with 11% Quicklime DRY

Remarks: Sample ID: TPL1-101 (5-7 ft.) with 11% Quicklime added DRY. 7-day curing period.

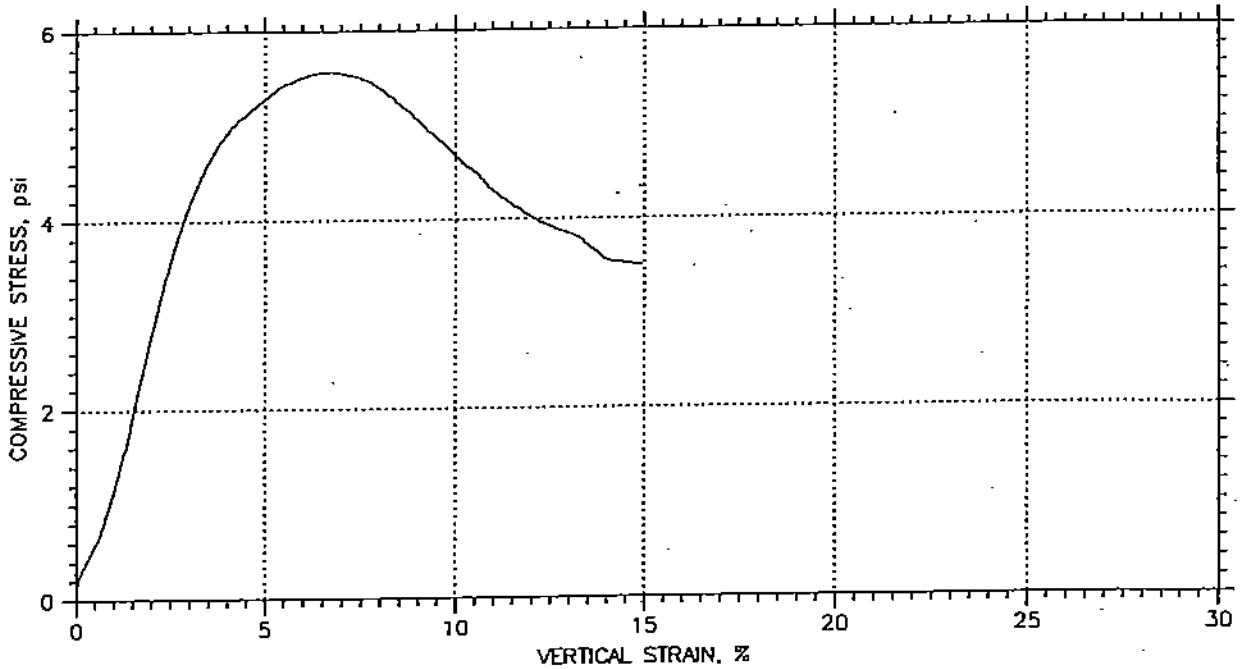
UNCONFINED COMPRESSION TEST REPORT

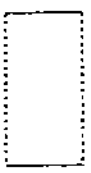
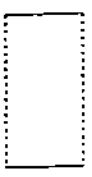


Symbol					
Test No.		4363uc17			
Initial	Diameter, in	2.01			
	Height, in	4			
	Water Content, %	42.88			
	Dry Density, pcf	62.389			
	Saturation, %	68.04			
	Void Ratio	1.7017			
Unconfined Compressive Strength, psi		9.1497			
Undrained Shear Strength, psi		4.5748			
Time to Failure, min		2.4519			
Strain Rate, %/min		1			
Specific Gravity		2.70			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: Pownal Superfund Site
Location: Pownal, VT
Project No.: GTX-4363
Boring No.: 13% lime
Sample Type: remolded
Description: Wet, black silt and organics with 13% Quicklime DRY
Remarks: Sample ID: TPL1-101 (5-7 ft.) with 13% Quicklime added DRY. 7-day curing period.

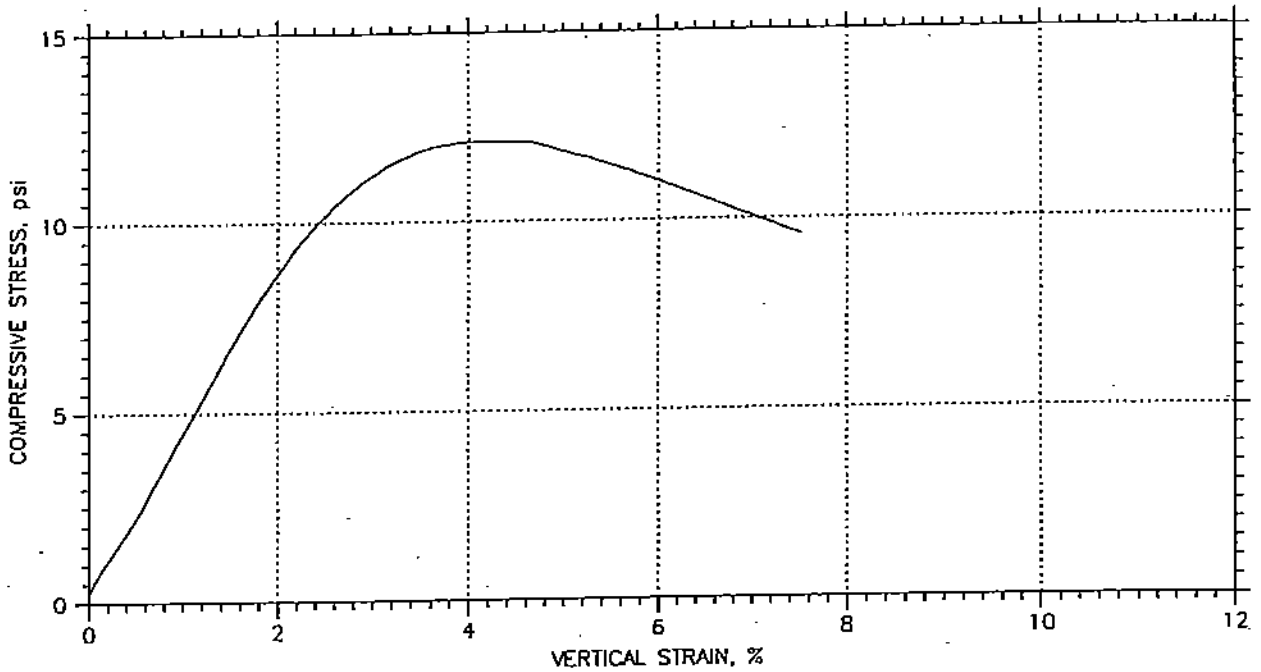
UNCONFINED COMPRESSION TEST REPORT

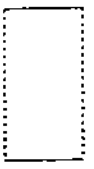
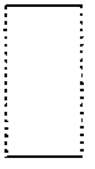


Symbol					
Test No.		4363-UC1			
Initial	Diameter, in	2			
	Height, in	4			
	Water Content, %	63.70			
	Dry Density, pcf	56.057			
	Saturation, %	85.70			
	Void Ratio	2.0069			
Unconfined Compressive Strength, psi		5.5688			
Undrained Shear Strength, psi		2.7844			
Time to Failure, min		1.6818			
Strain Rate, %/min		1			
Specific Gravity		2.70			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: Pownal Superfund Site
Location: Pownal, VT
Project No.: GTX-4363
Boring No.: 10% L/2% C
Sample Type: remolded
Description: Wet, black silt and organics with 10% Quicklime and 2% Cement
Remarks: Sample ID: TPL1-101 (5-7 ft.) with 10% Quicklime and 2% Portland Cement added. 3-day curing period.

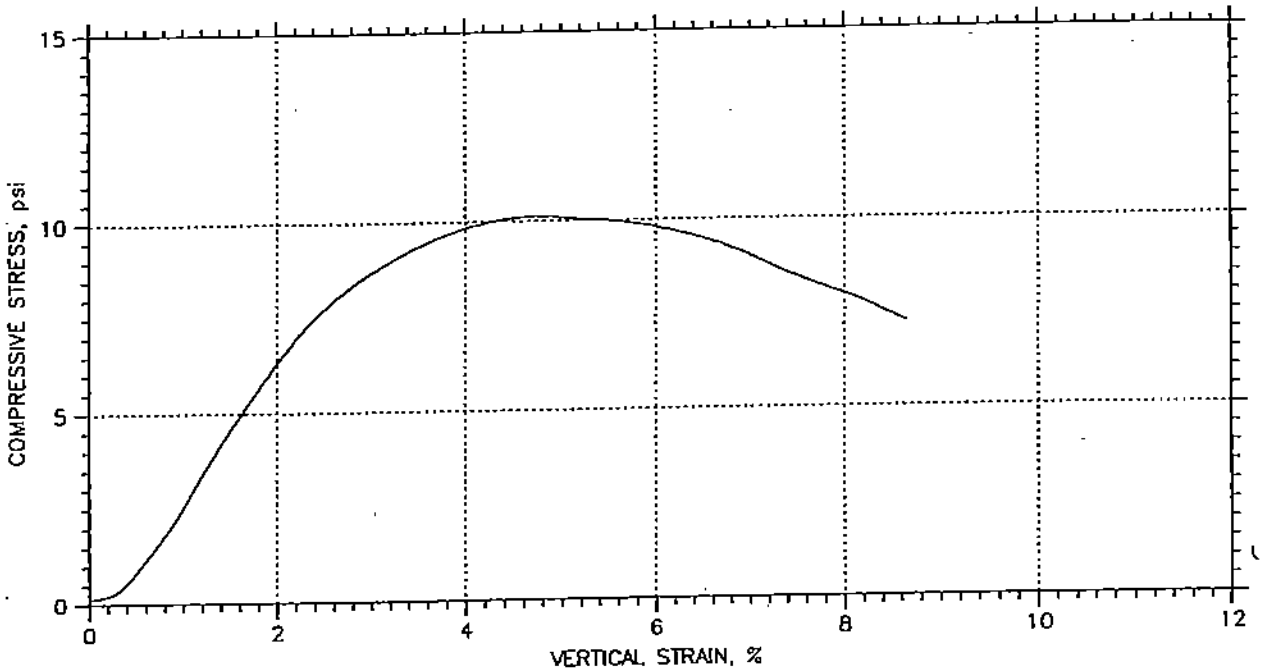
UNCONFINED COMPRESSION TEST REPORT

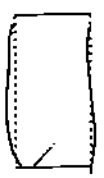
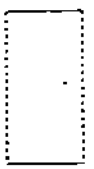
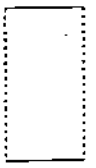
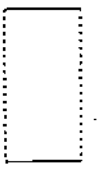


Symbol					
Test No.		4363-UC2			
Initial	Diameter, in	2			
	Height, in	4			
	Water Content, %	58.34			
	Dry Density, pcf	57.113			
	Saturation, %	80.72			
	Void Ratio	1.9513			
Unconfined Compressive Strength, psi		12.113			
Undrained Shear Strength, psi		6.0565			
Time to Failure, min		1.0935			
Strain Rate, %/min		1.			
Specific Gravity		2.70			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: Pownal Superfund Site
Location: Pownal, VT
Project No.: GTX-4363
Boring No.: 8% L/4% C
Sample Type: remolded
Description: Wet, black silt and organics with 8 Quicklime and 4% Cement
Remarks: Sample ID: TPL1-101 (5-7 ft.) with 8% Quicklime and 4% Portland Cement added. 3-day curing period.

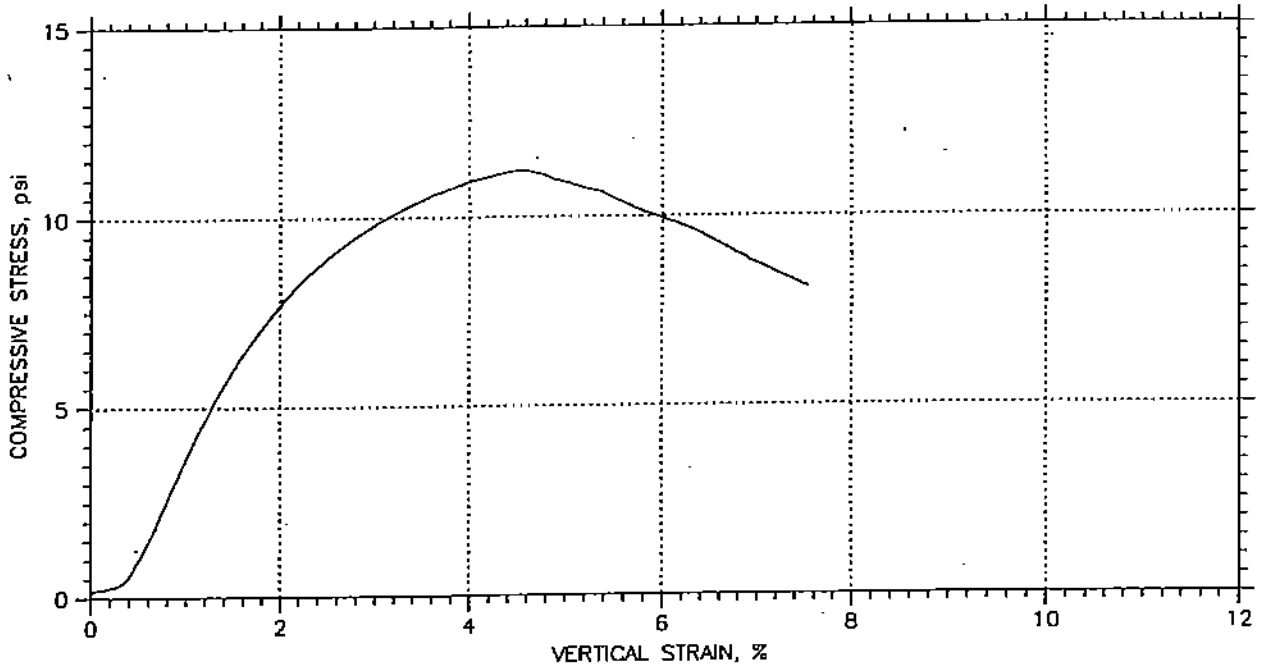
UNCONFINED COMPRESSION TEST REPORT

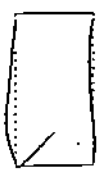
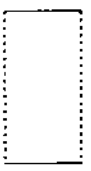
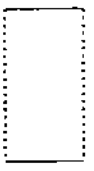
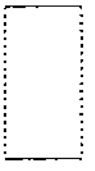


Symbol					
Test No.		4363-UC3			
Initial	Diameter, in	2			
	Height, in	4			
	Water Content, %	63.25			
	Dry Density, pcf	55.021			
	Saturation, %	82.76			
	Void Ratio	2.0635			
Unconfined Compressive Strength, psi		10.114			
Undrained Shear Strength, psi		5.057			
Time to Failure, min		1.1934			
Strain Rate, %/min		1			
Specific Gravity		2.70			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: Pownal Superfund Site
Location: Pownal, VT
Project No.: GTX-4363
Boring No.: 6% L/6% C
Sample Type: remolded
Description: Wet, black silt and organics with 6% Quicklime and 6% Cement
Remarks: Sample ID: TPL1-101 (5-7 ft.) with 6% Quicklime and 6% Portland Cement added. 3-day curing period.

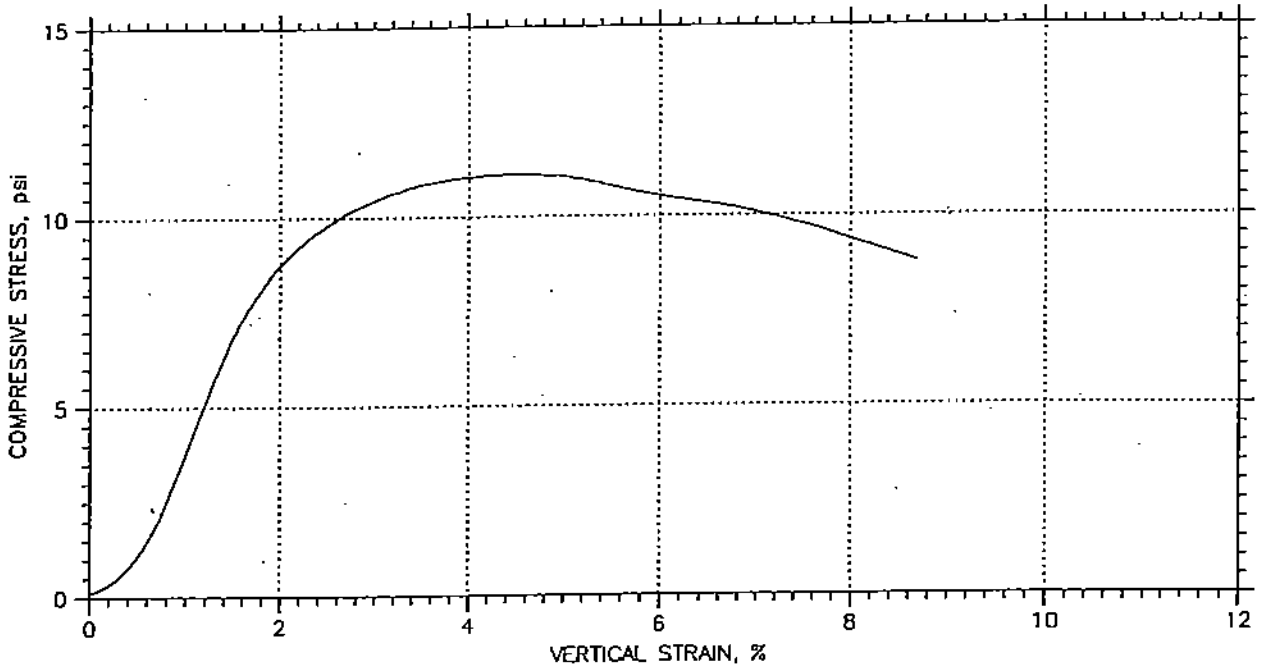
UNCONFINED COMPRESSION TEST REPORT

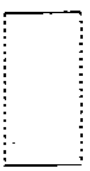
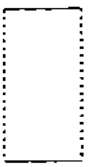


Symbol					
Test No.		4363-UC4			
Initial	Diameter, in	2			
	Height, in	4			
	Water Content, %	62.30			
	Dry Density, pcf	57.834			
	Saturation, %	87.86			
	Void Ratio	1.9145			
Unconfined Compressive Strength, psi		11.211			
Undrained Shear Strength, psi		5.6053			
Time to Failure, min		1.1521			
Strain Rate, %/min		1			
Specific Gravity		2.70			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: Pownal Superfund Site
Location: Pownal, VT
Project No.: GTX-4363
Boring No.: 11% Cement
Sample Type: remolded
Description: Wet, black silt and organics with 11% Portland Cement
Remarks: Sample ID: TPL1-101 (5-7 ft.) with 11% Portland Cement added. 3-day curing period.

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		4363-UC5			
Initial	Diameter, in	2			
	Height, in	4			
	Water Content, %	63.11			
	Dry Density, pcf	57.989			
	Saturation, %	89.37			
	Void Ratio	1.9067			
Unconfined Compressive Strength, psi		11.109			
Undrained Shear Strength, psi		5.5545			
Time to Failure, min		1.1225			
Strain Rate, %/min		1			
Specific Gravity		2.70			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: Pownal Superfund Site
Location: Pownal, VT
Project No.: GTX-4363
Boring No.: 13% Cement
Sample Type: remolded
Description: Wet, black silt and organics with 13% Portland Cement
Remarks: Sample ID: TPL1-101 (5-7 ft.) with 13% Portland Cement added. 3-day curing period.

GeoTesting Express
1145 Mass Avenue - Boxborough, MA 01719
(978) 635-0424 - Fax (978) 635-0266

LETTER OF TRANSMITTAL

TO:

Mr. Don Dwight
Metcalf & Eddy
30 Harvard Mill Square
Wakefield, MA 01888

DATE: 06/25/03	GTX NO: 4363
RE: Pownal Tannery Superfund Site Project	
Pages (excluding transmittal): 7	

We are sending you ☑ Attached ☐ Under separate cover via _____ the following items:
☑ Test results ☐ Proposal ☑ Report ☐ Samples ☐ Specifications ☐ Invoice
☐ Copy of letter ☐ Change order
☐ Other

COPIES	DATE	DESCRIPTION
1	06/25/03	**June 2003 Laboratory Test Reports**
		5 Unconfined Compressive Strength Tests (ASTM D 2166)

THESE ITEMS ARE TRANSMITTED as checked below:
☐ For approval ☐ Approved as submitted ☐ Resubmit _____ Copies for approval
☑ For your use ☐ Approved as noted ☐ Submit _____ Copies for distribution
☑ As requested ☐ Returned for corrections ☐ Return
☐ For review and comment
☐ For bids due _____, 20
☐ _____

REMARKS

_____

COPY TO Mr. Greg Mischel
TRC Environmental
Foot of John Street
Lowell, MA 01852

SIGNED _____
Joseph Tomei - Laboratory Manager

Geotechnical Test Report

Pownal Tannery Superfund Site
Pownal, VT

Prepared for:

Metcalf & Eddy

Wakefield, MA

Prepared by:

GeoTesting Express, Inc.

Boxborough, MA

June 25, 2003

Unconfined Compressive Strength of Soil by ASTM D 2166

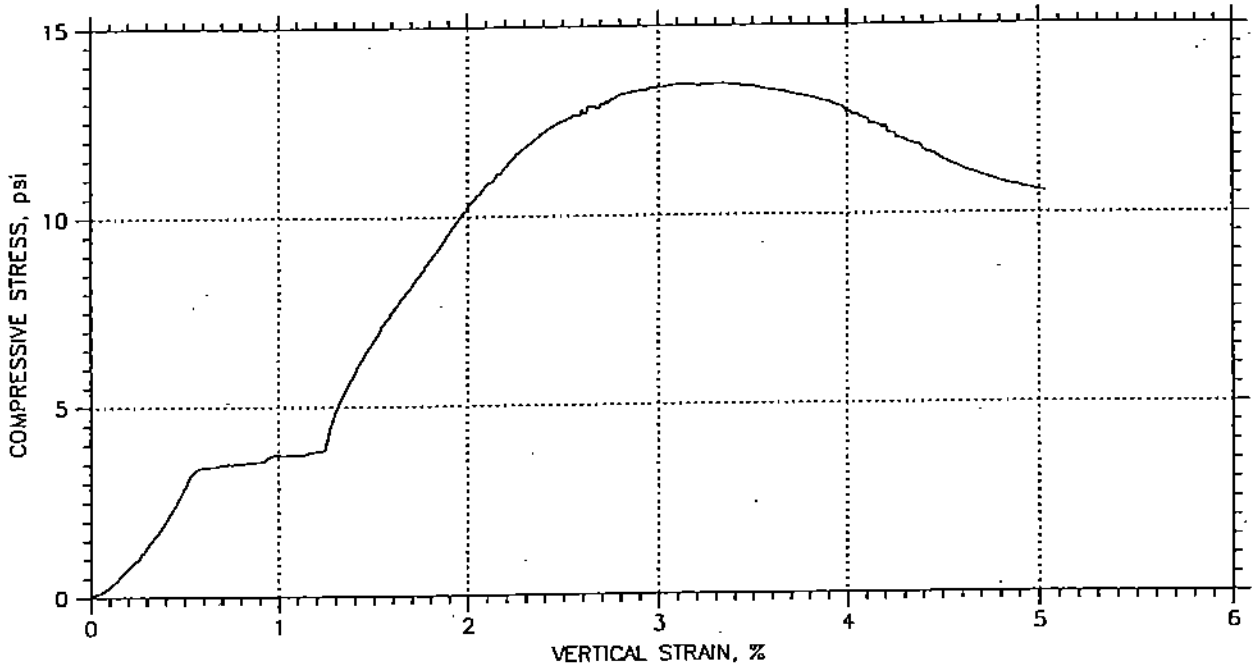
Client:	Metcalf & Eddy	GTX #:	4363
Project Name:	Pownal Tannery Superfund Site	Report Date:	06/25/03
Project Location:	Pownal, VT	Tested By:	rbd
		Checked By:	jdt

Sample ID	% Portland Cement	% Quicklime	Moisture Content, %	Bulk Density, pcf	Unconfined Compressive Strength, psi	
					3 day cure	7 day cure
TPL1-101 (5-7 ft.)	9 (DRY)	0	69	90.5	8.5	—
TPL1-101 (5-7 ft.)	9 (SLURRY)	0	55	91.0	4.7	—
TPL1-101 (5-7 ft.)	11	0	62	93.9	11.2	13.5
TPL1-101 (5-7 ft.)	13	0	63	94.6	11.1	23.8
TPL1-101 (5-7 ft.)	0	13 (DRY)	42	95.4	9.2	—
TPL1-101 (5-7 ft.)	0	13 (DRY)	43	89.1	—	9.1
TPL1-101 (5-7 ft.)	0	11 (DRY)	45	92.9	9.7	—
TPL1-101 (5-7 ft.)	0	11 (DRY)	47	92.2	—	7.2
TPL1-101 (5-7 ft.)	2	10	64	91.8	5.6	9.9
TPL1-101 (5-7 ft.)	4	8	58	90.4	12.1	18.2
TPL1-101 (5-7 ft.)	6	6	63	89.8	10.1	10.6

Notes: Moisture Contents determined by ASTM D 2216 at 60 Celsius.
See attached Unconfined Compression Test Reports for sample dimensions and Stress vs. Strain plots

Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material.

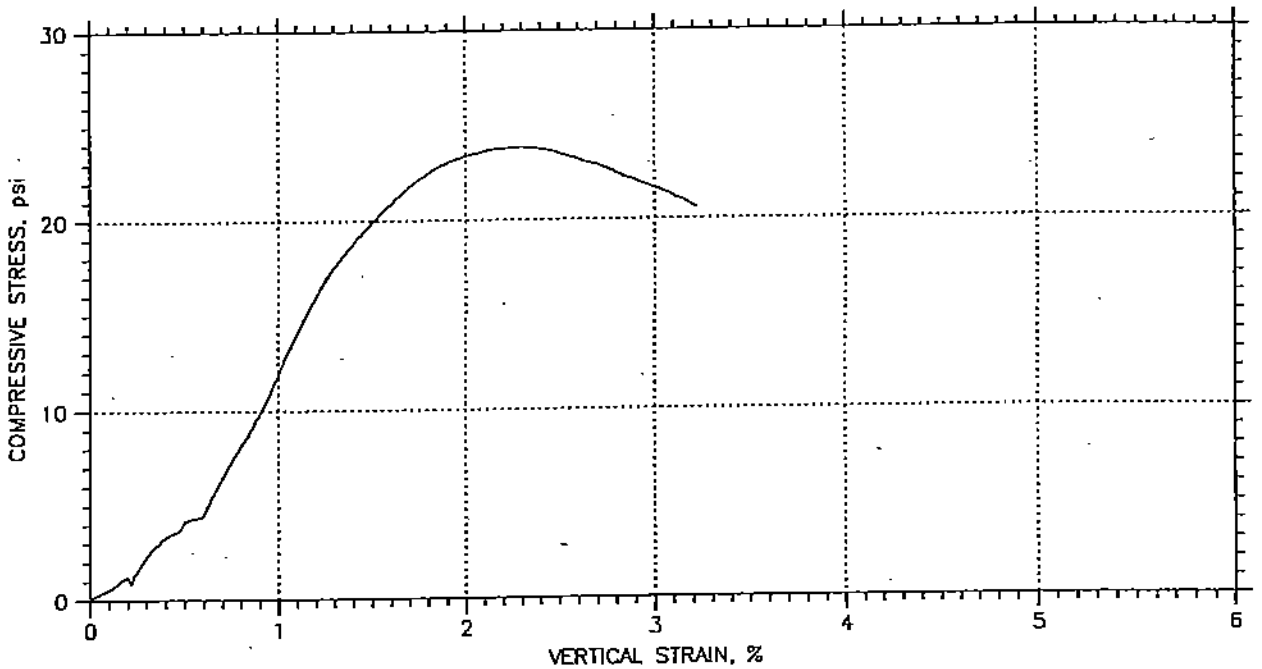
UNCONFINED COMPRESSION TEST REPORT

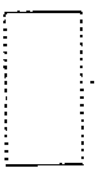
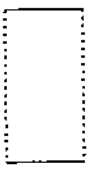
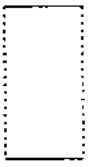


Symbol					
Test No.		4363uc5			
Initial	Diameter, in	2			
	Height, in	3.95			
	Water Content, %	73.30			
	Dry Density, pcf	53.589			
	Saturation, %	92.25			
	Void Ratio	2.1453			
Unconfined Compressive Strength, psi		13.469			
Undrained Shear Strength, psi		6.7343			
Time to Failure, min		3.0303			
Strain Rate, %/min		1			
Specific Gravity		2.70			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: Pownal Tannery Superfund
Location: Pownal, VT
Project No.: GTX-4363
Boring No.: 11% Cement
Sample Type: remolded
Description: Wet, black silt and organics with 11% Portland Cement
Remarks: Sample ID: TPL1-101 (5-7 ft.) with 11% Portland Cement added. 7-day curing period.

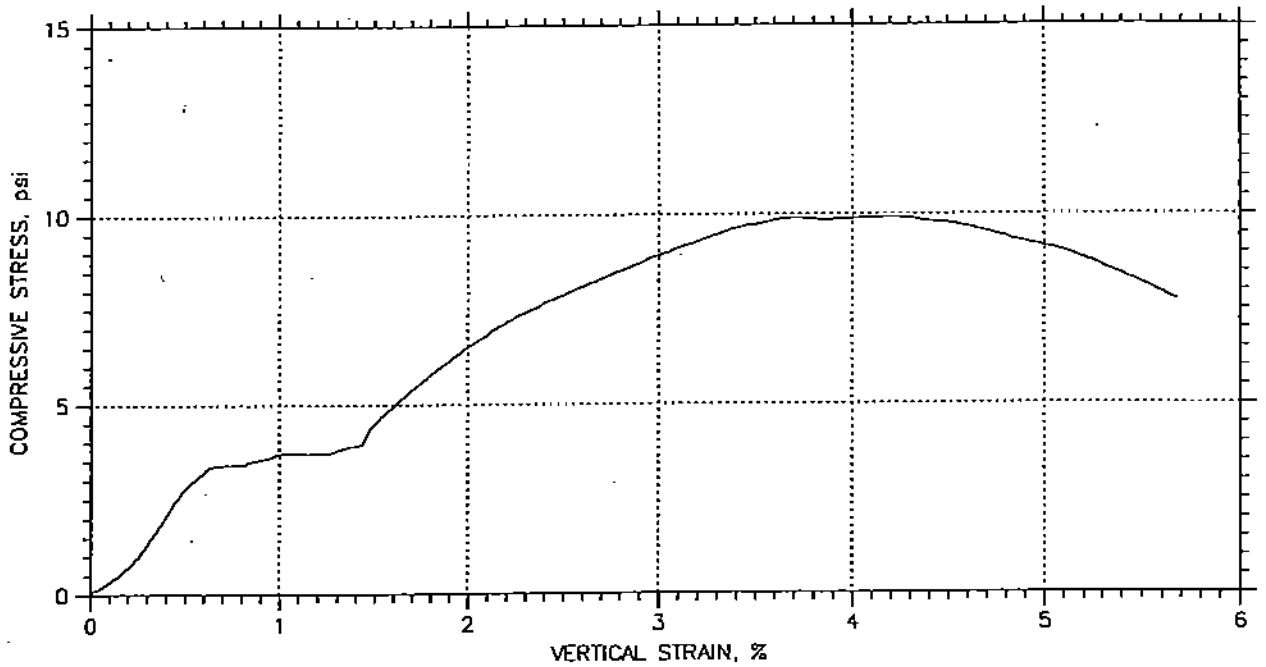
UNCONFINED COMPRESSION TEST REPORT

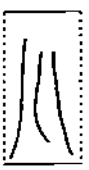
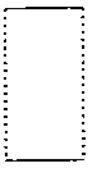
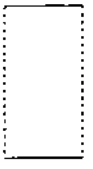


Symbol					
Test No.		4363uc6			
Initial	Diameter, in	2			
	Height, in	3.95			
	Water Content, %	60.41			
	Dry Density, pcf	59.57			
	Saturation, %	89.15			
	Void Ratio	1.8295			
Unconfined Compressive Strength, psi		23.836			
Undrained Shear Strength, psi		11.918			
Time to Failure, min		2.263			
Strain Rate, %/min		1			
Specific Gravity		2.70			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: Pownal Tannery Superfund
Location: Pownal, VT
Project No.: GTX-4363
Boring No.: 13% Cement
Sample Type: remolded
Description: Wet, black silt and organics with 13% Portland Cement
Remarks: Sample ID: TPL1-101 (5-7 ft.) with 13% Portland Cement added. 7-day curing period.

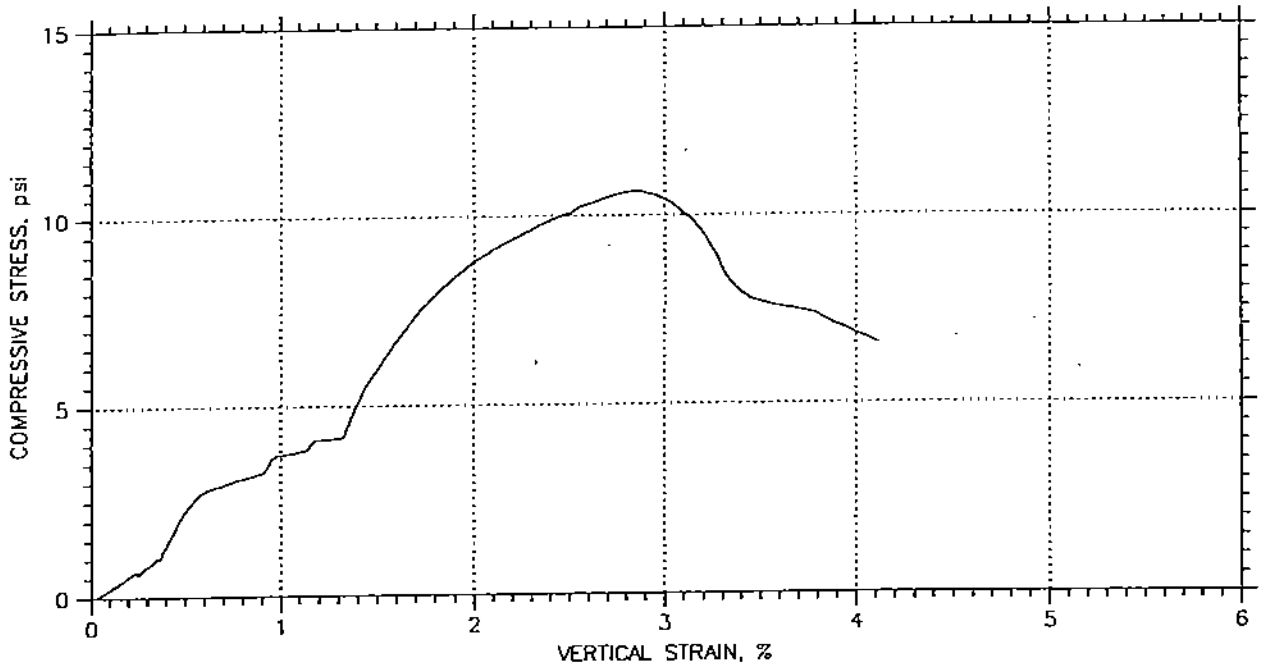
UNCONFINED COMPRESSION TEST REPORT

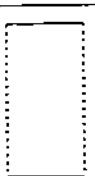
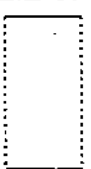


Symbol					
Test No.		4363uc4			
Initial	Diameter, in	2			
	Height, in	3.95			
	Water Content, %	56.49			
	Dry Density, pcf	56.569			
	Saturation, %	77.05			
	Void Ratio	1.9796			
Unconfined Compressive Strength, psi		9.9043			
Undrained Shear Strength, psi		4.9521			
Time to Failure, min		2.7316			
Strain Rate, %/min		1.5			
Specific Gravity		2.70			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: Pownal Tannery Superfund
Location: Pownal, VT
Project No.: GTX-4363
Boring No.: 10% L/2% C
Sample Type: remolded
Description: Wet, black silt and organics with 10% Quicklime and 2% Cement
Remarks: Sample ID: TPL1-101 (5-7 ft.) with 10% Quicklime and 2% Portland Cement added. 7-day curing period.

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		4363uc2			
Initial	Diameter, in	2			
	Height, in	3.95			
	Water Content, %	59.01			
	Dry Density, pcf	56.235			
	Saturation, %	79.78			
	Void Ratio	1.9974			
Unconfined Compressive Strength, psi		10.649			
Undrained Shear Strength, psi		5.3244			
Time to Failure, min		2.7607			
Strain Rate, %/min		1			
Specific Gravity		2.70			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: Pownal Tannery Superfund
Location: Pownal, VT
Project No.: GTX-4363
Boring No.: 6% L/6% C
Sample Type: remolded
Description: Wet, black silt and organics with 6% Quicklime and 6% Cement
Remarks: Sample ID: TPL1-101 (5-7 ft.) with 6% Quicklime and 6% Portland Cement added. 7-day curing period.

APPENDIX D

TRC MEMORANDUM ON WASTEWATER DISCHARGE

TRC

TRC Reference Number: 02136-0510-01N9B

May 9, 2003

Mr. Brian Woods
Vermont Department of Environmental Conservation
Waste Management Division
103 South Main Street / West Building
Waterbury, VT 05671-0404

Subject: Technical Memorandum
Proposed Discharge Criteria for Dewater Effluent
Pownal Tannery Superfund Site

Dear Mr. Woods:

Please find enclosed the above referenced technical memorandum. This memorandum presents proposed Hoosic River discharge criteria for treated dewater effluent generated during the Remedial Action at the Pownal Tannery Superfund Site.

If you have any questions please contact me at 978-656-3560.

Sincerely;

Dale S. Weiss

Dale S. Weiss, P.G.
Senior Program Manager

cc: Leslie McVickar, EPA
Don Dwight, M&E

TECHNICAL MEMORANDUM
PROPOSED DISCHARGE CRITERIA FOR DEWATER EFFLUENT
POWNAL TANNERY SUPERFUND SITE
POWNAL, VERMONT

1.0 INTRODUCTION

This technical memorandum presents the development of discharge criteria proposed to be implemented for the dewatering discharge generated during the Remedial Action (RA) at the Pownal Tannery Superfund Site. The methods and assumptions used to develop the discharge standards were recommended by Mr. Brian Woods of the Vermont Department of Environmental Conservation (VTDEC) in an email to Dale Weiss of TRC Environmental Corporation (TRC) dated April 9, 2003.

A dewatering pump and treat system with a capacity of approximately 300 gallons per minute (gpm) is anticipated. This system will remove existing accumulated surface water and excavation water that needs to be removed prior to and during sludge excavation from Lagoons 1 and 5. Subsequent dewatering may be conducted to allow for confirmatory sample collection. An estimated 2 million gallons of existing standing water will be pumped from Lagoons 1 and 5. At 300 gpm, or 18,000 gallons per hour (gph), the initial pumping period will be approximately 111 hours. Additionally, an estimated 2 million gallons will be pumped intermittently during the excavation work. The project is expected to be conducted in fall 2003 and spring 2004.

As described in the Lagoon Area Remediation 30% Basis of Design Report (March 2003) by TRC, water removed from the excavation will be treated employing best management practices to remove potential contaminants. The technical specifications for the RA will require the contractor to provide a water treatment system to remove contaminants of concern including volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), metals, polychlorinated biphenyls (PCBs), and dioxin. Typical treatment system arrangements for these types of compounds consist of settling tanks to remove bulk solids and granular activated carbon (GAC) units in series. Additional methods to remove suspended solids may be required to remove the organic compounds that are likely adsorbed to the organic matter in the sludge materials. Other treatment methods will be evaluated in the pre-final design including metals precipitation (chemical precipitation, electrochemical precipitation, and iron co-precipitation) and other suspended solids removal (coagulation, clarification, and filtration). Discharge effluent will be pumped directly to the Hoosic River. All filtered sediment will be placed in the consolidation landfill.

2.0 CALCULATION OF DISCHARGE CRITERIA

Remedial Investigation (RI) data are used to develop the list of Contaminants of Concern (COCs). Compounds detected in each medium (i.e., soil, sludge, groundwater, surface water, and sediment) are summarized in Table 1. Each medium in which contaminants were detected during the Remedial Investigation is indicated. If a compound was detected in any medium, it is considered a potential COC.

Pesticides are eliminated as a COC since they were generally detected at low concentrations in surface soil samples and are not likely to be present in subsurface sludge excavations. In addition, pesticides were not detected in surface water samples collected during the RI.

The applicable in-stream standards for discharge are the Vermont Water Quality Standards (July 2000). The lower of *Protection of Human Health/Consumption of Organisms Only* and *Protection of Aquatic Biota/Average Allowable Concentration - Chronic Criteria* is selected. For those standards that vary with hardness, a hardness of 100 ppm $CaCO_3$ is assumed. For contaminants of concern that do not have corresponding Vermont Water Quality Standards, the VT Groundwater Enforcement Standard or Federal Drinking Water Maximum Contaminant Level (MCL) is used. If none of the above standards exist for a compound, it is not further considered a COC.

To calculate the discharge criterion for a compound, the selected in-stream standard is modified to consider dilution provided by the Hoosic River using the 7Q10 Flow of 56 cubic feet per second (cfs). The discharge criterion is then calculated by multiplying the selected COC standard by the ratio of the 7Q10 Flow to the discharge flow rate.

$$\text{Discharge Criteria (ug/L)} = \frac{\text{7Q10 Flow (cfs)}}{\text{Discharge Flow (gpm)}} \times \text{Selected Standard (ug/L)} \times \frac{448.8 \text{ gpm}}{\text{cfs}}$$

For 300 gpm flow, the dilution is 56/300 x 448.8 (a factor of 84). Table 1 presents the calculated discharge criteria at three different flow rates (100, 300, and 500 gpm) for potential COCs. An abbreviated list summarizing discharge criteria for final COCs is presented in Table 2.

It should be noted that the discharge criterion for PCBs is less than the average practical quantitation limit (PQL) of 0.02 µg/L. Therefore, the discharge criterion will be raised to the PQL for PCBs. Similarly, the discharge criterion for dioxin at 500 gpm is less than the average PQL of 1E-6 µg/L. The discharge criterion for dioxin will be raised to the PQL.

3.0 OTHER WATER QUALITY CRITERIA

In addition to COC testing, several relevant criteria from the Vermont Water Quality Standards, temperature, pH, and turbidity apply to the discharge.

Temperature
The Vermont Water Quality Standards indicate that the maximum allowed ambient water temperature increase is 1.0°F. A very high effluent temperature effluent would be needed to raise the river by 1.0°F considering 84 to 1 dilution. Because no heating of water is anticipated, and stored waste water will typically not exceed ambient air temperature, no effluent monitoring of temperature will be necessary.

pH
The Vermont Water Quality Standards indicate that the maximum river water shall be between 6.5 and 8.5. Similar to temperature, because of the 84 to 1 dilution in the mixing zone, effluent

with extreme pH values could be tolerated. However, because of potential localized impacts to the river at the effluent, a lower limit of 4 and an upper limit of 10 will be used as the discharge criteria.

Turbidity
The Vermont Water Quality Standards indicate that a turbidity of 10 NTU shall be achieved for Class B Cold Water Fish Habitat waters. Similar to temperature and pH, because of the 84 to 1 dilution in the mixing zone, effluent with high turbidity could be tolerated. However, in consideration of the requirements of Section 2-04 of the Water Quality Standards, an upper limit of 50 NTU will be used as the discharge criteria.

4.0 SAMPLE FREQUENCY

Discharge of the treated dewater effluent will occur in stages. The first stage is discharge of pilot test water. The Contractor will be required to conduct a pilot test to evaluate the performance of the treatment system. Approximately 20,000 gallons, or one fractionation (frac) tank, will be treated as part of the pilot test. One sample from the frac tank will be collected. If the discharge criteria are achieved, the water will be discharged. If not, the treatment system will be modified, and the effluent will be retested.

Next, the surface water from Lagoons 1 and 5 will be removed. Estimated volume of surface water is 2 million gallons. One sample will be collected per 100,000 gallons for the first 500,000 gallons. If discharge criteria are achieved, the frequency will be decreased to one sample per 500,000 gallons.

The third stage is dewatering during excavation. The estimated volume of water to be generated during the excavation is 2 million gallons. The protocol will be similar as the surface water. One sample will be collected per 100,000 gallons for the first 500,000 gallons. If discharge criteria are achieved, the frequency will be decreased to one sample per 500,000 gallons.

TABLE 1
CALCULATION OF TREATED WATER DISCHARGE CRITERIA
POWNAL TANNERY SUPERFUND SITE
LAGOON AREA REMEDIATION

	7Q10 Flow:	50	cubic feet per second (VTDEC)				Conversions:	7.48	gallons per cubic foot				
	Hardness:	100	ppm, CaCO3 (assumed value)					60	seconds per minute				
						Vermont Water Quality Standards, July 2000							
						Protection of Human Health	Protection of Aquatic Biota				Discharge Criteria (ug/L)		
		Soil/Sludge	GW	SW	Sediment	Consumption of Organisms Only	Average Allowable Concentration - Chronic Criteria	Vermont Groundwater Enforcement Standard (January 2000)	EPA MCL (July 2002)	Applicable Standard	100	300	500
						(ug/L)	ug/L	ug/L	ug/L	ug/L	gpm	gpm	gpm
VOCs													
	Acetone	X	X	X	X	--	--	700	--	700	175,930	58,643	35,186
	Benzene	X				71	--	5	5	71	17,844	5,948	3,569
	Bromodichloromethane (Bromodichloromethane)	X				22	--	100	80	22	5,529	1,843	1,106
	Bromoform	X				360	--	100	80	360	90,478	30,159	18,096
	Bromomethane (Methyl Bromide)	X				4000	--	10	--	4000	1,005,312	335,104	201,062
	2-Butanone (MEK)	X		X	X	--	--	4200	--	4200	1,055,578	351,859	211,116
	Carbon disulfide	X			X	--	--	--	--	--	NA	NA	NA
	Carbon tetrachloride	X	X			4.4	--	5	5	4.4	1,106	369	221
	Chlorobenzene (Monochlorobenzene)	X	X			21000	--	100	100	21000	5,277,868	1,759,298	1,055,578
	Chloroform	X				470	--	100	80	470	118,124	39,375	23,626
	Cyclohexane	X				--	--	--	--	--	NA	NA	NA
	1,2-Dichlorobenzene	X	X			17000	--	600	600	17000	4,272,576	1,424,192	854,515
	1,3-Dichlorobenzene	X	X			2600	--	600	--	2600	653,453	217,818	130,691
	1,4-Dichlorobenzene	X	X			2600	--	75	75	2600	653,453	217,818	130,691
	1,1-Dichloroethane	X				--	--	70	--	70	17,593	5,864	3,519
	1,2-Dichloroethane	X				99	--	5	5	99	24,881	8,294	4,976
	1,1-Dichloroethene				X	3.2	--	7	7	3.2	804	268	161
	trans-1,2-Dichloroethene	X				--	--	100	100	100	25,133	8,378	5,027
	Ethylbenzene	X	X			29000	--	700	700	29000	7,288,512	2,429,504	1,457,702
	2-Hexanone	X				--	--	--	--	--	NA	NA	NA
	Isopropylbenzene	X	X			--	--	--	--	--	NA	NA	NA
	4-Methyl-2-pentanone	X				--	--	560	--	560	140,744	46,915	28,149
	Methyl acetate	X				--	--	--	--	--	NA	NA	NA
	Methyl tert-butyl ether		X	X		--	--	40	--	40	10,053	3,351	2,011
	Methylcyclohexane	X	X			--	--	--	--	--	NA	NA	NA
	Methylene chloride	X	X		X	1600	--	5	5	1600	402,125	134,042	80,425
	Styrene	X				--	--	100	100	100	25,133	8,378	5,027
	Tetrachloroethylene	X	X			8.85	--	5	5	8.85	2,224	741	445
	Tetrahydrofuran	X				--	--	--	--	--	NA	NA	NA
	Toluene	X	X	X	X	200000	--	1000	1000	200000	50,265,600	16,755,200	10,053,120
	1,2,4-Trichlorobenzene	X	X			--	--	70	70	70	17,593	5,864	3,519
	1,1,1-Trichloroethane	X				--	--	200	200	200	50,266	16,755	10,053
	Trichloroethene	X	X			81	--	5	5	81	20,358	6,786	4,072
	Xylene	X	X			--	--	10000	10000	10000	2,513,280	837,760	502,656
SVOCs													
	Acenaphthene	X			X	--	--	--	--	--	NA	NA	NA
	Acenaphthylene	X			X	--	--	--	--	--	NA	NA	NA
	Acetophenone	X				--	--	--	--	--	NA	NA	NA
	Anthracene	X			X	110000	--	2100	--	110000	27,646,080	9,215,360	5,529,216
	Atrazine		X			--	--	3	3	3	754	251	151
	Benzaldehyde	X			X	--	--	--	--	--	NA	NA	NA
	Benzo(a)anthracene	X			X	0.031	--	--	--	0.031	7.8	2.6	1.6
	Benzo(a)pyrene	X			X	0.031	--	0.2	0.2	0.031	7.8	2.6	1.6
	Benzo(b)fluoranthene	X			X	0.031	--	--	--	0.031	7.8	2.6	1.6
	Benzo(g,h,i)perylene	X			X	--	--	--	--	--	NA	NA	NA
	Benzo(k)fluoranthene	X			X	0.031	--	--	--	0.031	8	3	2
	1,1-Biphenyl	X				--	--	--	--	--	NA	NA	NA

TABLE 1
CALCULATION OF TREATED WATER DISCHARGE CRITERIA
POWNAL TANNERY SUPERFUND SITE
LAGOON AREA REMEDIATION

	7Q10 Flow:	56	cubic feet per second (VTDEC)				Conversions:	7.48	gallons per cubic foot					
	Hardness:	100	ppm, CaCO3 (assumed value)					60	seconds per minute					
						Vermont Water Quality Standards, July 2000								
						Protection of Human Health	Protection of Aquatic Biota				Discharge Criteria (ug/L)			
		Soil/Sludge	GW	SW	Sediment	Consumption of Organisms Only	Average Allowable Concentration - Chronic Criteria	Vermont Groundwater Enforcement Standard (January 2000)	EPA MCL (July 2002)	Applicable Standard	100	300	500	
						(ug/L)	ug/L	ug/L	ug/L	ug/L	ppm	ppm	ppm	
	Bis(2-chloroethoxy)methane	X				--	--	--	--	--	NA	NA	NA	
	Bis(2-chloroethyl)ether	X				1.4	--	--	--	1.4	352	117	70	
	Bis(2-ethylhexyl)phthalate	X	X	X	X	5.9	--	6	6	5.9	1,483	494	297	
	Butylbenzylphthalate				X	--	--	--	--	--	NA	NA	NA	
	Caprolactam	X				--	--	--	--	--	NA	NA	NA	
	Carbazole	X			X	--	--	--	--	--	NA	NA	NA	
	Chrysene	X			X	0.031	--	--	--	0.031	7.8	2.6	1.6	
	4-Chloro-3-methylphenol	X				--	--	--	--	--	NA	NA	NA	
	4-Chloroaniline	X			X	--	--	--	--	--	NA	NA	NA	
	Dibenzo(a,h)anthracene	X			X	0.031	--	--	--	0.031	7.8	2.6	1.6	
	Dibenzofuran	X			X	--	--	--	--	--	NA	NA	NA	
	2,4-Dichlorophenol	X				790	--	--	--	790	198,649	66,183	39,710	
	Diethylphthalate	X	X		X	120000	--	--	--	120000	30,159,360	10,053,120	6,031,872	
	2,4-Dimethylphenol	X				--	--	--	--	--	NA	NA	NA	
	Di-n-butylphthalate	X	X		X	12000	--	--	--	12000	3,015,936	1,005,312	603,187	
	Di-n-octylphthalate	X				--	--	--	--	--	NA	NA	NA	
	Fluoranthene	X			X	370	--	280	--	370	92,991	30,997	18,598	
	Fluorene	X			X	14000	--	280	--	14000	3,518,592	1,172,864	703,718	
	Hexachloroethane		X			8.9	--	--	--	8.9	2,237	746	447	
	Indeno(1,2,3-cd)pyrene	X			X	0.031	--	--	--	0.031	7.8	2.6	1.6	
	Isophorone	X				600	--	100	--	600	150,797	50,266	30,159	
	2-Methylnaphthalene	X			X	--	--	--	--	--	NA	NA	NA	
	2-Methylphenol	X				--	--	--	--	--	NA	NA	NA	
	4-Methylphenol	X	X		X	--	--	--	--	--	NA	NA	NA	
	Naphthalene	X	X		X	--	--	20	--	20	5,027	1,676	1,005	
	2-Nitroaniline	X				--	--	--	--	--	NA	NA	NA	
	Nitrobenzene	X				1900	--	--	--	1900	477,523	159,174	95,505	
	2-Nitrophenol	X				--	--	--	--	--	NA	NA	NA	
	4-Nitrophenol	X				--	--	--	--	--	NA	NA	NA	
	N-Nitroso-di-n-propylamine	X				--	--	--	--	--	NA	NA	NA	
	2,2-oxybis-1-Chloropropane (bis-2 Chloroisopropyl ether)	X				170000	--	300	--	170000	42,725,760	14,241,920	8,545,152	
	Pentachlorophenol	X	X		X	8.2	5.725901475	1	1	5.725901475	1,439	480	288	
	Phenanthrene	X			X	--	--	--	--	--	NA	NA	NA	
	Phenol	X				4600000	--	4000	--	4600000	1,156,108,800	385,369,600	231,221,760	
	Pyrene	X			X	11000	--	--	--	11000	2,764,608	921,536	552,922	
	2,4,5-Trichlorophenol	X				--	--	--	--	--	NA	NA	NA	
	2,4,6-Trichlorophenol	X				6.5	--	--	--	6.5	1,634	545	327	
Metals														
	Aluminum	X	X	X	X	--	--	200	--	200	50,268	16,755	10,053	
	Antimony	X	X	X	X	4300	--	6	6	4300	1,080,710	360,237	216,142	
	Arsenic	X	X	X	X	1.5	190	50	10	1.5	377	126	75	
	Barium	X	X	X	X	--	--	2000	2000	2000	502,656	167,552	100,531	
	Beryllium	X		X	X	--	--	4	4	4	1,005	335	201	
	Cadmium	X	X	X	X	--	1.134259063	5	5	1.134259063	285	95	57	
	Calcium	X	X	X	X	--	--	--	--	--	NA	NA	NA	
	Chromium	X	X	X	X	--	206.9825277	100	100	206.9825277	52,021	17,340	10,404	
	Cobalt	X	X	X	X	--	--	--	--	--	NA	NA	NA	
	Copper	X	X	X	X	--	11.82384108	1300	1300	11.82384108	2,972	991	594	

TABLE 1
CALCULATION OF TREATED WATER DISCHARGE CRITERIA
POWNAL TANNERY SUPERFUND SITE
LAGOON AREA REMEDIATION

	7Q10 Flow:	56	cubic feet per second (VTDEC)			Conversions:		7.48	gallons per cubic foot				
	Hardness:	100	ppm, CaCO3 (assumed value)					60	seconds per minute				
						Vermont Water Quality Standards, July 2000							
						Protection of Human Health	Protection of Aquatic Biota				Discharge Criteria (ug/L)		
		Soil/Sludge	GW	SW	Sediment	Consumption of Organisms Only	Average Allowable Concentration - Chronic Criteria	Vermont Groundwater Enforcement Standard (January 2000)	EPA MCL (July 2002)	Applicable Standard	100	300	500
						(ug/L)	ug/L	ug/L	ug/L	ug/L	ppm	ppm	ppm
	Iron	X	X	X	X	--	1000	300	--	1000	251,328	83,776	50,266
	Lead	X	X	X	X	--	3.181591829	15	15	3.181591829	800	267	160
	Magnesium	X	X	X	X	--	--	--	--	--	NA	NA	NA
	Manganese	X	X	X	X	--	--	840	--	840	211,116	70,372	42,223
	Mercury	X	X	X	X	0.15	0.012	2	2	0.012	3.0	1.0	0.6
	Nickel	X	X	X	X	4600	157.6652284	100	--	157.6652284	39,626	13,209	7,925
	Potassium	X	X	X	X	--	--	--	--	--	NA	NA	NA
	Selenium	X	X	X	X	--	5	50	50	5	1,257	419	251
	Silver	X	X	X	X	--	--	100	--	100	25,133	8,378	5,027
	Sodium	X	X	X	X	--	--	250000	--	250000	62,832,000	20,944,000	12,566,400
	Thallium	X	X	X	X	6.3	--	2	2	6.3	1,583	528	317
	Vanadium	X	X	X	X	--	--	--	--	--	NA	NA	NA
	Zinc	X	X	X	X	--	105.9916904	5000	--	105.9916904	26,619	8,880	5,328
	Cyanide	X	X	X	X	220000	5.2	200	200	5.2	1,307	436	261
Pest/PCBs													
	Aldrin	X			X	0.00014	--	0.05	--	0.00014	0.035	0.012	0.007
	Aroclor 1242	X			X	0.000045	0.014	0.5	0.5	0.000045	0.011	0.004	0.002
	Aroclor 1248	X				0.000045	0.014	0.5	0.5	0.000045	0.011	0.004	0.002
	Aroclor 1254	X			X	0.000045	0.014	0.5	0.5	0.000045	0.011	0.004	0.002
	Aroclor 1260	X			X	0.000045	0.014	0.5	0.5	0.000045	0.011	0.004	0.002
	alpha-BHC	X			X	0.013	--	--	--	0.013	3.287	1.088	0.653
	beta-BHC	X			X	0.046	--	--	--	0.046	11.661	3.854	2.312
	delta-BHC	X			X	--	--	--	--	--	NA	NA	NA
	alpha-Chlordane	X			X	--	--	--	--	--	NA	NA	NA
	4,4'-DDD	X			X	0.00084	--	--	--	0.00084	0.211	0.070	0.042
	4,4'-DDE	X			X	0.00059	--	--	--	0.00059	0.148	0.049	0.030
	4'4'-DDT	X			X	0.00059	0.001	--	--	0.00059	0.148	0.049	0.030
	Dichlorobiphenyls				X	--	--	0.5	0.5	0.5	126	42	25
	Dieldrin	X			X	0.00014	--	0.02	--	0.00014	0.035	0.012	0.007
	Endosulfan I	X				2	0.056	--	--	0.056	14.074	4.691	2.815
	Endosulfan II	X				2	0.056	--	--	0.056	14.074	4.691	2.815
	Endosulfan sulfate	X			X	2	--	--	--	2	503	168	101
	Endrin	X			X	0.81	0.0023	2	2	0.0023	0.578	0.193	0.116
	Endrin aldehyde	X				0.81	--	--	--	0.81	204	68	41
	Endrin ketone	X			X	--	--	--	--	--	NA	NA	NA
	gamma-BHC (Lindane)	X			X	0.063	0.9	0.2	0.2	0.063	16	5	3
	gamma-Chlordane	X			X	--	--	--	--	--	NA	NA	NA
	Heptachlor	X			X	0.00021	0.0038	0.4	0.4	0.00021	0.053	0.018	0.011
	Heptachlor epoxide	X	X		X	0.00011	0.0038	0.2	0.2	0.00011	0.028	0.009	0.006
	Heptachlorobiphenyls				X	--	--	0.5	0.5	0.5	126	42	25
	Hexachlorobiphenyls				X	--	--	0.5	--	0.5	126	42	25
	Methoxychlor	X			X	--	--	40	40	40	10,053	3,351	2,011
	Pentachlorobiphenyls				X	--	--	0.5	0.5	0.5	126	42	25
	Tetrachlorobiphenyls	X			X	--	--	0.5	0.5	0.5	126	42	25
	Trichlorobiphenyls				X	--	--	0.5	0.5	0.5	126	42	25
	Toxaphene	X				0.00075	0.0002	3	3	0.0002	0.050	0.017	0.010
Dioxin													
	Dioxin (2,3,7,8-TCDD)	X	X	X	X	1.40E-08	--	3.00E-05	3.00E-05	1.40E-08	3.51659E-06	1.17286E-06	7.03718E-07

TABLE 2
DISCHARGE CRITERIA
POWNAL TANNERY SUPERFUND SITE
LAGOON AREA REMEDIATION

Compound	Discharge Criteria (ug/L) 100 gpm	300 gpm	500 gpm	Basis of Criteria
VOCs				
Acetone	176,000	58,600	35,200	Vermont Groundwater Enforcement Standard
Benzene	17,800	5,950	3,570	Protection of Human Health
Bromodichloromethane (Bromodichloromethane)	5,530	1,840	1,110	Protection of Human Health
Bromoform	90,500	30,200	18,100	Protection of Human Health
Bromomethane (Methyl Bromide)	1,010,000	335,000	201,000	Protection of Human Health
2-Butanone (MEK)	1,060,000	352,000	211,000	Vermont Groundwater Enforcement Standard
Carbon tetrachloride	1,110	369	221	Protection of Human Health
Chlorobenzene (Monochlorobenzene)	5,280,000	1,760,000	1,060,000	Protection of Human Health
Chloroform	118,000	39,400	23,600	Protection of Human Health
1,2-Dichlorobenzene	4,270,000	1,420,000	855,000	Protection of Human Health
1,3-Dichlorobenzene	653,000	218,000	131,000	Protection of Human Health
1,4-Dichlorobenzene	653,000	218,000	131,000	Protection of Human Health
1,1-Dichloroethane	17,600	5,880	3,520	Vermont Groundwater Enforcement Standard
1,2-Dichloroethane	24,900	8,290	4,980	Protection of Human Health
1,1-Dichloroethene	804	268	161	Protection of Human Health
trans-1,2-Dichloroethene	25,100	8,360	5,030	Vermont Groundwater Enforcement Standard
Ethylbenzene	7,290,000	2,430,000	1,460,000	Protection of Human Health
4-Methyl-2-pentanone	141,000	46,900	28,100	Vermont Groundwater Enforcement Standard
Methyl tert-butyl ether	10,100	3,350	2,010	Vermont Groundwater Enforcement Standard
Methylene chloride	402,000	134,000	80,400	Protection of Human Health
Styrene	25,100	8,380	5,030	Vermont Groundwater Enforcement Standard
Tetrachloroethylene	2,220	741	445	Protection of Human Health
Toluene	50,300,000	16,800,000	10,100,000	Protection of Human Health
1,2,4-Trichlorobenzene	17,600	5,880	3,520	Vermont Groundwater Enforcement Standard
1,1,1-Trichloroethane	50,300	16,800	10,100	Vermont Groundwater Enforcement Standard
Trichloroethene	20,400	6,790	4,070	Protection of Human Health
Xylene	2,610,000	838,000	503,000	Vermont Groundwater Enforcement Standard
SVOCs				
Anthracene	27,600,000	9,220,000	5,530,000	Protection of Human Health
Atrazine	754	251	151	Vermont Groundwater Enforcement Standard
Benzo(a)anthracene	7.79	2.60	1.56	Protection of Human Health
Benzo(a)pyrene	7.79	2.60	1.56	Protection of Human Health
Benzo(b)fluoranthene	7.79	2.60	1.56	Protection of Human Health
Benzo(k)fluoranthene	7.79	2.60	1.56	Protection of Human Health
Bis(2-chloroethyl)ether	352	117	70.4	Protection of Human Health
Bis(2-ethylhexyl)phthalate	1,480	494	297	Protection of Human Health
Chrysene	7.79	2.60	1.56	Protection of Human Health
Dibenzo(a,h)anthracene	7.79	2.60	1.56	Protection of Human Health
2,4-Dichlorophenol	199,000	66,200	39,700	Protection of Human Health
Diethylphthalate	30,200,000	10,100,000	6,030,000	Protection of Human Health
Di-n-butylphthalate	3,020,000	1,010,000	603,000	Protection of Human Health
Fluoranthene	93,000	31,000	18,600	Protection of Human Health
Fluorene	3,520,000	1,170,000	704,000	Protection of Human Health
Hexachloroethane	2,240	748	447	Protection of Human Health
Indeno(1,2,3-cd)pyrene	7.79	2.60	1.56	Protection of Human Health
Isophorone	151,000	50,300	30,200	Protection of Human Health
Naphthalene	5,030	1,680	1,010	Vermont Groundwater Enforcement Standard
Nitrobenzene	478,000	159,000	95,500	Protection of Human Health
2,2-oxybis-1-Chloropropane (bis-2 Chloroisopropyl ether	42,700,000	14,200,000	8,550,000	Protection of Human Health
Pentachlorophenol	1,440	480	288	Protection of Aquatic Biota
Phenol	1,156,100,000	385,400,000	231,200,000	Protection of Human Health
Pyrene	2,780,000	922,000	553,000	Protection of Human Health
2,4,6-Trichlorophenol	1,630	545	327	Protection of Human Health
Metals				
Aluminum	50,300	16,800	10,100	Vermont Groundwater Enforcement Standard
Antimony	1,080,000	360,000	216,000	Protection of Human Health
Arsenic	377	126	75	Protection of Human Health
Barium	503,000	168,000	101,000	Vermont Groundwater Enforcement Standard
Beryllium	1,010	335	201	Vermont Groundwater Enforcement Standard
Cadmium	285	95.0	57.0	Protection of Aquatic Biota
Chromium	52,000	17,300	10,400	Protection of Aquatic Biota
Copper	2,970	991	594	Protection of Aquatic Biota
Iron	251,000	83,800	50,300	Protection of Aquatic Biota
Lead	800	267	160	Protection of Aquatic Biota
Manganese	211,000	70,400	42,200	Vermont Groundwater Enforcement Standard
Mercury	3.02	1.01	0.60	Protection of Aquatic Biota
Nickel	39,600	13,200	7,930	Protection of Aquatic Biota
Selenium	1,260	419	251	Protection of Aquatic Biota
Silver	25,100	8,380	5,030	Vermont Groundwater Enforcement Standard
Sodium	62,800,000	20,900,000	12,600,000	Vermont Groundwater Enforcement Standard
Thallium	1,580	528	317	Protection of Human Health
Zinc	26,500	8,580	5,330	Protection of Aquatic Biota
Cyanide	1,310	438	281	Protection of Aquatic Biota
PCBs				
Total PCBs	0.0113	0.00377	0.00226	Protection of Human Health (MDL = 0.02 ug/L)
Dioxin				
Dioxin (2,3,7,8-TCDD)	3.52E-06	1.17E-06	7.04E-07	Protection of Human Health (MDL = 1 E-8 ug/L)
Water Quality Parameters				
pH	4 < pH < 10			Vermont Water Quality Standard
Turbidity	50 NTU			Vermont Water Quality Standard

Calandra, Frank

From: Calandra, Frank
Sent: Tuesday, July 15, 2003 8:00 AM
To: 'Dale Weiss'; Brian Woods
Cc: Mischel, Greg; Plumb, Mike; McVickar, Leslie; Denly,
Subject: RE: Pownal water discharge

Brian,

Attached are the revised discharge criteria. They were revised per your conversation on June 27, 2003 with Dale Weiss. In summary, the 7Q10 flow of 56 cfs was replaced by the annual mean flow of 166 cfs for carcinogenic compounds and compounds that do not have a water quality standard. Carcinogenic compounds are denoted by a "C" in Table 1. As a result of these revisions, criteria for the affected compounds increased by a factor of 166/56 (or approx. 3 times).

Please call me if you have any questions.

Frank

-----Original Message-----
From: Dale Weiss [mailto:dweiss@ix.netcom.com]
Sent: Friday, June 27, 2003 3:39 PM
To: Calandra, Frank
Cc: Mischel, Greg; Plumb, Mike; Brian Woods; McVickar, Leslie; Denly, Elizabeth
Subject: Pownal water discharge

Frank:

Brian Woods just called to ask us to make a few modification to the Wastewater Discharge Plan.

1. We need to use the annual median flow rate of the Hoosic for all carcinogenic compounds. Therefore, add a column to indicate which compounds are "toxic" and which are "carcinogenic" and calculate the dilution accordingly. Use 166cfs as the median flow as measured in Williamstown.

2. For compounds where there is no water quality standard, but there is a ground water standard, use the ground water standard with the 166cfs flow.

3. For compounds that are not on either list of standards, we need to include toxicity testing in the pilot study for the treated effluent. Short Term Methods for Chronic Toxicity Testing Methods 1000 (fathead minnow) and 1002.0 (Daphnid) should be used. The test requires 2-3 periodic samples of the receiving water and the treated effluent, 2-3 days apart, and the test takes about 7 days.

If you have further questions, call Brian now, since he is out all next week!

Dale Weiss, P.G.
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TABLE 1
CALCULATION OF TREATED WATER DISCHARGE CRITERIA
POWNAL TANNERY SUPERFUND SITE
LAGOON AREA REMEDIATION

	7Q10 Flow:		68	cubic feet per second (VTDEC)				Conversions:	7.48	gallons per cubic foot					
	Median Flow (Williamstown):		168	cubic feet per second					60	seconds per minute					
	Hardness:		100	ppm, CaCO3 (assumed value)											
							Vermont Water Quality Standards, July 2000								
							Protection of Human Health	Protection of Aquatic Biota					Discharge Criteria (ug/L)		
		C = Carcinogen	Soil/Sludge	GW	SW	Sediment	Consumption of Organisms Only (ug/L)	Average Allowable Concentration - Chronic Criteria ug/L	Vermont Groundwater Enforcement Standard (January 2000) ug/L	EPA MCL (July 2002) ug/L	Applicable Standard ug/L	River Flow (cfs)	100 gpm	300 gpm	500 gpm
VOCs															
	Acetone		X	X	X	X	–	–	700	–	700	168	521,506	173,835	104,301
	Benzene	C	X				71	–	5	5	71	168	52,898	17,632	10,579
	Bromodichloromethane (Bromodichloromethane)	C	X				22	–	100	80	22	56	5,529	1,843	1,106
	Bromoform	C	X				360	–	100	80	360	168	268,203	89,401	53,641
	Bromomethane (Methyl Bromide)		X				4000	–	10	–	4000	56	1,005,312	335,104	201,062
	2-Butanone (MEK)		X		X	X	–	–	4200	–	4200	168	3,129,034	1,043,011	625,807
	Carbon disulfide		X			X	–	–	–	–	–	56	NA	NA	NA
	Carbon tetrachloride	C	X	X			4.4	–	5	5	4.4	168	3,278	1,093	656
	Chlorobenzene (Monochlorobenzene)		X	X			21000	–	100	100	21000	56	5,277,888	1,759,296	1,055,578
	Chloroform	C	X				470	–	100	80	470	168	350,154	116,718	70,031
	Cyclohexane		X				–	–	–	–	–	56	NA	NA	NA
	1,2-Dichlorobenzene		X	X			17000	–	600	600	17000	56	4,272,576	1,424,192	854,515
	1,3-Dichlorobenzene		X	X			2600	–	600	–	2600	56	653,453	217,818	130,691
	1,4-Dichlorobenzene	C	X	X			2600	–	75	75	2600	168	1,937,021	645,674	387,404
	1,1-Dichloroethane		X				–	–	70	–	70	168	52,151	17,384	10,430
	1,2-Dichloroethane	C	X				99	–	5	5	99	168	73,756	24,585	14,751
	1,1-Dichloroethene	C				X	3.2	–	7	7	3.2	168	2,384	795	477
	trans-1,2-Dichloroethene		X				–	–	100	100	100	168	74,501	24,834	14,900
	Ethylbenzene		X	X			29000	–	700	700	29000	56	7,288,512	2,429,504	1,457,702
	2-Hexanone		X				–	–	–	–	–	56	NA	NA	NA
	Isopropylbenzene		X	X			–	–	–	–	–	56	NA	NA	NA
	4-Methyl-2-pentanone		X				–	–	560	–	560	168	417,204	139,068	83,441
	Methyl acetate		X				–	–	–	–	–	56	NA	NA	NA
	Methyl tert-butyl ether			X	X		–	–	40	–	40	168	29,800	9,933	5,960
	Methylcyclohexane		X	X			–	–	–	–	–	56	NA	NA	NA
	Methylene chloride	C	X	X		X	1600	–	5	5	1600	168	1,192,013	397,338	238,403
	Styrene	C	X				–	–	100	100	100	168	74,501	24,834	14,900
	Tetrachloroethylene	C	X	X			8.85	–	5	5	8.85	168	6,593	2,198	1,319
	Tetrahydrofuran		X				–	–	–	–	–	56	NA	NA	NA
	Toluene		X	X	X	X	200000	–	1000	1000	200000	56	50,265,600	16,755,200	10,053,120
	1,2,4-Trichlorobenzene		X	X			–	–	70	70	70	168	52,151	17,384	10,430
	1,1,1-Trichloroethane		X				–	–	200	200	200	168	149,002	49,667	29,800
	Trichloroethene	C	X	X			81	–	5	5	81	168	60,346	20,115	12,069
	Xylene		X	X			–	–	10000	10000	10000	168	7,450,080	2,483,360	1,490,016
SVOCs															
	Acenaphthene		X			X	–	–	–	–	–	56	NA	NA	NA
	Acenaphthylene		X			X	–	–	–	–	–	56	NA	NA	NA
	Acetophenone		X				–	–	–	–	–	56	NA	NA	NA
	Anthracene		X			X	110000	–	2100	–	110000	56	27,648,960	9,216,320	5,529,216
	Atrazine			X			–	–	3	3	3	168	2,235	745	447
	Benzaldehyde		X			X	–	–	–	–	–	56	NA	NA	NA
	Benzo(a)anthracene	C	X			X	0.031	–	–	–	0.031	168	23	8	5
	Benzo(a)pyrene	C	X			X	0.031	–	0.2	0.2	0.031	168	23	8	5
	Benzo(b)fluoranthene	C	X			X	0.031	–	–	–	0.031	168	23	8	5
	Benzo(g,h,i)perylene		X			X	–	–	–	–	–	56	NA	NA	NA
	Benzo(k)fluoranthene	C	X			X	0.031	–	–	–	0.031	168	23	8	5
	1,1-Biphenyl		X				–	–	–	–	–	56	NA	NA	NA
	Bis(2-chloroethoxy)methane		X				–	–	–	–	–	56	NA	NA	NA
	Bis(2-chloroethyl)ether	C	X				1.4	–	–	–	1.4	168	1,043	348	209
	Bis(2-ethylhexyl)phthalate		X	X	X	X	5.9	–	6	6	5.9	56	1,483	494	297
	Butylbenzylphthalate					X	–	–	–	–	–	56	NA	NA	NA

TABLE 1
CALCULATION OF TREATED WATER DISCHARGE CRITERIA
POWNAL TANNERY SUPERFUND SITE
LAGOON AREA REMEDIATION

7Q10 Flow:	58	cubic feet per second (VTDEC)				Conversions:	7.48	gallons per cubic foot							
Median Flow (Williamstown):	168	cubic feet per second					60	seconds per minute							
Hardness:	100	ppm, CaCO3 (assumed value)													
						Vermont Water Quality Standards, July 2000									
						Protection of Human Health	Protection of Aquatic Biota								
	C = Carcinogen	Soil/Sludge	GW	SW	Sediment	Consumption of Organisms Only	Average Allowable Concentration - Chronic Criteria	Vermont Groundwater Enforcement Standard (January 2000)	EPA MCL (July 2002)	Applicable Standard	River Flow (cfs)	Discharge Criteria (ug/L)		
						(ug/L)	ug/L	ug/L	ug/L	ug/L		100	300	500
												ppm	ppm	ppm
Caprolactam		X				--	--	--	--	--	56	NA	NA	NA
Carbazole		X			X	--	--	--	--	--	56	NA	NA	NA
Chrysene	C	X			X	0.031	--	--	--	0.031	168	23	8	5
4-Chloro-3-methylphenol		X				--	--	--	--	--	56	NA	NA	NA
4-Chloroaniline		X			X	--	--	--	--	--	56	NA	NA	NA
Dibenzo(a,h)anthracene	C	X			X	0.031	--	--	--	0.031	168	23	8	5
Dibenzofuran		X			X	--	--	--	--	--	56	NA	NA	NA
2,4-Dichlorophenol		X				790	--	--	--	790	56	196,549	66,183	39,710
Diethylphthalate		X	X		X	120000	--	--	--	120000	56	30,159,360	10,053,120	6,031,872
2,4-Dimethylphenol		X				--	--	--	--	--	56	NA	NA	NA
Di-n-butylphthalate		X	X		X	12000	--	--	--	12000	56	3,015,936	1,005,312	603,187
Di-n-octylphthalate		X				--	--	--	--	--	56	NA	NA	NA
Fluoranthene		X			X	370	--	280	--	370	56	92,991	30,997	18,598
Fluorene		X			X	14000	--	280	--	14000	56	3,518,592	1,172,864	703,718
Hexachloroethane	C		X			8.9	--	--	--	8.9	168	8,631	2,210	1,326
Indeno(1,2,3-cd)pyrene	C	X			X	0.031	--	--	--	0.031	168	23	8	5
Isophorone		X				600	--	100	--	600	56	150,797	50,268	30,159
2-Methylnaphthalene		X			X	--	--	--	--	--	56	NA	NA	NA
2-Methylphenol		X				--	--	--	--	--	56	NA	NA	NA
4-Methylphenol		X	X		X	--	--	--	--	--	56	NA	NA	NA
Naphthalene		X	X		X	--	--	--	--	--	56	NA	NA	NA
2-Nitroaniline		X				--	--	20	--	20	168	14,900	4,967	2,980
Nitrobenzene		X				1900	--	--	--	1900	56	477,523	159,174	95,505
2-Nitrophenol		X				--	--	--	--	--	56	NA	NA	NA
4-Nitrophenol		X				--	--	--	--	--	56	NA	NA	NA
N-Nitroso-di-n-propylamine		X				--	--	--	--	--	56	NA	NA	NA
2,2-oxybis-1-Chloropropane (bis-2 Chloroisopropyl ether)		X				170000	--	300	--	170000	56	42,725,760	14,241,920	8,545,152
Pentachlorophenol	C	X	X		X	8.2	5.725901475	1	1	5.725901475	168	4,266	1,422	853
Phenanthrene		X			X	--	--	--	--	--	56	NA	NA	NA
Phenol		X				4800000	--	4000	--	4800000	56	1,156,108,800	385,369,600	231,221,760
Pyrene		X			X	11000	--	--	--	11000	56	2,764,608	921,536	552,922
2,4,5-Trichlorophenol		X				--	--	--	--	--	56	NA	NA	NA
2,4,6-Trichlorophenol	C	X				6.5	--	--	--	6.5	168	4,843	1,614	969
Metals														
Aluminum		X	X	X	X	--	--	200	--	200	168	149,002	49,667	29,800
Antimony		X	X	X	X	4300	--	6	6	4300	56	1,080,710	360,237	216,142
Arsenic	C	X	X	X	X	1.5	190	50	10	1.5	168	1,118	373	224
Barium		X	X	X	X	--	--	2000	2000	2000	168	1,490,016	496,672	298,003
Beryllium		X		X	X	--	--	4	4	4	168	2,980	993	596
Cadmium		X	X	X	X	--	1.134259063	5	5	1.134259063	56	285	95	57
Calcium		X	X	X	X	--	--	--	--	--	56	NA	NA	NA
Chromium		X	X	X	X	--	206.9825277	100	100	206.9825277	56	52,021	17,340	10,404
Cobalt		X	X	X	X	--	--	--	--	--	56	NA	NA	NA
Copper		X	X	X	X	--	11.82384108	1300	1300	11.82384108	56	2,972	991	594
Iron		X	X	X	X	--	1000	300	--	1000	56	251,328	83,776	50,266
Lead		X	X	X	X	--	3.181591829	15	15	3.181591829	56	800	267	160
Magnesium		X	X	X	X	--	--	--	--	--	56	NA	NA	NA
Manganese		X	X	X	X	--	--	840	--	840	168	625,807	208,602	125,161
Mercury		X	X	X	X	0.15	0.012	2	2	0.012	56	3.0	1.0	0.8
Nickel		X	X	X	X	4600	157.9652284	100	--	157.9652284	56	39,626	13,209	7,925
Potassium		X	X	X	X	--	--	--	--	--	56	NA	NA	NA
Selenium		X	X	X	X	--	5	50	50	5	56	1,257	419	251

TABLE 1

CALCULATION OF TREATED WATER DISCHARGE CRITERIA

POWNAL TANNERY SUPERFUND SITE

LAGOON AREA REMEDIATION

	7Q10 Flow:		56 cubic feet per second (VTDEC)					Conversions:	7.48 gallons per cubic foot						
	Median Flow (Williamstown):		166 cubic feet per second						60 seconds per minute						
	Hardness:		100 ppm, CaCO3 (assumed value)												
							Vermont Water Quality Standards, July 2000								
							Protection of Human Health	Protection of Aquatic Biota					Discharge Criteria (ug/L)		
		C = Carcinogen	Soil/Sludge	GW	SW	Sediment	Consumption of Organisms Only	Average Allowable Concentration - Chronic Criteria	Vermont Groundwater Enforcement Standard (January 2000)	EPA MCL (July 2002)	Applicable Standard	River Flow (cfs)	100	300	500
							(ug/L)	ug/L	ug/L	ug/L	ug/L		ppm	ppm	ppm
	Silver		X	X	X	X	--	--	100	--	100	166	74,501	24,834	14,900
	Sodium		X	X	X	X	--	--	250000	--	250000	166	186,252,000	62,084,000	37,250,400
	Thallium		X	X	X	X	6.3	--	2	2	6.3	56	1,583	528	317
	Vanadium		X	X	X	X	--	--	--	--	--	56	NA	NA	NA
	Zinc		X	X	X	X	--	105.9916904	5000	--	105.9916904	56	26,639	8,880	5,328
	Cyanide		X	X	X	X	220000	5.2	200	200	5.2	56	1,307	436	261
Pest/PCBs															
	Aldrin	C	X			X	0.00014	--	0.05	--	0.00014	166	0.104	0.035	0.021
	Arocior 1242	C	X			X	0.000045	0.014	0.5	0.5	0.000045	166	0.034	0.011	0.007
	Arocior 1248	C	X				0.000045	0.014	0.5	0.5	0.000045	166	0.034	0.011	0.007
	Arocior 1254	C	X			X	0.000045	0.014	0.5	0.5	0.000045	166	0.034	0.011	0.007
	Arocior 1260	C	X			X	0.000045	0.014	0.5	0.5	0.000045	166	0.034	0.011	0.007
	alpha-BHC		X			X	0.013	--	--	--	0.013	56	3.267	1.089	0.653
	beta-BHC		X			X	0.046	--	--	--	0.046	56	11.561	3.854	2.312
	delta-BHC		X			X	--	--	--	--	--	56	NA	NA	NA
	alpha-Chlordane		X			X	--	--	--	--	--	56	NA	NA	NA
	4,4'-DDD	C	X			X	0.00084	--	--	--	0.00084	166	0.626	0.209	0.125
	4,4'-DDE	C	X			X	0.00059	--	--	--	0.00059	166	0.440	0.147	0.088
	4'4'-DDT	C	X			X	0.00059	0.001	--	--	0.00059	166	0.440	0.147	0.088
	Dichlorobiphenyls					X	--	--	0.5	0.5	0.5	166	373	124	75
	Dieldrin	C	X			X	0.00014	--	0.02	--	0.00014	166	0.104	0.035	0.021
	Endosulfan I		X				2	0.056	--	--	0.056	56	14.074	4.691	2.815
	Endosulfan II		X				2	0.056	--	--	0.056	56	14.074	4.691	2.815
	Endosulfan sulfate		X			X	2	--	--	--	2	56	503	168	101
	Endrin		X			X	0.81	0.0023	2	2	0.0023	56	0.578	0.193	0.116
	Endrin aldehyde		X				0.81	--	--	--	0.81	56	204	68	41
	Endrin ketone		X			X	--	--	--	--	--	56	NA	NA	NA
	gamma-BHC (Lindane)		X			X	0.063	0.08	0.2	0.2	0.063	56	16	5	3
	gamma-Chlordane		X			X	--	--	--	--	--	56	NA	NA	NA
	Heptachlor	C	X			X	0.00021	0.0036	0.4	0.4	0.00021	166	0.156	0.052	0.031
	Heptachlor epoxide	C	X	X		X	0.00011	0.0036	0.2	0.2	0.00011	166	0.082	0.027	0.016
	Heptachlorobiphenyls					X	--	--	0.5	0.5	0.5	166	373	124	75
	Hexachlorobiphenyls					X	--	--	0.5	--	0.5	166	373	124	75
	Methoxychlor		X			X	--	--	40	40	40	166	29,800	9,933	5,960
	Pentachlorobiphenyls					X	--	--	0.5	0.5	0.5	166	373	124	75
	Tetrachlorobiphenyls		X			X	--	--	0.5	0.5	0.5	166	373	124	75
	Trichlorobiphenyls					X	--	--	0.5	0.5	0.5	166	373	124	75
	Toxaphene	C	X				0.00075	0.0002	3	3	0.0002	166	0.149	0.050	0.030
Dioxin															
	Dioxin (2,3,7,8-TCDD)	C	X	X	X	X	1.40E-08	--	3.00E-05	3.00E-05	1.40E-08	166	1.04301E-05	3.4767E-06	2.08502E-06

TABLE 2
DISCHARGE CRITERIA
POWNAL TANNERY SUPERFUND SITE
LAGOON AREA REMEDIATION

Compound	Discharge Criteria (ug/L) 100 gpm	300 gpm	500 gpm	Basis of Criteria
VOCs				
Acetone	622,000	174,000	104,000	Vermont Groundwater Enforcement Standard
Benzene	52,900	17,600	10,600	Protection of Human Health
Bromodichloromethane (Bromodichloromethane)	6,630	1,840	1,110	Protection of Human Health
Bromoform	288,000	89,400	53,600	Protection of Human Health
Bromomethane (Methyl Bromide)	1,010,000	335,000	201,000	Protection of Human Health
2-Butanone (MEK)	3,130,000	1,040,000	626,000	Vermont Groundwater Enforcement Standard
Carbon tetrachloride	3,260	1,090	656	Protection of Human Health
Chlorobenzene (Monochlorobenzene)	6,260,000	1,760,000	1,060,000	Protection of Human Health
Chloroform	350,000	117,000	70,000	Protection of Human Health
1,2-Dichlorobenzene	4,270,000	1,420,000	855,000	Protection of Human Health
1,3-Dichlorobenzene	653,000	218,000	131,000	Protection of Human Health
1,4-Dichlorobenzene	1,940,000	648,000	387,000	Protection of Human Health
1,1-Dichloroethane	52,200	17,400	10,400	Vermont Groundwater Enforcement Standard
1,2-Dichloroethane	73,800	24,600	14,800	Protection of Human Health
1,1-Dichloroethene	2,380	795	477	Protection of Human Health
trans-1,2-Dichloroethene	74,500	24,800	14,900	Vermont Groundwater Enforcement Standard
Ethylbenzene	7,290,000	2,430,000	1,460,000	Protection of Human Health
4-Methyl-2-pentanone	417,000	139,000	83,400	Vermont Groundwater Enforcement Standard
Methyl tert-butyl ether	29,800	9,930	5,960	Vermont Groundwater Enforcement Standard
Methylene chloride	1,190,000	397,000	238,000	Protection of Human Health
Styrene	74,500	24,800	14,900	Vermont Groundwater Enforcement Standard
Tetrachloroethylene	6,590	2,200	1,320	Protection of Human Health
Toluene	50,300,000	16,800,000	10,100,000	Protection of Human Health
1,2,4-Trichlorobenzene	62,200	17,400	10,400	Vermont Groundwater Enforcement Standard
1,1,1-Trichloroethane	149,000	49,700	29,800	Vermont Groundwater Enforcement Standard
Trichloroethene	60,300	20,100	12,100	Protection of Human Health
Xylene	7,450,000	2,480,000	1,490,000	Vermont Groundwater Enforcement Standard
SVOCs				
Anthracene	27,600,000	9,220,000	5,530,000	Protection of Human Health
Atrazine	2,240	745	447	Vermont Groundwater Enforcement Standard
Benzo(a)anthracene	23.10	7.70	4.62	Protection of Human Health
Benzo(a)pyrene	23.10	7.70	4.62	Protection of Human Health
Benzo(b)fluoranthene	23.10	7.70	4.62	Protection of Human Health
Benzo(k)fluoranthene	23.10	7.70	4.62	Protection of Human Health
Bis(2-chloroethyl)ether	1,040	348	209.0	Protection of Human Health
Bis(2-ethylhexyl)phthalate	1,480	494	297	Protection of Human Health
Chrysene	23.10	7.70	4.62	Protection of Human Health
Dibenzo(a,h)anthracene	23.10	7.70	4.62	Protection of Human Health
2,4-Dichlorophenol	199,000	66,200	39,700	Protection of Human Health
Diethylphthalate	30,200,000	10,100,000	6,030,000	Protection of Human Health
Di-n-butylphthalate	3,020,000	1,010,000	603,000	Protection of Human Health
Fluoranthene	93,000	31,000	18,600	Protection of Human Health
Fluorene	3,520,000	1,170,000	704,000	Protection of Human Health
Hexachloroethane	6,630	2,210	1,330	Protection of Human Health
Indeno(1,2,3-cd)pyrene	23.10	7.70	4.62	Protection of Human Health
Isophorone	151,000	50,300	30,200	Protection of Human Health
Naphthalene	14,900	4,970	2,980	Vermont Groundwater Enforcement Standard
Nitrobenzene	478,000	159,000	95,500	Protection of Human Health
2,2-oxybis-1-Chloropropane (bis-2 Chloroisopropyl ether	42,700,000	14,200,000	8,650,000	Protection of Human Health
Pentachlorophenol	4,270	1,420	853	Protection of Aquatic Biota
Phenol	1,168,100,000	385,400,000	231,200,000	Protection of Human Health
Pyrene	2,760,000	922,000	553,000	Protection of Human Health
2,4,6-Trichlorophenol	4,840	1,810	969	Protection of Human Health
Metals				
Aluminum	149,000	49,700	29,800	Vermont Groundwater Enforcement Standard
Antimony	1,080,000	360,000	216,000	Protection of Human Health
Arsenic	1,120	373	224	Protection of Human Health
Barium	1,490,000	497,000	298,000	Vermont Groundwater Enforcement Standard
Beryllium	2,980	993	596	Vermont Groundwater Enforcement Standard
Cadmium	285	95.0	57.0	Protection of Aquatic Biota
Chromium	52,000	17,300	10,400	Protection of Aquatic Biota
Copper	2,970	991	594	Protection of Aquatic Biota
Iron	251,000	83,800	50,300	Protection of Aquatic Biota
Lead	800	267	160	Protection of Aquatic Biota
Manganese	626,000	209,000	125,000	Vermont Groundwater Enforcement Standard
Mercury	3.02	1.01	0.60	Protection of Aquatic Biota
Nickel	39,600	13,200	7,930	Protection of Aquatic Biota
Selenium	1,260	419	251	Protection of Aquatic Biota
Silver	74,500	24,800	14,900	Vermont Groundwater Enforcement Standard
Sodium	186,300,000	62,100,000	37,300,000	Vermont Groundwater Enforcement Standard
Thallium	1,580	528	317	Protection of Human Health
Zinc	26,600	8,860	5,330	Protection of Aquatic Biota
Cyanide	1,310	436	261	Protection of Aquatic Biota
PCBs				
Total PCBs	0.0335	0.01118	0.00671	Protection of Human Health (MDL = 0.02 ug/L)
Dioxin				
Dioxin (2,3,7,8-TCDD)	1.04E-05	3.48E-06	2.09E-06	Protection of Human Health
Water Quality Parameters				
pH	4 < pH < 10			Vermont Water Quality Standard
Turbidity	50 NTU			Vermont Water Quality Standard

Calandra, Frank

From: Brian Woods [Brianw@dec.anr.state.vt.us]
Sent: Friday, July 18, 2003 11:26 AM
To: Dale Weiss; Calandra, Frank
Cc: Mischel, Greg; Plumb, Mike; McVickar, Leslie; Denly, Elizabeth; doug.burnham@anr.state.vt.us
Subject: RE: Pownal water discharge

The Water Quality Division has completed review of the proposed discharge limits for the Pownal Tannery dewatering event that you forwarded on July 15. Following are some additional comments:

1. The table still has a few errors. All aquatic biota criteria are to be calculated at 7Q10 flow regardless of carcinogenicity. Annual median flow is used only for human health criteria that are considered probable human carcinogens. For those carcinogenic substances that list both Protection of Human Health and Protection of Aquatic Biota criteria, the calculation needs to be done for both at the applicable flows, and the lower value selected. For example, pentachlorophenol has an aquatic biota criterion that is applied at 7Q10 and a Protection of Human Health criterion that is applied at annual median flow (since it is a carcinogen). Review of the latest table indicates the following three entries need to be edited:
pentachlorophenol - aq. biota at 7Q10, the criteria for the three discharge scenarios become 1438, 481, and 287 ug/l for 100, 300 and 500 gpm respectively;
4,4-DDT - becomes .251, .084, and .050 ug/l;
Toxaphene becomes .050, .017, and .010 ug/l.
Please review the entire table to ensure there are no more adjustments of this type to be made.

2. This table illustrates the problem with developing criteria for a long list of compounds that may or may not be present in the discharge and which are calculated at the maximum allowed to comply with water quality standards. As you have no doubt observed, several substances have calculated effluent concentrations that are quite high. If a discharge was proposed that contained concentrations approaching the maximums it would be subject to a great deal of scrutiny and likely alternative standards would be developed. However, in this case it is not anticipated that any of the substances will be detected at anything near the proposed discharge limits, particularly after filtration and carbon treatment.

3. Toxicity testing - toxicity testing does not evaluate specific pollutants but measures a cumulative effect. It is used primarily in addition to chemical monitoring to ensure that there are no unexpected toxic effects resulting from unmeasured pollutants or unanticipated synergistic or additive effects. A permit limit based on toxicity can be established without knowing causative agents. For example, if testing shows that the effluent has a significant toxic effect at a 50% dilution, then a permit limit could be developed to ensure that the instream waste concentration in the receiving water never exceeded 50% (always had more than 2 to 1 dilution at 7Q10). At the 500 gpm scenario, there is a 50 to 1 dilution at 7Q10 (if I have calculated correctly) which means the instream waste concentration is 1/50 = .02 or 2%. As long as the significant toxic effect measured in the toxicity test only occurs at a dilution of greater than 2% effluent, an instream effect would be considered unlikely.

4. Routine toxicity testing measures effect not cause. If regulating the effect through limiting volume of discharge is inappropriate, there are ways to manipulate the toxicity testing to identify potential causative pollutants. Identification is usually pretty general, such as classes of compounds, but can lead to some treatment applications that will reduce the toxic effect. Below is an excerpt from the Toxic Discharge Control Strategy:

If Tier II evaluation results in a positive finding (reasonable potential of

water quality standard exceedence) by the Department, the discharger will then have the option of pursuing one of two alternatives; (A) immediate initiation of a toxicity identification-reduction evaluation, TIE-TRE, or (B) generation of additional chemical and/or WET effluent characterization data.

A. Toxicity Identification-Reduction Evaluation - The goal of a Toxicity Identification-Reduction Evaluation,TIE-TRE, is to isolate the causative pollutants or manufacturing processes that produce toxic properties in the discharge and to identify and implement control options that will reduce or eliminate the causative pollutants from the discharge such that compliance with appropriate water quality criteria and permit limits can be achieved. TIE-TRE implementation will be evaluated by repeating the Tier II evaluation process. Guidance for TRE implementation is provided by USEPA for both Municipal (USEPA 1989) and Industrial (Fava et al. 1988) Wastewater Treatment Plants. In addition, USEPA provides guidance for conducting acute Toxicity Identification Evaluations (TIE's) in three documents developed by the National Effluent Toxicity Assessment Center - Phase I, II, and III Acute Toxicity Identification Procedures, and chronic TIE's in one document, Toxicity Identification Evaluation: Characterization of Chronically Toxic Effluents - Phase I.

B. Additional Data Generation - The objective of expanding the data base is to reduce the variability associated with the Tier II determination of "reasonable potential". This data-base expansion will be generated by the discharger with minimum requirements as outlined in Tier III of this document.

Subject: RE: Pownal water discharge
Date sent: Tue, 15 Jul 2003 08:00:25 -0400
From: "Calandra, Frank" <FCalandra@TRCSOLUTIONS.com>
To: "Dale Weiss" <dweiss@ix.netcom.com>,
"Brian Woods" <Brianw@dec.anr.state.vt.us>
Copies to: "Mischel, Greg" <GMischel@TRCSOLUTIONS.com>,
"Plumb, Mike" <MPlumb@TRCSOLUTIONS.com>,
"McVickar, Leslie" <Mcvickar.Leslie@epamail.epa.gov>,
"Denly, Elizabeth" <edenly@TRCSOLUTIONS.com>

Brian,

Attached are the revised discharge criteria. They were revised per your conversation on June 27, 2003 with Dale Weiss. In summary, the 7Q10 flow of 56 cfs was replaced by the annual mean flow of 166 cfs for carcinogenic compounds and compounds that do not have a water quality standard. Carcinogenic compounds are denoted by a "C" in Table 1. As a result of these revisions, criteria for the affected compounds increased by a factor of 166/56 (or approx. 3 times).

Please call me if you have any questions.

Frank
--

Brian Woods
Vermont Department of Environmental Conservation
Waste Management Division
103 South Main Street / West Building
Waterbury, VT 05671-0404
(802)241-3885

TABLE 1

CALCULATION OF TREATED WATER DISCHARGE CRITERIA

POWNAL TANNERY SUPERFUND SITE

LAGOON AREA REMEDIATION

	7Q10 Flow:		58	cubic feet per second (VTDEC)				Conversions:	7.48	gallons per cubic foot					
	Median Flow (Williamstown):		188	cubic feet per second					60	seconds per minute					
	Hardness:		100	ppm, CaCO3 (assumed value)											
							Vermont Water Quality Standards, July 2000								
							Protection of Human Health	Protection of Aquatic Biota					Discharge Criteria (ug/L)		
		C = Carcinogen	Soil/Sludge	GW	SW	Sediment	Consumption of Organisms Only (ug/L)	Average Allowable Concentration - Chronic Criteria ug/L	Vermont Groundwater Enforcement Standard (January 2000) ug/L	EPA MCL (July 2002) ug/L	Applicable Standard ug/L	River Flow (cfs)	100 ppm	300 ppm	400 ppm
VOCs															
	Acetone		X	X	X	X	–	–	700	–	700	166	521,506	173,835	130,376
	Benzene	C	X				71	–	5	5	71	166	52,696	17,632	13,224
	Bromodichloromethane (Bromodichloromethane)		X				22	–	100	80	22	56	5,529	1,843	1,382
	Bromoform	C	X				360	–	100	80	360	166	268,203	89,401	67,051
	Bromomethane (Methyl Bromide)		X				4000	–	10	–	4000	56	1,006,312	335,104	251,328
	2-Butanone (MEK)		X		X	X	–	–	4200	–	4200	166	3,129,034	1,043,011	782,258
	Carbon disulfide		X			X	–	–	–	–	–	56	NA	NA	NA
	Carbon tetrachloride	C	X	X			4.4	–	5	5	4.4	166	3,278	1,093	820
	Chlorobenzene (Monochlorobenzene)		X	X			21000	–	100	100	21000	56	5,277,888	1,759,296	1,319,472
	Chloroform	C	X				470	–	100	80	470	166	350,154	116,718	87,538
	Cyclohexane		X				–	–	–	–	–	56	NA	NA	NA
	1,2-Dichlorobenzene		X	X			17000	–	600	600	17000	56	4,272,576	1,424,192	1,068,144
	1,3-Dichlorobenzene		X	X			2600	–	600	–	2600	56	653,453	217,818	163,363
	1,4-Dichlorobenzene	C	X	X			2600	–	75	75	2600	166	1,937,021	645,674	484,255
	1,1-Dichloroethane		X				–	–	70	–	70	166	52,151	17,384	13,038
	1,2-Dichloroethane	C	X				99	–	5	5	99	166	73,756	24,585	18,439
	1,1-Dichloroethene	C				X	3.2	–	7	7	3.2	166	2,384	795	596
	trans-1,2-Dichloroethene		X				–	–	100	100	100	166	74,501	24,834	18,625
	Ethylbenzene		X	X			29000	–	700	700	29000	56	7,288,512	2,429,504	1,822,128
	2-Hexanone		X				–	–	–	–	–	56	NA	NA	NA
	Isopropylbenzene		X	X			–	–	–	–	–	56	NA	NA	NA
	4-Methyl-2-pentanone		X				–	–	560	–	560	166	417,204	139,068	104,301
	Methyl acetate		X				–	–	–	–	–	56	NA	NA	NA
	Methyl tert-butyl ether			X	X		–	–	40	–	40	166	29,800	9,933	7,450
	Methylcyclohexane		X	X			–	–	–	–	–	56	NA	NA	NA
	Methylene chloride	C	X	X		X	1600	–	5	5	1600	166	1,192,013	397,338	298,003
	Styrene	C	X				–	–	100	100	100	166	74,501	24,834	18,625
	Tetrachloroethylene	C	X	X			8.85	–	5	5	8.85	166	6,593	2,198	1,648
	Tetrahydrofuran		X				–	–	–	–	–	56	NA	NA	NA
	Toluene		X	X	X	X	200000	–	1000	1000	200000	56	50,265,600	16,755,200	12,566,400
	1,2,4-Trichlorobenzene		X	X			–	–	70	70	70	166	52,151	17,384	13,038
	1,1,1-Trichloroethane		X				–	–	200	200	200	166	149,002	49,667	37,250
	Trichloroethene	C	X	X			81	–	5	5	81	166	60,346	20,115	15,086
	Xylene		X	X			–	–	10000	10000	10000	166	7,450,080	2,483,360	1,862,520
SVOCs															
	Acenaphthene		X			X	–	–	–	–	–	56	NA	NA	NA
	Acenaphthylene		X			X	–	–	–	–	–	56	NA	NA	NA
	Acetophenone		X				–	–	–	–	–	56	NA	NA	NA
	Anthracene		X			X	110000	–	2100	–	110000	56	27,648,080	9,215,360	6,911,520
	Atrazine			X			–	–	3	3	3	166	2,235	745	559
	Benzaldehyde		X			X	–	–	–	–	–	56	NA	NA	NA
	Benzo(a)anthracene	C	X			X	0.031	–	–	–	0.031	166	23	8	8
	Benzo(a)pyrene	C	X			X	0.031	–	0.2	0.2	0.031	166	23	8	8
	Benzo(b)fluoranthene	C	X			X	0.031	–	–	–	0.031	166	23	8	8
	Benzo(g,h,i)perylene		X			X	–	–	–	–	–	56	NA	NA	NA
	Benzo(k)fluoranthene	C	X			X	0.031	–	–	–	0.031	166	23	8	8
	1,1-Biphenyl		X				–	–	–	–	–	56	NA	NA	NA
	Bis(2-chloroethoxy)methane		X				–	–	–	–	–	56	NA	NA	NA
	Bis(2-chloroethyl)ether	C	X				1.4	–	–	–	1.4	166	1,043	348	261
	Bis(2-ethylhexyl)phthalate		X	X	X	X	5.9	–	6	6	5.9	56	1,483	494	371
	Butylbenzylphthalate					X	–	–	–	–	–	56	NA	NA	NA
	Caprolactam		X				–	–	–	–	–	56	NA	NA	NA
	Carbazole		X			X	–	–	–	–	–	56	NA	NA	NA
	Chrysene	C	X			X	0.031	–	–	–	0.031	166	23	8	8
	4-Chloro-3-methylphenol		X				–	–	–	–	–	56	NA	NA	NA
	4-Chloroaniline		X			X	–	–	–	–	–	56	NA	NA	NA

TABLE 1
CALCULATION OF TREATED WATER DISCHARGE CRITERIA
POWNAL TANNERY SUPERFUND SITE
LAGOON AREA REMEDIATION

	7Q10 Flow:		56	cubic feet per second (VTDEC)				Conversions:	7.48	gallons per cubic foot						
	Median Flow (Williamstown):		168	cubic feet per second					60	seconds per minute						
	Hardness:		100	ppm, CaCO3 (assumed value)												
							Vermont Water Quality Standards, July 2000									
							Protection of Human Health	Protection of Aquatic Biota						Discharge Criteria (ug/L)		
		C = Carcinogen	Soil/Sludge	GW	SW	Sediment	Consumption of Organisms Only (ug/L)	Average Allowable Concentration - Chronic Criteria ug/L	Vermont Groundwater Enforcement Standard (January 2000) ug/L	EPA MCL (July 2002) ug/L	Applicable Standard ug/L	River Flow (cfs)	100 gpm	300 gpm	400 gpm
	Dibenzo(a,h)anthracene	C	X			X	0.031	--	--	--	0.031	168	23	8	6
	Dibenzofuran		X			X	--	--	--	--	--	56	NA	NA	NA
	2,4-Dichlorophenol		X				790	--	--	--	790	56	166,549	66,183	49,637
	Diethylphthalate		X	X		X	120000	--	--	--	120000	56	30,158,380	10,053,120	7,539,840
	2,4-Dimethylphenol		X				--	--	--	--	--	56	NA	NA	NA
	Di-n-butylphthalate		X	X		X	12000	--	--	--	12000	56	3,015,938	1,005,312	753,984
	Di-n-octylphthalate		X				--	--	--	--	--	56	NA	NA	NA
	Fluoranthene		X			X	370	--	280	--	370	56	92,991	30,997	23,248
	Fluorene		X			X	14000	--	280	--	14000	56	3,518,592	1,172,864	879,648
	Hexachloroethane	C		X			8.9	--	--	--	8.9	168	6,831	2,210	1,658
	Indeno(1,2,3-cd)pyrene	C	X			X	0.031	--	--	--	0.031	168	23	8	6
	Isophorone		X				600	--	100	--	600	56	150,797	50,266	37,699
	2-Methylnaphthalene		X			X	--	--	--	--	--	56	NA	NA	NA
	2-Methylphenol		X				--	--	--	--	--	56	NA	NA	NA
	4-Methylphenol		X	X		X	--	--	--	--	--	56	NA	NA	NA
	Naphthalene		X	X		X	--	--	20	--	20	168	14,900	4,967	3,725
	2-Nitroaniline		X				--	--	--	--	--	56	NA	NA	NA
	Nitrobenzene		X				1900	--	--	--	1900	56	477,523	159,174	119,381
	2-Nitrophenol		X				--	--	--	--	--	56	NA	NA	NA
	4-Nitrophenol		X				--	--	--	--	--	56	NA	NA	NA
	N-Nitroso-di-n-propylamine		X				--	--	--	--	--	56	NA	NA	NA
	2,2-oxybis-1-Chloropropane (bis-2 Chloroisopropyl ether)		X				170000	--	300	--	170000	56	42,725,760	14,241,920	10,681,440
	Pentachlorophenol	C	X	X		X	8.2	5.725901475	1	1	5.725901475	56	1,439	480	360
	Phenanthrene		X			X	--	--	--	--	--	56	NA	NA	NA
	Phenol		X				4600000	--	4000	--	4600000	56	1,156,108,800	385,369,600	289,027,200
	Pyrene		X			X	11000	--	--	--	11000	56	2,764,508	921,536	691,152
	2,4,5-Trichlorophenol		X				--	--	--	--	--	56	NA	NA	NA
	2,4,6-Trichlorophenol	C	X				6.5	--	--	--	6.5	168	4,843	1,614	1,211
Metals																
	Aluminum		X	X	X	X	--	--	200	--	200	168	148,902	49,607	37,250
	Antimony		X	X	X	X	4300	--	6	6	4300	56	1,080,710	360,237	270,178
	Arsenic	C	X	X	X	X	1.5	190	50	10	1.5	168	1,118	373	279
	Barium		X	X	X	X	--	--	2000	2000	2000	168	1,490,016	496,672	372,504
	Beryllium		X		X	X	--	--	4	4	4	168	2,980	993	745
	Cadmium		X	X	X	X	--	1.134259063	5	5	1.134259063	56	285	95	71
	Calcium		X	X	X	X	--	--	--	--	--	56	NA	NA	NA
	Chromium		X	X	X	X	--	208.9825277	100	100	208.9825277	56	52,021	17,340	13,005
	Cobalt		X	X	X	X	--	--	--	--	--	56	NA	NA	NA
	Copper		X	X	X	X	--	11.82384108	1300	1300	11.82384108	56	2,972	991	743
	Iron		X	X	X	X	--	1000	300	--	1000	56	251,328	83,776	62,832
	Lead		X	X	X	X	--	3.181591829	15	15	3.181591829	56	800	267	200
	Magnesium		X	X	X	X	--	--	--	--	--	56	NA	NA	NA
	Manganese		X	X	X	X	--	--	840	--	840	168	825,807	206,602	156,452
	Mercury		X	X	X	X	0.15	0.012	2	2	0.012	56	3.0	1.0	0.8
	Nickel		X	X	X	X	4600	157.6652284	100	--	157.6652284	56	39,626	13,209	9,906
	Potassium		X	X	X	X	--	--	--	--	--	56	NA	NA	NA
	Selenium		X	X	X	X	--	5	50	50	5	56	1,257	419	314
	Silver		X	X	X	X	--	--	100	--	100	168	74,501	24,834	18,625
	Sodium		X	X	X	X	--	--	250000	--	250000	168	186,252,000	62,084,000	46,563,000
	Thallium		X	X	X	X	6.3	--	2	2	6.3	56	1,583	528	396
	Vanadium		X	X	X	X	--	--	--	--	--	56	NA	NA	NA
	Zinc		X	X	X	X	--	105.9918904	5000	--	105.9918904	56	26,609	8,880	6,660
	Cyanide		X	X	X	X	220000	5.2	200	200	5.2	56	1,307	436	327
Pest/PCBs																
	Aldrin	C	X			X	0.00014	--	0.05	--	0.00014	168	0.104	0.035	0.026
	Arocior 1242	C	X			X	0.000045	0.014	0.5	0.5	0.000045	168	0.034	0.011	0.008
	Arocior 1248	C	X				0.000045	0.014	0.5	0.5	0.000045	168	0.034	0.011	0.008

TABLE 1
CALCULATION OF TREATED WATER DISCHARGE CRITERIA
POWNAL TANNERY SUPERFUND SITE
LAGOON AREA REMEDIATION

	7Q10 Flow:		58	cubic feet per second (VTDEC)				Conversions:	7.48	gallons per cubic foot					
	Median Flow (Williamstown):		168	cubic feet per second					60	seconds per minute					
	Hardness:		100	ppm, CaCO3 (assumed value)											
							Vermont Water Quality Standards, July 2000								
							Protection of Human Health	Protection of Aquatic Biota					Discharge Criteria (ug/L)		
		C = Carcinogen	Soil/Sludge	GW	SW	Sediment	Consumption of Organisms Only	Average Allowable Concentration - Chronic Criteria	Vermont Groundwater Enforcement Standard (January 2000)	EPA MCL (July 2002)	Applicable Standard	River Flow (cfs)	100	300	400
							(ug/L)	ug/L	ug/L	ug/L	ug/L		ppm	ppm	ppm
	Aroclor 1254	C	X			X	0.000045	0.014	0.5	0.5	0.000045	168	0.034	0.011	0.008
	Aroclor 1260	C	X			X	0.000045	0.014	0.5	0.5	0.000045	168	0.034	0.011	0.008
	alpha-BHC		X			X	0.013	--	--	--	0.013	58	3.287	1.089	0.817
	beta-BHC		X			X	0.046	--	--	--	0.046	58	11.581	3.854	2.890
	delta-BHC		X			X	--	--	--	--	--	58	NA	NA	NA
	alpha-Chlordane		X			X	--	--	--	--	--	58	NA	NA	NA
	4,4'-DDD	C	X			X	0.00084	--	--	--	0.00084	168	0.826	0.209	0.156
	4,4'-DDE	C	X			X	0.00059	--	--	--	0.00059	168	0.440	0.147	0.110
	4'4'-DDT	C	X			X	0.00059	0.001	--	--	0.001	58	0.251	0.084	0.063
	Dichlorobiphenyls					X	--	--	0.5	0.5	0.5	168	373	124	93
	Dieldrin	C	X			X	0.00014	--	0.02	--	0.00014	168	0.104	0.035	0.026
	Endosulfan I		X				2	0.056	--	--	0.056	58	14.074	4.691	3.519
	Endosulfan II		X				2	0.056	--	--	0.056	58	14.074	4.691	3.519
	Endosulfan sulfate		X			X	2	--	--	--	2	58	500	168	126
	Endrin		X			X	0.81	0.0023	2	2	0.0023	58	0.578	0.193	0.145
	Endrin aldehyde		X				0.81	--	--	--	0.81	58	204	68	51
	Endrin ketone		X			X	--	--	--	--	--	58	NA	NA	NA
	gamma-BHC (Lindane)		X			X	0.063	0.8	0.2	0.2	0.063	58	18	5	4
	gamma-Chlordane		X			X	--	--	--	--	--	58	NA	NA	NA
	Heptachlor	C	X			X	0.00021	0.0038	0.4	0.4	0.00021	168	0.158	0.052	0.038
	Heptachlor epoxide	C	X	X		X	0.00011	0.0038	0.2	0.2	0.00011	168	0.082	0.027	0.020
	Heptachlorobiphenyls					X	--	--	0.5	0.5	0.5	168	373	124	93
	Hexachlorobiphenyls					X	--	--	0.5	--	0.5	168	373	124	93
	Methoxychlor		X			X	--	--	40	40	40	168	29,800	9,933	7,450
	Pentachlorobiphenyls					X	--	--	0.5	0.5	0.5	168	373	124	93
	Tetrachlorobiphenyls		X			X	--	--	0.5	0.5	0.5	168	373	124	93
	Trichlorobiphenyls					X	--	--	0.5	0.5	0.5	168	373	124	93
	Toxaphene	C	X				0.00075	0.0002	3	3	0.0002	58	0.050	0.017	0.013
Dioxin															
	Dioxin (2,3,7,8-TCDD)	C	X	X	X	X	1.40E-08	--	3.00E-05	3.00E-05	1.40E-08	168	1.04301E-05	3.4767E-06	2.60753E-06

TABLE 2
DISCHARGE CRITERIA
POWNAL TANNERY SUPERFUND SITE
LAGOON AREA REMEDIATION

Compound	Discharge Criteria (ug/L)	Basis of Criteria
VOCs		
Acetone	130,000	Vermont Groundwater Enforcement Standard
Benzene	13,200	Protection of Human Health
Bromodichloromethane (Bromodichloromethane)	1,380	Protection of Human Health
Bromoform	87,100	Protection of Human Health
Bromomethane (Methyl Bromide)	251,000	Protection of Human Health
2-Butanone (MEK)	782,000	Vermont Groundwater Enforcement Standard
Carbon tetrachloride	820	Protection of Human Health
Chlorobenzene (Monochlombenzene)	1,320,000	Protection of Human Health
Chloroform	87,500	Protection of Human Health
1,2-Dichlorobenzene	1,070,000	Protection of Human Health
1,3-Dichlombenzene	163,000	Protection of Human Health
1,4-Dichlorobenzene	484,000	Protection of Human Health
1,1-Dichloroethane	13,000	Vermont Groundwater Enforcement Standard
1,2-Dichloroethane	18,400	Protection of Human Health
1,1-Dichloroethene	596	Protection of Human Health
trans-1,2-Dichloroethene	18,600	Vermont Groundwater Enforcement Standard
Ethylbenzene	1,820,000	Protection of Human Health
4-Methyl-2-pentanone	104,000	Vermont Groundwater Enforcement Standard
Methyl tert-butyl ether	7,450	Vermont Groundwater Enforcement Standard
Methylene chloride	298,000	Protection of Human Health
Styrene	18,600	Vermont Groundwater Enforcement Standard
Tetrachloroethylene	1,650	Protection of Human Health
Toluene	12,600,000	Protection of Human Health
1,2,4-Trichlorobenzene	13,000	Vermont Groundwater Enforcement Standard
1,1,1-Trichloroethane	37,300	Vermont Groundwater Enforcement Standard
Trichloroethene	15,100	Protection of Human Health
Xylene	1,860,000	Vermont Groundwater Enforcement Standard
SVOCs		
Anthracene	6,910,000	Protection of Human Health
Atrazine	559	Vermont Groundwater Enforcement Standard
Benzo(a)anthracene	5.77	Protection of Human Health
Benzo(a)pyrene	5.77	Protection of Human Health
Benzo(b)fluoranthene	5.77	Protection of Human Health
Benzo(k)fluoranthene	5.77	Protection of Human Health
Bis(2-chloroethyl)ether	261.0	Protection of Human Health
Bis(2-ethylhexyl)phthalate	371	Protection of Human Health
Chrysene	5.77	Protection of Human Health
Dibenzo(a,h)anthracene	5.77	Protection of Human Health
2,4-Dichlorophenol	49,800	Protection of Human Health
Diethylphthalate	7,540,000	Protection of Human Health
Di-n-butylphthalate	754,000	Protection of Human Health
Fluoranthene	23,200	Protection of Human Health
Fluorene	880,000	Protection of Human Health
Hexachloroethane	1,660	Protection of Human Health
Indono(1,2,3-cd)pyrene	5.77	Protection of Human Health
Isophorone	37,700	Protection of Human Health
Naphthalene	3,730	Vermont Groundwater Enforcement Standard
Nitrobenzene	119,000	Protection of Human Health
2,2-oxybis-1-Chloropropane (bis-2 Chloroisopropyl ether	10,700,000	Protection of Human Health
Pentachlorophenol	360	Protection of Aquatic Biota
Phenol	289,000,000	Protection of Human Health
Pyrene	691,000	Protection of Human Health
2,4,6-Trichlorophenol	1,210	Protection of Human Health
Metals		
Aluminum	37,300	Vermont Groundwater Enforcement Standard
Antimony	270,000	Protection of Human Health
Arsenic	278	Protection of Human Health
Barium	373,000	Vermont Groundwater Enforcement Standard
Beryllium	745	Vermont Groundwater Enforcement Standard
Cadmium	71.3	Protection of Aquatic Biota
Chromium	13,000	Protection of Aquatic Biota
Copper	743	Protection of Aquatic Biota
Iron	62,800	Protection of Aquatic Biota
Lead	200	Protection of Aquatic Biota
Manganese	156,000	Vermont Groundwater Enforcement Standard
Mercury	0.75	Protection of Aquatic Biota
Nickel	8,910	Protection of Aquatic Biota
Selenium	314	Protection of Aquatic Biota
Silver	18,600	Vermont Groundwater Enforcement Standard
Sodium	46,600,000	Vermont Groundwater Enforcement Standard
Thallium	396	Protection of Human Health
Zinc	8,680	Protection of Aquatic Biota
Cyanide	327	Protection of Aquatic Biota
PCBs		
Total PCBs	0.00838	Protection of Human Health (MDL = 0.02 ug/L)
Dioxin		
Dioxin (2,3,7,8-TCDD)	2.61E-06	Protection of Human Health
Water Quality Parameters		
pH	4 < pH <10	Vermont Water Quality Standard
Turbidity	50 NTU	Vermont Water Quality Standard

Note:
Discharge criteria calculated for discharge flow rate of 400 gallons per minute.

APPENDIX E

FINAL PLAN FOR MINIMIZING ENVIRONMENTAL AND PUBLIC IMPACTS

FINAL PLAN FOR MINIMIZING ENVIRONMENTAL AND PUBLIC IMPACTS

POWNAL TANNERY SUPERFUND SITE
POWNAL, VERMONT

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September 2003

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ATTACHMENT

A Preliminary Air Monitoring Plan

1.0 INTRODUCTION

This plan identifies and summarizes the measures that will be followed to minimize environmental and public impacts during design and construction of the Remedy at the Pownal Tannery Superfund Site (Site) in Pownal, Vermont.

This plan includes a discussion of engineering controls that will be included in the remedy design for sludge and water handling. The plan also describes monitoring and exposure control procedures, and other measures to mitigate the following possible impacts:

- The release of contaminated water;
- The release of contaminated sludge;
- Fugitive emissions of odor and dust;
- Noise; and
- Traffic.

Further, as agreed with Warren Foster of the Vermont Department of Environmental Conservation (DEC), this document also includes a discussion of the anticipated or potential impacts and planned mitigation related to the ten Act 250 criteria. Although an Act 250 Permit is not required, this document demonstrates compliance with each Act 250 criteria.

1.1 Site Description

The Pownal Tannery Superfund Site consists of a 28-acre set of parcels located between Route 346 and the Hoosic River in the Village of North Pownal, Vermont (Figure 1). The Site was a former hide tanning and finishing facility owned by the Pownal Tanning Company, Inc. The Site has been inactive since 1988, when the company declared bankruptcy. The Site originally consisted of three contamination sources: the former tannery building complex, a capped sludge landfill, and a lagoon system. The US Environmental Protection Agency (EPA), during a Non-Time Critical Removal Action that was completed in 2001 permanently capped the landfill and removed the building complex. Under a Memorandum of Agreement between EPA and the Vermont Department of Environmental Conservation (VTDEC), the State of Vermont is operating and maintaining the sludge landfill.

The area surrounding the Site is a rural and residential community with approximately 3,500 residents, with the nearest residences being approximately 200 feet from the lagoons. These residences rely upon ground water from private wells for their water supply. Currently, the lagoon area is fenced and locked, but is regularly broken into by the neighboring population to use it for recreational purposes. The lagoon complex is partially covered with soil, over which disturbed wetlands vegetation occurs. Three of the five lagoons on its western side border the Hoosic River, which is also used for recreational purposes during the warm months (Vermont Water Quality Standards, Class B for high quality habitat). On the eastern border of the Site there is an access road to Route 346, which is adjacent to railroad tracks owned and operated by Boston and Maine Corp. To the south of the lagoon complex is the former tannery building parcel and a hydroelectric facility and dam that were built in 1955 for use by the tannery

(Figure 2). The remaining area (except the tannery landfill) was removed of all contamination to CERCLA residential standards, re-graded, and seeded.

1.2 Selected Remedy

The Remedy for the remaining lagoon area (as presented in the September 30, 2002 Record of Decision) includes the excavation of contaminated sludge materials from Lagoons 1 and 5, consolidation over Lagoon 3 and the southeast corner of Lagoon 4, and capping the consolidated sludge with a cover system. Development of a landfill design appropriate for the site required evaluation of various site factors including the volume of material to be landfilled, impacts to the Hoosic River, and the intended future use and other site-specific design considerations.

Implementation of the selected remedy identified in the ROD is anticipated to include the following components:

- Pre-construction activities;
- Erosion and sedimentation controls;
- Construct staging area over Lagoon 2;
- Clearing and grubbing of Lagoons 1, 2, 3, 4 (southeast portion only), and 5;
- Excavation of wastes from Lagoons 1 and 5;
- Consolidation of wastes over Lagoon 3 and the southeast portion of Lagoon 4;
- Construction of a solid waste cover system over the waste sludge;
- Institutional controls;
- Long-term ground water and river sediment monitoring;
- Operation and maintenance of the remedial action;
- Institutional control inspections; and
- Five-year Site reviews.

2.0 SUMMARY OF ACT 250 CRITERIA AND COMPLIANCE

The Act 250 review process was created by the Vermont Legislature in 1970 and is intended to cover significant development and subdivisions in Vermont. In passing Act 250, the Vermont Legislature declared that "it is necessary to regulate and control the utilization and usages of land and the environment to insure that only usages which will be permitted are not unduly detrimental to the environment, will promote the general welfare through orderly growth and development, and are suitable to the demands and needs of the people of Vermont." In order to obtain a Land Use Permit under Act 250, an applicant needs to demonstrate to a District Environmental Commission that the development or subdivision can meet ten specific performance criteria, including:

- Water and Air Pollution;
- Water Supply;
- Soil Erosion and Drainage;
- Highways;
- Educational Services;
- Municipal Services;
- Scenic Beauty, Historic Sites, and Natural Areas;
- Impact of Growth; and
- Local and Regional Plans.

Table 1 summarizes the Act 250 criteria and sub-criteria. As shown in that table, many of the criteria/sub-criteria are not applicable to the Pownal Tannery Remedy. The following subsections describe how the Remedy will generally comply with each of the ten criteria. Only the criteria that are applicable to the Remedy are discussed. The sections are presented by general topic, as some of the criteria overlap. Table 1 cross-references where each criteria is addressed in the following sections.

3.0 SUMMARY OF POTENTIAL ENVIRONMENTAL IMPACTS AND MITIGATION

This section addresses the following topics:

- Air and Noise;
- Water Resources, including water quality and supply, floodways, streams, shorelines, and wetlands;
- Storm Water Management and Soil Erosion Control;
- Transportation;
- Scenic Beauty, Historic Sites, and Natural Areas; and
- Impacts of Growth and other Act 250 Criteria.

3.1 Air and Noise

3.1.1 Air

During the field investigation program portion of the Remedial Investigation (RI), hydrogen sulfide gas and noxious odors were encountered emanating from boreholes advanced in Lagoon 3. This condition requires special consideration during the detailed design and construction phases of the Remedy.

Due to the potential issues associated with generation of hydrogen sulfide gas and odors, design and implementation of appropriate air monitoring procedures will be required for all activities involving the handling of contaminated materials. The potential for worker exposure will be addressed by implementing monitoring techniques suitable to ensure exposure limits set by the Occupational Safety and Health Agency (OSHA) are not exceeded. The requirements for appropriate personal protection equipment (PPE) and location, frequency, and parameters to be monitored during all aspects of the air monitoring program, will be evaluated by a Certified Industrial Hygienist (CIH) and incorporated into the construction procedures and methods required for remedy implementation. In addition to worker exposure issues, hydrogen sulfide gas also has the potential to pose an explosion hazard.

Further, off-site exposure to hydrogen sulfide concentrations must also be evaluated and controlled to the extent possible.

Measures have be incorporated in the design and construction of the Remedy to monitor and control air and odor impacts to onsite and offsite receptors. Such measures include the following:

- Continuous monitoring of the potential for explosive conditions in the work area;
- Use of non-sparking equipment;
- Addition of lime during excavation to reduce concentrations of hydrogen sulfide;
- Limiting exposure of excavation area;

- Lifting portions of the clay layer on Lagoon 3 prior to excavation work to off gas hydrogen sulfide vapors; and
- Covering open excavations at the end of each workday, with dust and emission control foam and/or tarps.

Appropriate requirements have been fully evaluated and identified in the specifications for construction of the Remedy.

A specification has been prepared for the constructor of the Remedy to develop a detailed Health and Safety Plan. Past site evaluations generated significant data in relation to this project and have been incorporated into the specification. Remedial activities have the greatest risk for potential exposure and will require careful planning to maintain low risk of exposure during the remediation. A critical component of the specification details the appropriate level of training for site personnel with the intention of reducing the potential for exposure to the constituents of concern. The specification details air monitoring procedures, (short and long term), exposure control procedures, and other safety issues associated with the site. The plan will be part of the comprehensive remedial plan for the site and will be designed to comply with OHSA and EPA standards.

A perimeter air-monitoring program has been specified for protection of persons not associated with the remediation construction. Measures to mitigate fugitive air emissions have been specified in the event that action levels are exceeded. A preliminary draft of the air-monitoring program is provided as Attachment A.

Further, fugitive dust emissions during construction may result from earthwork (excavation, grading, landscaping, etc.), movement of vehicles on site, roadways, and wind erosion. Fugitive dust mitigation measures may include limiting vehicle speeds on site, and routinely wetting roads and work areas. Heavy traffic areas, such as the Site access road and the laydown and parking areas, will be covered with aggregate. Trucks transporting loose soil will be covered or their loads will be wetted to reduce loss. Construction industry experience suggests that these measures will be adequate to control fugitive dust emissions. If construction-related dust becomes a nuisance, additional dust control measures (increasing watering frequencies, covering exposed surfaces) will be considered as further mitigation measures. If needed, stockpiles and other exposed soil surfaces may be covered with vinyl (or similar) sheeting or planted with grass, as appropriate, to minimize emissions.

3.1.2 Noise

Construction of the Remedy is anticipated to occur over a nine-month time frame. During the construction period, there may be some temporary offsite noise disturbances associated with operation of construction equipment and delivery of materials. It is anticipated that the following equipment will be operated at the Project site:

- Articulated dump trucks (two);
- Excavator (two);
- Compactors (two); and
- Bull dozers (two).

In addition, there will be deliveries of materials to construct the landfill. Noise would be generated primarily from the diesel engines that power this equipment. Exhaust noise usually is the predominant source of diesel engine noise.

It is estimated that noise levels may fluctuate in the range of 73 to 82 dBA at the closest residences, depending on the number of pieces of equipment simultaneously in use. There will of course be times when noise levels are at or near ambient when no equipment are in operation or are just idling.

To mitigate noise impacts, the design specifications will require that functional mufflers be maintained on all diesel-powered equipment to maintain construction noise levels as low as possible. In addition, construction activities will be restricted primarily to the daytime hours of 7:00 am to 7:00 pm. Noise producing construction activities will be limited to the weekday to the extent possible, although some weekend work may be required to meet the project's schedule.

Further, the noisier activities, such as excavation could be scheduled to occur during midday hours to the extent possible, avoiding early morning or evening hours if off site noise impacts pose a problem.

3.2 Water Resources

3.2.1 Water Quality and Supply

Dewatering of the excavation may be required for short periods of time to confirm that all of the sludge material was removed or to place clean backfill into the excavation. The design of the water treatment system will ensure that any potentially contaminated water is properly handled and treated prior discharge to the Hoosic River. The water treatment system has been specified to remove contaminants of concern including PAH compounds, dioxins, and metals. The treatment system will reduce the turbidity of the influent water in order to remove the organic compounds that are likely adsorbed to the organic matter in the sludge materials. Discharge criteria have been established during the detailed design to meet the requirements of the Vermont Water Quality Standards.

Minimal quantities of water are required for construction of the Remedy, and will be trucked in on an as needed basis.

3.2.2 Floodways

The Project lies within the current floodway and the 100-year floodplain of the Hoosic River. The area of the 100-year floodplain is the area subject to flooding on the average of at least once every 100 years. The Hoosic River flows generally from south to north along the western boundary of the lagoon area, separated by a single, continuous elevated soil berm. Vegetation present along the surface of this soil berm varies from scrub vegetations to mature trees, which currently stabilizes the berm surface from erosion. During periods of flood flows within the Hoosic River, the water surface rises up the western face of this soil berm. Under extreme flood flow conditions (i.e., 100-year flood) this berm is over-topped, and the river waters spill into the lagoon area, submerging Lagoons 1, 4, and 5.

As described in the ROD, EPA has made a specific determination that construction of the landfill within the 100-year floodplain of the Hoosic River is the most practicable alternative to address the former lagoons. Off-site disposal of the contaminated materials was investigated, but was determined in feasible.

The design of the remedial action, particularly the consolidation landfill, takes into account the potential impacts from the Hoosic River during the 100 year flood. In addition, a pre-design hydrologic modeling study was completed by TRC to evaluate the affect of the proposed facility on the Hoosic River flood stage. The results of the TRC hydrologic study are discussed in a separate document (Hoosic River Modeling Report) that is included in the FS.

The site land surface in the model included the landfill located on the east side of Lagoon 4 and Lagoon 3, and the removal of portions of the soil berm separating the river from the site. The soil berm in the model was lowered along south side of Lagoons 1 and 5, and at the north end of Lagoon 4. The results of hydrologic modeling conducted by TRC showed that the construction of the facility would have minimal impact on the 100-year flood elevation presented in the FEMA study by eliminating the existing constrictions in the floodway (e.g. the soil berm). The TRC Hoosic River modeling study showed that the proposed facility would result in only a minor increase in the 100-year flood elevation in some locations and a decrease in the 100-year flood elevation in other locations adjacent to the proposed facility. Furthermore, the upper elevation of the proposed facility (landfill) is projected to lie well above the 100-year flood elevation; therefore scour of the upper landfill surface is not a concern.

A separate river model was conducted by the VTDEC during design. Based on the VTDEC river model, the VTDEC directed TRC to modify the design as follows:

- Maintain the soil berm height along the south side of Lagoons 1 and 5,
- Lower 125 linear feet of soil berm at the north end of Lagoon 4 to an elevation of between 495 and 500 feet above MSL to create an outlet for flood waters;
- Design erosion controls (riprap armor) for the Lagoon 4 berm outlet and the side slopes of the landfill for an overbank water flow velocity of 8.5 fps;

- Maintain a setback of 140 feet between the toe of the landside of the soil berm and the toe of the landfill;
- Backfill and re-grade the overbank area between the river and the landfill to a level that will not extend above a plane starting at elevation 500 at the north end of Lagoon 4 with a 0.4 percent slope up to the east end of Lagoon 1.

Residences across from the Site are located at the top of a steep embankment overlooking the River well above the 100-year flood elevation. Therefore, the results of the model indicate that the project will not have a negative impact on the public and riparian owners during flood events.

The Remedy has been designed to resist flood damage and to minimize the effects on the existing floodplain. Several actions are included in the design that will minimize the impact of floods and preserve the natural and beneficial values of the floodplain. These actions include the following:

- Regrading to make changes to the floodway shape and location;
- Covering the waste materials in the lagoons with a protective cap that will be designed to resist the erosion forces of the 100-year flood event;
- Consolidating some of the saturated waste to areas above the water table; and
- Restoring natural vegetation along the Hoosic River bank..

The cap will be inspected regularly and maintained by the State of Vermont.

3.2.3 Streams

Figure 3 shows the boundaries of all streams and riparian wetlands on or ajdancent to the Project site and includes the following:

- Hoosic River;
- Wetland HR 1 Hoosic River Riparian Fringe; and
- Wetland HR 2 Hoosic River Riparian Fringe.

The Remedy includes the excavation of sludge within the boundary of the 100 foot riparian buffer and the 50 foot wetland buffer zones. Once completed, the area will be restored with floodplain vegetation, including but not limited to the tree and shrub species listed in Table 2. In addition the area will be planted with a New England Conservation seed mix to establish native herbaceous species.

During construction, the stream banks and riparian wetlands will be protected with silt fence/hay bales, stabilized construction entrances, and other Best Management Practices (BMPs) as described in the Erosion and Sediment Control Plan (Attachment J of the Basis of Design Report). Additionally, the Vermont DEC has requested that a 100-foot buffer from the river be maintained. Impacts within this buffer zone will be minimized to the extent possible. Any impacts will be restored with native vegetation.

In that the Remedy will modify the cross-section of the Hoosic River through the alteration of the banks within the vicinity of the lagoons, this project would be required to meet the substantive requirements of a Stream Alteration Permit. Pursuant to 10 VSA Chapter 41, Section 1023 a permit would be granted for this work, subject to such conditions determined to be warranted, since the proposed work:

(1) Will not adversely affect the public safety by increasing flood hazards;

(2) Will not significantly damage fish life or wildlife;

(3) Will not significantly damage the rights of riparian owners; and

(4) In case of any waters designated by the board as outstanding resource waters, will not adversely affect the values sought to be protected by designation.

This Remedy meets these requirements and does not involve the construction of a permanent dam, or the withdrawal of water from a stream, river, pond, or lake.

3.2.4 Shorelines

Pursuant to Title 10, Chapter 151, of Vermont's Land Use and Development Law, shorelines include the land between the mean high water mark and the mean low water mark of the waters of lakes, ponds, reservoirs, and rivers. The Hoosic River is the only body of open water that possesses a shoreline on the site (see Sheets C-2 and C-3 of the Design Drawings).

The only portion of the Hoosic River shoreline that will be directly impacted will occur along those reaches adjacent to the lagoons. During construction, the shoreline of undisturbed portions of the Hoosic River will be protected with standard BMPs including silt fence and hay bales (see Sediment and Erosion Control Plan).

3.2.5 Wetlands

The Vermont Wetland Rules are applicable to those wetlands, which are so significant that they merit protection under that program. Pursuant to Section 4 of the Rules, all wetlands in Vermont are designated as Class One, Class Two, or Class Three Wetlands. Those wetlands designated as Class One or Class Two have been deemed by the Board to be so significant that they merit protection, and Class Three Wetlands are those wetlands that have not been determined by the Board to be so significant that they merit protection under the Vermont Wetland Rules. The Vermont DEC does not consider the man-made lagoons to be significant wetlands, and as such the work proposed in these areas is not subject to the Vermont Wetland Rules.

The location and areal extent of all significant wetlands and associated 50-foot buffer zones on the site are depicted on Sheet C-2 and C-3 of the Design Drawings.

The design will incorporate DEC's recommendations for wetland restoration. The buffer zone areas will be then restored with native floodplain vegetation as described above in Section 3.2.3. The restored areas will provide: storage for floodwater and storm water, water quality protection, wildlife habitat, and some erosion control. Accordingly, all work will be performed in accordance with the intent of the Vermont Wetland Rules.

Disturbance of the natural vegetation will be minimized to the extent practicable. Prior to construction activities, sediment and erosion control measures such as silt fence and hay bales will be used to protect against erosion and siltation into the Hoosic River or wetland (see Erosion and Sediment Control Plan in Attachment K of the Basis of Design Report).

The sediment and erosion controls will be left in place until exposed soils have successfully re-vegetated. Temporary devices and structures to control erosion and sedimentation in and around

the mitigation site shall be disassembled and properly disposed of before November of the third full growing season after planting. Sediment collected by these devices will be removed and placed upland in a manner that prevents its erosion and transport to a waterway or wetlands.

3.3 Storm Water Management and Soil Erosion Control

The Existing Site Conditions Map is presented as Sheets C-2 and C-3 of the Design Drawings.

The current topography of the lagoon area includes a series of soil berms surrounding Lagoons 1, 4, and 5. Each of these lagoons has a generally flat, low-lying surface within their respective surrounding soil berms. Surface topography of Lagoon 3 is higher than the elevation of the Lagoons 1, 4, and 5. Lagoon 2 has been subject to a removal action, which left the area as an isolated surface depression.

Storm water drainage patterns under current conditions are controlled by the elevated soil berms surrounding the individual lagoons and the lagoon area as a whole. Under the extreme flood flow conditions, the surface of the lagoon area is subjected to significant erosive forces, and potentially mobilizes contaminated materials down stream. As these floodwaters subside, the berms and the lagoon area remain flooded for some period of time as the retained water percolates downward.

The Remedy will not have any impermeable areas (i.e. structures or paved areas). Design of the final site grades provides for positive drainage of surface water runoff away from the landfill cover system. Design of site drainage patterns also considers the proposed construction of the Town's Waste Water Treatment Plant within the footprint of Lagoon 2 and the proximity of the site property line along the eastern edge of the proposed landfill. Storm water runoff flowing from the landfill cover towards the east will be diverted away from these features via swales which will discharge this water within the current footprint of the lagoon area. The Remedy has been designed to prevent the potential for contaminated materials to run offsite due to storm water flows.

The design of the landfill includes relatively flat ground surface slopes over the top portion, with steeper slopes (up to 33%) on the side slopes. The steeper side slopes will be armored to resist erosion associated with flooding events of the Hoosic River. Erosion of the top, flatter portion of the cover system will be minimized by minimizing the length of overland flow paths by which runoff must travel prior to entering an engineered storm water control feature (e.g., drainage swales).

Selection and maintenance of appropriate ground cover is also a critical component of minimizing surface runoff. The top, flatter portion of the landfill will have a grass vegetative cover. The specific species of grass is appropriate for the region, which provides a relatively low maintenance cover.

Lining of each drainage swale has been determined based on the calculated velocities within each respective swale. Portions of drainage swales with flatter slopes, and hence generally lower flow velocities, have been designed as grass-lined swales. Channels conveying storm water

runoff down steeper slopes will likely be exposed to higher flow velocities and therefore require stabilized linings such as a rock lining. A stabilized outlet structure has been designed at the discharge location of each drainage swale to adsorb the energy of the storm water flow and dissipate runoff evenly over the ground surface. These structures will also direct runoff away from the toe of the landfill slope.

Some modification of the soil berms will be undertaken to allow the Hoosic River to better utilize the lagoon area for flood flow and storage. The portions of the soil berms between Lagoons 1, 4, and 5 along with a section of the northern portion of the soil berm between the Hoosic River and the lagoon area require removal to ensure adequate storm water flow conveyance is maintained through this area.

Upon completion of modifications to these areas, stabilizing measures will be installed to minimize erosion potential at these locations. Particular stabilizing measures, whether vegetative or other, will be selected based on expected flow velocities, soil types, anticipated conditions during installation (i.e., sufficient remaining growing season at the time of installation) and constructability.

Attachment K of the Basis of Design Report provides an Erosion and Sediment Control Plan, which identifies the following:

- The erosion control measures that will be taken during construction to prevent eroded sediment from reaching a water body or adjoining property;
- Permanent erosion control measures that will be taken after construction to stabilize the site from continued erosion; and
- Inspection frequency of erosion controls measures.

Additional Controls to Prevent Pollution into Storm Water Runoff: The Sediment and Erosion Control Plan also describes the additional controls/practices to be undertaken during construction to reduce potential pollution in storm water runoff, including:

- Dust suppression practices;
- Proper material storage and handling;
- Proper sanitary waste disposal;
- Solid waste;
- Hazardous waste; and
- Spill prevention and control measures.

Demolition Debris: There are several small wooden and concrete structures associated with the former tannery lagoon operation that will be demolished and placed within the landfill. The volume of debris resulting from the demolition of the small on-Site structures is expected to be less than 100 cubic yards.

3.4 Transportation

Construction of the Remedy will not cause unreasonably dangerous or congested conditions with respect to highways or other means of transportation.

The access road to the lagoon area is located off Dean Road, which is off of Route 346. Route 346, which runs generally north to south, is a major collector highway. Route 346 links to US 7 (a principal arterial highway corridor along the west side of Vermont) National Highway, NY 22, and secondary roads in Pownal.

Approximately 20 construction workers, and 2-5 federal and/or state representatives will be required during the Project's peak construction period. Sufficient parking will be available onsite to safely accommodate the workers.

Construction of the Remedy will entail the delivery of materials for construction of the landfill cap. It is estimated that there will be approximately 30 truck deliveries per day throughout the workday. This would equate to approximately 3 truck deliveries per hour to the site. Truck routes will be coordinated with local agencies, as appropriate, to ensure that unreasonable congestion is not created and that site entrance/exits are safe. Adequate areas will be provided onsite to ensure that trucks are not parking on local roadways.

During construction, emergency vehicles and trucks will have sufficient access into the Project Site and will easily be able to turn around. Sheets C-3 and C-4 of the Design Drawings show the construction laydown plan, and shows the access road and construction worker vehicle parking areas.

3.5 Scenic Beauty, Historic Sites, and Natural Areas

The Remedy has been designed to be consistent with the visual character of the area and will not have undue adverse impacts on the asethics in the area.

The Site is located the Village of North Pownal. The Site is currently zoned as Rural Residential, although the Town is considering designating the Site as a combination industrial/recreation zone. The Site is an abandoned Superfund site, and is currently unsuitable for public use. The Site was a former hide tanning and finishing facility owned by the Pownal Tanning Company, Inc., and has been inactive since 1988.

The area surrounding the Site is a rural and residential community, with the nearest residences being approximately 150 to 200 feet, south and east, from the lagoons. Currently, the lagoon area is fenced and locked, but is regularly broken into by the neighboring population to use it for recreational purposes. The lagoon complex is partially covered with soil, over which disturbed wetlands vegetation occurs. Figure 3 shows current photographs of the lagoon area. To the south-west, three of the lagoons border the Hoosic River, which is also used for recreational purposes during the warm months. On the eastern border of the Site there is an access road to Route 346, which is adjacent to railroad tracks owned and operated by Boston and Maine Corp.

To the south of the lagoon complex is the former tannery building parcel and a hydroelectric facility and dam that were built in 1955 for use by the tannery. North of the Site is farmland and west of the Site is thickly wooded.

Based on cultural resources studies conducted for EPA, the lagoons do not contain any archeological features. A portion of the former Tannery Site is listed on the Vermont Register of Historic Places (SR No. 0208-8), as is the adjacent General Store and the steel truss bridge that spans the Hoosic River (now closed). The area encompassing the former tannery building, the General Store (located adjacent to the tannery property) and 16 off-site residences (located on the eastern side of State Route 346) is designated as the North Pownal Mill Historic District. The Remedy will not impact these areas.

Three structures in the Project site will be removed. These include two building foundations and a small shed. None of these structures are considered significant or eligible for listing in the National Register of Historic Places. (need to get photo of shed and verify that it is not significant)

Based on the ecological risk assessment conducted for EPA's RI and Feasibility Study (FS), none of the habitats identified either on or adjacent to the site are considered habitat for significant wildlife or endangered species. The Federally-listed threatened species *Haliaeetus leucocephalus* (bald eagle) may be present within the vicinity of the site as a transient. The Remedy will not impact or imperil significant wildlife or endangered species habitat. Further, the Project site does not contain any designated rare or fragile areas.

The Remedy involves the betterment of the property and will be consistent with the visual character of the area and will not have an undue adverse impact on the aesthetics of the area. During construction, the natural vegetation will be preserved to the maximum extent possible. The riparian and wetland buffer zone along the Hoosic River will be restored and planted with native species as described above in Section 3.2.3. The final elevation of the top of the landfill will not be that much higher than the existing berms. Thus, offsite views of the Project site after the landfill is constructed will be similar to views of the existing site.

The Town of Pownal will be taking ownership of the lagoon parcels, as well as other parcels within the site, for reuse and development. The Town's redevelopment plans include building a wastewater treatment facility in the area of Lagoon 2 after completion of the Remedy. Further, the Town supports using other portions of the site for mixed recreational uses, including a potential soccer field, seasonal ice skating rink, picnic area, and a boat launch. The Remedy will be designed to support these potential recreational uses.

3.6 Impact of Growth and Other Act 250 Criteria

The Remedy will not significantly affect the ability of the Town or region to accommodate growth. The Remedy is a significant benefit to the Town as it will remediate a currently abandoned Superfund Site, and make it suitable for reuse by the Town for an urgently needed wastewater treatment plant, and for potential recreational purposes, and restore flood storage capacity along the Hoosic River and Class Two wetlands.

- The Remedy will not generate tax revenues for the Town.
- The Remedy will not impact primary or secondary agricultural soils, or earth resources.

The Remedy will use borrow material from nearby sources. The selected contractor will determine the sources of borrow material. Local sources are preferred to minimize the transportation of materials and help the local economy. The contractor will be required to only use borrow sources with current Act 250 permits. A local transportation company will be contracted to transport borrow materials to the Site. Trucks will be required to be covered during transportation. It is currently proposed that approximately 30 truck trips per day will be required during backfilling activities. The hours of operation and extraction rates at the borrow pits are determined by each pits Act 250 permit.

Other Act 250 Criteria:

- EPA has worked closely with Town officials and local residents during the RI/FS. They both support the remedy presented in the ROD and are eager to see the Remedy occur. The Remedy is consistent with the Town's Plan. As stated in the Town Plan, one objective of the Town's current planning effort is to bring the Town Plan and the Zoning Bylaws into agreement by designating a Rural Commercial/Industrial district to separate commercial/industrial activities from residential areas thereby affording greater housing opportunities for current and future residents. An example of this is the current review of the Tannery site as possible combination industrial/recreational zone.

  Further, the Town Plan specifically discusses the plan for centralized wastewater collection in each of the three growth areas (Pownal Center, North Pownal, and Pownal Village), and pumping of the wastewater through pressure pipes to a new wastewater treatment facility at the former Tannery lagoon site. Currently, there is no public sewer system that serves these village areas.

  The Town does not have a capital program.

- The Remedy is consistent with the Bennington County Regional Plan, adopted May 23, 2002. The Remedy is consistent with the Plan's overall goals, including protecting important natural resources, and enhancing recreational opportunities. The Regional Plan specifically notes the recent acquisition of the Tannery mountain lands for multiple outdoor recreation use.
- The Remedy will not create a burden to educational services.
- The Remedy will not create a burden on the municipality.

Table 1. Pownal Tannery Remedy: Compliance with Act 250 Criteria	
Criteria	**Section Reference**
1) Air Pollution: Demonstrate that the project will not create undue air pollution:	
a) If the project involves manufacturing or industrial processes, describe any process air emissions, odors, or sources of noise and measures proposed to control them.	**N/A**
b) If buildings will be heated, describe the fuel source and the heating system, including its efficiency rating.	**N/A**
c) Is an Air Pollution Control Permit from the Agency of Natural Resources (ANR) required for the project? If yes what is the status of your application?	**N/A**
d) Indicate how dust will be controlled during and after construction.	**See Section 3.1.1**
e) Indicate what restrictions will apply to the hours of construction and/or operation and how noise will be controlled, especially in residential areas.	**See Section 3.1.2**
f) If the project involves any of the following, check them and contact the **ANR Air Pollution Control Division at 241-3840** for further directions: [ ] parking for more than 500 vehicles (existing and proposed), [ ] fuel burning equipment with over 10 million BTUs/hour, [ ] coal burning equipment.	**N/A**
g) If the project involves radioactive materials, check here [ ] and contact the District Coordinator for further guidance.	**N/A**
1A) Headwaters: Demonstrate that the project will meet any applicable environmental conservation department regulations regarding any reduction of the quality of ground or surface waters in a headwaters area: a) Is the project located in a headwaters area as defined in the statute?	**See Section 3.2.1**
Criterion 1B) Waste Disposal: Demonstrate that the project will meet any applicable health or environmental conservation department regulations regarding the disposal of wastes and demonstrate that the project will not involve the injection of wastes or toxic substances into ground waters:	
a) Will the project use an on-site system or will sewage be conveyed to a municipal system?	**N/A**
b) If an on-site system is to be used, describe the system and how sewage will be treated and isolated from groundwaters.	**N/A**
c) How many gallons of sewage per day will the treatment system be designed and/or approved to handle?	**N/A**
d) If an on-site sewage treatment system is to be shared by more than one owner, how will it	**N/A**

Table 1. Pownal Tannery Remedy: Compliance with Act 250 Criteria	
Criteria	**Section Reference**
be maintained and who will be legally and financially responsible for its eventual replacement?	
e) If a municipal sewer is to be used, provide the name of the municipal sewage treatment plant and provide a letter from the municipality demonstrating that the plant has the capacity to accommodate your project.	**N/A**
f) Is a Water Supply and Wastewater Disposal Permit or a Subdivision Permit required from the ANR Wastewater Management Division for the sewage disposal system? [ ] Yes or [ ] No.	**N/A**
g) If you answered Yes to the above question, are you relying on the Water Supply and Wastewater Disposal Permit or Subdivision Permit to satisfy this criterion? [ ] Yes or [ ] No.	**N/A**
h) What is the acreage of the project site which will be covered with buildings, roadways, parking areas, or other impervious areas?	**N/A**
i) Describe how stormwater runoff will be disposed of without causing undue water pollution from parking lots and roadway contaminants	**N/A**
j) Is a Stormwater Discharge Permit (or permit amendment) required from the ANR Wastewater Management Division for the discharge of the stormwater into a stream, lake, municipal storm drain system, or groundwater? [ ] Yes or [ ] No.	**N/A**
k) If you answered Yes to the above question, are you relying on the Stormwater Permit to satisfy this criterion? [ ] Yes or [ ] No?	**N/A**
l) If the project involves manufacturing or industrial processes, describe what they are, indicate how any wastewater generated will not contaminate ground or surface waters, and indicate whether all necessary discharge permits have been obtained.	**N/A**
m) If storage of oils, fuels, chemicals, cleaning fluids, solvents, batteries, pesticides, or other hazardous materials is associated with this project, indicate what measures will be taken to protect against spills and leaks, especially in a sensitive area such as a Public Water Source Protection Area (http://www.anr.state.vt.us/gismaps/index.htm) or near wells or streams.	**See Section 3.3** **N/A**
n) Is a permit from or registration with the ANR Hazardous Materials Management Program required for the storage listed in m)? [ ]Yes or [ ] No?	**See Section 3.3**
o) Indicate how construction debris, including stumps, will be disposed of without creating water pollution. If the project involves more than 10,000 square feet of building construction, renovation, or demolition, describe how construction and demolition waste prevention, reuse,	

Table 1. Pownal Tannery Remedy: Compliance with Act 250 Criteria	
Criteria	**Section Reference**
and recycling will be incorporated into the project. (Include in the description items required to be recycled through local recycling ordinances, and, if appropriate, the environmentally-responsible management of scrap metals, brick and concrete, wood, drywall, roofing, cardboard, plastics, and any other wastes.) The Agency of Natural Resources has developed a Waste Reduction Plan Template that applicants can use to describe their management plan.	
Criterion 1C) Water Conservation: Demonstrate that the project will use the best available water conservation technology: a) Would you agree to a permit condition which read: "The permittee and all subsequent owners shall install and maintain only low-flow plumbing fixtures in any buildings, including toilets with flows not to exceed 1.6 gallons per flush, and low flow fixtures."? [ ] Yes or [ ] No. If No, indicate why and what water conservation measures will be taken. b) If the project involves significant use of water for manufacturing or other processes, indicate what measures will be taken to conserve water (include recycling, efficient machinery, etc.).	**N/A** **N/A** **N/A**
Criterion 1D) Floodways: Demonstrate that the project will not endanger the health, safety and welfare of the public or of riparian owners during flooding: a) If any portion of the project is in or adjacent to the 100-year floodway as identified on the National Flood Insurance Maps (on file with your municipality), demonstrate that the project will not involve any filling or construction within the floodway. b) If any portion of the project is in or adjacent to the 100-year floodway fringe as identified on the National Flood Insurance Maps, demonstrate that the project will not cause a significant increase in the peak flood levels of the river or stream. (Show location of floodway fringe on site plan.) c) If any fill, structures, storage of materials, or other operations are to be located in the floodway fringe, demonstrate that they will be floodproofed consistent with the National Flood Insurance Program.	**See Section 3.2.2**

Table 1. Pownal Tannery Remedy: Compliance with Act 250 Criteria	
Criteria	**Section Reference**
Criterion 1E) Streams: Demonstrate that the project will maintain the natural condition of any streams, when feasible: a) Indicate the name and location of streams, drainageways, or riparian wetlands on or adjacent to the project site. What is the distance to the closest construction disturbance. b) If a stream is located within or near the project boundary, describe how the stream and the lands along the stream will be maintained in their natural condition. c) Is a Stream Alteration Permit from the ANR Water Quality Division required for any work in a stream? [ ] Yes or [ ] No d) If the project involves the construction of a permanent dam or the withdrawal of water from a stream, river, pond, or lake, check here [ ] and contact the District Coordinator for further guidance.	**See Section 3.2.3**
Criterion 1F) Shorelines: Demonstrate that if the project is located along a shoreline, it complies with the four standards relating to the condition of the shoreline listed in b) below: a) Indicate the name and location of any river, lake, pond, or reservoir within or near the project tract and the distance to the closest disturbance. b) If the project is located on or near a shoreline, then answer i) through iv) below: i) Indicate how the shoreline will be maintained in its natural condition. ii) Indicate how and where any existing public access to the water body can be reasonably maintained. iii) Indicate how the vegetation will be provided or retained to screen the project from the waterbody. iv) Indicate how the shoreline will be stabilized from erosion with vegetation. c) Do you need a Shoreland Encroachment Permit from the ANR Water Quality Division? [ ] Yes [ ] No. Contact the **Water Quality Division at 241-3777** for further guidance.	**See Section 3.2.4**

Table 1. Pownal Tannery Remedy: Compliance with Act 250 Criteria	
Criteria	**Section Reference**
Criterion 1G) Wetlands: Demonstrate that the project will meet applicable Water Resources Board regulations regarding any impacts on designated significant wetlands: a) If wetlands exist on or near the project site, show the location of these wetlands on the site plan and indicate the distance to the closest disturbance b) For Class One and Two wetlands indicate how the wetlands and the lands along the wetlands will be maintained consistent with the **Water Resources Board** (www.state.vt.us/wtrboard) regulations. Show undisturbed buffers, erosion controls, isolation distances to any sewage systems, etc. on site plan. Contact the ANR Wetlands Biologist for assistance. c) Is a Conditional Use Determination (CUD) from the ANR Water Quality Division required? [ ] Yes [ ] No. If a CUD is required, are you relying on the CUD to satisfy this Criterion? [ ] Yes [ ] No. d) If Class Three wetlands will be impacted by the project, be sure to address the value of the wetlands under applicable criteria including 1E (streams), 1F (shorelines), 4 (soil erosion), 8 (scenic beauty, rare and irreplaceable natural areas), and 8A (wildlife habitat).	**See Section 3.2.5**
Criteria 2 and 3) Water Supply: Demonstrate that the project has sufficient water available for its needs; and that the project will not cause an unreasonable burden on an existing water supply: a) Describe the source(s) of domestic water which will be utilized for the project. (Show location of wells, springs, piping, etc. on site plan.) b)How many gallons of water per day will be needed? Gpd. How was this figure determined? c) Demonstrate that the source listed in a) will be of sufficient quantity to meet the daily needs (include nearby well information, pump test results, letter from municipal or private water company, hydrologic study, etc.) d) If a domestic water source is to be shared by more than one owner, indicate who is legally responsible for its maintenance and possible replacement. e) Is approval from the ANR Water Supply Division necessary for a shared water system or extension of a municipal water line? f) Describe the source of any commercial or industrial water supply (if different from above)	**N/A** **N/A** **N/A** **N/A** **N/A** **N/A** **N/A**

Table 1. Pownal Tannery Remedy: Compliance with Act 250 Criteria	
Criteria	**Section Reference**
and demonstrate that water exists in sufficient quantity for the needs of the project. g) Demonstrate that the use of any of the water sources listed in a) or f) above will not restrict the flow of water to other existing users. h) If there are any public water supply sources nearby (for example, in mobile home parks, condominium projects, high density subdivisions, etc.) which might be affected by your project, contact the **ANR Water Supply Division at 241-3400 or 1-800-823-6500** to see whether its review is necessary. If this review is necessary, attach a review letter if available.	**N/A** **N/A**
Criterion 4) Soil Erosion: Demonstrate that the project will not cause unreasonable soil erosion; and will not cause a reduction in the capacity of the land to hold water so that a dangerous situation results: a) Describe the topography of the project site, the proximity of sloping lands to water bodies and property boundaries, and the potential for soil erosion. b) Indicate what erosion control measures will be taken during construction to prevent eroded sediment from reaching a water body or adjoining property. c) Indicate what permanent erosion control measures will be taken after construction to stabilize the site from continued erosion. (Include stone-lined ditches, grassed swales, paving, rip-rap, seeding mixtures, etc.) (Show details on site plan.) d) If exterior site work or earth moving will occur between October 1 and April 15, would you agree to incorporate the special winter erosion controls outlined in the *Vermont Handbook for Soil Erosion and Sediment Control on Construction Sites* (available from the ANR Water Quality Division)? [ ] Yes [ ] No. Describe any other special erosion control measures that will be taken to stabilize bare soils through the winter months. e) How frequently will the erosion controls be inspected during construction and who will be accountable for their maintenance? f) Demonstrate how stormwater runoff from paved areas will not create a dangerous or unhealthy situation for adjoining property owners or downstream areas due to stream bank erosion or flooding.	**See Section 3.3** **And Erosion and Sediment Control Plan, Attachment J, Basis of Design Report**

Table 1. Pownal Tannery Remedy: Compliance with Act 250 Criteria	
Criteria	**Section Reference**
Criterion 5) Highways and Other Means of Transportation: Demonstrate that the project will not cause unreasonable congestion or unsafe conditions with respect to the use of highways and other means of transportation:	**See Section 3.4**
a) Indicate where you propose vehicles will have access to a state or local highway from this project.	**N/A**
b) Describe the design of the driveway(s) or road intersection(s) and demonstrate adequate safety (include number of lanes, traffic controls or signals, approach grades, corner sight distances in each direction along the state or local highway, legal or posted speed limits, etc.).	**N/A**
c) Is a permit required from the **Utilities Unit of the Vermont Agency of Transportation (Vtrans)** for commercial or residential access onto a state highway? [ ] Yes or [ ] No. If yes, what is the status of your application?	**N/A**
d) Is a permit required from your municipality for access onto a town or city highway? [ ] Yes [ ] No. (Contact the zoning administrator, town manager, or road commissioner.) If Yes, what is the status of your application?	**N/A**
e) If a new roadway is involved, indicate the length of the road and the maximum gradient.	**N/A**
f) If a subdivision roadway is involved, will the road be built to municipal specifications? [ ] Yes [ ] No. Has the town agreed to accept the roadway after it is constructed? [ ] Yes [ ] No. (Include letter from the municipality confirming this.) IF YOU ANSWERED NO TO EITHER QUESTION, BE CERTAIN TO ADDRESS CRITERION 9G (PRIVATE UTILITIES).	**N/A**
g) Demonstrate that emergency vehicles and trucks will have sufficient access into the project site and can easily turn around. (Show details on site plan.) Note that VTrans may not consider more than one access to a tract or site acceptable.	**See Section 3.4**
h) Demonstrate that adequate parking for peak periods will exist for the project. (Show details on site plan.)	**See Section 3.4**
i) Demonstrate that the traffic associated with the project will not create unreasonable congestion or unsafe conditions on nearby highways or nearby intersections. Include existing traffic counts for affected roadways and predicted traffic volumes (during peak hours) to be generated by the project. (Contact the District Coordinator for guidance and to determine if a traffic study is necessary.)	**See Section 3.4**
j) Demonstrate that pedestrian safety on and off site has been adequately addressed. (Show	**N/A**

Table 1. Pownal Tannery Remedy: Compliance with Act 250 Criteria	
Criteria	**Section Reference**
details of sidewalks, crosswalks, and other walkways on site plan.) k) Demonstrate that the proposed project will not cause unreasonable delays or unsafe conditions for users of existing pedestrian, bicycle, and/or public transportation facilities. l) If the project involves or may affect a railroad, airport, or other means of transportation not addressed in a) through k) above, check here [ ] and contact the District Coordinator for guidance.	**N/A** **N/A**
Criterion 6) Educational Services: Demonstrate that the project will not cause an unreasonable burden on the ability of local governments to provide educational services: a) If the project is residential or involves the creation of jobs, estimate how many school age children will likely result from the project and how that figure was determined. b) Demonstrate whether the local schools have the capacity to accommodate the additional students listed under a). Include **School Impact Questionnaire** attached to application (or letter from school district), estimates of student capacity at local schools, etc. c) If the local schools do not have the capacity to accommodate the additional students, indicate what mitigation measures can be utilized to offset any unreasonable burdens on the local schools created by the project. (Include impact fees to paid by the project, phasing schedules, plans for a school addition, etc.)	**N/A** **N/A** **N/A** **N/A**
Criterion 7) Municipal Services: Demonstrate that the project will not cause an unreasonable burden on the ability of local governments to provide municipal or governmental services: a) Indicate which municipal services will be required by the project: [ ] Police; [ ] Fire Protection; [ ] Solid Waste Disposal; [ ] Water Supply; [ ] Sewage Disposal; [ ] Road Maintenance; [ ] Rescue Services. b) Attach letters from representatives of any of the services checked above indicating that the services can be provided by the municipality and that an undue burden will not result **OR** submit a completed and signed **Municipal Impact Questionnaire** (attached to the application).	**N/A**

Table 1. Pownal Tannery Remedy: Compliance with Act 250 Criteria	
Criteria	**Section Reference**
Criterion 8) Scenic Beauty, Historic Sites, and Natural Areas: Demonstrate that the project will not have an undue adverse effect on the scenic or natural beauty of the area, aesthetics, historic sites, or rare or irreplaceable natural areas:	**See Section 3.5**
a) Describe the visual appearance of the project site and surrounding area as it exists without the project (include open and wooded areas, mountains, ridgelines, wetlands, streams or shorelines, existing structures nearby, etc.). (Show existing features on site plan and attach photos if available.)	**See Section 3.5**
b) Will the project "fit" within the existing context described above? Specifically:	
i) Is the project use (residential, retail, industrial, etc.) consistent with the existing or planned land uses in the area?	**See Section 3.5**
ii) Will the project generate any significant noise related impacts during and/or after construction? If so, what mitigation efforts are being proposed.	**See Section 3.1.2**
iii) Explain how the building size, density, and location are not out of character with the terrain of the site, the size of nearby buildings, surrounding vegetation, and nearby scenic vistas from highways or community centers. (Show details on site plan.)	**N/A**
iv) Describe the proposed architectural style and building materials and colors in relation to the style of area buildings. Provide elevation drawing(s) of building(s).	**N/A**
v) Describe proposed parking areas, including size, location, and visibility from the highway or nearby residences. (Show on site plan.)	**N/A**
vi) Describe any proposed signs, including location, size, illumination, and colors. (Show location(s) on site plan.)	**N/A**
vii) Describe proposed exterior lighting, including location, lamp wattage, fixture style, and height of pole. Also, please describe how lights will be controlled or switched. For major parking lots and roadways, provide details about light levels. How has the lighting been designed to minimize its visual impact on the surrounding area at night? Show lighting on site plan and include manufacturer's specification sheet.	**N/A**
viii) Describe how utilities (propane tanks, trash dumpsters, electric distribution lines and poles, etc.) have been designed to minimize their visibility from the highway or nearby residences.	**N/A**

Table 1. Pownal Tannery Remedy: Compliance with Act 250 Criteria	
Criteria	**Section Reference**
ix) Describe any landscaping proposed for the project site. How will this landscaping minimize any of the visual impacts discussed above? (Show landscaping on site plan.)	**See Section 3.5**
x) Indicate if any restrictions on tree cutting or earth disturbance will be used to minimize any of the visual impacts discussed above. (Show details on site plan.)	**See Section 3.5**
c) Does the project contain any standing buildings or structures which are more than 50 years old? [ ] Yes [ ] No. If yes, attach a photo of each building.	**See Section 3.5**
d) Is the project area within a village or city or among other older buildings? [ ] Yes [ ] No. If yes, briefly explain.	**See Section 3.5**
e) Does the project area contain any stone walls, cellar holes, or other evidence of past human settlement or use? [ ] Yes [ ] No. If yes, show details on site plan. Will any such historic features by affected by the project? [ ] Yes [ ] No.	**N/A**
f) Briefly describe any plans to rehabilitate, alter, demolish, or move any existing buildings, structures, or historic features that are more than 50 years old.	**N/A**
g) If wetlands exist on or near the project site, show the location of these wetlands on the site plan and indicate the distance to the closest disturbance. Contact the **ANR Wetlands Biologist at 241-3770** for assistance in identifying wetland areas.	**See Section 3.2.5**
h) For Class Three wetlands indicate how the wetlands and the lands along the wetlands will be maintained. Show undisturbed buffers, erosion controls, isolation distances to any sewage systems, etc. on site plan. Contact the ANR Wetlands Biologist for assistance. (Class One and Class Two wetlands should be addressed under Criterion 1G.)	**See Section 3.2.5**
i) Are there any designated rare or irreplaceable natural or fragile area on or near the project site? Contact the **Vermont Natural Heritage Program at 241-3700** for assistance in identifying natural or fragile areas. Will the project have a significant impact on any designated sites? [ ] Yes [ ] No. If Yes, what type of mitigation is proposed?	**N/A**
Criterion 8A) Wildlife and Endangered Species: Demonstrate that the project will not destroy or significantly imperil necessary wildlife or endangered species habitat: a.) Indicate whether any significant wildlife or endangered species habitat exists on or near the project site (this may include but not be limited to: deer wintering areas, significant black bear feeding areas and travel corridors, rivers or streams, wetlands, or the like.) (Show habitat	**See Section 3.5**

Table 1. Pownal Tannery Remedy: Compliance with Act 250 Criteria	
Criteria	**Section Reference**
areas on site plan.) b) If critical wildlife habitat exists on or near the project site, explain how the project will not destroy or imperil that habitat, or indicate what measures can be taken to minimize the impact. Show details on site plan and attach review letter from the Department of Fish and Wildlife.	
Criterion 9A) Impact of Growth: Demonstrate that the project will not significantly affect the ability of the town and region to accommodate growth: The term "growth" includes: a) growth that will occur generally regardless of the project and b) growth that will occur specifically because of the project. Growth also includes population growth as well as economic growth. Relevant measures of economic growth may include employment growth, growth in personal income, sales growth, or growth in tourism taking place in the region. For more guidance under this Criterion see the following two documents: *Fiscal and Economic Analyses in Act 250*, and Re: St. Albans Group and Wal*Mart Stores, Inc., #6F0471-EB, Findings of Fact, Conclusions of Law, and Order (Altered) (June 27, 1995), both of which are available on the Environmental Board's web site: www.state.vt.us/envboard. a) For residential projects, indicate how many additional people may live in the project, what portion may be seasonal, and what percentage of the total population of the municipality these additional people represent. b) For commercial or recreational projects provide information regarding anticipated employment growth, growth in personal income, retail sales growth, or growth in tourism. c) For all projects, provide an estimate of the tax revenues the project will generate. This includes property tax revenues paid to the municipality as well as income tax, sales, and rooms and meals taxes paid to the state, if appropriate. d) If the project is anticipated to result in a significant amount of growth in relation to historic growth rates for the town and region, you will be required to provide the following information: 1) The growth in population experienced by the town and region in question. 2) The *total* growth and *rate* of growth, which is otherwise expected for the town and	**N/A**

Table 1. Pownal Tannery Remedy: Compliance with Act 250 Criteria	
Criteria	**Section Reference**
region. 3) The *total* growth and *rate* of growth for the town and region, which will result from the proposed project if approved. 4) The anticipated costs for education, highway access and maintenance, sewage disposal, water supply, police and fire services and other factors relating to the public health, safety, and welfare. 5) Based on (1) through (5), that the proposed project will not cause an undue burden on the existing and potential financial capacity of the town and region in accommodating growth caused by the proposed project.	
Criterion 9B) Primary Agricultural Soils: Demonstrate that the project will not significantly reduce the agricultural potential of primary agricultural soils: a) Does the project site contain primary agricultural soils? [ ] Yes [ ] No. If you are unsure, the **U.S. Natural Resources Conservation Service (NRCS) District Soil Conservationist (951-6795)** or a consulting soil scientist may be of assistance. b) If primary agricultural soils exist on the site, provide the following information: i) the total number of acres of each type of primary agricultural soils on the site (there is no minimum, so report all acreage and show on site plan) and the number of acres of each type of primary agricultural soils to be impacted by the project, ii) whether the site is currently being farmed or has been farmed in the past, iii) the name, location, and type of neighboring agricultural operations, including leased farmland. c) Explain how the project has been designed to minimize the impact on the future agricultural use of the primary agricultural soils on the site. Attach a copy of any review letter from the Department of Agriculture. d) If the project cannot avoid a significant reduction in the potential of the primary agricultural soils identified in a) above, you may be required to address the four subcriteria of this section.	**N/A**

Table 1. Pownal Tannery Remedy: Compliance with Act 250 Criteria	
Criteria	**Section Reference**
Criterion 9C) Forest and Secondary Agricultural Soils: Demonstrate that the project will not significantly reduce the potential of secondary agricultural soils or forest soils: a) Does the project site contain soils which are not primary agricultural soils but which have reasonable potential for commercial forestry or commercial agriculture? [ ] Yes [ ] No. b) If the project site does contain forest or secondary agricultural soils, indicate how the project has been designed to minimize the impact on the future use of the soils. c) If the project cannot avoid a significant reduction of the forest or secondary agricultural soils identified in a) above, you may be required to address the three subcriteria of this section.	**N/A**
Criteria 9D) and 9E) Earth Resources: Demonstrate that the project will not interfere with the future extraction of earth resources; and demonstrate that if the project involves the extraction of earth resources, it will not unduly harm the environment or neighboring land uses, and will be reclaimed for an alternative use: a) Does the project site have a high potential for extraction of mineral or earth resources? [ ]Yes [ ] No b) If the site does contain earth resources, will these resources be extracted as part of the project? If the resources will not be extracted as part of the project, indicate how access to the resources can be maintained in the future. c) If the project involves the extraction of earth resources for commercial sale, or involves extensive use of borrow material from on site or nearby, answer i) through iii) below: i) Demonstrate that any proposed blasting will not damage nearby water supplies or structures. Include a blasting plan which describes the duration and size of blasting charges, insurance information, notification process, hydrogeologic reports, etc. ii) Demonstrate that any trucking of excavated material will not unduly damage area highways. Describe truck routes, duration and frequency of trucking, truck trips per day, hours of operation, extraction rates, day, etc. iii) Describe the reclamation plans for the extraction area and how those plans can be financially assured. Include site plan with final contours, landscaping plan, information on future land uses, bonding plan, escrow contribution schedule, etc.	**See Section 3.6**

Table 1. Pownal Tannery Remedy: Compliance with Act 250 Criteria	
Criteria	**Section Reference**
Criterion 9F) Energy Conservation: Demonstrate that the project reflects the principles of energy conservation and utilizes the best available technology for energy efficiency: a) If the project involves commercial, institutional, or industrial buildings, indicate what minimum standards or guidelines (ASHRAE, *Act 250 Energy Guidelines,* Energy Star, etc) will be used to make the project energy efficient. Otherwise, include details about insulation, windows and doors, heating and ventilation, lighting, etc. Describe any additional measures planned to conserve energy. b) Residential projects three stories or less are subject to Vermont's Residential Building Energy Standards (RBES) (21 V.S.A. §§266-267). Conformance with these standards assures compliance with this Criterion. Will the project comply with the RBES? [ ] Yes [ ] No. For more information, contact the Energy Code Assistance Center at 1-888-373-2255 or www.state.vt.us/psd/ee/ee12rbesbook.pdf. c) Would you agree to a permit condition which read: "The installation of electric resistance space heating or stand-alone electric domestic water heating equipment in any building subject to this permit is expressly prohibited without prior District Environmental Commission approval"? [ ] Yes or [ ] No.	**N/A**
Criterion 9G) Private Utilities: Demonstrate that any private utilities shared by two or more owners will not become a burden on the municipality if it must assume responsibility for them: a) Indicate whether the project involves any utilities (road, water system, sewer line, septic system, etc.) which will be controlled by more than one owner, and if so, indicate who will be legally and financially responsible for ongoing maintenance and eventual replacement. b) If a private utility will likely be transferred to the municipality, indicate whether it will meet municipal specifications. c) If a private utility will not be transferred to the municipality, indicate how the utility will continue to be maintained so as to not become a burden for the municipality at a later date. Indicate whether a sinking fund or other long term fund will be established to provide for	**N/A**

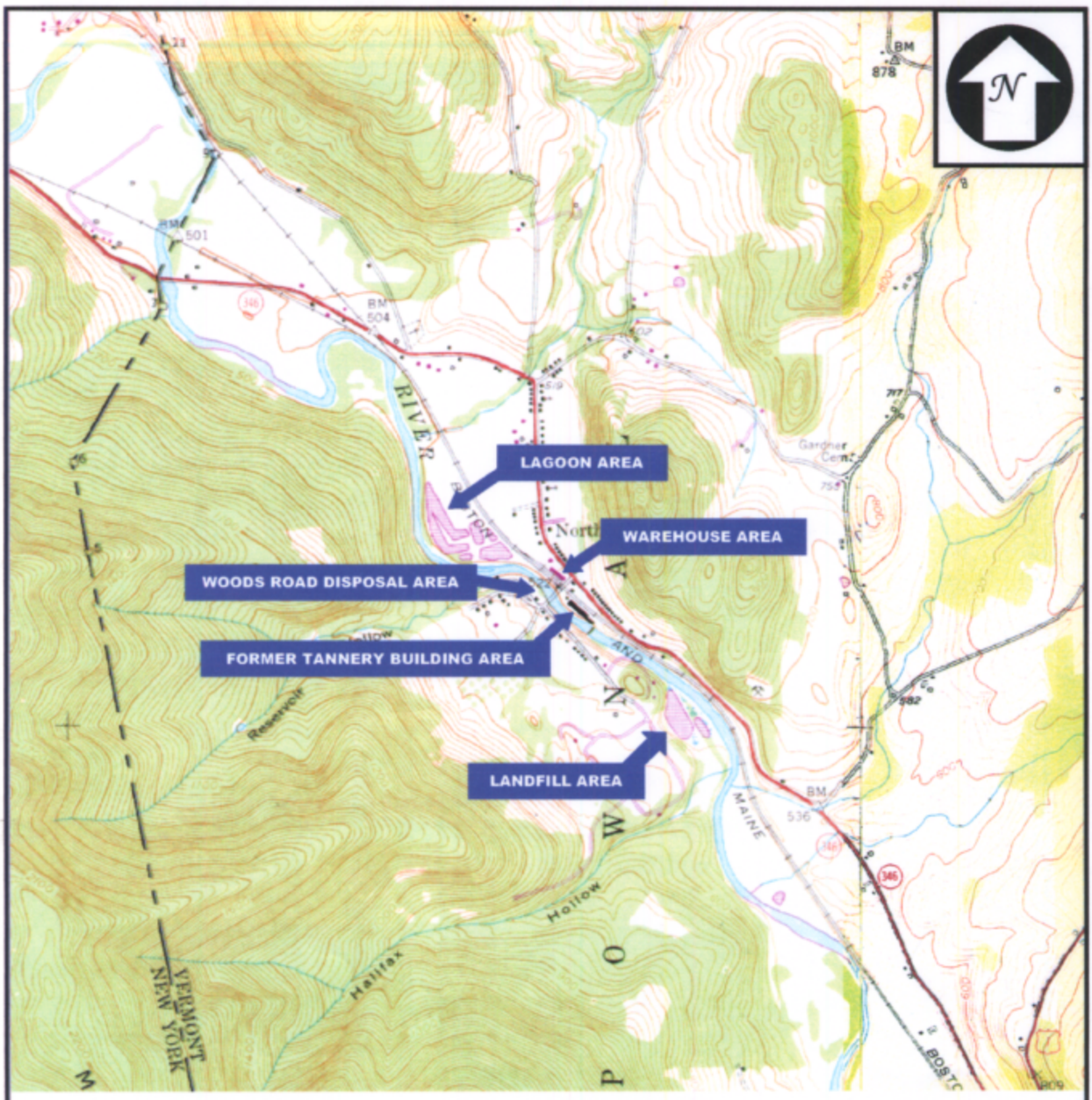
Table 1. Pownal Tannery Remedy: Compliance with Act 250 Criteria	
Criteria	**Section Reference**
future repair or replacement of the private utilities. (Attach copy of deed restrictions, maintenance schedule, or other evidence which will ensure private maintenance and eventual replacement of the utilities.)	
Criterion 9H) Scattered Development: Demonstrate that if the project is not physically contiguous to an existing settlement, it will not result in greater costs to the municipality than it provides in additional tax revenues and other public benefits: a) Indicate whether the project tract is physically contiguous to an existing settlement. Existing settlement has been defined by Environmental Board case precedent as "an extant community center similar to the traditional Vermont center in that it is compact in size and contains a mix of uses, including commercial and industrial uses, and, importantly, a significant residential component. It is a place in which people may live and work and in which the uses largely are within walking distance of each other." For more information see the Environmental Board's decision Re: St. Albans Group and Wal*Mart Stores, Inc., Application #6F0471-EB, Findings Of Fact, Conclusions Of Law, And Order (Altered)(Jun. 27, 1995). (www.state.vt.us/envboard/decisions.htm) b) If the project is not contiguous to an existing settlement, provide an analysis comparing the public benefits and costs of the project. "Public benefits" include, but are not limited to, tax revenues generated by the project, increased employment opportunities, and the provision of needed and balanced housing accessible to existing or planned employment centers. "Public costs" include the costs of public services and facilities caused directly or indirectly by the proposed development. Information generated under criteria 5, 6, 7 and 9A may also be relevant under this criterion. **If you are uncertain how to address this part of the criterion, contact the District Coordinator.**	**N/A**
Criterion 9J) Public Utilities: Demonstrate that the project will not place an excessive or uneconomic demand on any necessary governmental or public utility facilities or services: a) Indicate what governmental services or public utility services are needed and demonstrate that such services can be provided without undue burdens. Examples of public utility services are natural gas, electric, telephone, cable, water, and sewer services. Include an "ability to serve" letter from the utility company.	**N/A**

Table 1. Pownal Tannery Remedy: Compliance with Act 250 Criteria	
Criteria	**Section Reference**
b) If the project involves commercial, institutional, or industrial uses, indicate how electrical use will be minimized during peak periods of energy demand in the service area for the utility (include major sources of energy usage, letter from the utility serving the project, etc.). c) If any utility lines cross the project site other than along the highway, demonstrate that the utility lines will not be significantly affected (include letter from utility company). Show any existing utility lines on site plan.	
Criterion 9K) Public Investments: Demonstrate that the project will not endanger any adjacent public investment: a) If any public facilities or lands (highways, parks, schools, fire stations, sewer lines, state access or conservation areas, etc.) are located adjacent to or on the project site, demonstrate that the project will not significantly affect those facilities. Provide a letter from the municipality or other owner of the public facility.	**N/A**
Criterion 9L) Rural Growth Areas: To the extent that the project parcel or any area within the parcel is identified as a "rural growth area," indicate how the project has been clustered or otherwise designed to provide for reasonable population densities and rates of growth to economize on the cost of roads, utilities and land usage: a) Rural growth areas are lands which are not natural resources such as streams, wetlands, significant wildlife habitats, primary agricultural soils, and earth resources. (Contact the District Coordinator if you need assistance in determining how to address this Criterion.)	**N/A**
Criterion 10) Local and Regional Plans: Demonstrate that the project conforms to the municipal plan and regional plan. a) Is there a duly adopted town plan? [ ] Yes [ ] No. If Yes, explain how the project conforms to that plan with regard to land use, goals and objectives, and comments from local authorities. Evidence of plan conformance can include a copy of the plan's land use map and relevant sections of the plan regarding appropriate land uses or building densities. A letter from the planning commission or town planner may be relevant evidence but is generally not sufficient on its own.	**See Section 3.6** **See Section 3.6** **See Section 3.6**

Table 1. Pownal Tannery Remedy: Compliance with Act 250 Criteria	
Criteria	**Section Reference**
b) Indicate what type of land uses are encouraged or allowed on the project site under the regional plan if one exists (include copy of plan's land use map, relevant plan language on appropriate land uses or building densities). (Contact your regional planning commission for assistance.) c) Does the municipality have a capital program? If so, indicate how the project conforms to that program. (Contact your town planner or planning commission for assistance.)	**N/A**

Table 2. List of Proposed Floodplain Plant Species		
Scientific Name	**Common Name**	**USFWS Indicator Status***
TREES		
Ulmus rubra	Slippery elm	FAC+
Populus delitoides	Cottonwood	FAC
Acer negundo	Box Elder Maple	FAC
SHRUBS		
Amelanchier canadensis	Shadblow	FAC
Aronia melanocarpa	Black chokeberry	FAC
Hamamelis virginiana	American witch hazel	FAC-

FIGURES



BASE MAP IS A PORTION OF THE FOLLOWING 7.5' USGS TOPOGRAPHIC QUADRANGLES: POWNAL, VT, 1954; NORTH POWNAL, VT-NY, 1954, PHOTOREVISED 1980

0 1000 2000 3000

approximate scale in feet

Figure 1

SITE LOCATION MAP

REMEDIAL INVESTIGATION/FEASIBILITY STUDY
POWNAL TANNERY
POWNAL, VERMONT

Metcalf & Eddy

TRC

Boott Mills South
Foot of John Street
Lowell, MA 01852
978-970-5600

QUADRANGLE LOCATION

VT

TRC PROJ. NO.: 02136-0220-01N91

EPA CONTRACT NO.: 68-W6-0042

RAC SUBCONTRACTOR NO.: 107061

01236/POWNAL/ENVIRON IMPACT/SITE LOCATION

02136\POWNAL\ENVIRON IMPACT\PHTOS1

TRC

Boott Mills South
Foot of John Street
Lowell, MA 01852
978-970-5600

TRC PROJ. NO.: 02136-0220-01N91

EPA CONTRACT NO.: 68-W6-0042

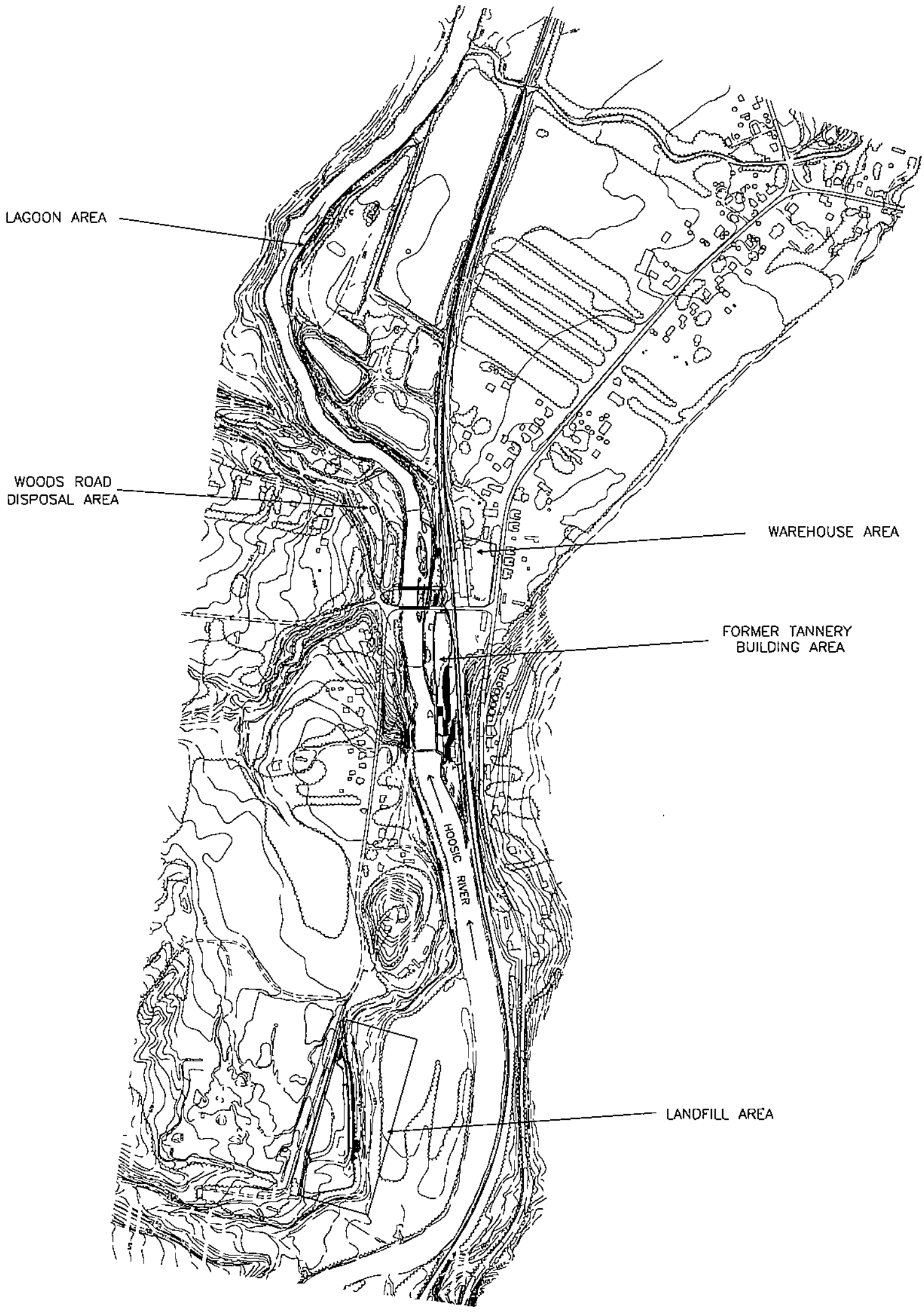
RAC SUBCONTRACTOR NO.: 107061

Figure 3

PHOTOGRAPHS OF LAGOON AREA

FORMER POWNAL TANNERY SUPERFUND SITE
POWNAL, VERMONT

M&E Metcalf & Eddy



0 200 400 600 800 1000

SCALE IN FEET

LEGEND

TANNERY PROPERTY BOUNDARY

02136/POWNAL/GEOTECH FSP/ SITE PLAN

TRC

Boott Mills South
Foot of John Street
Lowell, MA 01852
978-970-5600

TRC PROJ. NO.: 02136-0220-01N93

EPA CONTRACT NO.: 68-W6-0042

RAC SUBCONTRACTOR NO.: 107061

FIGURE 2

SITE PLAN

POWNAL TANNERY
POWNAL, VERMONT

Metcalf & Eddy

ATTACHMENT A

PRELIMINARY DRAFT
AIR MONTORING PROGRAM

The following methods will be employed to measure the concentration of air-borne hazards at the site.

During the excavation and stockpiling of lagoons sludge, the possibility exists that site workers will be exposed to airborne concentrations of the chemicals that have been detected at this facility. Additionally, the detected presence of hydrogen sulfide in the soil gas could be released during the sludge movement and create a potential off-site airborne hazard. The following methods will be employed to measure the concentration of air-borne hazards at the site.

Field Monitoring

Continuous monitoring for the presence of organic vapors, dust, and hydrogen sulfide will be performed in the breathing zone prior to entry into an area during all activities where there is a possible air/breathing zone hazard. If work is being completed in areas where air borne hazards are not anticipated (e.g. post-treatment soil cell area), the SSC may elect not to conduct air-monitoring activities. Ambient monitoring will be conducted at up wind and downwind locations during disturbance of the lagoon areas.

Hydrogen sulfide will be included in the air-monitoring program since it was detected above the IDLH concentration of 100 ppm in the bore hole at some locations during the various sampling phases. Decisions to upgrade or downgrade the protective equipment worn by workers at the site will be based on the measured levels of hydrogen sulfide. Monitoring will consist of a combination of real-time instrumentation and integrated sampling. Ambient monitoring will be conducted in accordance with NIOSH Method 6013 or other method capable of detecting hydrogen sulfide below 60 ppb. Decisions regarding air monitoring will be made by the SSC. Following the evolution of excavation activities at the Project Site, the SSC, in consultation with the Corporate Health and Safety Officer, may elect to limit the need for certain air monitoring devices if a negative exposure assessment is successfully completed.

A daily monitoring log kept by the SSC in the site field book will record the following for each piece of air monitoring equipment.

- Name of the equipment;
- Field work to be performed;
- Air monitoring results and monitoring locations;
- PPE worn;
- Accidents or incidents; and
- Unusual occurrences and personnel complaints.

A daily calibration log kept by the SSC in a separate field book will record the following for each piece of air equipment.

- Name, model number, and serial number of equipment;
- Calibration standards used; and
- Calibration Results.

A portable weather station located at the field trailer will calculate temperature, wind direction and wind speed. Temperature monitoring is important for preventing heat and cold stress among field personnel. Wind monitoring is important for preventing the movement of chemical and physical hazards across and off the site including gasses, vapors, and dust. These observations will be recorded with the air monitoring data in the site field book. The data can also be used to conduct modeling of measured hydrogen sulfide levels to the nearest residences to determine if ambient thresholds have been reached.

Air monitoring instruments will be calibrated prior to the start of each shift using a field calibration standard.

Equipment

The following monitoring instruments shall be used for health and safety related monitoring. The SSC is responsible for ensuring that photocopies of all manufacturers instructions/manuals are available at the site for use with backup copies available in the project files

Volatile Organic Compound Gases and Vapors

A photoionization detector (PID) or a flame ionization detector (FID) will be used to monitor breathing zone concentrations of volatile organic compounds (VOCs). A sustained reading of 10 parts per million (ppm) or more for 1 minute in the breathing zone will prompt the evacuation of the area by TRC and contractor personnel. The goal of this measure is to allow elevated VOCs to off-gas, as this may be a temporary condition as a result of excavation activities.

If VOC readings continue to exceed the 10 ppm action level, colormetric Draeger tubes will be used to determine individual contaminants in the breathing zone. Calibration gas to be used will be specific to the instrument per manufacturer instructions.

The potential for vapor exposure is considered low based on the maximum concentrations of VOCs detected in the lagoon soils. Monitoring will be conducted to validate this assumption.

Negative Exposure Assessment

VOC monitoring will be continuous during the start of all excavations in "new" regions of the source area. If the action level for VOCs is not exceeded after one day of monitoring in a "new" region and the data collected is believed to be reflective of exposure conditions, then the SSC can make a Negative Exposure Assessment. By demonstrating a Negative Exposure

Assessment, the SSC is showing that field personnel exposure is consistently below permissible exposure limits. If a Negative Exposure Assessment is demonstrated, then VOC monitoring in that region will be halted. Continuous VOC monitoring will be reinstated if there is an addition or change to the scope of work.

Dust Monitoring

Dust monitoring will be conducted during excavation using an MIE DataRAM, PDR dust monitor, or equivalent. If no active excavation or similar dust generating activity is being completed, the contractor may elect not to monitor for dust in the work zone due to the low potential for exposure. For example, if excavation is complete and the contractor later completes confirmatory soil screening/sampling, dust monitoring would not be required.

Personal monitoring will be performed continuously in areas where dust generating operations are being conducted. The dust monitor will record continuous dust levels as well as an average. Based on maximum concentrations of contaminants of concern in soil samples, a maximum total dust exposure level that is specific to the site will be calculated that is specific to the work area. The dust monitor alarm will be set at one-half of the calculated maximum exposure level. If dust levels continually exceed the calculated maximum exposure level then operations will be halted and dust control procedures will be carried out. If dust control measures do not succeed in suppressing dust levels, the SSC will decide to upgrade the level of personal protection.

The dust monitoring trigger level will be 0.73 mg/m^3 based on the maximum concentrations of inorganics and semi-volatile compounds in the soil. Respirators will be required if dust levels reach 0.73 mg/m^3 when working in the lagoon areas. This will also trigger the need to conduct personal sampling for inorganic compounds when handling soils from the lagoon. This limit is a cumulative exposure limit that is based on maximum concentration, toxicity and the OSHA PEL. The dust monitoring trigger level will be based on the measured concentrations of inorganics and semi-volatile compounds in the soil.

Hydrogen Sulfide Monitoring

The potential for exposure to hydrogen sulfide is high based on data collected during the sampling phases of this project.

Hydrogen Sulfide will be monitored during excavation in the lagoon areas. Hydrogen Sulfide will be measured utilizing a battery-operated ToxiRAE H_2S meter, or equivalent, which detects hydrogen sulfide levels in the parts per million (ppm) range. The meter is calibrated so that the alarm will sound at any hydrogen sulfide readings at or above 5 ppm. If H_2S levels exceed the permissible limits then operations will be halted and the excavation will be evacuated to allow off-gassing. If H_2S levels continue to exceed permissible limits, the SSC will decide to upgrade the level of personal protection.

Ambient samples will be collected at the property line downwind of site operations using battery powered low flow sample pumps and adsorbent media. These samples will be analyzed by ion chromatography and used to determine the off-site migration of hydrogen sulfide is occurring. If

detectable levels are recorded the data will be modeled to nearest downwind residential receptors for comparison to the 24 hour Threshold Effects Level.

Ambient Monitoring

Fugitive dust and hydrogen sulfide emissions will likely occur during the initial excavation and during stockpiling. The following table is a summary of the air monitoring results conducted during the evaluation process.

Compound	Concentration(ppm)	Exposure Limit (ppm)	IDLH (ppm)
Hydrogen sulfide	240	5 ACGIH TLV	100
Carbonyl sulfide	13	No exposure limit data	No data
Methylene chloride	0.0047	12 (OSHA Action Level)	2300
Benzene	0.016	0.1	500
Trichloroethene	0.0023	50 (TLV)	1,000
Toluene	0.065	50 (TLV)	500
Ethylbenzene	0.064	100	800
Xylene (total)	0.290	100	900
1,4-dichlorobenzene	0.005	25 (TLV)	150
1,2-dichlorobenzene	0.034	10 (TLV)	200
1,3,5-trimethylbenzene	0.100	25	N.D.
1,2,4-trimethylbenzene	0.140	25	N.D.

Dust monitoring was not conducted during the field sampling since the sampling did not cause significant dust emissions.

The goal of an effective ambient monitoring program is to document that off-site receptors have not been impacted significantly by the remedial process and to demonstrate that control procedures are adequate. Air monitoring will be conducted using a combination of instrumentation and grab sampling with adequate detection limits protective of the people living near the site.

Dust control measures will comply with EPA guidance on adequate dust control procedures and could include chemical stabilizing, wet techniques, covering and laying gravel beds in the high traffic areas. Fugitive dust monitoring will be performed to document that the dust control procedures are adequate and protective of the public. Monitoring instruments will be set up to sample at least 2 meters above the ground at presumed downwind locations.

APPENDIX F

HELP MODEL ANALYSIS OF ALTERNATIVE CAP CONFIGURATIONS

TRC Reference Number: 02136-0510-01N98

December 23, 2002

Leslie McVickar
Remedial Project Manager
EPA – New England, Region 1
One Congress Street
Suite 1100 HBT
Boston, MA 02114-2023

Subject: Hydrologic Evaluation of Cover System Performance
Pownal Tannery Superfund Site

Dear Leslie:

The attached memorandum was prepared in support of the remedial design being performed for Pownal Tannery Superfund Site. TRC performed this analysis in order to evaluate the effectiveness of alternative landfill cover designs versus the cover system specified in the Vermont Solid Waste Rules.

If you have any questions please contact me at 978-656-3560.

Sincerely;

Dale S. Weiss, P.G.
Senior Program Manager

cc: Brian Woods, VTANR (2 copies)
Don Dwight, M&E (2 copies)

HELP MODEL ANALYSIS OF ALTERNATIVE CAP CONFIGURATIONS
POWNAL TANNERY SUPERFUND SITE
REMEDIUAL DESIGN

1.0 INTRODUCTION

1.1 Objective

The remedial action presented in the Record of Decision (ROD) for the Site includes a landfill to consolidate and isolate contaminated sludge from direct exposure using an engineered cover system. In accordance with the Vermont Solid Waste Rules, the design for the landfill must have a minimum top slope of 5 percent. However, the Town of Pownal desires to use the top of the Landfill as a soccer field, requiring a flatter slope. This design analysis was performed to determine whether a flatter alternative cover system could be designed to perform equivalent to the cover system required by the Vermont Solid Waste Rules.

1.2 Background

It is common for Superfund landfills to be designed with shallow surface slopes to accommodate post-closure re-use as playing fields (see "Reusing Superfund Sites," EPA 540-K-01-002, March 2001).

The purpose of the Solid Waste Management Rule requirement is to minimize surface water infiltration through landfill cover systems by promoting drainage and preventing ponding of standing water. The concern with the shallower slopes needed for playing fields is that storm water will take longer to run off of the cap and more water will seep through the cover soils into the waste. In addition, there is a concern that settlement within the landfill footprint could result in the formation of flatter slopes or shallow depressions.

Various methods for addressing differential settlement can be employed including geogrid reinforcement materials to strengthen the cover system. However, differential settlement is not anticipated to be concern for this landfill since the waste consolidation properties are well understood and the placement and compaction of the material will be carefully controlled during construction.

When settlement is not a concern, the design focus is on preventing the development of hydraulic head over the cover system barrier layer. A common design approach is to maintain the minimum slope of the barrier layer while varying the thickness of the protective cover soil to achieve a flatter surface slope. A lateral drainage layer with a high transmissivity is then used between the barrier and protective cover layers to facilitate subsurface drainage and prevent the buildup of hydraulic head. .

Minimization of the hydraulic head on top of the barrier layer and minimization of percolation through the barrier layer need to be considered when designing a landfill cover system. The concern with constructing a flatter (i.e. 1-2 percent) cover slope is that it will cause an increase in hydraulic head on top of the cover, and increased percolation of water through the cover system.

However, it is possible to reduce the hydraulic head and the percolation by using low permeability, geosynthetic barriers are used for the barrier layer instead of soil.

The alternative cover systems evaluated in this analysis examine both soil and geosynthetic barrier layers with various slopes to determine if a flatter cover system (using a geosynthetic barrier layer) can be designed to perform equivalent to a five percent sloping cover system using a low permeability soil barrier layer.

2.0 METHODOLOGY

The evaluation of landfill cover systems was made using the EPA Hydrologic Evaluation of Landfill Performance (HELP) computer program (Version 3.07, November 1, 1997). The HELP model was developed in 1986 by the USAE Waterways Experiment Station Environmental Laboratory for the EPA Risk Reduction Engineering Laboratory for use in evaluating the long term hydrologic performance of proposed landfill designs. The model accepts climatological, soil and design data, including various combinations of temperature, precipitation, vegetation, soil types, waste cells, geosynthetic materials, initial moisture conditions, material thickness, slopes, and drainage conditions to compute estimates of hydrologic water balances in landfills and other disposal facilities. Components of the hydrologic water balance accounted for in the HELP model include surface storage, snowmelt, frozen soil, runoff, infiltration, evapotranspiration, vegetative growth, soil moisture storage, lateral subsurface drainage, unsaturated vertical drainage, leachate re-circulation, and leakage through soil, geomembrane, or composite liners.

2.1 HELP Model Input

Table 1 shows ten different cap configurations representing a range of design alternatives for the Pownal Lagoon Cap that were evaluated using the HELP model.

2.1.1 Climate/Evapotranspiration

In all scenarios, default climatological data for Albany, New York was used as input (stored within the HELP program). Out of the available cities, Albany was considered the location most comparable to Pownal, Vermont (default climatological data was not available for any city in Vermont). The default climatological data includes actual historical values for temperature, precipitation, solar radiation and evapotranspiration in the selected geographic area.

A summary of the values of default evapotranspiration and weather data utilized by the HELP program begins on page 2 or 3 of each HELP model output file (see Attachment 1). In addition to the default climatological data, other evapotranspiration input variables required by the HELP program and specified by the user are evaporative zone depth of cover soils and maximum leaf area index for the vegetative cover. For all the Pownal Cap scenarios, TRC assumed an evaporative zone depth of 18 inches. For topsoil and vegetative support layers with a combined thickness less than 18 inches (i.e., Cap Scenario #1), the evaporative zone depth automatically defaults to 6 inches. TRC assumed a maximum leaf area index of 2 in all scenarios, indicating a fair strand of grass.

2.1.2 Time Period

A time period of 50 years was specified for the model.

2.1.3 Cap Area

A discrete cap area of one acre with a drainage length of 100 feet was assumed in all the Pownal Cap scenarios modeled using the HELP program.

2.1.4 Cap Configuration

A description of the remaining input variables considered and utilized in the Pownal Cap HELP scenarios is provided in the following section.

Table 1 summarizes the thickness and composition of each layer specified as part of the cap in each scenario. A summary of the thickness and geotechnical properties of each individual cap layer is presented at the beginning of each HELP output file (see Attachment 1) for all the scenarios modeled.

Table 2 shows the relevant geotechnical properties for the default cap materials used in the evaluation including porosity, field capacity, wilting point, and saturated hydraulic conductivity.

2.2 Description Of Cap Configurations

2.2.1 Cover Configuration 1

Scenario 1 represents the state of Vermont minimum acceptable solid waste cover design. This scenario includes (in order from the top) a 6-inch topsoil layer and a 24-inch low permeability soil barrier layer over the wastes. As shown in Table 1, default soil texture numbers of Texture 8 and Texture 23 were used in the Pownal Cap model for the topsoil and barrier layer, respectively. The topsoil was specified as a vertical percolation layer (layer Type 1) within the required soil design program input, and the barrier layer was entered as a barrier soil liner (layer Type 3). Scenario 1 assumes a 5 percent slope for both layers (topsoil and barrier).

2.2.2 Cover Configuration 2

Scenario 2 represents a typical waste cap required by the state of Vermont Department of Environmental Conservation (VTDEC) for solid waste landfills. This scenario includes (in order from the top) a 6-inch topsoil layer, an 18-inch root penetration layer, a 24-inch low permeability soil barrier layer, and a 12-inch gas vent layer over the wastes. As shown in Table 1, default soil texture numbers used in this scenario were as follows: Texture 8 for the topsoil, Texture 7 for the root penetration layer, Texture 23 for the barrier, and Texture 5 for the gas vent layer. The topsoil layer was entered as vertical percolation layer (layer Type 1). In addition, half of the root penetration layer was assigned the characteristic of a lateral drainage layer (layer Type 2) within the required soil design program input. As above, the barrier layer was entered as a Type 3 layer, and the gas vent layer was entered as a vertical percolation layer (layer Type 1). Scenario 2 assumes a 5 percent slope for the top of the cap and all underlying layers.

2.2.3 Cover Configurations 3 through 10

Scenarios 3 through 10 represent eight variations of alternative cap configurations evaluated by TRC. Each of these configurations consists of a five-layer cap comprised of (in order from top): topsoil or erosion protection layer, root penetration layer, lateral drainage layer, barrier layer, and gas vent layer. The materials for the barrier and lateral drainage layer were varied to investigate the effect on cover system performance. The slope of the barrier and lateral drainage layers was maintained at five percent but the surface slope was varied from one to two percent.

Scenarios 3 and 4 both represent 5-layer caps with the following components: a 6-inch topsoil, a 12-inch root penetration layer, a 12-inch sand drainage layer, a 24-inch low-permeability soil barrier layer, and a 12-inch sand gas vent layer. (Note that geosynthetics are not used in either of these scenarios.) The main difference between these two scenarios and the previous cap scenarios is the addition of the drainage layer. The cap system of Scenario 3 assumes a 1 percent surface slope and Scenario 4 assumes a 2 percent surface slope. In both scenarios, the upper vegetative support layers (topsoil and root penetration layer) are maintained at a shallow, 1 percent or 2 percent slope, while the bottom 3 layers (drainage, barrier, and gas vent layers) are oriented with a 5 percent slope.

Scenarios 5 and 8 represent identical cap arrangements with the exception of differing surface slopes (1 percent in Scenario 5, and 2 percent in Scenario 8). Scenarios 5 and 8 also represent 5-layer cap systems; however, a geocomposite has been incorporated into the cap in place of the sand drainage layer. Again, the bottom 3 layers, including and beginning with the geocomposite drainage net, are oriented at a slope of 5 percent. Material Texture 20 (a 0.5-cm. Drainage Net) was assumed as the material for the drainage layer geocomposite material. This layer was entered as layer Type 2 (lateral drainage layer).

Scenarios 6 and 9 use the same general 5-layer cap configuration. However, in these two scenarios, the drainage layer consists of the 12-inch course sand that was assumed in Scenarios 3 and 4, and the barrier layer in these two scenarios has been changed to a 40-mil, low-density polyethylene (LDPE) geomembrane. This barrier layer was entered as layer Type 4 (geomembrane liner). Default soil Texture 1 and layer Type 2 (lateral drainage layer) were assigned to the drainage layer. Surface slopes of one and two percent were assigned Scenario 6 and Scenario 9, respectively.

Scenarios 7 and 10 include a geocomposite drainage net (0.5 cm thick), and a 40-mil low-density polyethylene (LDPE) geomembrane barrier layer. Surface slopes of one and two percent were assigned Scenario 7 and Scenario 10, respectively. Again, the drainage net was entered as a lateral drainage layer (layer Type 2) with material Texture 20 (0.5-cm. Drainage Net) and the geomembrane barrier was entered as a Type 4 layer (geomembrane liners) with material Texture 36 (LDPE).

3.0 SUMMARY OF RESULTS

Attachment 1 contains the HELP Model output for the ten cap configurations.

Table 3 shows the hydrologic output parameters generated as a result of running these HELP Model scenarios. These parameters include the average yearly totals (over the 50-year period that was modeled) for precipitation, runoff, evapotranspiration, head over the barrier layer, and percolation through the barrier (all parameters in inches). Other output parameters that aid in the comparative evaluation of cap scenarios are the Peak Daily Values (over the 50-year duration) for precipitation, runoff, average and maximum head over the barrier layer, and percolation through the barrier. These parameters were also summarized in Table 3.

As shown in Table 3, Scenario 1 (2-layer Vermont minimum required solid waste cover) resulted in the most appreciable average annual percolations and hydraulic head. Although Scenario 2 (VTDEC typical cover) offered improved long-term hydrological cap performance over Scenario 1 and reduced the average annual head and percolation, this scenario resulted in the highest peak daily values for percolation through the barrier and average head over the barrier.

3.1.1 Percolation Through Barrier Layer

All of the alternative cap designs (Configurations 3-10) resulted equivalent hydrological performance to that of the VTDEC typical cover. The alternative cap configurations that incorporated a soil barrier layer and a sand drainage layer (Scenarios 3 and 4) provided essentially equivalent performance to the VTDEC typical cover. Replacement of the sand drainage layer (Scenario 3) with a geocomposite (Scenario 5) reduced the percolation rate slightly. Replacing the soils barrier layer (Scenario 3) with a geomembrane (Scenario 6) reduced percolation by a factor of approximately ten. Replacing the soil barrier and drainage layers (Scenario 3) with a geomembrane and a geocomposite reduced percolation by a factor of approximately 1000.

3.1.2 Hydraulic Head Over Barrier Layer

The hydraulic head of water over the barrier layer is a related to the permeability of the barrier layer and the transmissivity of the lateral drainage layer. Given the same barrier layer, the head can be reduced by using a coarse sand material, and further reduced using a geocomposite. The results show that a greater head would develop over the geomembrane as opposed to the soils barrier because less water is allowed to percolate through the geomembrane. This is supported by the lower percolation values calculated for the geomembrane. Overall the alternative configurations outperformed the VTDEC typical cover.

3.1.3 Effect of Cover Surface Slope

Identical cover systems with slightly different surface slopes (one percent vs. two percent) showed no appreciable difference in percolation or head. As seen in Table 3, there was no significant change in the hydrologic performance of the TRC caps when comparing the output values for 1 percent versus 2 percent surface slopes for comparable cap configurations.

4.0 CONCLUSIONS

The following conclusions were developed as a result of the HELP model evaluation.

- An alternative cover system with a flatter surface slope can be designed with equivalent performance to the Vermont typical solid waste cap using soil or geosynthetic barrier and drainage layers. The slope of the barrier and drainage layers of the alternative cap would be constructed at a five percent slope, while a shallow top slope will be achieved by varying the thickness of the overlying protective soil layers.

- The performance of the cover system, as defined by percolation, can be increased by a factor of up to 1000 by using geomembrane barrier and geocomposite drainage layers.

- Changing the top surface slope of the alternative cover system design from one to two percent has little effect on the rate of percolation and the level of hydraulic head buildup.

TRC proposes that the landfill cover be designed using on of the alternative cover systems that will allow the future development of the landfill as a playing field. The selection of the cover system materials will be performed during the design process and will include an evaluation of cost, constructability, and availability of materials.

TABLES

TABLE 1:
CAP DESCRIPTIONS AND HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE[1] MODEL INPUT PARAMETERS

General Cap Model Description						Cap Layer Properties and Related HELP Model Input Parameters[1]									
Scenario	Cap Description	Basic Properties of Cap	Portion of Cap Modeled	Slope Cover	Slope Layers 3 to 5	Topsoil (Layer 1)		Root Penetration Layer (Layer 2)		Drainage Layer (Layer 3)		Barrier Layer (Layer 4)		Gas Vent Layer (Layer 5)	
						Type and Thickness	HELP Parameters	Type and Thickness	HELP Parameters	Type and Thickness	HELP Parameters	Type and Thickness	HELP Parameters	Type and Thickness	HELP Parameters
1	Vermont Minimum Required Solid Waste Cover	5% surface slope, 2 layers over waste	Top	5%	NA	6-in. Loam	Soil Type 8	NA	NA	NA	NA	24-in. Silt	Soil Type 23	NA	NA
2	Vermont DEC Typical Required Cap (lined landfills)	5% surface slope, 4 layers over waste, (18-in. vegetative support layer)	Top	5%	5%	6-in. Loam	Soil Type 8	18-in. Silty Sand	Soil Type 7, 12-in. as lateral drainage	NA	NA	24-in. Silt	Soil Type 23	12-in. Silty Sand	Soil Type 5
3	1% TRC Cap, no geosynthetic layers	1% surface slope, 5 layers over waste	Top	1%	5%	6-in. Loam	Soil Type 8	12-in. Silty Sand	Soil Type 7	12-in. Coarse Sand	Soil Type 1	24-in. Silt	Soil Type 23	12-in. Silty Sand	Soil Type 5
4	2% TRC Cap, no geosynthetic layers	2% surface slope, 5 layers over waste	Top	2%	5%	6-in. Loam	Soil Type 8	12-in. Silty Sand	Soil Type 7	12-in. Coarse Sand	Soil Type 1	24-in. Silt	Soil Type 23	12-in. Silty Sand	Soil Type 5
5	1% TRC Cap, Geocomposite in place of drainage layer	1% surface slope, 5 layers over waste	Top	1%	5%	6-in. Loam	Soil Type 8	18-in. Fine Sandy Loam	Soil Type 7	0.5-cm Geo-composite	Material Type 20 (Drainage Net)	24-in. Silt	Soil Type 23	12-in. Silty Sand	Soil Type 5
6	1% TRC Cap, Geomembrane in place of barrier layer	1% surface slope, 5 layers over waste	Top	1%	5%	6-in. Loam	Soil Type 8	12-in. Silty Sand	Soil Type 7	12-in. Coarse Sand	Soil Type 1	40-mil LDPE Geo-membrane	Material Type 36[2]	12-in. Silty Sand	Soil Type 5
7	1% TRC Cap, Geocomposite and Geomembrane	1% surface slope, 5 layers over waste	Top	1%	5%	6-in. Loam	Soil Type 8	18-in. Silty Sand	Soil Type 7	0.5-cm Geo-composite	Material Type 20 (Drainage Net)	40-mil LDPE Geo-membrane	Material Type 36[2]	12-in. Silty Sand	Soil Type 5
8	2% TRC Cap, Geocomposite in place of drainage layer	2% surface slope, 5 layers over waste	Top	2%	5%	6-in. Loam	Soil Type 8	18-in. Silty Sand	Soil Type 7	0.5-cm Geo-composite	Material Type 20 (Drainage Net)	24-in. Silt	Soil Type 23	12-in. Silty Sand	Soil Type 5
9	2% TRC Cap, Geomembrane in place of barrier layer	2% surface slope, 5 layers over waste	Top	2%	5%	6-in. Loam	Soil Type 8	12-in. Silty Sand	Soil Type 7	12-in. Coarse Sand	Soil Type 1	40-mil LDPE Geo-membrane	Material Type 36[2]	12-in. Silty Sand	Soil Type 5
10	2% TRC Cap, Geocomposite and Geomembrane	2% surface slope, 5 layers over waste	Top	2%	5%	6-in. Loam	Soil Type 8	18-in. Silty Sand	Soil Type 7	0.5-cm Geo-composite	Material Type 20 (Drainage Net)	40-mil LDPE Geo-membrane	Material Type 36[2]	12-in. Silty Sand	Soil Type 5

[1] HELP Model Version 3.07 (11/1/97). Refer to Table 2 for descriptions of default soil and geosynthetic material model parameters.

[2] Additional HELP input parameters for Geomembrane: pinhole density = 1 holes/acre; installation defects = 7 holes/acre; and placement quality = 3 (good).

NA - Not Applicable.

Units -"in." = inches; "cm" = centimeters.

TABLE 2: DEFAULT SOIL, WASTE, AND GEOSYNTHETIC CHARACTERISTICS

Classification			Total Porosity	Field Capacity	Wilting Point	Saturated Hydraulic Conductivity
HELP	USDA	USCS	vol/vol	vol/vol	vol/vol	cm/sec
1	CoS	SP	0.417	0.045	0.018	1.0×10^{-2}
5	LFS	SM	0.457	0.131	0.058	1.0×10^{-3}
7	FSL	SM	0.473	0.222	0.104	5.2×10^{-4}
8	L	ML	0.463	0.232	0.116	3.7×10^{-4}
20	Drainage Net (0.5 cm/sec)		0.850	0.010	0.005	1.0×10^{1}
23	SiL*	ML	0.461	0.360	0.203	9.0×10^{-6}
36	Low Density Polyethylene (LDPE)		NA	NA	NA	4.0×10^{-13}

* Moderately Compacted
NA - Not Applicable

TABLE 3:
COMPARISON OF CAP SCENARIOS IN
HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE[1] MODEL

Scenario[2]	Cap Description	Average Annual Totals (Inches) Over 50-year Duration					Peak Daily Values (Inches) Over 50-year Duration				
		Precipitation	Runoff	Evapo-transpiration	Head over Barrier	Percolation Through Barrier	Precipitation	Runoff	Average Head Over Barrier	Maximum Head Over Barrier	Percolation Through Barrier
1	Vermont Minimum Required Solid Waste Cover	35.43	8.572	18.784	0.098	6.055	3.21	3.036	5.783	NA	0.379
2	Vermont DEC Typical Required Cap (lined landfills)	35.43	7.544	22.18	0.065	5.664	3.21	2.903	8.977	12.811	0.4206
3	1% TRC Cap, no geosynthetic layers	35.43	7.459	22.207	0.038	5.376	3.21	2.903	4.985	7.811	0.3697
4	2% TRC Cap, no geosynthetic layers	35.43	7.5	22.192	0.038	5.354	3.21	2.903	4.985	7.811	0.3697
5	1% TRC Cap, Geocomposite in place of drainage layer	35.43	7.533	22.268	0.000	4.2884	3.21	2.904	0.021	0.042	0.3062
6	1% TRC Cap, Geomembrane in place of barrier layer	35.43	7.459	22.207	0.507	0.5179	3.21	2.903	6.157	9.353	0.0131
7	1% TRC Cap, Geocomposite and Geomembrane	35.43	7.533	22.268	0.001	0.0025	3.21	2.904	0.03	0.06	0.0002
8	2% TRC Cap, Geocomposite in place of drainage layer	35.43	7.577	22.255	0.000	4.2735	3.21	2.904	0.021	0.042	0.3062
9	2% TRC Cap, Geomembrane in place of barrier layer	35.43	7.5	22.192	0.504	0.5107	3.21	2.903	6.137	9.328	0.013
10	2% TRC Cap, Geocomposite and Geomembrane	35.43	7.577	22.255	0.001	0.0025	3.21	2.904	0.03	0.06	0.0002

[1] HELP Model Version 3.07 (11/1/97).

[2] Refer to Tables 1 and 2 for further information on scenarios and cap layer properties.

ATTACHMENT 1:

HELP MODEL OUTPUT FILES

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**                                                                              **
**                                                                              **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE                   **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                    **
**                   DEVELOPED BY ENVIRONMENTAL LABORATORY                      **
**                     USAE WATERWAYS EXPERIMENT STATION                        **
**                FOR USEPA RISK REDUCTION ENGINEERING LABORATORY               **
**                                                                              **
**                                                                              **
**********************************************************************************
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PRECIPITATION DATA FILE:     C:\HELP3\PWNLPREC.D4
TEMPERATURE DATA FILE:       C:\HELP3\PWNLTEMP.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\PWNLRAD.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\PWNLEVAP.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\VTMINTS3.D10
OUTPUT DATA FILE:            C:\HELP3\VTMINTR3.OUT


TIME:  11: 1     DATE:  12/18/2002


**********************************************************************************

     TITLE:  Pownal VT Solid Waste Cover 3 - Top

**********************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
               COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                    LAYER  1
                                    --------

                        TYPE 1 - VERTICAL PERCOLATION LAYER
                            MATERIAL TEXTURE NUMBER   8
          THICKNESS                     =      6.00   INCHES
          POROSITY                      =      0.4630 VOL/VOL
          FIELD CAPACITY                =      0.2320 VOL/VOL
          WILTING POINT                 =      0.1160 VOL/VOL
          INITIAL SOIL WATER CONTENT    =      0.3881 VOL/VOL
          EFFECTIVE SAT. HYD. COND.     =  0.369999994000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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LAYER 2

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 23

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4610	VOL/VOL
FIELD CAPACITY	=	0.3600	VOL/VOL
WILTING POINT	=	0.2030	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4610	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.900000032000E-05	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 8 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 5.% AND A SLOPE LENGTH OF 100. FEET.

SCS RUNOFF CURVE NUMBER	=	86.90	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	6.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.328	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	2.778	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.696	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	13.392	INCHES
TOTAL INITIAL WATER	=	13.392	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
ALBANY NEW YORK

STATION LATITUDE	=	42.45	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	123	
END OF GROWING SEASON (JULIAN DATE)	=	282	
EVAPORATIVE ZONE DEPTH	=	6.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	8.90	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	66.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	74.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	74.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ALBANY NEW YORK

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
2.39	2.26	3.01	2.94	3.31	3.29
3.00	3.34	3.23	2.93	3.04	3.00

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ALBANY NEW YORK

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
21.10	23.40	33.80	46.60	57.50	66.70
71.40	69.20	61.20	50.50	39.30	26.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ALBANY NEW YORK
AND STATION LATITUDE = 42.45 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 50

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.40	2.40	3.19	3.00	3.33	2.97
	2.98	2.99	3.32	2.91	3.00	2.95
STD. DEVIATIONS	1.00	1.11	1.34	1.20	1.27	1.29
	1.11	1.17	1.90	1.56	1.29	1.33
RUNOFF						
TOTALS	0.424	0.996	5.153	0.963	0.092	0.078
	0.031	0.047	0.217	0.148	0.080	0.345
STD. DEVIATIONS	0.617	1.054	2.285	1.130	0.257	0.125
	0.050	0.086	0.346	0.239	0.162	0.559

EVAPOTRANSPIRATION

TOTALS	0.563	0.514	0.571	2.129	2.547	2.366
	2.652	2.505	1.862	1.477	1.047	0.552
STD. DEVIATIONS	0.087	0.075	0.218	0.740	0.756	0.931
	0.918	0.784	0.747	0.450	0.200	0.134

PERCOLATION/LEAKAGE THROUGH LAYER 2

TOTALS	0.0017	0.0000	0.2659	1.2911	0.6996	0.5516
	0.3747	0.3907	1.0326	1.2423	1.5262	0.6793
STD. DEVIATIONS	0.0118	0.0000	0.4756	0.6641	0.6899	0.5308
	0.3862	0.4552	1.0198	1.1193	1.2230	0.8115

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2

AVERAGES	0.0000	0.0000	0.0592	0.2580	0.0894	0.0810
	0.0321	0.0379	0.1720	0.1815	0.1983	0.0648
STD. DEVIATIONS	0.0003	0.0000	0.1081	0.1325	0.1532	0.1368
	0.0501	0.0591	0.2065	0.2149	0.2214	0.1357

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 50

	INCHES	CU. FEET	PERCENT
PRECIPITATION	35.43 (4.747)	128593.5	100.00
RUNOFF	8.572 (2.8012)	31117.45	24.198
EVAPOTRANSPIRATION	18.784 (2.1044)	68187.21	53.025
PERCOLATION/LEAKAGE THROUGH LAYER 2	8.05563 (2.49566)	29241.922	22.73982
AVERAGE HEAD ON TOP OF LAYER 2	0.098 (0.040)		
CHANGE IN WATER STORAGE	0.013 (1.8567)	46.90	0.036

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 50

	(INCHES)	(CU. FT.)
PRECIPITATION	3.21	11652.300
RUNOFF	3.036	11020.0264
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.379900	1379.03625
AVERAGE HEAD ON TOP OF LAYER 2	5.783	
SNOW WATER	9.06	32898.1094

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4630
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1160

****

****

FINAL WATER STORAGE AT END OF YEAR 50

LAYER	(INCHES)	(VOL/VOL)
1	1.9088	0.3181
2	11.0640	0.4610
SNOW WATER	1.066	

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE                   **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                    **
**                   DEVELOPED BY ENVIRONMENTAL LABORATORY                      **
**                     USAE WATERWAYS EXPERIMENT STATION                        **
**                FOR USEPA RISK REDUCTION ENGINEERING LABORATORY               **
**                                                                              **
**                                                                              **
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PRECIPITATION DATA FILE:     C:\HELP3\PWNLPREC.D4
TEMPERATURE DATA FILE:       C:\HELP3\PWNLTEMP.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\PWNLRAD.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\PWNLEVAP.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\VTCAPTS3.D10
OUTPUT DATA FILE:            C:\HELP3\VTCAPTR3.OUT


TIME:  11:23     DATE:  12/18/2002


**********************************************************************************

     TITLE:  Pownal VTDEC Min. Landfill Cap 3 - Top

**********************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                      MATERIAL TEXTURE NUMBER   8
          THICKNESS                     =      6.00   INCHES
          POROSITY                      =      0.4630 VOL/VOL
          FIELD CAPACITY                =      0.2320 VOL/VOL
          WILTING POINT                 =      0.1160 VOL/VOL
          INITIAL SOIL WATER CONTENT    =      0.4498 VOL/VOL
          EFFECTIVE SAT. HYD. COND.     =  0.369999994000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 7

THICKNESS	=	6.00	INCHES
POROSITY	=	0.4730	VOL/VOL
FIELD CAPACITY	=	0.2220	VOL/VOL
WILTING POINT	=	0.1040	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2630	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.520000001000E-03	CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 7

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4730	VOL/VOL
FIELD CAPACITY	=	0.2220	VOL/VOL
WILTING POINT	=	0.1040	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2467	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.520000001000E-03	CM/SEC
SLOPE	=	5.00	PERCENT
DRAINAGE LENGTH	=	100.0	FEET

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 23

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4610	VOL/VOL
FIELD CAPACITY	=	0.3600	VOL/VOL
WILTING POINT	=	0.2030	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4610	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.900000032000E-05	CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 5

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4570	VOL/VOL
FIELD CAPACITY	=	0.1310	VOL/VOL
WILTING POINT	=	0.0580	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1990	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 8 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 5.% AND A SLOPE LENGTH OF 100. FEET.

SCS RUNOFF CURVE NUMBER	=	86.90	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.906	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.454	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.944	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	20.690	INCHES
TOTAL INITIAL WATER	=	20.690	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM ALBANY NEW YORK

STATION LATITUDE	=	42.45	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	123	
END OF GROWING SEASON (JULIAN DATE)	=	282	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	8.90	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	66.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	74.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	74.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR ALBANY NEW YORK

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
2.39	2.26	3.01	2.94	3.31	3.29
3.00	3.34	3.23	2.93	3.04	3.00

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ALBANY NEW YORK

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
21.10	23.40	33.80	46.60	57.50	66.70
71.40	69.20	61.20	50.50	39.30	26.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ALBANY NEW YORK
AND STATION LATITUDE = 42.45 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 50

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.40	2.40	3.19	3.00	3.33	2.97
	2.98	2.99	3.32	2.91	3.00	2.95
STD. DEVIATIONS	1.00	1.11	1.34	1.20	1.27	1.29
	1.11	1.17	1.90	1.56	1.29	1.33
RUNOFF						
TOTALS	0.344	0.843	4.545	0.849	0.084	0.072
	0.027	0.045	0.202	0.157	0.078	0.298
STD. DEVIATIONS	0.523	0.940	2.135	1.008	0.218	0.118
	0.042	0.087	0.301	0.243	0.108	0.472
EVAPOTRANSPIRATION						
TOTALS	0.563	0.514	0.577	2.703	3.376	3.477
	3.137	2.787	2.049	1.467	0.989	0.541
STD. DEVIATIONS	0.087	0.075	0.217	0.685	0.882	1.053
	1.182	0.919	0.839	0.393	0.167	0.119
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	0.0000	0.0000	0.0036	0.0243	0.0003	0.0001
	0.0000	0.0000	0.0005	0.0019	0.0021	0.0010
STD. DEVIATIONS	0.0000	0.0000	0.0081	0.0145	0.0012	0.0004
	0.0000	0.0000	0.0018	0.0045	0.0045	0.0024

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0061	0.0000	0.3428	2.1937	0.2616	0.0615
	0.0087	0.0003	0.1944	0.7029	1.1396	0.7524
STD. DEVIATIONS	0.0290	0.0000	0.6886	0.8846	0.5080	0.1910
	0.0543	0.0004	0.4464	1.0444	1.0558	0.7585

PERCOLATION/LEAKAGE THROUGH LAYER 5

TOTALS	0.2469	0.0891	0.1893	1.7672	0.5898	0.1956
	0.1172	0.0644	0.0867	0.5147	0.8212	0.9830
STD. DEVIATIONS	0.1775	0.0306	0.3510	0.5991	0.4676	0.1684
	0.1458	0.0218	0.1435	0.8189	0.9359	0.7874

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.0001	0.0000	0.0799	0.5561	0.0089	0.0026
	0.0001	0.0000	0.0130	0.0437	0.0536	0.0258
STD. DEVIATIONS	0.0004	0.0000	0.1773	0.3287	0.0272	0.0105
	0.0007	0.0000	0.0424	0.1003	0.1022	0.0533

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 50

	INCHES	CU. FEET	PERCENT
PRECIPITATION	35.43 (4.747)	128593.5	100.00
RUNOFF	7.544 (2.6644)	27385.33	21.296
EVAPOTRANSPIRATION	22.180 (2.2011)	80511.74	62.610
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.03386 (0.01554)	122.921	0.09559
PERCOLATION/LEAKAGE THROUGH LAYER 4	5.66412 (2.28022)	20560.746	15.98895
AVERAGE HEAD ON TOP OF LAYER 4	0.065 (0.029)		
PERCOLATION/LEAKAGE THROUGH LAYER 5	5.66513 (2.24773)	20564.439	15.99182
CHANGE IN WATER STORAGE	0.002 (1.8470)	9.05	0.007

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 50

	(INCHES)	(CU. FT.)
PRECIPITATION	3.21	11652.300
RUNOFF	2.903	10536.1270
DRAINAGE COLLECTED FROM LAYER 3	0.01320	47.91102
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.420641	1526.92786
AVERAGE HEAD ON TOP OF LAYER 4	8.977	
MAXIMUM HEAD ON TOP OF LAYER 4	12.811	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	28.5 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.356057	1292.48657
SNOW WATER	9.06	32898.1094

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3992
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1080

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 50

LAYER	(INCHES)	(VOL/VOL)
1	1.9581	0.3263
2	1.4630	0.2438
3	2.9268	0.2439
4	11.0640	0.4610
5	2.3369	0.1947
SNOW WATER	1.066	

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE                   **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                    **
**                DEVELOPED BY ENVIRONMENTAL LABORATORY                         **
**                USAE WATERWAYS EXPERIMENT STATION                             **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY                  **
**                                                                              **
**                                                                              **
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PRECIPITATION DATA FILE:     C:\HELP3\PWNLPREC.D4
TEMPERATURE DATA FILE:       C:\HELP3\PWNLTEMP.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\PWNLRAD.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\PWNLEVAP.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\TRCM1TS3.D10
OUTPUT DATA FILE:            C:\HELP3\TRCM1TR3.OUT

TIME:  11:59     DATE:  12/18/2002

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     TITLE:  Pownal 1% Slope TRC Cap Design - Run 3

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

                                  LAYER  1
                                  --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                      MATERIAL TEXTURE NUMBER   8
          THICKNESS                     =      6.00   INCHES
          POROSITY                      =      0.4630 VOL/VOL
          FIELD CAPACITY                =      0.2320 VOL/VOL
          WILTING POINT                 =      0.1160 VOL/VOL
          INITIAL SOIL WATER CONTENT    =      0.4498 VOL/VOL
          EFFECTIVE SAT. HYD. COND.     =  0.369999994000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 7

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4730	VOL/VOL
FIELD CAPACITY	=	0.2220	VOL/VOL
WILTING POINT	=	0.1040	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2673	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.520000001000E-03	CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 1

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4170	VOL/VOL
FIELD CAPACITY	=	0.0450	VOL/VOL
WILTING POINT	=	0.0180	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0450	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999978000E-02	CM/SEC
SLOPE	=	5.00	PERCENT
DRAINAGE LENGTH	=	100.0	FEET

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 23

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4610	VOL/VOL
FIELD CAPACITY	=	0.3600	VOL/VOL
WILTING POINT	=	0.2030	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4610	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.900000032000E-05	CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 5

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4570	VOL/VOL
FIELD CAPACITY	=	0.1310	VOL/VOL
WILTING POINT	=	0.0580	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1989	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 8 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 1.% AND A SLOPE LENGTH OF 100. FEET.

SCS RUNOFF CURVE NUMBER	=	86.30	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.906	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.454	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.944	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	19.897	INCHES
TOTAL INITIAL WATER	=	19.897	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM ALBANY NEW YORK

STATION LATITUDE	=	42.45	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	123	
END OF GROWING SEASON (JULIAN DATE)	=	282	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	8.90	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	66.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	74.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	74.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR ALBANY NEW YORK

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
2.39	2.26	3.01	2.94	3.31	3.29
3.00	3.34	3.23	2.93	3.04	3.00

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ALBANY NEW YORK

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
21.10	23.40	33.80	46.60	57.50	66.70
71.40	69.20	61.20	50.50	39.30	26.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ALBANY NEW YORK
AND STATION LATITUDE = 42.45 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 50

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.40	2.40	3.19	3.00	3.33	2.97
	2.98	2.99	3.32	2.91	3.00	2.95
STD. DEVIATIONS	1.00	1.11	1.34	1.20	1.27	1.29
	1.11	1.17	1.90	1.56	1.29	1.33
RUNOFF						
TOTALS	0.344	0.843	4.545	0.843	0.074	0.063
	0.021	0.038	0.182	0.141	0.068	0.296
STD. DEVIATIONS	0.523	0.940	2.136	1.009	0.204	0.106
	0.035	0.079	0.280	0.226	0.097	0.472
EVAPOTRANSPIRATION						
TOTALS	0.563	0.514	0.577	2.704	3.382	3.478
	3.148	2.789	2.053	1.469	0.989	0.541
STD. DEVIATIONS	0.087	0.075	0.217	0.685	0.884	1.045
	1.186	0.923	0.838	0.391	0.167	0.119
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	0.0000	0.0000	0.0413	0.2616	0.0046	0.0011
	0.0000	0.0000	0.0080	0.0238	0.0274	0.0117
STD. DEVIATIONS	0.0001	0.0000	0.0900	0.1515	0.0161	0.0052
	0.0001	0.0000	0.0261	0.0542	0.0537	0.0268

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0061	0.0000	0.3131	1.9538	0.2638	0.0627
	0.0081	0.0009	0.2015	0.6978	1.1283	0.7399
STD. DEVIATIONS	0.0289	0.0000	0.6197	0.7764	0.5097	0.1942
	0.0537	0.0026	0.4517	1.0160	1.0299	0.7402

PERCOLATION/LEAKAGE THROUGH LAYER 5

TOTALS	0.2484	0.0893	0.1658	1.5272	0.5869	0.1951
	0.1180	0.0642	0.0889	0.5090	0.8104	0.9738
STD. DEVIATIONS	0.1811	0.0306	0.2872	0.5186	0.4649	0.1670
	0.1471	0.0221	0.1485	0.7982	0.9112	0.7678

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.0001	0.0000	0.0474	0.3115	0.0065	0.0017
	0.0001	0.0000	0.0102	0.0294	0.0367	0.0168
STD. DEVIATIONS	0.0003	0.0000	0.1030	0.1780	0.0193	0.0068
	0.0006	0.0001	0.0313	0.0630	0.0640	0.0311

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 50

	INCHES	CU. FEET	PERCENT
PRECIPITATION	35.43 (4.747)	128593.5	100.00
RUNOFF	7.459 (2.6599)	27076.08	21.056
EVAPOTRANSPIRATION	22.207 (2.1973)	80611.44	62.687
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.37963 (0.16443)	1378.068	1.07165
PERCOLATION/LEAKAGE THROUGH LAYER 4	5.37608 (2.20104)	19515.158	15.17585
AVERAGE HEAD ON TOP OF LAYER 4	0.038 (0.016)		
PERCOLATION/LEAKAGE THROUGH LAYER 5	5.37706 (2.16685)	19518.729	15.17863
CHANGE IN WATER STORAGE	0.003 (1.8541)	9.16	0.007

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 50

	(INCHES)	(CU. FT.)
PRECIPITATION	3.21	11652.300
RUNOFF	2.903	10536.1777
DRAINAGE COLLECTED FROM LAYER 3	0.14094	511.62659
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.369720	1342.08435
AVERAGE HEAD ON TOP OF LAYER 4	4.985	
MAXIMUM HEAD ON TOP OF LAYER 4	7.811	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	21.5 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.327270	1187.98840
SNOW WATER	9.06	32898.1094

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3993
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1080

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 50

LAYER	(INCHES)	(VOL/VOL)
1	1.9580	0.3263
2	3.0578	0.2548
3	0.5400	0.0450
4	11.0640	0.4610
5	2.3381	0.1948
SNOW WATER	1.066	

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE                   **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                    **
**                   DEVELOPED BY ENVIRONMENTAL LABORATORY                      **
**                     USAE WATERWAYS EXPERIMENT STATION                        **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY                 **
**                                                                              **
**                                                                              **
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PRECIPITATION DATA FILE:     C:\HELP3\PWNLPREC.D4
TEMPERATURE DATA FILE:       C:\HELP3\PWNLTEMP.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\PWNLRAD.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\PWNLEVAP.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\TRCM2TS3.D10
OUTPUT DATA FILE:            C:\HELP3\TRCM2TR3.OUT


TIME:  14:38     DATE:  12/18/2002

**********************************************************************************

     TITLE:  Pownal 2% Slope TRC Cap Design - Run 3

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                      MATERIAL TEXTURE NUMBER   8
          THICKNESS                     =      6.00   INCHES
          POROSITY                      =      0.4630 VOL/VOL
          FIELD CAPACITY                =      0.2320 VOL/VOL
          WILTING POINT                 =      0.1160 VOL/VOL
          INITIAL SOIL WATER CONTENT    =      0.4498 VOL/VOL
          EFFECTIVE SAT. HYD. COND.     = 0.369999994000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 7

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4730	VOL/VOL
FIELD CAPACITY	=	0.2220	VOL/VOL
WILTING POINT	=	0.1040	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2673	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.520000001000E-03	CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 1

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4170	VOL/VOL
FIELD CAPACITY	=	0.0450	VOL/VOL
WILTING POINT	=	0.0180	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0450	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999978000E-02	CM/SEC
SLOPE	=	5.00	PERCENT
DRAINAGE LENGTH	=	100.0	FEET

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 23

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4610	VOL/VOL
FIELD CAPACITY	=	0.3600	VOL/VOL
WILTING POINT	=	0.2030	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4610	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.900000032000E-05	CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 5

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4570	VOL/VOL
FIELD CAPACITY	=	0.1310	VOL/VOL
WILTING POINT	=	0.0580	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1989	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 8 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 100. FEET.

SCS RUNOFF CURVE NUMBER	=	86.60	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.906	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.454	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.944	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	19.896	INCHES
TOTAL INITIAL WATER	=	19.896	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM ALBANY NEW YORK

STATION LATITUDE	=	42.45	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	123	
END OF GROWING SEASON (JULIAN DATE)	=	282	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	8.90	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	66.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	74.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	74.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR ALBANY NEW YORK

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
2.39	2.26	3.01	2.94	3.31	3.29
3.00	3.34	3.23	2.93	3.04	3.00

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ALBANY NEW YORK

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
21.10	23.40	33.80	46.60	57.50	66.70
71.40	69.20	61.20	50.50	39.30	26.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ALBANY NEW YORK
AND STATION LATITUDE = 42.45 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 50

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.40	2.40	3.19	3.00	3.33	2.97
	2.98	2.99	3.32	2.91	3.00	2.95
STD. DEVIATIONS	1.00	1.11	1.34	1.20	1.27	1.29
	1.11	1.17	1.90	1.56	1.29	1.33
RUNOFF						
TOTALS	0.344	0.843	4.545	0.846	0.079	0.067
	0.024	0.042	0.192	0.148	0.073	0.296
STD. DEVIATIONS	0.523	0.940	2.135	1.009	0.211	0.112
	0.038	0.083	0.290	0.235	0.102	0.472
EVAPOTRANSPIRATION						
TOTALS	0.563	0.514	0.577	2.704	3.382	3.474
	3.144	2.787	2.049	1.469	0.988	0.541
STD. DEVIATIONS	0.087	0.075	0.217	0.685	0.883	1.047
	1.185	0.922	0.838	0.391	0.166	0.119
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	0.0000	0.0000	0.0413	0.2611	0.0046	0.0008
	0.0000	0.0000	0.0075	0.0231	0.0258	0.0121
STD. DEVIATIONS	0.0001	0.0000	0.0900	0.1512	0.0157	0.0044
	0.0001	0.0000	0.0245	0.0549	0.0504	0.0281

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0056	0.0000	0.3129	1.9522	0.2600	0.0605
	0.0089	0.0008	0.1965	0.6901	1.1240	0.7422
STD. DEVIATIONS	0.0288	0.0000	0.6198	0.7751	0.5033	0.1872
	0.0542	0.0028	0.4423	1.0055	1.0251	0.7403

PERCOLATION/LEAKAGE THROUGH LAYER 5

TOTALS	0.2484	0.0893	0.1656	1.5253	0.5828	0.1949
	0.1171	0.0644	0.0872	0.5007	0.8078	0.9713
STD. DEVIATIONS	0.1808	0.0306	0.2868	0.5158	0.4587	0.1660
	0.1449	0.0220	0.1431	0.7860	0.9096	0.7660

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.0001	0.0000	0.0473	0.3109	0.0064	0.0014
	0.0001	0.0000	0.0096	0.0285	0.0348	0.0172
STD. DEVIATIONS	0.0003	0.0000	0.1030	0.1777	0.0188	0.0057
	0.0006	0.0000	0.0294	0.0637	0.0602	0.0327

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 50

	INCHES		CU. FEET	PERCENT
PRECIPITATION	35.43	(4.747)	128593.5	100.00
RUNOFF	7.500	(2.6618)	27223.65	21.170
EVAPOTRANSPIRATION	22.192	(2.2030)	80556.74	62.645
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.37638	(0.16473)	1366.247	1.06245
PERCOLATION/LEAKAGE THROUGH LAYER 4	5.35375	(2.18545)	19434.102	15.11282
AVERAGE HEAD ON TOP OF LAYER 4	0.038	(0.016)		
PERCOLATION/LEAKAGE THROUGH LAYER 5	5.35470	(2.15155)	19437.564	15.11551
CHANGE IN WATER STORAGE	0.003	(1.8472)	9.27	0.007

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 50

	(INCHES)	(CU. FT.)
PRECIPITATION	3.21	11652.300
RUNOFF	2.903	10536.1885
DRAINAGE COLLECTED FROM LAYER 3	0.14094	511.61896
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.369719	1342.08081
AVERAGE HEAD ON TOP OF LAYER 4	4.985	
MAXIMUM HEAD ON TOP OF LAYER 4	7.811	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	21.5 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.327513	1188.87378
SNOW WATER	9.06	32898.1094

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3993
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1080

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 50

LAYER	(INCHES)	(VOL/VOL)
1	1.9581	0.3263
2	3.0578	0.2548
3	0.5400	0.0450
4	11.0640	0.4610
5	2.3385	0.1949
SNOW WATER	1.066	

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE                   **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                    **
**                DEVELOPED BY ENVIRONMENTAL LABORATORY                         **
**                USAE WATERWAYS EXPERIMENT STATION                             **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY                  **
**                                                                              **
**                                                                              **
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PRECIPITATION DATA FILE:     C:\HELP3\PWNLPREC.D4
TEMPERATURE DATA FILE:       C:\HELP3\PWNLTEMP.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\PWNLRAD.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\PWNLEVAP.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\TRCM1GS4.D10
OUTPUT DATA FILE:            C:\HELP3\TRCM1TG4.OUT


TIME:  14:56     DATE:  12/18/2002


**********************************************************************************

     TITLE:  Pownal 1% Slope TRC Cap 2 - Geocomposite Only

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                      MATERIAL TEXTURE NUMBER   8
          THICKNESS                     =      6.00   INCHES
          POROSITY                      =      0.4630 VOL/VOL
          FIELD CAPACITY                =      0.2320 VOL/VOL
          WILTING POINT                 =      0.1160 VOL/VOL
          INITIAL SOIL WATER CONTENT    =      0.4497 VOL/VOL
          EFFECTIVE SAT. HYD. COND.     = 0.369999994000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 7

THICKNESS	=	18.00	INCHES
POROSITY	=	0.4730	VOL/VOL
FIELD CAPACITY	=	0.2220	VOL/VOL
WILTING POINT	=	0.1040	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2579	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.520000001000E-03	CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.19	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0113	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	5.00	PERCENT
DRAINAGE LENGTH	=	100.0	FEET

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 23

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4610	VOL/VOL
FIELD CAPACITY	=	0.3600	VOL/VOL
WILTING POINT	=	0.2030	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4610	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.900000032000E-05	CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 5

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4570	VOL/VOL
FIELD CAPACITY	=	0.1310	VOL/VOL
WILTING POINT	=	0.0580	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2136	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 8 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 1.% AND A SLOPE LENGTH OF 100. FEET.

SCS RUNOFF CURVE NUMBER	=	86.30	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.944	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.454	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.944	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	20.969	INCHES
TOTAL INITIAL WATER	=	20.969	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM ALBANY NEW YORK

STATION LATITUDE	=	42.45	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	123	
END OF GROWING SEASON (JULIAN DATE)	=	282	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	8.90	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	66.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	74.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	74.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR ALBANY NEW YORK

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
2.39	2.26	3.01	2.94	3.31	3.29
3.00	3.34	3.23	2.93	3.04	3.00

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ALBANY NEW YORK

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
21.10	23.40	33.80	46.60	57.50	66.70
71.40	69.20	61.20	50.50	39.30	26.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ALBANY NEW YORK
AND STATION LATITUDE = 42.45 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 50

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.40	2.40	3.19	3.00	3.33	2.97
	2.98	2.99	3.32	2.91	3.00	2.95
STD. DEVIATIONS	1.00	1.11	1.34	1.20	1.27	1.29
	1.11	1.17	1.90	1.56	1.29	1.33
RUNOFF						
TOTALS	0.346	0.847	4.559	0.851	0.081	0.067
	0.023	0.039	0.194	0.150	0.077	0.300
STD. DEVIATIONS	0.525	0.942	2.139	1.010	0.215	0.113
	0.037	0.079	0.295	0.233	0.111	0.476
EVAPOTRANSPIRATION						
TOTALS	0.563	0.514	0.577	2.704	3.382	3.543
	3.180	2.782	2.031	1.463	0.988	0.541
STD. DEVIATIONS	0.087	0.075	0.217	0.683	0.885	1.034
	1.180	0.916	0.836	0.371	0.166	0.119
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	0.0044	0.0000	0.0781	0.5879	0.0595	0.0057
	0.0024	0.0000	0.0279	0.1498	0.2385	0.1785
STD. DEVIATIONS	0.0130	0.0000	0.1784	0.2933	0.1195	0.0190
	0.0155	0.0000	0.0819	0.2843	0.3272	0.2315

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0752	0.0000	0.1670	1.3903	0.4092	0.0757
	0.0276	0.0008	0.0980	0.4668	0.7909	0.7868
STD. DEVIATIONS	0.1194	0.0000	0.3472	0.4111	0.4065	0.1575
	0.1320	0.0023	0.2532	0.7091	0.7146	0.5403

PERCOLATION/LEAKAGE THROUGH LAYER 5

TOTALS	0.3620	0.1183	0.0942	0.8123	0.7284	0.2679
	0.1486	0.0807	0.0524	0.2913	0.5113	0.8220
STD. DEVIATIONS	0.2203	0.0464	0.0766	0.3965	0.3651	0.1803
	0.1327	0.0404	0.0188	0.4611	0.5843	0.6317

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.0000	0.0000	0.0001	0.0011	0.0002	0.0000
	0.0000	0.0000	0.0001	0.0003	0.0006	0.0005
STD. DEVIATIONS	0.0001	0.0000	0.0003	0.0004	0.0002	0.0001
	0.0001	0.0000	0.0002	0.0005	0.0005	0.0004

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 50

	INCHES	CU. FEET	PERCENT
PRECIPITATION	35.43 (4.747)	128593.5	100.00
RUNOFF	7.533 (2.6677)	27345.36	21.265
EVAPOTRANSPIRATION	22.268 (2.1863)	80833.55	62.860
LATERAL DRAINAGE COLLECTED FROM LAYER 3	1.33279 (0.70916)	4838.017	3.76226
PERCOLATION/LEAKAGE THROUGH LAYER 4	4.28840 (1.68497)	15566.895	12.10551
AVERAGE HEAD ON TOP OF LAYER 4	0.000 (0.000)		
PERCOLATION/LEAKAGE THROUGH LAYER 5	4.28943 (1.62346)	15570.644	12.10842
CHANGE IN WATER STORAGE	0.002 (1.8586)	5.92	0.005

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 50

	(INCHES)	(CU. FT.)
PRECIPITATION	3.21	11652.300
RUNOFF	2.904	10541.8066
DRAINAGE COLLECTED FROM LAYER 3	0.59714	2167.63354
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.306215	1111.55994
AVERAGE HEAD ON TOP OF LAYER 4	0.021	
MAXIMUM HEAD ON TOP OF LAYER 4	0.042	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	0.0 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.284612	1033.14111
SNOW WATER	9.06	32898.1094

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3996
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1080

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 50

LAYER	(INCHES)	(VOL/VOL)
1	1.9575	0.3263
2	4.4495	0.2472
3	0.0021	0.0110
4	11.0640	0.4610
5	2.5118	0.2093
SNOW WATER	1.066	

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                   DEVELOPED BY ENVIRONMENTAL LABORATORY                  **
**                     USAE WATERWAYS EXPERIMENT STATION                    **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:     C:\HELP3\PWNLPREC.D4
TEMPERATURE DATA FILE:       C:\HELP3\PWNLTEMP.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\PWNLRAD.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\PWNLEVAP.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\TRCM1GS5.D10
OUTPUT DATA FILE:            C:\HELP3\TRCM1TG5.OUT

TIME:  15:57     DATE:  12/18/2002

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     TITLE:  Pownal 1% Slope TRC Cap - Geomembrane Only (2)

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                LAYER  1
                                --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                      MATERIAL TEXTURE NUMBER   8
          THICKNESS                     =      6.00   INCHES
          POROSITY                      =      0.4630 VOL/VOL
          FIELD CAPACITY                =      0.2320 VOL/VOL
          WILTING POINT                 =      0.1160 VOL/VOL
          INITIAL SOIL WATER CONTENT    =      0.4498 VOL/VOL
          EFFECTIVE SAT. HYD. COND.     = 0.369999994000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 7

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4730	VOL/VOL
FIELD CAPACITY	=	0.2220	VOL/VOL
WILTING POINT	=	0.1040	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2673	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.520000001000E-03	CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 1

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4170	VOL/VOL
FIELD CAPACITY	=	0.0450	VOL/VOL
WILTING POINT	=	0.0180	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0646	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999978000E-02	CM/SEC
SLOPE	=	5.00	PERCENT
DRAINAGE LENGTH	=	100.0	FEET

LAYER 4

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 36

THICKNESS	=	0.04	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.399999993000E-12	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	7.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 5

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4570	VOL/VOL
FIELD CAPACITY	=	0.1310	VOL/VOL
WILTING POINT	=	0.0580	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1624	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 8 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 1.% AND A SLOPE LENGTH OF 100. FEET.

SCS RUNOFF CURVE NUMBER	=	86.30	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.906	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.454	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.944	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	8.629	INCHES
TOTAL INITIAL WATER	=	8.629	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM ALBANY NEW YORK

STATION LATITUDE	=	42.45	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	123	
END OF GROWING SEASON (JULIAN DATE)	=	282	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	8.90	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	66.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	74.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	74.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR ALBANY NEW YORK

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
2.39	2.26	3.01	2.94	3.31	3.29
3.00	3.34	3.23	2.93	3.04	3.00

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR ALBANY NEW YORK

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
21.10	23.40	33.80	46.60	57.50	66.70
71.40	69.20	61.20	50.50	39.30	26.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ALBANY NEW YORK
AND STATION LATITUDE = 42.45 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 50

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.40	2.40	3.19	3.00	3.33	2.97
	2.98	2.99	3.32	2.91	3.00	2.95
STD. DEVIATIONS	1.00	1.11	1.34	1.20	1.27	1.29
	1.11	1.17	1.90	1.56	1.29	1.33
RUNOFF						
TOTALS	0.344	0.843	4.545	0.843	0.074	0.063
	0.021	0.038	0.182	0.141	0.068	0.296
STD. DEVIATIONS	0.523	0.940	2.136	1.009	0.204	0.106
	0.035	0.079	0.280	0.226	0.097	0.472
EVAPOTRANSPIRATION						
TOTALS	0.563	0.514	0.577	2.704	3.382	3.478
	3.148	2.789	2.053	1.469	0.989	0.541
STD. DEVIATIONS	0.087	0.075	0.217	0.685	0.884	1.045
	1.186	0.923	0.838	0.391	0.167	0.119
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	0.1818	0.0106	0.1411	1.6721	0.6851	0.1238
	0.0316	0.0024	0.0854	0.4957	0.8513	0.9572
STD. DEVIATIONS	0.2437	0.0161	0.3138	0.4909	0.5099	0.2053
	0.1319	0.0103	0.1983	0.7409	0.7618	0.7466

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0246	0.0027	0.0124	0.1454	0.0739	0.0179
	0.0051	0.0007	0.0093	0.0476	0.0830	0.0954
STD. DEVIATIONS	0.0248	0.0030	0.0268	0.0383	0.0442	0.0215
	0.0140	0.0019	0.0202	0.0665	0.0659	0.0623

PERCOLATION/LEAKAGE THROUGH LAYER 5

TOTALS	0.0712	0.0554	0.0435	0.0118	0.0484	0.0712
	0.0609	0.0475	0.0324	0.0207	0.0158	0.0337
STD. DEVIATIONS	0.0538	0.0283	0.0193	0.0087	0.0325	0.0259
	0.0179	0.0114	0.0099	0.0133	0.0177	0.0396

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.2074	0.0133	0.1609	1.9713	0.7816	0.1459
	0.0360	0.0027	0.1007	0.5655	1.0036	1.0921
STD. DEVIATIONS	0.2780	0.0203	0.3580	0.5788	0.5817	0.2420
	0.1505	0.0117	0.2338	0.8452	0.8981	0.8518

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 50

	INCHES	CU. FEET	PERCENT
PRECIPITATION	35.43 (4.747)	128593.5	100.00
RUNOFF	7.459 (2.6599)	27076.08	21.056
EVAPOTRANSPIRATION	22.207 (2.1973)	80611.44	62.687
LATERAL DRAINAGE COLLECTED FROM LAYER 3	5.23818 (2.10032)	19014.604	14.78660
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.51793 (0.18579)	1880.099	1.46205
AVERAGE HEAD ON TOP OF LAYER 4	0.507 (0.202)		
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.51255 (0.17356)	1860.555	1.44685
CHANGE IN WATER STORAGE	0.008 (1.8114)	30.80	0.024

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 50

	(INCHES)	(CU. FT.)
PRECIPITATION	3.21	11652.300
RUNOFF	2.903	10536.1777
DRAINAGE COLLECTED FROM LAYER 3	0.17408	631.91528
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.013065	47.42489
AVERAGE HEAD ON TOP OF LAYER 4	6.157	
MAXIMUM HEAD ON TOP OF LAYER 4	9.353	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	23.9 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.010536	38.24429
SNOW WATER	9.06	32898.1094

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3993
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1080

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 50

LAYER	(INCHES)	(VOL/VOL)
1	1.9580	0.3263
2	3.0578	0.2548
3	0.7543	0.0629
4	0.0000	0.0000
5	2.2175	0.1848
SNOW WATER	1.066	

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**                                                                           **
**                                                                           **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE                **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                 **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                    **
**                  USAE WATERWAYS EXPERIMENT STATION                        **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY               **
**                                                                           **
**                                                                           **
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PRECIPITATION DATA FILE:     C:\HELP3\PWNLPREC.D4
TEMPERATURE DATA FILE:       C:\HELP3\PWNLTEMP.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\PWNLRAD.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\PWNLEVAP.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\TRCM1GS6.D10
OUTPUT DATA FILE:            C:\HELP3\TRCM1TG6.OUT


TIME:  16: 9     DATE:  12/18/2002

*******************************************************************************

     TITLE:  Pownal 1% Slope TRC Cap - Geomembrane & Geocomposite (2)

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                      MATERIAL TEXTURE NUMBER   8
          THICKNESS                     =      6.00   INCHES
          POROSITY                      =      0.4630 VOL/VOL
          FIELD CAPACITY                =      0.2320 VOL/VOL
          WILTING POINT                 =      0.1160 VOL/VOL
          INITIAL SOIL WATER CONTENT    =      0.4497 VOL/VOL
          EFFECTIVE SAT. HYD. COND.     =  0.369999994000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 7

THICKNESS	=	18.00	INCHES
POROSITY	=	0.4730	VOL/VOL
FIELD CAPACITY	=	0.2220	VOL/VOL
WILTING POINT	=	0.1040	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2579	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.520000001000E-03	CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.19	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0113	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	5.00	PERCENT
DRAINAGE LENGTH	=	100.0	FEET

LAYER 4

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 36

THICKNESS	=	0.04	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.399999993000E-12	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	7.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 5

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4570	VOL/VOL
FIELD CAPACITY	=	0.1310	VOL/VOL
WILTING POINT	=	0.0580	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1299	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 8 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 1.% AND A SLOPE LENGTH OF 100. FEET.

SCS RUNOFF CURVE NUMBER	=	86.30	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.944	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.454	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.944	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	8.901	INCHES
TOTAL INITIAL WATER	=	8.901	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM ALBANY NEW YORK

STATION LATITUDE	=	42.45	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	123	
END OF GROWING SEASON (JULIAN DATE)	=	282	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	8.90	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	66.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	74.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	74.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR ALBANY NEW YORK

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
2.39	2.26	3.01	2.94	3.31	3.29
3.00	3.34	3.23	2.93	3.04	3.00

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ALBANY NEW YORK

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
21.10	23.40	33.80	46.60	57.50	66.70
71.40	69.20	61.20	50.50	39.30	26.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ALBANY NEW YORK
AND STATION LATITUDE = 42.45 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 50

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.40	2.40	3.19	3.00	3.33	2.97
	2.98	2.99	3.32	2.91	3.00	2.95
STD. DEVIATIONS	1.00	1.11	1.34	1.20	1.27	1.29
	1.11	1.17	1.90	1.56	1.29	1.33
RUNOFF						
TOTALS	0.346	0.847	4.559	0.851	0.081	0.067
	0.023	0.039	0.194	0.150	0.077	0.300
STD. DEVIATIONS	0.525	0.942	2.139	1.010	0.215	0.113
	0.037	0.079	0.295	0.233	0.111	0.476
EVAPOTRANSPIRATION						
TOTALS	0.563	0.514	0.577	2.704	3.382	3.543
	3.180	2.782	2.031	1.463	0.988	0.541
STD. DEVIATIONS	0.087	0.075	0.217	0.683	0.885	1.034
	1.180	0.916	0.836	0.371	0.166	0.119
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	0.0798	0.0000	0.2442	1.9780	0.4688	0.0813
	0.0300	0.0009	0.1255	0.6163	1.0288	0.9652
STD. DEVIATIONS	0.1313	0.0000	0.5156	0.6584	0.5195	0.1752
	0.1474	0.0024	0.3320	0.9792	1.0250	0.7565

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0001	0.0000	0.0001	0.0008	0.0003	0.0001
	0.0000	0.0000	0.0001	0.0003	0.0005	0.0005
STD. DEVIATIONS	0.0001	0.0000	0.0002	0.0002	0.0002	0.0001
	0.0001	0.0000	0.0001	0.0004	0.0004	0.0003

PERCOLATION/LEAKAGE THROUGH LAYER 5

TOTALS	0.0004	0.0000	0.0000	0.0007	0.0011	0.0005
	0.0004	0.0003	0.0003	0.0004	0.0008	0.0010
STD. DEVIATIONS	0.0004	0.0000	0.0001	0.0006	0.0007	0.0005
	0.0003	0.0002	0.0003	0.0004	0.0006	0.0008

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.0001	0.0000	0.0003	0.0023	0.0005	0.0001
	0.0000	0.0000	0.0001	0.0007	0.0012	0.0011
STD. DEVIATIONS	0.0001	0.0000	0.0006	0.0008	0.0006	0.0002
	0.0002	0.0000	0.0004	0.0011	0.0012	0.0009

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 50

	INCHES	CU. FEET	PERCENT
PRECIPITATION	35.43 (4.747)	128593.5	100.00
RUNOFF	7.533 (2.6677)	27345.36	21.265
EVAPOTRANSPIRATION	22.268 (2.1863)	80833.55	62.860
LATERAL DRAINAGE COLLECTED FROM LAYER 3	5.61872 (2.32530)	20395.937	15.86079
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00247 (0.00093)	8.972	0.00698
AVERAGE HEAD ON TOP OF LAYER 4	0.001 (0.000)		
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00581 (0.00357)	21.105	0.01641
CHANGE IN WATER STORAGE	-0.001 (1.8392)	-2.47	-0.002

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 50

	(INCHES)	(CU. FT.)
PRECIPITATION	3.21	11652.300
RUNOFF	2.904	10541.8066
DRAINAGE COLLECTED FROM LAYER 3	0.84937	3083.22168
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000204	0.74198
AVERAGE HEAD ON TOP OF LAYER 4	0.030	
MAXIMUM HEAD ON TOP OF LAYER 4	0.060	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	0.6 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000136	0.49318
SNOW WATER	9.06	32898.1094

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3996
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1080

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 50

LAYER	(INCHES)	(VOL/VOL)
1	1.9575	0.3263
2	4.4495	0.2472
3	0.0021	0.0110
4	0.0000	0.0000
5	1.3919	0.1160
SNOW WATER	1.066	

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                   DEVELOPED BY ENVIRONMENTAL LABORATORY                  **
**                     USAE WATERWAYS EXPERIMENT STATION                    **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:     C:\HELP3\PWNLPREC.D4
TEMPERATURE DATA FILE:       C:\HELP3\PWNLTEMP.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\PWNLRAD.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\PWNLEVAP.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\TRCM2GS1.D10
OUTPUT DATA FILE:            C:\HELP3\TRCM2TG1.OUT


TIME:  18:12     DATE:  12/18/2002


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     TITLE:  Pownal 2% Slope TRC Cap - Geocomposite Only

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                LAYER  1
                                --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                      MATERIAL TEXTURE NUMBER   8
          THICKNESS                     =      6.00   INCHES
          POROSITY                      =      0.4630 VOL/VOL
          FIELD CAPACITY                =      0.2320 VOL/VOL
          WILTING POINT                 =      0.1160 VOL/VOL
          INITIAL SOIL WATER CONTENT    =      0.4497 VOL/VOL
          EFFECTIVE SAT. HYD. COND.     = 0.369999994000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 7

THICKNESS	=	18.00	INCHES
POROSITY	=	0.4730	VOL/VOL
FIELD CAPACITY	=	0.2220	VOL/VOL
WILTING POINT	=	0.1040	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2579	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.520000001000E-03	CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.19	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0113	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	5.00	PERCENT
DRAINAGE LENGTH	=	100.0	FEET

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 23

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4610	VOL/VOL
FIELD CAPACITY	=	0.3600	VOL/VOL
WILTING POINT	=	0.2030	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4610	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.900000032000E-05	CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 5

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4570	VOL/VOL
FIELD CAPACITY	=	0.1310	VOL/VOL
WILTING POINT	=	0.0580	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2136	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 8 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 100. FEET.

SCS RUNOFF CURVE NUMBER	=	86.60	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.944	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.454	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.944	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	20.969	INCHES
TOTAL INITIAL WATER	=	20.969	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM ALBANY NEW YORK

STATION LATITUDE	=	42.45	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	123	
END OF GROWING SEASON (JULIAN DATE)	=	282	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	8.90	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	66.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	74.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	74.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR ALBANY NEW YORK

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
2.39	2.26	3.01	2.94	3.31	3.29
3.00	3.34	3.23	2.93	3.04	3.00

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ALBANY NEW YORK

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
21.10	23.40	33.80	46.60	57.50	66.70
71.40	69.20	61.20	50.50	39.30	26.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ALBANY NEW YORK
AND STATION LATITUDE = 42.45 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 50

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.40	2.40	3.19	3.00	3.33	2.97
	2.98	2.99	3.32	2.91	3.00	2.95
STD. DEVIATIONS	1.00	1.11	1.34	1.20	1.27	1.29
	1.11	1.17	1.90	1.56	1.29	1.33
RUNOFF						
TOTALS	0.346	0.847	4.559	0.854	0.086	0.072
	0.025	0.043	0.205	0.158	0.082	0.301
STD. DEVIATIONS	0.525	0.942	2.139	1.009	0.222	0.118
	0.040	0.083	0.306	0.242	0.116	0.476
EVAPOTRANSPIRATION						
TOTALS	0.563	0.514	0.577	2.704	3.383	3.532
	3.184	2.780	2.033	1.457	0.987	0.541
STD. DEVIATIONS	0.087	0.075	0.217	0.683	0.885	1.020
	1.186	0.916	0.827	0.385	0.167	0.119
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	0.0044	0.0000	0.0768	0.5908	0.0600	0.0046
	0.0033	0.0000	0.0273	0.1415	0.2340	0.1748
STD. DEVIATIONS	0.0130	0.0000	0.1725	0.2947	0.1224	0.0145
	0.0223	0.0000	0.0807	0.2682	0.3253	0.2233

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0752	0.0000	0.1683	1.3846	0.4060	0.0744
	0.0263	0.0007	0.0941	0.4664	0.7877	0.7898
STD. DEVIATIONS	0.1194	0.0000	0.3508	0.4072	0.3990	0.1593
	0.1237	0.0019	0.2450	0.7138	0.7105	0.5463

PERCOLATION/LEAKAGE THROUGH LAYER 5

TOTALS	0.3619	0.1182	0.0948	0.8071	0.7255	0.2687
	0.1459	0.0804	0.0515	0.2890	0.5079	0.8235
STD. DEVIATIONS	0.2201	0.0465	0.0764	0.3999	0.3588	0.1823
	0.1249	0.0404	0.0169	0.4629	0.5825	0.6360

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.0000	0.0000	0.0001	0.0011	0.0002	0.0000
	0.0000	0.0000	0.0001	0.0003	0.0006	0.0005
STD. DEVIATIONS	0.0001	0.0000	0.0003	0.0004	0.0003	0.0001
	0.0001	0.0000	0.0002	0.0005	0.0005	0.0004

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 50

	INCHES		CU. FEET	PERCENT
PRECIPITATION	35.43	(4.747)	128593.5	100.00
RUNOFF	7.577	(2.6706)	27503.79	21.388
EVAPOTRANSPIRATION	22.255	(2.1853)	80784.80	62.822
LATERAL DRAINAGE COLLECTED FROM LAYER 3	1.31752	(0.70434)	4782.611	3.71917
PERCOLATION/LEAKAGE THROUGH LAYER 4	4.27346	(1.67468)	15512.649	12.06332
AVERAGE HEAD ON TOP OF LAYER 4	0.000	(0.000)		
PERCOLATION/LEAKAGE THROUGH LAYER 5	4.27450	(1.61323)	15516.424	12.06626
CHANGE IN WATER STORAGE	0.002	(1.8580)	5.87	0.005

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 50

	(INCHES)	(CU. FT.)
PRECIPITATION	3.21	11652.300
RUNOFF	2.904	10541.8027
DRAINAGE COLLECTED FROM LAYER 3	0.59685	2166.56885
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.306214	1111.55713
AVERAGE HEAD ON TOP OF LAYER 4	0.021	
MAXIMUM HEAD ON TOP OF LAYER 4	0.042	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	0.6 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.287888	1045.03247
SNOW WATER	9.06	32898.1094

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3995

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1080

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 50

LAYER	(INCHES)	(VOL/VOL)
1	1.9575	0.3263
2	4.4495	0.2472
3	0.0019	0.0100
4	11.0640	0.4610
5	2.5113	0.2093
SNOW WATER	1.066	

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE                **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                 **
**                   DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                     USAE WATERWAYS EXPERIMENT STATION                     **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY               **
**                                                                           **
**                                                                           **
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PRECIPITATION DATA FILE:     C:\HELP3\PWNLPREC.D4
TEMPERATURE DATA FILE:       C:\HELP3\PWNLTEMP.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\PWNLRAD.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\PWNLEVAP.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\TRCM2GS2.D10
OUTPUT DATA FILE:            C:\HELP3\TRCM2TG2.OUT

TIME:  18:15     DATE:  12/18/2002

*******************************************************************************

     TITLE:  Pownal 2% Slope TRC Cap - Geomembrane Only

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                      MATERIAL TEXTURE NUMBER   8
          THICKNESS                     =      6.00   INCHES
          POROSITY                      =      0.4630 VOL/VOL
          FIELD CAPACITY                =      0.2320 VOL/VOL
          WILTING POINT                 =      0.1160 VOL/VOL
          INITIAL SOIL WATER CONTENT    =      0.4498 VOL/VOL
          EFFECTIVE SAT. HYD. COND.     = 0.369999994000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 7

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4730	VOL/VOL
FIELD CAPACITY	=	0.2220	VOL/VOL
WILTING POINT	=	0.1040	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2673	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.520000001000E-03	CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 1

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4170	VOL/VOL
FIELD CAPACITY	=	0.0450	VOL/VOL
WILTING POINT	=	0.0180	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0645	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999978000E-02	CM/SEC
SLOPE	=	5.00	PERCENT
DRAINAGE LENGTH	=	100.0	FEET

LAYER 4

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 36

THICKNESS	=	0.04	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.399999993000E-12	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	7.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 5

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4570	VOL/VOL
FIELD CAPACITY	=	0.1310	VOL/VOL
WILTING POINT	=	0.0580	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1623	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 8 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 100. FEET.

SCS RUNOFF CURVE NUMBER	=	86.60	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.906	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.454	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.944	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	8.628	INCHES
TOTAL INITIAL WATER	=	8.628	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM ALBANY NEW YORK

STATION LATITUDE	=	42.45	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	123	
END OF GROWING SEASON (JULIAN DATE)	=	282	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	8.90	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	66.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	74.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	74.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR ALBANY NEW YORK

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
2.39	2.26	3.01	2.94	3.31	3.29
3.00	3.34	3.23	2.93	3.04	3.00

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ALBANY NEW YORK

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
21.10	23.40	33.80	46.60	57.50	66.70
71.40	69.20	61.20	50.50	39.30	26.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ALBANY NEW YORK
AND STATION LATITUDE = 42.45 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 50

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.40	2.40	3.19	3.00	3.33	2.97
	2.98	2.99	3.32	2.91	3.00	2.95
STD. DEVIATIONS	1.00	1.11	1.34	1.20	1.27	1.29
	1.11	1.17	1.90	1.56	1.29	1.33
RUNOFF						
TOTALS	0.344	0.843	4.545	0.846	0.079	0.067
	0.024	0.042	0.192	0.148	0.073	0.296
STD. DEVIATIONS	0.523	0.940	2.135	1.009	0.211	0.112
	0.038	0.083	0.290	0.235	0.102	0.472
EVAPOTRANSPIRATION						
TOTALS	0.563	0.514	0.577	2.704	3.382	3.474
	3.144	2.787	2.049	1.469	0.988	0.541
STD. DEVIATIONS	0.087	0.075	0.217	0.685	0.883	1.047
	1.185	0.922	0.838	0.391	0.166	0.119
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	0.1819	0.0106	0.1410	1.6699	0.6821	0.1218
	0.0315	0.0025	0.0825	0.4886	0.8456	0.9566
STD. DEVIATIONS	0.2435	0.0160	0.3137	0.4888	0.5066	0.2005
	0.1304	0.0103	0.1924	0.7327	0.7577	0.7442

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0246	0.0027	0.0124	0.1452	0.0736	0.0177
	0.0051	0.0007	0.0090	0.0470	0.0825	0.0954
STD. DEVIATIONS	0.0248	0.0030	0.0268	0.0381	0.0440	0.0211
	0.0139	0.0020	0.0196	0.0659	0.0656	0.0622

PERCOLATION/LEAKAGE THROUGH LAYER 5

TOTALS	0.0709	0.0553	0.0435	0.0118	0.0482	0.0710
	0.0607	0.0474	0.0324	0.0208	0.0154	0.0332
STD. DEVIATIONS	0.0535	0.0282	0.0193	0.0087	0.0324	0.0258
	0.0177	0.0113	0.0098	0.0132	0.0170	0.0392

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.2075	0.0133	0.1609	1.9686	0.7782	0.1436
	0.0359	0.0028	0.0972	0.5574	0.9969	1.0913
STD. DEVIATIONS	0.2778	0.0202	0.3579	0.5763	0.5779	0.2364
	0.1488	0.0118	0.2268	0.8359	0.8932	0.8490

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 50

	INCHES		CU. FEET	PERCENT
PRECIPITATION	35.43	(4.747)	128593.5	100.00
RUNOFF	7.500	(2.6618)	27223.65	21.170
EVAPOTRANSPIRATION	22.192	(2.2030)	80556.74	62.645
LATERAL DRAINAGE COLLECTED FROM LAYER 3	5.21452	(2.08467)	18928.703	14.71980
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.51602	(0.18446)	1873.161	1.45665
AVERAGE HEAD ON TOP OF LAYER 4	0.504	(0.201)		
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.51066	(0.17279)	1853.680	1.44150
CHANGE IN WATER STORAGE	0.008	(1.8056)	30.70	0.024

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 50

	(INCHES)	(CU. FT.)
PRECIPITATION	3.21	11652.300
RUNOFF	2.903	10536.1885
DRAINAGE COLLECTED FROM LAYER 3	0.17354	629.93756
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.013032	47.30566
AVERAGE HEAD ON TOP OF LAYER 4	6.137	
MAXIMUM HEAD ON TOP OF LAYER 4	9.328	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	23.8 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.010488	38.07294
SNOW WATER	9.06	32898.1094

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3993
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1080

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 50

LAYER	(INCHES)	(VOL/VOL)
1	1.9581	0.3263
2	3.0578	0.2548
3	0.7533	0.0628
4	0.0000	0.0000
5	2.2157	0.1846
SNOW WATER	1.066	

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE        **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)        **
**                   DEVELOPED BY ENVIRONMENTAL LABORATORY          **
**                     USAE WATERWAYS EXPERIMENT STATION            **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY      **
**                                                                  **
**                                                                  **
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PRECIPITATION DATA FILE:     C:\HELP3\PWNLPREC.D4
TEMPERATURE DATA FILE:       C:\HELP3\PWNLTEMP.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\PWNLRAD.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\PWNLEVAP.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\TRCM2GS3.D10
OUTPUT DATA FILE:            C:\HELP3\TRCM2TG3.OUT


TIME:  17:48     DATE:  12/18/2002


**********************************************************************

     TITLE:  Pownal 2% Slope TRC Cap - Geomembrane & Geocomposite

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                LAYER  1
                                --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                      MATERIAL TEXTURE NUMBER   8
          THICKNESS                     =      6.00   INCHES
          POROSITY                      =      0.4630 VOL/VOL
          FIELD CAPACITY                =      0.2320 VOL/VOL
          WILTING POINT                 =      0.1160 VOL/VOL
          INITIAL SOIL WATER CONTENT    =      0.4497 VOL/VOL
          EFFECTIVE SAT. HYD. COND.     =  0.369999994000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 7

THICKNESS	=	18.00	INCHES
POROSITY	=	0.4730	VOL/VOL
FIELD CAPACITY	=	0.2220	VOL/VOL
WILTING POINT	=	0.1040	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2579	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.520000001000E-03	CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.19	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0113	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	5.00	PERCENT
DRAINAGE LENGTH	=	100.0	FEET

LAYER 4

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 36

THICKNESS	=	0.04	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.399999993000E-12	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	7.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 5

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4570	VOL/VOL
FIELD CAPACITY	=	0.1310	VOL/VOL
WILTING POINT	=	0.0580	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1299	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 8 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 100. FEET.

SCS RUNOFF CURVE NUMBER	=	86.60	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.944	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.454	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.944	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	8.900	INCHES
TOTAL INITIAL WATER	=	8.900	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
ALBANY NEW YORK

STATION LATITUDE	=	42.45	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	123	
END OF GROWING SEASON (JULIAN DATE)	=	282	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	8.90	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	66.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	74.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	74.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR ALBANY NEW YORK

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
2.39	2.26	3.01	2.94	3.31	3.29
3.00	3.34	3.23	2.93	3.04	3.00

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ALBANY NEW YORK

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
21.10	23.40	33.80	46.60	57.50	66.70
71.40	69.20	61.20	50.50	39.30	26.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ALBANY NEW YORK
AND STATION LATITUDE = 42.45 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 50

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.40	2.40	3.19	3.00	3.33	2.97
	2.98	2.99	3.32	2.91	3.00	2.95
STD. DEVIATIONS	1.00	1.11	1.34	1.20	1.27	1.29
	1.11	1.17	1.90	1.56	1.29	1.33
RUNOFF						
TOTALS	0.346	0.847	4.559	0.854	0.086	0.072
	0.025	0.043	0.205	0.158	0.082	0.301
STD. DEVIATIONS	0.525	0.942	2.139	1.009	0.222	0.118
	0.040	0.083	0.306	0.242	0.116	0.476
EVAPOTRANSPIRATION						
TOTALS	0.563	0.514	0.577	2.704	3.383	3.532
	3.184	2.780	2.033	1.457	0.987	0.541
STD. DEVIATIONS	0.087	0.075	0.217	0.683	0.885	1.020
	1.186	0.916	0.827	0.385	0.167	0.119
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	0.0798	0.0000	0.2442	1.9750	0.4661	0.0790
	0.0297	0.0007	0.1212	0.6070	1.0214	0.9644
STD. DEVIATIONS	0.1313	0.0000	0.5155	0.6562	0.5147	0.1731
	0.1458	0.0020	0.3226	0.9679	1.0188	0.7552

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0001	0.0000	0.0001	0.0008	0.0003	0.0001
	0.0000	0.0000	0.0001	0.0003	0.0004	0.0005
STD. DEVIATIONS	0.0001	0.0000	0.0002	0.0002	0.0002	0.0001
	0.0001	0.0000	0.0001	0.0004	0.0004	0.0003

PERCOLATION/LEAKAGE THROUGH LAYER 5

TOTALS	0.0004	0.0000	0.0000	0.0007	0.0011	0.0005
	0.0004	0.0003	0.0003	0.0004	0.0008	0.0010
STD. DEVIATIONS	0.0004	0.0000	0.0001	0.0006	0.0007	0.0005
	0.0003	0.0002	0.0002	0.0004	0.0006	0.0008

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.0001	0.0000	0.0003	0.0023	0.0005	0.0001
	0.0000	0.0000	0.0001	0.0007	0.0012	0.0011
STD. DEVIATIONS	0.0001	0.0000	0.0006	0.0008	0.0006	0.0002
	0.0002	0.0000	0.0004	0.0011	0.0012	0.0009

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 50

	INCHES		CU. FEET	PERCENT
PRECIPITATION	35.43	(4.747)	128593.5	100.00
RUNOFF	7.577	(2.6706)	27503.79	21.388
EVAPOTRANSPIRATION	22.255	(2.1853)	80784.80	62.822
LATERAL DRAINAGE COLLECTED FROM LAYER 3	5.58852	(2.31194)	20286.316	15.77554
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00246	(0.00093)	8.929	0.00694
AVERAGE HEAD ON TOP OF LAYER 4	0.001	(0.000)		
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00581	(0.00349)	21.076	0.01639
CHANGE IN WATER STORAGE	-0.001	(1.8386)	-2.48	-0.002

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 50

	(INCHES)	(CU. FT.)
PRECIPITATION	3.21	11652.300
RUNOFF	2.904	10541.8027
DRAINAGE COLLECTED FROM LAYER 3	0.84908	3082.15649
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000204	0.74177
AVERAGE HEAD ON TOP OF LAYER 4	0.030	
MAXIMUM HEAD ON TOP OF LAYER 4	0.060	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	0.0 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000135	0.49175
SNOW WATER	9.06	32898.1094

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3995
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1080

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

****

****

FINAL WATER STORAGE AT END OF YEAR 50

LAYER	(INCHES)	(VOL/VOL)
1	1.9575	0.3263
2	4.4495	0.2472
3	0.0021	0.0110
4	0.0000	0.0000
5	1.3914	0.1159
SNOW WATER	1.066	

****
****

APPENDIX G

LANDFILL CAP DRAINAGE LAYER EVALUATION

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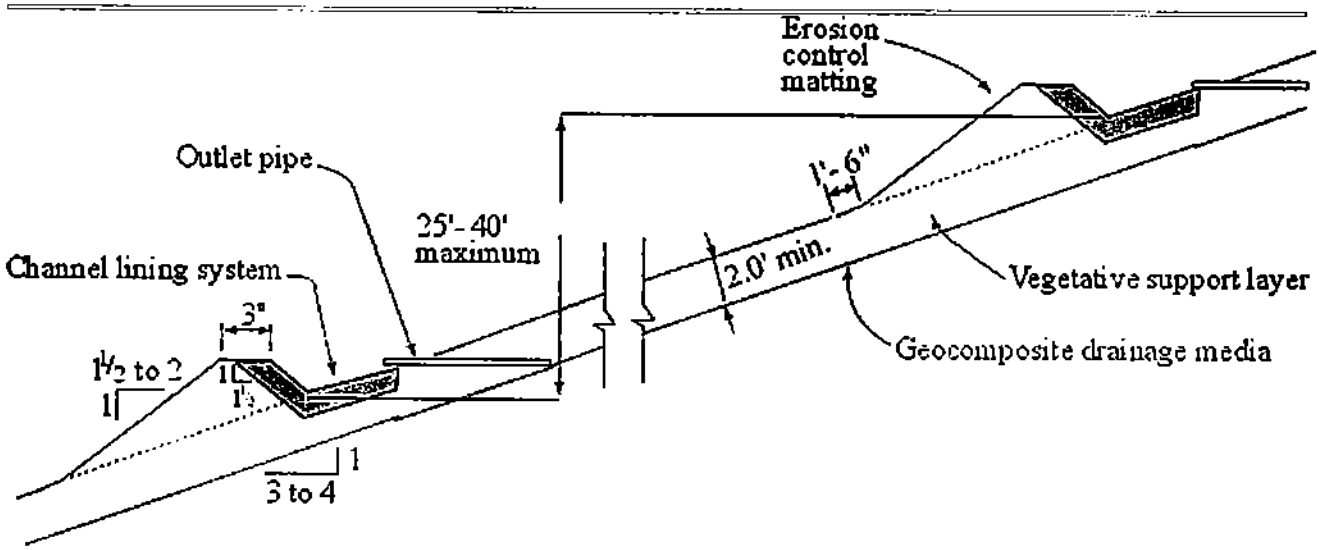
Unit Gradient Method - Design Calculator

Pownal Tannery Superfund Site
Sludge Consolidation Landfill
Side slopes with Vegetated Cover.

Problem Statement



The transmissivity of a drainage geocomposite must be great enough to carry all of the infiltrating flow from the soil layer(s) above. If the drainage geocomposite can not carry all the infiltrating water (very long slope, or very permeable cover soil,...); swales can be placed as shown in the above figure. The three conditions for stability are:

1. The interface shear strength of all interfaces is adequate
2. Pore water pressures do not build up and reduce the contact stress between the geomembrane and the soil. The Seepage Force Stability Calculator can be used to determine the factor of safety of a landfill cover with consideration of seepage forces
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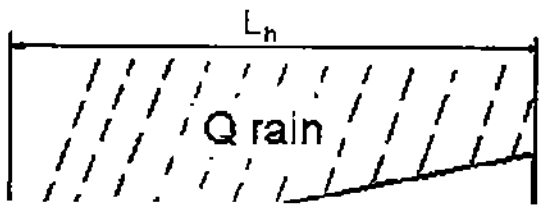
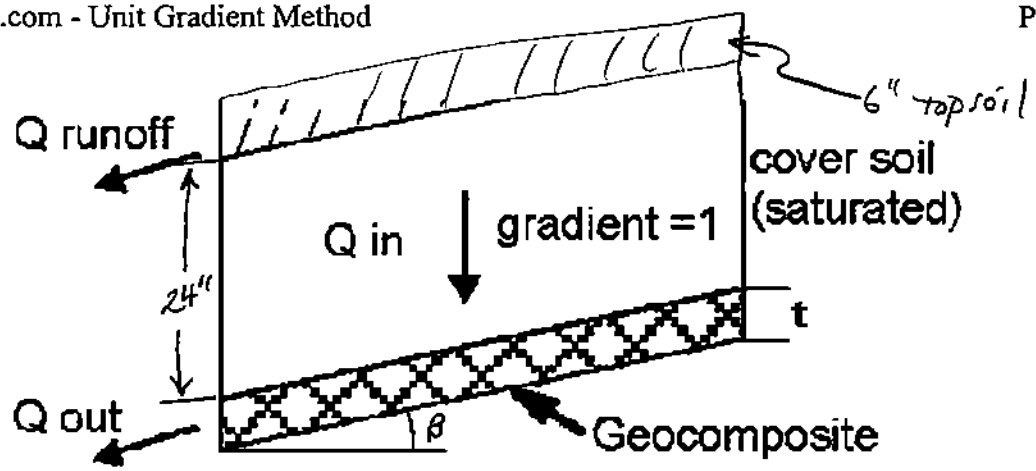
This webpage determines the ultimate transmissivity sufficient to transmit all incoming flow within the thickness of the geocomposite; i.e. maximum head < geonet thickness; therefore seepage forces in the cover soil will be zero.





With Darcy's law:

$$Q = k * i * A$$

Inflow of water in the geocomposite

$$Q_{in} = k_{veg} * i * A = k_{veg} * 1 * L_h * 1$$

Outflow of water from the geocomposite at the toe of the slope

$$Q_{out} = k_{comp} * i * A = k_{comp} * i * t * 1 = \theta_{required} * \sin \beta$$

Inflow equals outflow (Factor of Safety = 1)

$$Q_{in} = Q_{out}$$

This results in a required transmissivity of the geocomposite of:

$$\theta_{required} = \frac{k_{veg} * L_h}{\sin \beta}$$

Which results in the ultimate transmissivity after multiplying by the Total Serviceability Factor (TSF)

$$\theta_{ultimate} = \theta_{required} * FS_d * RF_{in} * RF_{cr} * RF_{cc} * RF_{bc}$$

Required Data

Symbol	Name	Dimensions
L_h	Drainage pipe spacing or length of slope measured horizontally	Length
k_{veg}	Permeability of the vegetative supporting soil	Length/Time
S	The liner's slope, S = tan **b**	-
FS_{slope}	Minimum factor of safety against sliding, for soil/geocomposite or geocomposite/geomembrane interfaces	-

FS_d	Overall factor of safety for drainage
RF_{in}	Intrusion Reduction Factor
RF_{cr}	Creep Reduction Factor
RF_{cc}	Chemical Clogging Reduction Factor
RF_{bc}	Biological Clogging Reduction Factor

Input Values

Note: If you do not wish to perform calculations for 3 cases, please leave default data as is.

	Case 1	Case 2	Case 3
S	33 %	33 %	33 %
L_h	12.192 m	60 m	90 m
k_{veg}	1E-4 cm/sec	1E-4 cm/sec	1E-4 cm/sec
FS_{slope}	1.5	1.5	1.5

L_h = maximum horizontal slope length of 40 ft.

Reduction Factors and Safety Factor

	Case 1	Case 2	Case 3	Surface Water Drains
RF_{in}	1.2	1.2	1.2	[1] 1.0 - 1.2
RF_{cr}	1.4	1.4	1.4	[2] Calculate RF_{CR}
RF_{cc}	1.2	1.2	1.2	[3] 1.0 - 1.2
RF_{bc}	2	3.5	3.5	[3] 1.2 - 3.5
FS_d	2	3	3	[4] 2.0 - 10.0

Calculate Transmissivity

[1] Intrusion reduction factor from 100 hour to design life. Giroud et. al (2000)
[2] Creep reduction factor from 100 hour to design life (for instance, 30 years). RF_{CR} is determined from 10,000 hour compressive creep test.

extrapolated to design life, GRI-GC8 (2001). RF_{CR} is product and normal load specific.
[3] GRI-GC8
[4] FS value = 2-3. Giroud, et. al (2000)
FS value > 10 for filtration and drainage. Koerner (2001)
[5] Note: The calculated transmissivity is corresponding to the case where the sealing time is 100 hours and the boundary conditions due to adjacent materials are simulated in the hydraulic transmissivity test.

Solution

Symbol	Name	Dimensions
gradient	Gradient	
$\theta_{ultimate}$	Ultimate Transmissivity	Length^2/Time
$\delta_{req'd}$	Minimum interface friction angle	degrees

	Case 1		Case 2		Case 3	
gradient	0.31		0.31		0.31	
$\theta_{ultimate}$	3.14E-004	m^2/s	4.05E-003	m^2/s	6.08E-003	m^2/s
$\delta_{req'd}$	26.34	degrees	26.34	degrees	26.34	degrees

Material Selection

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GFR GEOTECHNICAL FABRICS REPORT Online Specifiers Guide

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References

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Design of Lateral Drainage System in Landfill - Design Calculator

Pownal Tannery Superfund Site
Sludge Consolidation Landfill

Problem Statement

Top slope — No Underdrain Pipes.

The ultimate transmissivity of a geocomposite drainage layer is calculated by two methods:

The first method is based on the McEnroes equations. From the McEnroes equations, the required permeability of a drainage media is calculated. Iteration procedure is used to find the required permeability such that the liquid thickness is equal to the thickness of the liquid collection layer. This permeability multiplied by the thickness of the liquid collection layer result in the required transmissivity. The ultimate geocomposite transmissivity can then be calculated by incorporating the total serviceability factor (product of safety factor and reduction factors).

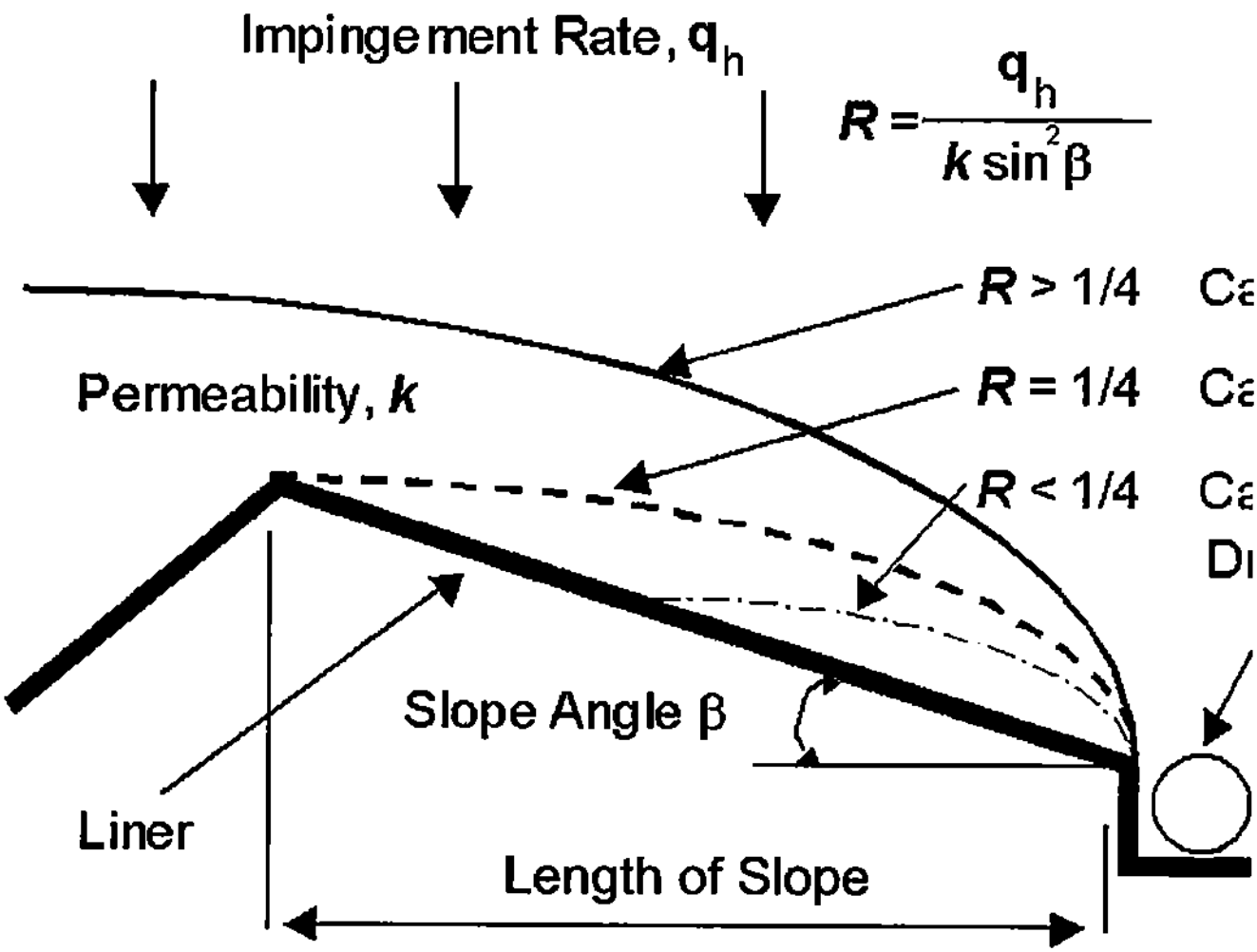
The McEnroe equation requires the input of an impingement rate (q_h), a drainage media permeability (k) and a liner slope (b). This information is used here to find the liquid thickness on the liner.

The McEnroes solutions are for three cases.

1. Case 1 is for a saw-tooth bottom, with the liquid mound overtopping the peak. (R > 1/4)
2. Case 2 has the liquid mound starting at the peak of the saw-tooth. (R = 1/4)
3. Case 3 has the mound starting below the peak of the tooth. (R > 1/4)

McEnroe Equation

$$\frac{t_{LCL}}{L} = \begin{cases} \sin\beta\sqrt{R-RS+R^2S^2}\left[\dfrac{(1-A-2R)(1+A-2RS)}{(1+A-2R)(1-A-2RS)}\right]^{\frac{1}{2A}} \\ \sin\beta\dfrac{R(1-2RS)}{1-2R}\exp\left[\dfrac{2R(S-1)}{(1-2RS)(1-2R)}\right] \\ \sin\beta\sqrt{R-RS+R^2S^2}\exp\left[\dfrac{1}{B}\tan^{-1}\left(\dfrac{2RS-1}{B}\right)-\dfrac{1}{B}\tan^{-1}\left(\dfrac{2}{-}\right.\right. \end{cases}$$



The second method is based on Giroud's equation. The geocomposite's ultimate transmissivity is calculated directly.

Giroud's equation, with great simplicity, produces a very close solution as compared to McEnroe's equations.

Giroud Equation

$$\Theta = \mathrm{TSF}\,\frac{q_h L}{\sin\beta + \dfrac{t_{LCL}/L}{TSF}\cos^2\beta}$$

Note: Giroud's equation is based on a factor of safety applied to maximum liquid thickness to ensure unconfined flow.

Required Data

Symbol	Name	Dimensions

S	The liner slope, S = tan **b**	%
q_h	Impingement rate	Length / Time
L	Length of slope measure horizontally	Length
t_{LCL}	Thickness of the Liquid Collection Layer for geocomposite.	Length

FS_d	Overall factor of safety for drainage
RF_{in}	Intrusion Reduction Factor
RF_{cr}	Creep Reduction Factor
RF_{cc}	Chemical Clogging Reduction Factor
RF_{bc}	Biological Clogging Reduction Factor

Input Values

Note: If you do not wish to perform calculations for 3 cases, please leave default data as is.

	Case 1		Case 2		Case 3	
S	5	%	2	%	2	%
q_h	1.0E-4	cm/s	1.0E-5	cm/s	1.0E-5	cm/s
L	45.72	m	60	m	90	m
t_{LCL}	0.75	cm	0.75	cm	0.75	cm

Factor	Case 1	Case 2	Case 3		Leachate Collection and Removal	Leachate Detection Systems
RF_{in}	1.2	1.2	1.2	[1]	1.0 - 1.2	1.0 - 1.2
RF_{cr}	1.4	1.4	1.4	[2] Calculate RF_{CR}		
RF_{cc}	1.5	1.5	1.5	[3]	1.5 - 2.0	1.1 - 1.5
RF_{bc}	1.3	1.3	1.3	[3]	1.1 - 1.3	1.1 - 1.3
FS	2	3	3	[4]	2.0 - 10.0	2.0 - 10.0

Note: The reduction factor values given correspond to the case where the seating time exceeds 100 hours and the boundary conditions due to adjacent materials are simulated in the hydraulic transmissivity test.

Calculate Transmissivity

[1] Intrusion reduction factor from 100 hour to design life. Giroud et. al (2000)
[2] Creep reduction factor from 100 hour to design life (for instance, 30 years). RF_{CR} is determined from 10,000 hour compressive creep test, extrapolated to design life, GRI-GC8 (2001). RF_{CR} is product and normal load specific.
[3] GRI-GC8
[4] FS value = 2-3. Giroud, et. al (2000)
FS value > 10 for filtration and drainage. Koerner (2001)
[5] Note: The calculated transmissivity is corresponding to the case where the seating time is 100 hours and the boundary conditions due to adjacent materials are simulated in the hydraulic transmissivity test

adjacent materials are simulated in the hydraulic transmissivity test.

Solution

Symbol	Name	Dimensions
R	$= q_h/(k \sin^2 b)$	-
Gradient	Gradient	-
θ	Transmissivity = $k\ t_{LCL}$ TSF	Length^2 / Time

Case 1

McEnroe	Giroud
R = 3.34E-003 R < 1/4 Case 1	θ = 6.00E-003 m^2/s
Gradient = 0.05	
θ = 5.90E-003 m^2/s	

Case 2

McEnroe	Giroud
R = 6.42E-003 R < 1/4 Case 1	θ = 2.95E-003 m^2/s
Gradient = 0.02	
θ = 2.87E-003 m^2/s	

Case 3

McEnroe	Giroud
R = 4.25E-003 R < 1/4 Case 1	θ = 4.42E-003 m^2/s
Gradient = 0.02	
θ = 4.34E-003 m^2/s	

Material Selection

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"Maximum Saturated depth over Landfill Liners". B. McEnroe, Journal of Environmental Engineering (Vol. 19, No. 2, March/April, 1993).

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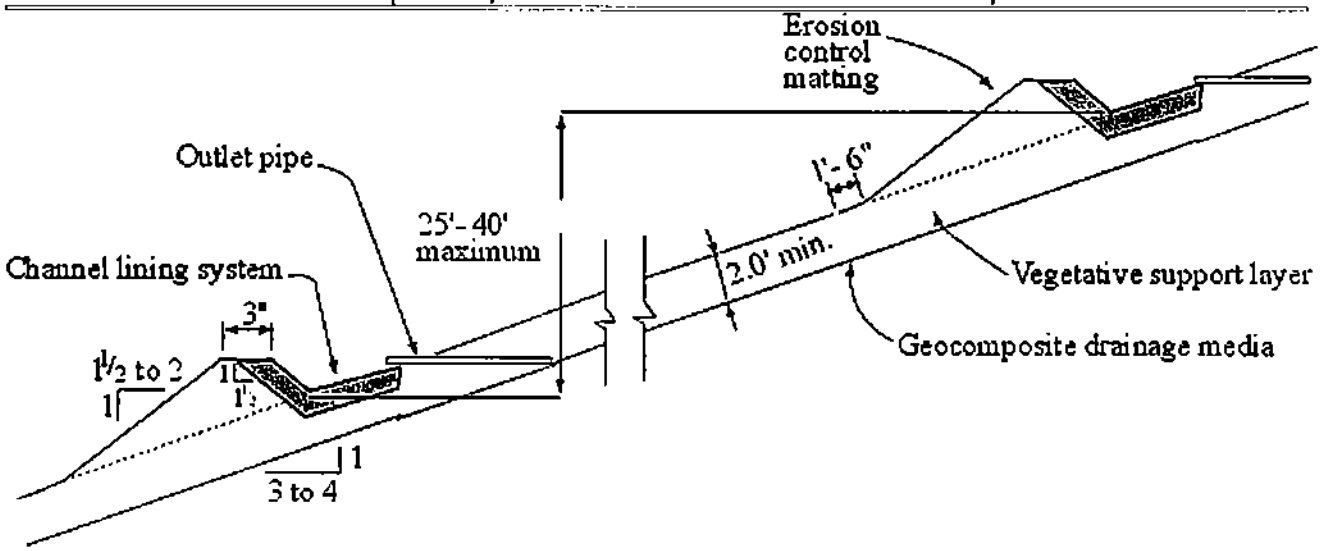
Unit Gradient Method - Design Calculator

Pownal Tannery Superfund Site
Sludge Consolidation Landfill

Problem Statement Top Slope — No Underdrain Pipes



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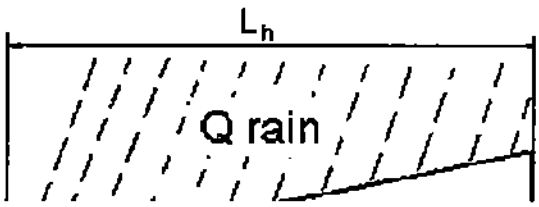
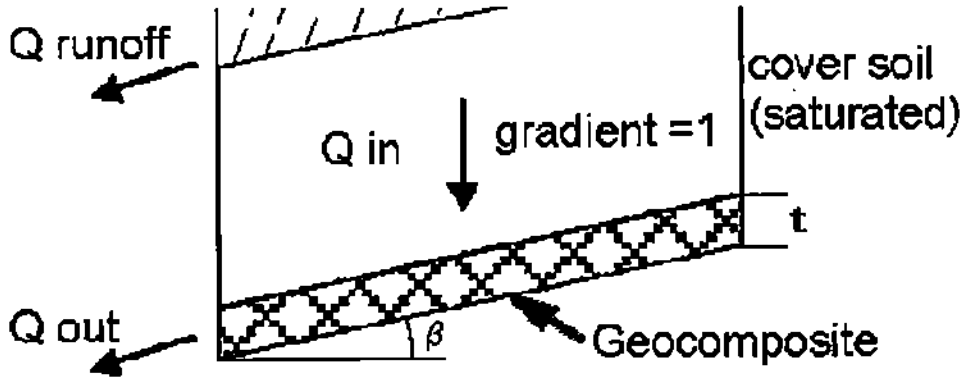
1. The interface shear strength of all interfaces is adequate
2. Pore water pressures do not build up and reduce the contact stress between the geomembrane and the soil. The Seepage Force Stability Calculator can be used to determine the factor of safety of a landfill cover with consideration of seepage forces
3. Landfill gas pressures beneath the liner are vented properly.The Landfill Gas Pressure Relief Calculator can be used to determine the gas transmissivity of the relief layer. The Landfill Gas Stability Calculator can be used to verify the factor of safety of a landfill cover subject to landfill gas pressure underneath a geomembrane liner.

This webpage determines the ultimate transmissivity sufficient to transmit all incoming flow within the thickness of the geocomposite; i.e. maximum head < geonet thickness; therefore seepage forces in the cover soil will be zero.





With Darcy's law:

$$Q = k * i * A$$

Inflow of water in the geocomposite

$$Q_{in} = k_{veg} * i * A = k_{veg} * 1 * L_h * 1$$

Outflow of water from the geocomposite at the toe of the slope

$$Q_{out} = k_{comp} * i * A = k_{comp} * i * t * 1 = \theta_{required} * \sin \beta$$

Inflow equals outflow (Factor of Safety = 1)

$$Q_{in} = Q_{out}$$

This results in a required transmissivity of the geocomposite of:

$$\theta_{required} = \frac{k_{veg} * L_h}{\sin \beta}$$

Which results in the ultimate transmissivity after multiplying by the Total Serviceability Factor (TSF)

$$\theta_{ultimate} = \theta_{required} * FS_d * RF_{in} * RF_{cr} * RF_{cc} * RF_{bc}$$

Required Data

Symbol	Name	Dimensions
L_h	Drainage pipe spacing or length of slope measured horizontally	Length
k_{veg}	Permeability of the vegetative supporting soil	Length/Time
S	The liner's slope, S = tan b	-
FS_{slope}	Minimum factor of safety against sliding, for soil/geocomposite or geocomposite/geomembrane interfaces	-

FS_d	Overall factor of safety for drainage
RF_{in}	Intrusion Reduction Factor
RF_{cr}	Creep Reduction Factor
RF_{cc}	Chemical Clogging Reduction Factor
RF_{bc}	Biological Clogging Reduction Factor

Input Values

Note: If you do not wish to perform calculations for 3 cases, please leave default data as is.

	Case 1		Case 2		Case 3	
S	5	%	33	%	33	%
L_h	45.72	m	60	m	90	m
k_{veg}	1E-4	cm/sec	1E-4	cm/sec	1E-4	cm/sec
FS_{slope}	1.5		1.5		1.5	

Reduction Factors and Safety Factor

	Case 1	Case 2	Case 3	Surface Water Drains
RF_{in}	1.2	1.2	1.2	[1] 1.0 - 1.2
RF_{cr}	1.4	1.4	1.4	[2] Calculate RF_{CR}
RF_{cc}	1.5	1.2	1.2	[3] 1.0 - 1.2
RF_{bc}	1.3	3.5	3.5	[3] 1.2 - 3.5
FS_d	2	3	3	[4] 2.0 - 10.0

Calculate Transmissivity

[1] Intrusion reduction factor from 100 hour to design life. Giroud et. al (2000)
[2] Creep reduction factor from 100 hour to design life (for instance, 30 years). RF_{CR} is determined from 10,000 hour compressive creep test.

extrapolated to design life, GRI-GC8 (2001). RF_{CR} is product and normal load specific.
[3] GRI-GC8
[4] FS value = 2-3. Giroud, et. al (2000)
FS value > 10 for filtration and drainage. Koerner (2001)
[5] Note: The calculated transmissivity is corresponding to the case where the seating time is 100 hours and the boundary conditions due to adjacent materials are simulated in the hydraulic transmissivity test.

Solution

Symbol	Name	Dimensions
gradient	Gradient	
$\theta_{ultimate}$	Ultimate Transmissivity	Length^2/Time
$\delta_{req'd}$	Minimum interface friction angle	degrees

	Case 1		Case 2		Case 3	
gradient	0.05		0.31		0.31	
$\theta_{ultimate}$	6.00E-003	m^2/s	4.05E-003	m^2/s	6.08E-003	m^2/s
$\delta_{req'd}$	4.29	degrees	26.84	degrees	26.34	degrees

Material Selection

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APPENDIX H

GEOTECHNICAL CALCULATIONS

APPENDIX H-1

POWNAL
XSTABL - LAGOON STABILITY MODELING

SHEET NO. 1 OF 2
PROJECT NO.
DATE 1/10/03
BY ALS
CHK'D GAM

TRC
Customer-Focused Solutions

SUBJECT Pownal Tannery Landfill

COMPARISON OF 2 METHODS USED TO DETERMINE SOIL UNIT WEIGHT AND STRENGTH PARAMETERS:

① METHOD 1 (USES WET UNIT WEIGHTS ADJUSTED BY RELATIVE DENSITY, D AND ϕ DET. GRAPHICALLY FROM σ'_v and SPT N_{60})

γ Assumptions for sands + gravels:
- Calculated wet unit weights using γ_{wet} ranges provided in Table 6 in NAVFAC Design manual. Applied the relative density percentage to the average γ_{wet} by multiplying the decimal form of D by the γ_{wet} average, then adding this number to the lowest γ_{wet} in the given range.

γ Assumptions for clay:
- γ_{clay} calculated using $\gamma_{wet} = \gamma_{dry}(1 + W_n)$ where W_n is the water content (%) determined from lab analysis of 2 clay samples and γ_{dry} is the dry density determined from laboratory compression testing of 2 clay samples. The average γ_{wet} for the 2 samples was used.

Calculating σ'_v:
- σ'_v was calculated for the midpoint of each soil layer (silty sand, gravel, and clay) in 3 borings located in the vicinity of the cross section being evaluated (D10-D10'), using $\sigma'_v = H\gamma_{wet}$
- The average of the σ'_v values for each soil type was calculated from the 3 borings (SBL4-102, SBL4-103, SBL4-104).

Calculation of SPT N_{60} (Adjusted SPT "N"):
- SPT "N" values determined for each soil layer by averaging "N" values from the 3 borings, were adjusted by applying the equation $N_{60} = ("N")(E_m)(C_b)(C_s)(C_r)$ where the E and C values are correction factors dependent on the drilling equipment used (see attached spreadsheet). N_{60} from each SPT depth were averaged for each soil type.

Determination of ϕ:
ϕ was determined graphically for the silty sand and gravel layers by using the σ'_v and SPT N_{60} values, as described above. This relationship is illustrated in the attached graphs titled Figure 4.19 and Figure 8.9 (unadjusted N) for both soil types.

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POWNAL
XSTABL - LAGOON STABILITY MODELING

SHEET NO. 2 OF 2
PROJECT NO.
DATE 1/10/03
BY ALS
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SUBJECT Pownal Tannery Landfill

COMPARISON OF 2 METHODS, CONTINUED:

Note:
METHOD 1 was used for preliminary evaluations in XSTABL Runs 1 through 3. For Runs 4 through 10, 17 was replaced by Method 2, which generated lower Ø values.

(2) METHOD 2 (USES WET UNIT WEIGHT TAKEN AS STRAIGHT AVERAGE OF γ_{WET}, AND Ø DET. GRAPHICALLY FROM AVE. DRY DENSITY AND SOIL TYPE BASED ON DENSITY)

γ Assumptions for sand + gravel (including Cap layer):
- Calculated wet unit weights as the direct average of γ_{wet} values, high and low values given as a range in Table 6 in the NAVFAC Design Manual on page 7.1-22.

γ Assumptions for Clay - same as in method 1.

γ Assumptions for Sludge -
- Calculated by taking 90% of the maximum dry densities (averaged for 6 sludge samples) at optimum water content determined during laboratory testing.

Dry unit weights (for graphical determination of Ø):
- Taken as direct average of γ_{dry} range provided in Table 6 in the NAVFAC manual.

Determination of Ø for granular soils:
- Ø was determined graphically using figure 7 on page 7.1-149 of the NAVFAC manual. Ø was taken from the correlation between soil dry density (as described above) and material type.

Determination of C (cohesion) values for Clay and Sludge:
- C values for the clay and sludge materials were taken as the average C values for multiple samples of each type of soil, determined during laboratory analysis.

CONCLUSION: method 2 was considered the more conservative method for determining soil strength parameters. Therefore, soil strength parameters determined by Method 2 were used in the XSTABL Global Stability Analysis.

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POWNAL 30% DESIGN
XSTABL - LAGOON STABILITY MODELING
CALCULATION OF SOIL STRENGTH / SOIL PARAMETERS FOR XSTABL INPUT SHEET NO. 1 OF 2

PROJECT NO.
DATE 1/03/03
BY ALS
CHK'D GM

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METHOD 1:

SUBJECT SOIL UNIT WEIGHTS - RUNS 1-3

Determine Unit weights for use in Empirical Correlation to Estimate ϕ:

- A: SLUDGE (WASTE COVER)
- B: SANDY FILL
- C: GRAVEL (SILTY, SANDY GRAVEL)
- D: CLAY

} LAYERS DEFINED PER LAGOON CROSS-SECTIONS SHOWN IN R.I. AND 2002 GEOTECH. INVESTIGATION

B. START WITH SANDY FILL (UPPER, NATIVE LAYER):

UNIT WEIGHT SANDY FILL = (γ_B)

γ_B assumptions:
1. From blow counts, get SPT number ("N") for relevant soil interval in geotech. borings in Lagoon 4 area (SBL4-102, SBL4-103, SBL4-104);
Ex: N_x = 8 (loose), 14 (med. dense), 16 (med. dense) x = 102, 103, 104 respectively.
2. Use Table 6 in NAVFACENGCOM Design Manual to obtain relationship between soil type, relative density (%) and γ (wet) pcf
(use D = 35% and γ = Ave (88-142) pcf
↳ From "Foundation Design" by Coduto, 1994.

$\gamma_B = 88 + [.35\ (142 - 88)]$ pcf

$\gamma_B = 106.9$ pcf

C. GRAVEL LAYER

UNIT WEIGHT GRAVEL = (γ_C)

γ_C assumptions:
1. Use SBL4-104 (Gravel layer) to get SPT (N) from blow counts
N_{104} (gravel) = 58 = very dense
2. From Table 6 in NAVFACENGCOM Manual use "well graded, gravel, sand, silt + clay mix" to get $\gamma_{(wet)}$ range of 125-150
(use D = 85% and γ = Ave (125-150) pcf

$\gamma_C = 125 + [.85\ (150 - 125)]$ pcf

$\gamma_C = 146$ pcf

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SUBJECT Pownal Tannery Landfill — SOIL UNIT WEIGHTS - RUNS 1-3

D. CLAY LAYER

Assumptions =

1. use dry density and water content from unconfined compression test completed on SBLH-103 (20-25 ft.) during 2002 geotechnical investigation

dry density clay, γ_d (clay) = 81.9 pcf. (from compression test)

water content, W_n (clay) = 38.88 % (" " ")
= 0.3888

γ_{clay} = $\gamma_d (1 + W_n)$ ... from $\left[\gamma_d = \frac{\gamma}{1+W_n}\right]$

= 81.9 (1 + 0.3888)

$\gamma_{clay\,1}$ = 113.7 pcf

2. Double check by calculating γ_{clay} from consolidation testing performed on same sample (SBLH-103 ( ))

γ_d (clay) = 87.89 pcf

W_n (clay) = 35.62 %
= 0.3562

γ_{clay} = $\gamma_d (1 + W_n)$

= 87.89 (1 + 0.3562)

$\gamma_{clay\,2}$ = 119.19

∴, Average these 2 γ_{clay} values

γ_{clay} = $\left(\frac{113.7 + 119.2}{2}\right)$ = 116.45 pcf

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PONNAL 30% DESIGN

XSTABL - LAGOON STABILITY MODELING

CALCULATION OF SOIL STRENGTH / SOIL PARAMETERS FOR XSTABL INPUT

SHEET NO. 1 OF 3

PROJECT NO.

DATE 1/07/03

BY ACS

TRC
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SUBJECT SOIL STRENGTHS / VERTICAL STRESS RUNS 1-3

CHK'D GAM

XSTABL Program requirements for soil strength parameters are:

① c (psf) - cohesion;

② ϕ (degrees) - angle of internal friction

Assumptions:
- use empirical correlation between SPT "N" and σ_v' to get ϕ for granular soils.
- conservatively assume c = 0 for granular soils.
- for clays - use the undrained shear strength for c & assume $\phi = 0$,

sludge	(not present at critical section)
sandy fill, gravel	need ϕ (degrees); calculate σ_v' first ($\sigma_v' = H\gamma_s$; γ_s ← depth; we use γ_{wet})
clay	need c only (no ϕ entered in XSTABL)

σ_v' calculations: Need to calculate σ_v' at the midpoint of each layer at each geotech. boring location (SBL4-102, 103, & 104.)

① SBL4-102

← ground surface elev. = 500 ft (from TRC topo. survey)

sand (0-6.5') (1) ← depth to g.w. = 3.9' (elev. = 496.1) $\gamma = 106.9$

gravel (6.5-10) (2) $\gamma = 146$

depth (1) = 6.5/2 = 3.25' b.g.s (above ▽)

depth (2) = [(10-6.5)/2] + 6.5 = 8.25'

$\sigma_v'(1) = H\gamma_{wet} = 3.25'(106.9\ pcf) = 347.43\ psf$ (sand)

$\sigma_v'(2) = 347.43 + (3.9' - 3.25')106.9 + (6.5' - 3.9')(106.9 - \gamma_{water})$

$= 347.43 + 0.65(106.9) + 2.6(106.9 - 62.4)$

$= 347.43 + 69.49 + 115.7$

$\sigma_v'(2) = 532.62\ psf$ (gravel)

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SUBJECT SOIL STRENGTHS / VERTICAL STRESS CHK'D GAM
RUNS 1-3

(2) SBL4-103

← ground surface elev. = 501.5 (from TRC topo. plan)

γ = 106.9 sand (0-5') • (1)

▽ ← depth to g.w. = 5.63' (elev. = 495.87)

γ = 146 gravel (5-9') • (2)

γ = 116.45 clay (9-73') • (3)

Bedrock @ ~73 ft

depth (1) = 2.5' b.g.s.
depth (2) = (9-5)/2 + 5 = 7' b.g.s.
depth (3) = (73-9)/2 + 9 = 41' b.g.s.

$\sigma_v'(1) = 2.5'(106.9) = \underline{267.25 \text{ psf}}$ (sand)

$\sigma_v'(2) = 267.25 + 2.5'(106.9) + 0.63'(146) +$
$+ (7-5.63)'(146-62.4)$
$= 267.25 + 267.25 + 91.98 + 1.37'(83.6)$
$\sigma_v'(2) = \underline{741.01 \text{ psf}}$ (gravel)

$\sigma_v'(3) = 741.01 + 2'(146-62.4) + 32'(116.45-62.4)$
$= 741.01 + 2'(83.6) + 32'(54.05)$
$= 741.01 + 167.20 + 1,729.60$
$\sigma_v'(3) = \underline{2,637.81 \text{ psf}}$ (clay)

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SUBJECT SOIL STRENGTHS / VERTICAL STRESS
RUNS 1-3

③ SBL4 - 104

ground surface elev. = 506.1

$\gamma = 106.9$ Sand (0-4') • (1) depth (1) = 2 ft. b.g.s.

depth (2) = (10-4)/2 + 4 = 7 ft. b.g.s.

$\gamma = 146$ gravel (4-10') • (2) ← depth to g.w. = 8.23' b.g.s. (elev. = 497.87)

σ_v' (1) = 2' (106.9) = 213.8 psf

σ_v' (2) = 213.8 + 3' (146) = 213.8 + 438

σ_v' (2) = 651.8 psf

Average σ_v' values for each soil (sand + gravel):

① $\bar{\sigma}_v'$ (sand) = $\dfrac{\sigma_v'(1)\ SBL4\text{-}102 + \sigma_v'(1)\ SBL4\text{-}103 + \sigma_v'(1)\ SBL4\text{-}10}{3}$

$\bar{\sigma}_v'$ (sand) = $\dfrac{(347.43 + 267.25 + 213.8)\ psf}{3}$

$\bar{\sigma}_v'$ (sand) = 828.48/3 = **276.16 psf** sand

② $\bar{\sigma}_v'$ (gravel) = $\dfrac{\sigma_v'(2)\ SBL4\text{-}102 + \sigma_v'(2)\ SBL4\text{-}103 + \sigma_v'(2)\ SBL4\text{-}104}{3}$

$\bar{\sigma}_v'$ (gravel) = $\dfrac{(532.62 + 741.01 + 651.8)}{3}$

$\bar{\sigma}_v'$ (gravel) = 1925.43/3 = **641.81 psf** gravel

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TABLE 6
Typical Values of Soil Index Properties

	Particle Size and Gradation				Voids[1]					Unit Weight[2] (lb./cu.ft.)						
	Approximate Size Range (mm)		Approx. D_{10} (mm)	Approx. Range Uniform Coefficient C_u	Void Ratio			Porosity (%)		Dry Weight			Wet Weight		Submerged Weight	
	D_{max}	D_{min}			e_{max} loose	e_{cr}	e_{min} dense	n_{max} loose	n_{min} dense	Min loose	100% Mod. AASHO	Max dense	Min loose	Max dense	Min loose	Max dense
GRANULAR MATERIALS																
Uniform Materials																
a. Equal spheres (theoretical values)	-	-	-	1.0	0.92	-	0.35	47.6	26	-	-	-	-	-	-	-
b. Standard Ottawa SAND	0.84	0.59	0.67	1.1	0.80	0.75	0.50	44	33	92	-	110	93	131	57	69
c. Clean, uniform SAND (fine or medium)	-	-	-	1.2 to 2.0	1.0	0.80	0.40	50	29	83	115	118	84	136	52	73
d. Uniform, inorganic SILT	0.05	0.005	0.012	1.2 to 2.0	1.1	-	0.40	52	29	80	-	118	81	136	51	73
Well-graded Materials																
a. Silty SAND	2.0	0.005	0.02	5 to 10	0.90	-	0.30	47	23	87	122	127	88	142	54	79
b. Clean, fine to coarse SAND	2.0	0.05	0.09	4 to 6	0.95	0.70	0.20	49	17	85	132	138	86	148	53	86
c. Micaceous SAND	-	-	-	-	1.2	-	0.40	55	29	76	-	120	77	138	48	76
d. Silty SAND & GRAVEL	100	0.005	0.02	15 to 300	0.85	-	0.14	46	12	89	-	146[3]	90	155[3]	56	92
MIXED SOILS																
Sandy or Silty CLAY	2.0	0.001	0.003	10 to 30	1.8	-	0.25	64	20	60	130	135	100	147	38	85
Skip-graded Silty CLAY with stones or rock fragments	250	0.001	-	-	1.0	-	0.20	50	17	84	-	140	115	151	53	89
Well-graded GRAVEL, SAND, SILT & CLAY mixture	250	0.001	0.002	25 to 1000	0.70	-	0.13	41	11	100	140	148[4]	125	156[4]	62	94
CLAY SOILS																
CLAY (30%-50% clay sizes)	0.05	0.5μ	0.001	-	2.4	-	0.50	71	33	50	105	112	94	133	31	71
Colloidal CLAY (~0.002 mm: 50%)	0.01	10Å	-	-	12	-	0.60	92	37	13	90	106	71	128	8	66
ORGANIC SOILS																
Organic SILT	-	-	-	-	3.0	-	0.55	75	35	40	-	110	87	131	25	69
Organic CLAY (30% - 50% clay sizes)	-	-	-	-	4.4	-	0.70	81	41	30		100	81	125	18	62

TABLE 6
NAVFAC Design Manual

For clean, normally consolidated sands:

$$E \approx 10\,\sigma_r N_{60} \qquad \text{(4.1}$$

SAND - METHOD 1

From Coduto, "Foundation Design", 1994

For clean, overconsolidated sands:

$$E \approx 15\,\sigma_r N_{60} \qquad \text{(4.1}$$

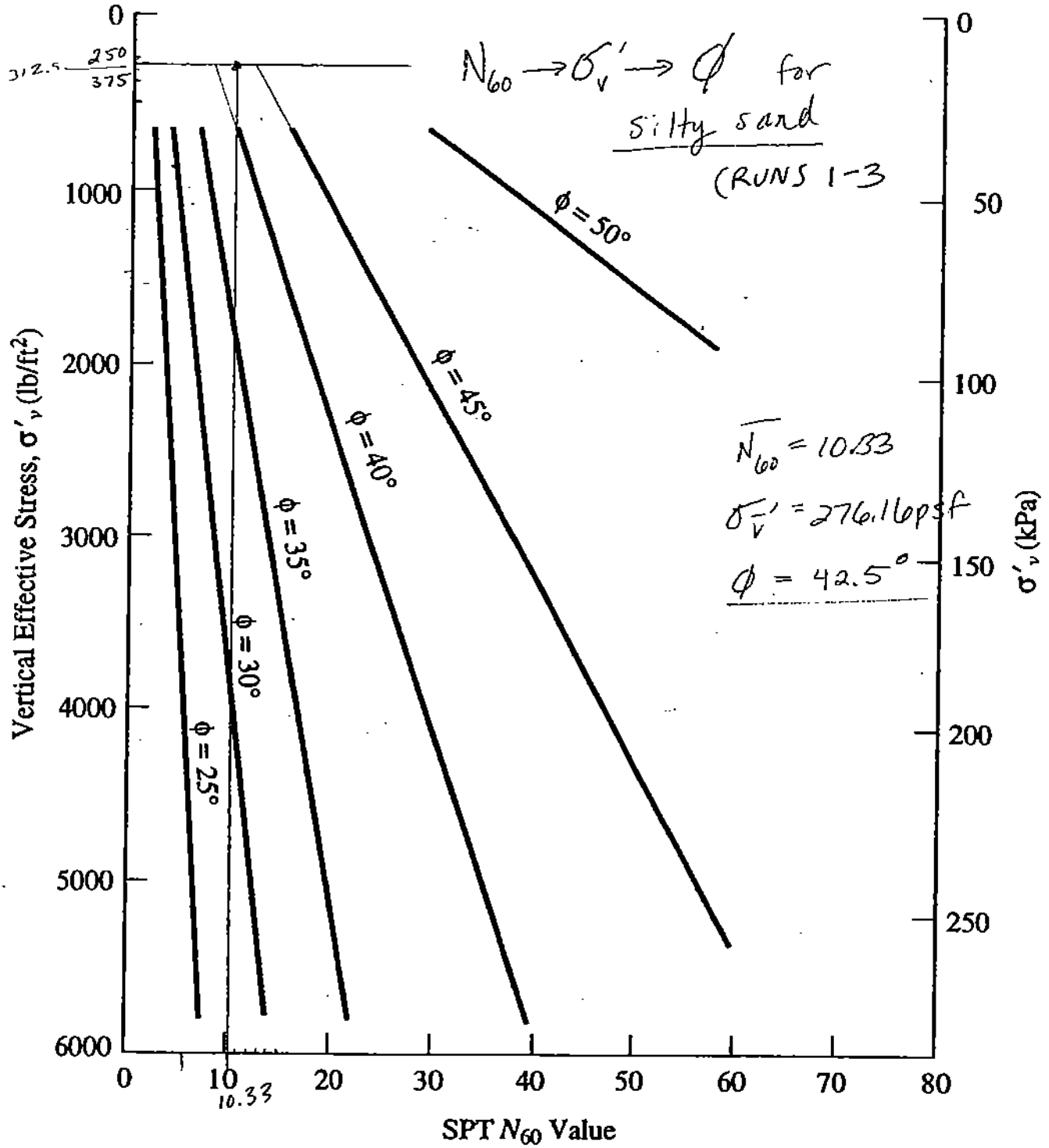


Figure 4.19 Empirical correlation between N'_{60} and ϕ for uncemented sands (Adapted from DeMello, 1971).

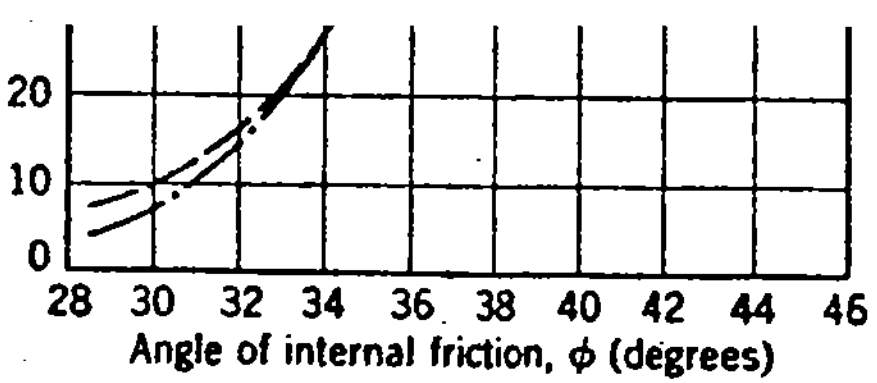


Fig. 14.16 Bearing capacity factors which automatically incorporate allowance for local shear failure (From Peck, Hansen, and Thornburn, 1953). SAND- METHOD 2 (RUNS 1-3)

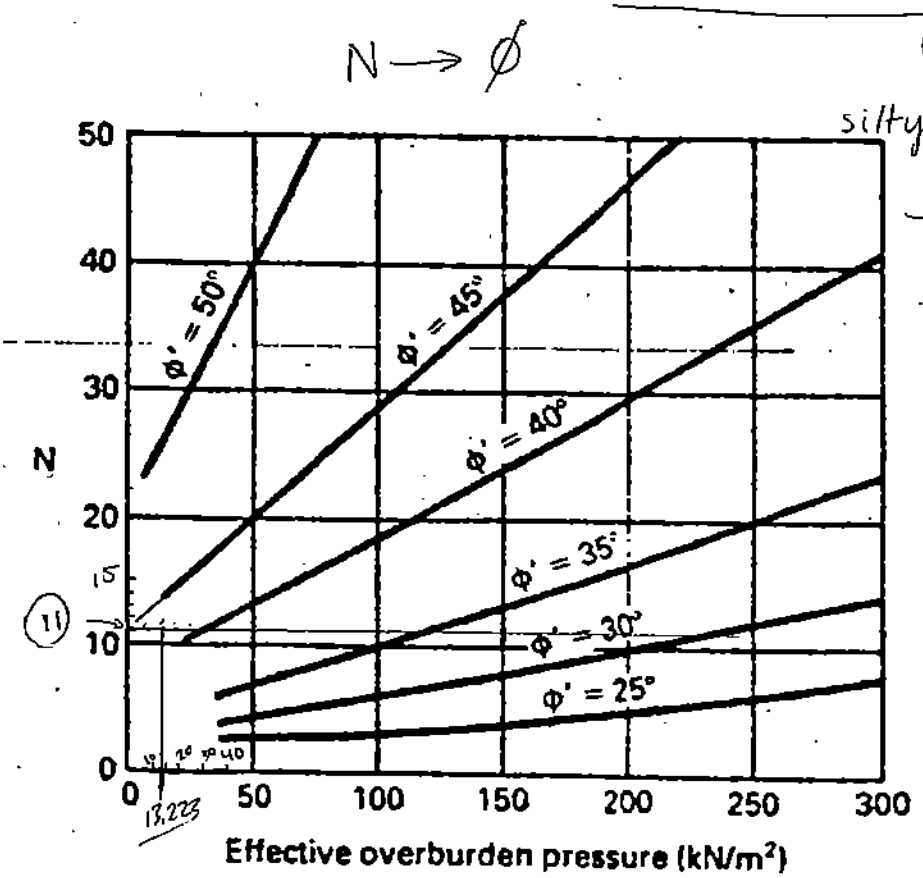


Fig. 8.9 Correlation between shear strength parameter ϕ', standard penetration resistance and effective overburden pressure. (Reproduced from J. H. Schmertmann (1975), *Proceedings of Conference on In-Situ Measurement of Soil Properties*, by permission of the American Society of Civil Engineers).

For clean, normally consolidated sands:

GRAVEL - METHOD 1

$$E \approx 10\,\sigma_r N_{60} \quad \text{(4.1:}$$

from Coduto, "Foundation Design, 1994" (Runs 1-3)

For clean, overconsolidated sands:

$$E \approx 15\,\sigma_r N_{60} \quad \text{(4.1:}$$

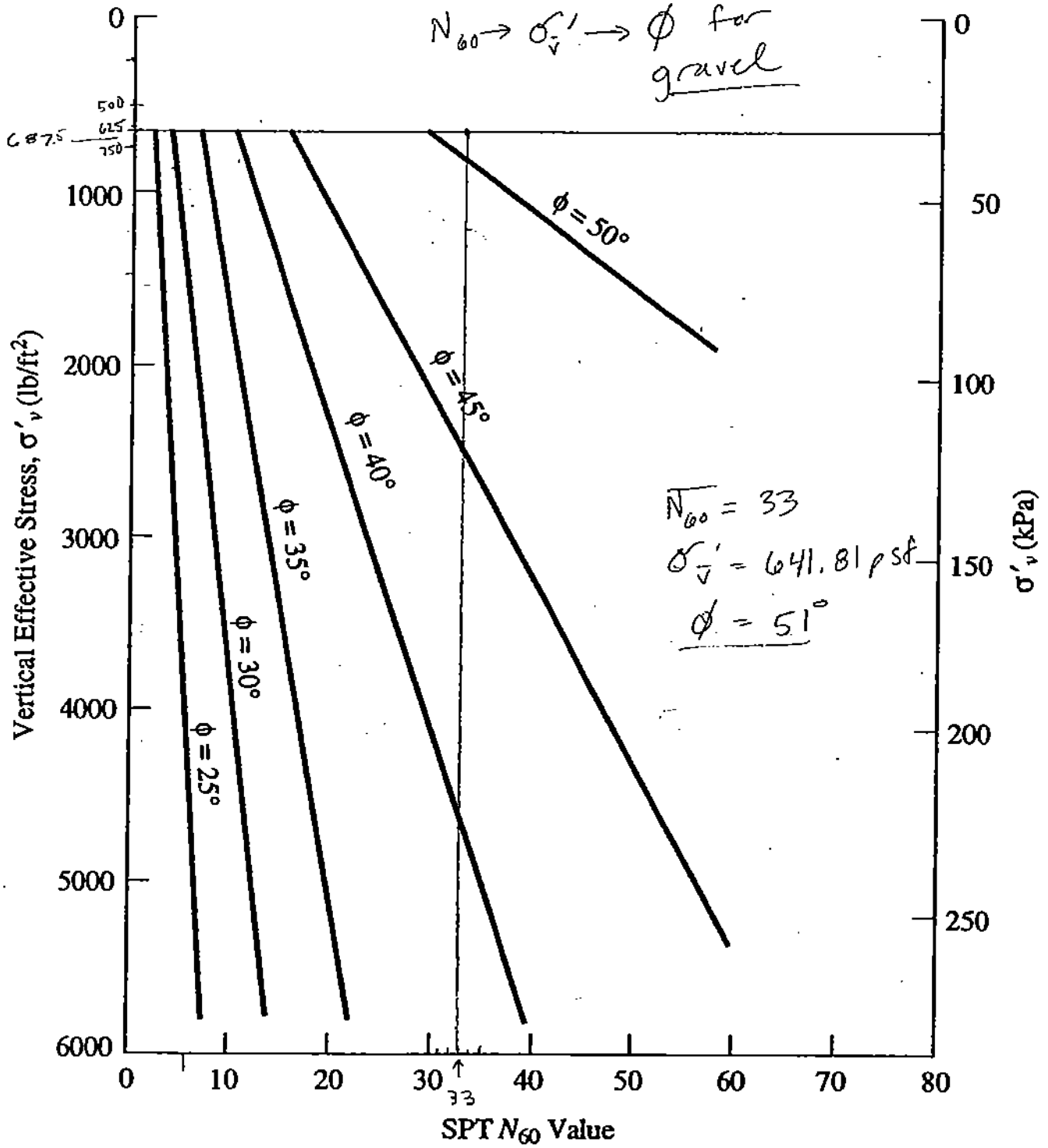


Figure 4.19 Empirical correlation between N'_{60} and ϕ for uncemented sands (Adapted from DeMello, 1971).

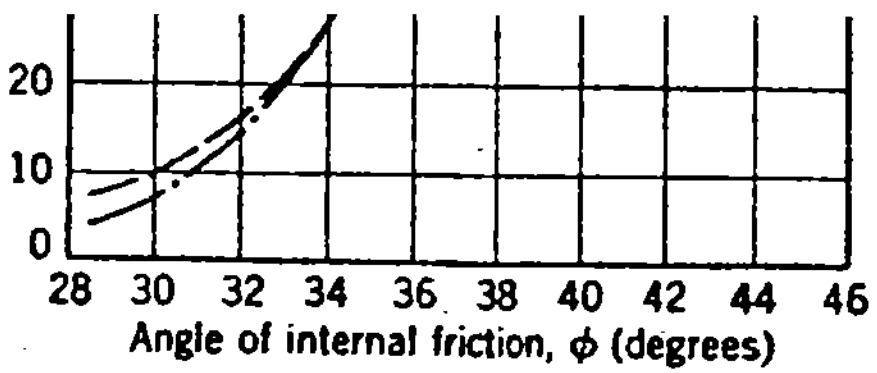
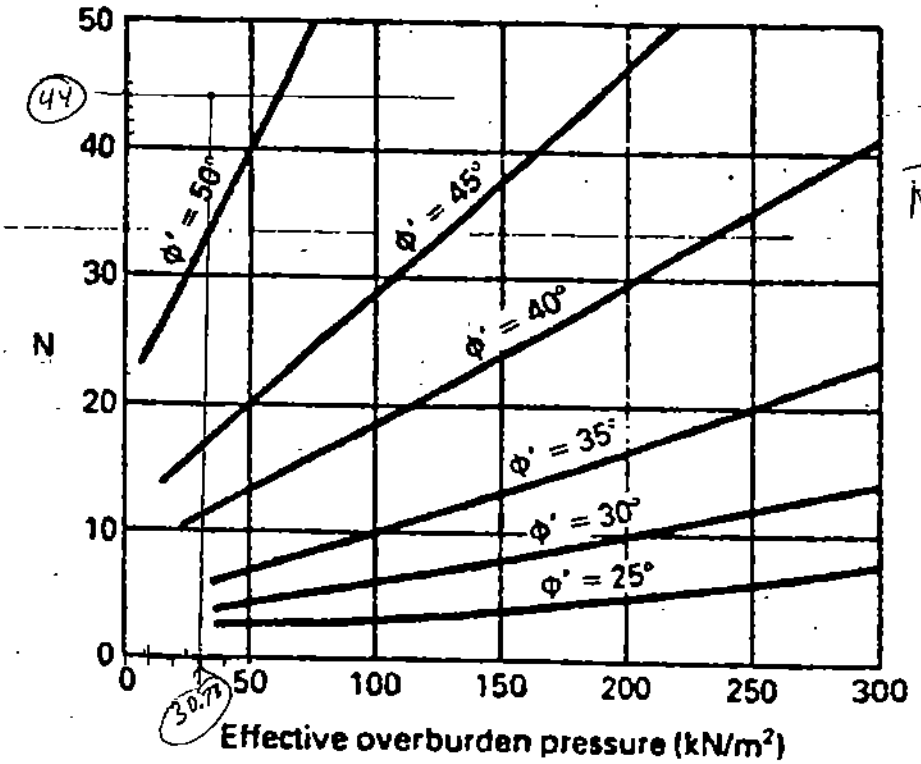


Fig. 14.16 Bearing capacity factors which automatically incorporate allowance for local shear failure (From Peck, Hansen, and Thornburn, 1953).

GRAVEL - METHOD 2

$N \rightarrow \phi$ (Runs 1-3)

Gravel



$\bar{N}_{60} = 33$

$\bar{N}_{\text{unadjusted}} = 44$

$\bar{\sigma}'_{v(psf)} = 641.81$

$= 30.73 \frac{kN}{m^2}$

$\phi = 51$

Fig. 8.9 Correlation between shear strength parameter ϕ', standard penetration resistance and effective overburden pressure. (Reproduced from J. H. Schmertmann (1975), *Proceedings of Conference on In-Situ Measurement of Soil Properties*, by permission of the American Society of Civil Engineers).

Corrected SPT (N) numbers for Pownal Geotechnical Borings Located in the Vicinity of Lagoon 4

01/06/03

Boring I.D.	Sample Depth	SPT (N), uncorrected	E(m) - donut	C(b) - 4 in. dia.	C(s)	Cr	N(60), corrected
SBL4-102	1	8	0.45	1	1	1	6
	5	8	0.45	1	1	1	6
	10	30	0.45	1	1	1	22.5
	15	17	0.45	1	1	1	12.75
	20	9	0.45	1	1	1	6.75
SBL4-103	1	10	0.45	1	1	1	7.5
	5	14	0.45	1	1	1	10.5
	10	22	0.45	1	1	1	16.5
	16	10	0.45	1	1	1	7.5
	30	5	0.45	1	1	1	3.75
	35	5	0.45	1	1	1	3.75
	40	4	0.45	1	1	1	3
	45	5	0.45	1	1	1	3.75
	50	4	0.45	1	1	1	3
	55	7	0.45	1	1	1	5.25
	60	6	0.45	1	1	1	4.5
	65	8	0.45	1	1	1	6
	70	7	0.45	1	1	1	5.25
SBL4-104	1	16	0.45	1	1	1	12
	5	58	0.45	1	1	1	43.5
	10	20	0.45	1	1	1	15
	15	12	0.45	1	1	1	9
	20	9	0.45	1	1	1	6.75

Averages from each soil type

Ave. N(60) Sand	**6**
N(60) Gravel	**22.5**
Ave. N(60) Clay	9.75
Ave. N(60) Sand	**9**
Ave. N(60) Clay	6.23
N(60) Sand	**16**
N(60) Gravel	**43.5**
Ave. N(60) Clay	7.88

Global Ave. Sand = 10.33
Global Ave. Gravel = 33

Summary of Soil Types and SPT (N) Values (uncorrected) Encountered During Pownal Geotechnical Drilling Program

BORING I.D.	Depth (feet)	SPT (N)	Soil Type
SBL3-101	1	27	SILT and CLAY
	3	24	SILT and CLAY
	5	6	SILT and CLAY
	17	100	GRAVEL
	21	38	SAND
	23	67	silty SAND
	25	61	silty SAND
	27	49	silty SAND
	29	22	CLAY
SBL3-102	1	12	silty SAND
	3	24	SLUDGE
	14	27	SAND
	21	46	SAND
	23	64	SAND
	25	23	CLAY
SBL4-101	1	6	SILT and CLAY
	3	8	SILT and CLAY
	5	6	SILT and CLAY
	7	26	SLUDGE
	11	42	silty SAND
	13	39	GRAVEL
	20	87	GRAVEL
	25	28	SILT and CLAY
SBL4-102	1	8	silty SAND
	5	8	silty SAND
	10	30	SAND and GRAVEL
	15	17	CLAY
	20	9	CLAY
SBL4-103	1	10	silty SAND
	5	14	silty SAND
	10	22	CLAY
	16	10	CLAY
	30	5	CLAY
	35	5	CLAY
	40	4	CLAY
	45	5	CLAY
	50	4	CLAY
	55	7	CLAY
	60	6	CLAY
	65	8	CLAY
	70	7	CLAY and SILT
SBL4-104	1	16	silty SAND
	5	58	GRAVEL
	10	20	silty SAND
	15	12	CLAY
	20	9	CLAY

POWNAL 30% DESIGN

XSTABL - LAGOON STABILITY MODELING

CALCULATION OF SOIL STRENGTH / SOIL PARAMETERS FOR XSTABL INPUT

SHEET NO. 1 OF 2

PROJECT NO.

DATE 1/08/03 - 1/09/03

BY ALB

CHK'D GAM

TRC Customer-Focused Solutions

SUBJECT METHOD 2 = SOIL STRENGTH PARAMETERS

(XSTABL RUNS 4 - 10)

1) SAND LAYER

$\gamma_{wet(ave)} = \frac{88 + 142}{2} = 115$ pcf (from NAVFAC Table 6 p. 7.1-22)

$\phi = 34°$ (determined 1/9/03 from Figure 7 in NAVFAC manual p. 7.1-149)

2) GRAVEL LAYER

$\gamma_{wet(ave)} = \frac{125 + 156}{2} = 140$ pcf (NAVFAC Table 6)

$\phi = 37°$ (1/9/03 per Figure 7, p. 7.1-149 in NAVFAC manual)

3) CLAY LAYER

$\gamma_{wet} = 116.45$ pcf

$C = 724$ psf

} determined based on laboratory tests conducted during geotechnical investigation

4) SLUDGE LAYER

$\gamma_{wet} = 96$ pcf (Ave. γ_{wet} calculated using 90% of max. dry density at optimum water content in lab for 6 sludge samples.)

$C = 382$ psf (382 psf used in runs 5-10; later modified on 1/09/03 in runs 8-10)

5) CAP LAYER (SILTY SAND & GRAVEL)

$\gamma_{wet(ave)} = \frac{90 + 155}{2} = 122.5$ pcf (from NAVFAC Table 6 p. 7.1-22)

$\phi = 36°$ (1/9/03 per Figure 7, p. 7.1-149 in NAVFAC manual)

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1/09/03

Runs 4-10 - Calculation of new ϕ values for XSTABL

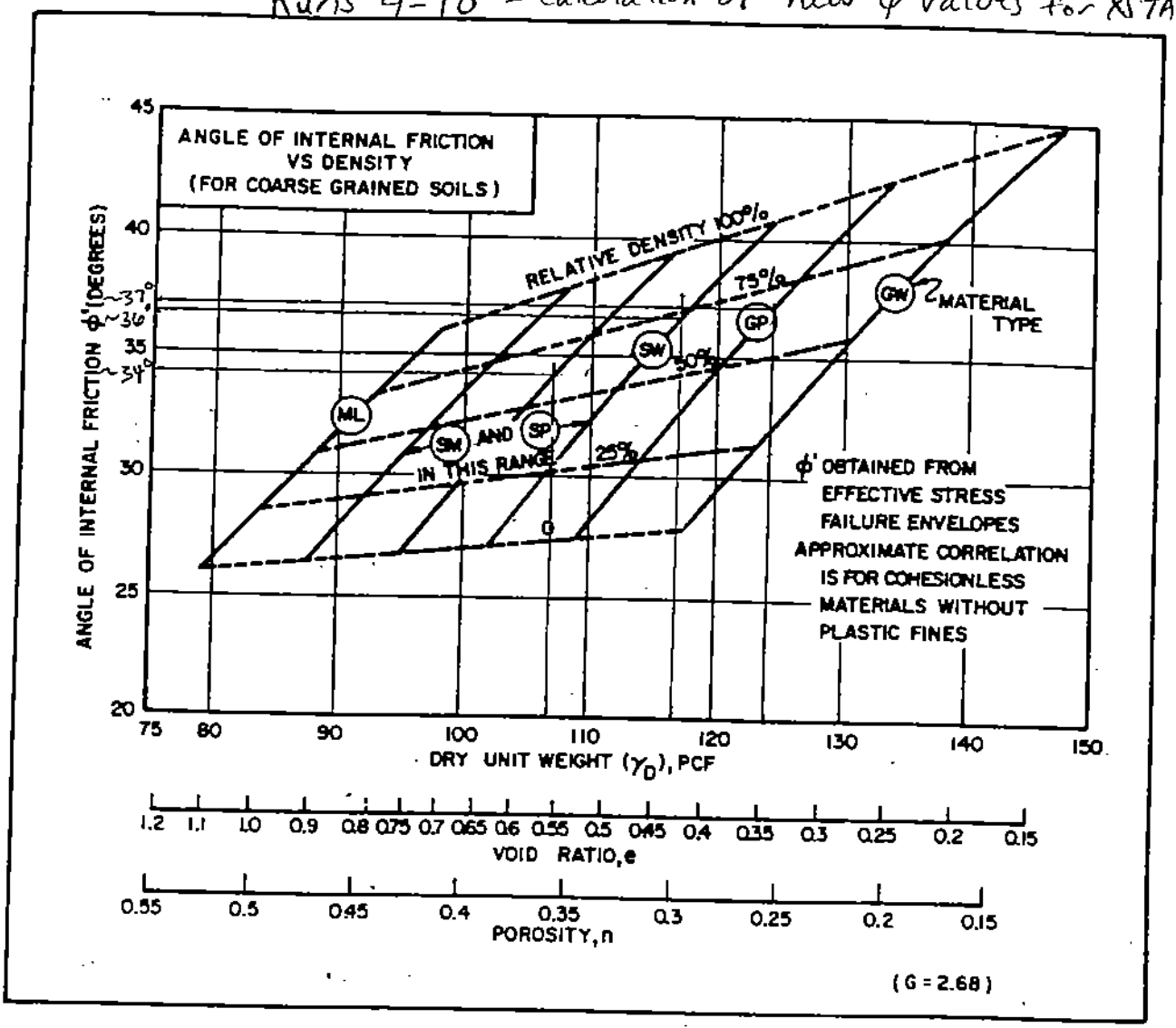


FIGURE 7
Correlations of Strength Characteristics for Granular Soils

Ave dry densities for each layer (from NAVFAC Table 6)

① Silty sand:

$\gamma_{dry\ (range)} = 87\text{-}127$

$\gamma_{dry\ (ave)} = \frac{87+127}{2} = 107$ pcf

② gravel:

$\gamma_{dry\ (range)} = 100\text{-}148$

$\gamma_{dry\ (ave)} = \frac{100+148}{2} = 124$ pcf

③ silty sand & gravel (cap material)

$\gamma_{dry\ (range)} = 89\text{-}146$

$\gamma_{dry\ (ave)} = \frac{89+146}{2}$

$= 117.5$ pcf

POWNAL
XSTABL - LAGOON STABILITY MODELING

SHEET NO. 1 OF 1
PROJECT NO.
DATE 1/10/03
BY ALS
CHK'D GAM

TRC
Customer-Focused Solutions

30% Design

SUBJECT XSTABL Global Stability Analysis

XSTABL computer modeling program (version 5.2) was used to evaluate Global Landfill Stability:

Ten (10) iterations of the program were run, using different assumptions and refining certain input parameters for each iteration to more accurately simulate expected global landfill conditions. Runs 5, 7 and 10 were selected as the analyses used in the design. A comparison of these XSTABL runs is provided in the attached Table.

Surfaces

Copies of the cross-section and related coordinates for the area used in the XSTABL analyses are also attached. A ground-water surface was also entered into XSTABL using ground water elevations measured at the site in July 2000. The coordinates for the approximated bedrock surface were entered as the lower boundary for the model. (groundwater was entered as a phreatic surface).

Soil Properties for Global Stability Model:

The soil strength type specified in XSTABL was the default type, "conventional": linear and isotropic. Therefore, the following soil strength parameters were included in the program input:

- C, cohesion parameter, in pounds per square foot (psf)
- ϕ, interface friction angle, in degrees.

(methods used to obtain values for these parameters for the Pownal soils are discussed further under "soil strength parameter" calculation pages.

- γ, unit weight, moist or saturated, in pounds per cubic ft. (pcf) (determined for granular soils and cap material by averaging the given γ_{wet} values from the NAVFAC Manual, TABLE 6, p. 7.1-22. for clay and sludge, The unit weight was calculated using geotechnical test results for actual samples.)

Stability Analysis:

The method selected for generating critical failure surfaces (from the XSTABL options menu) was the "Circular surface Search" using the "Bishop" method. The segment length used to comprise the failure surfaces was selected by XSTABL. The range of initiation points was set at x= 250 to 400 ft. and the termination ranges set at x= 405 to 500 ft. (varied in each run.)

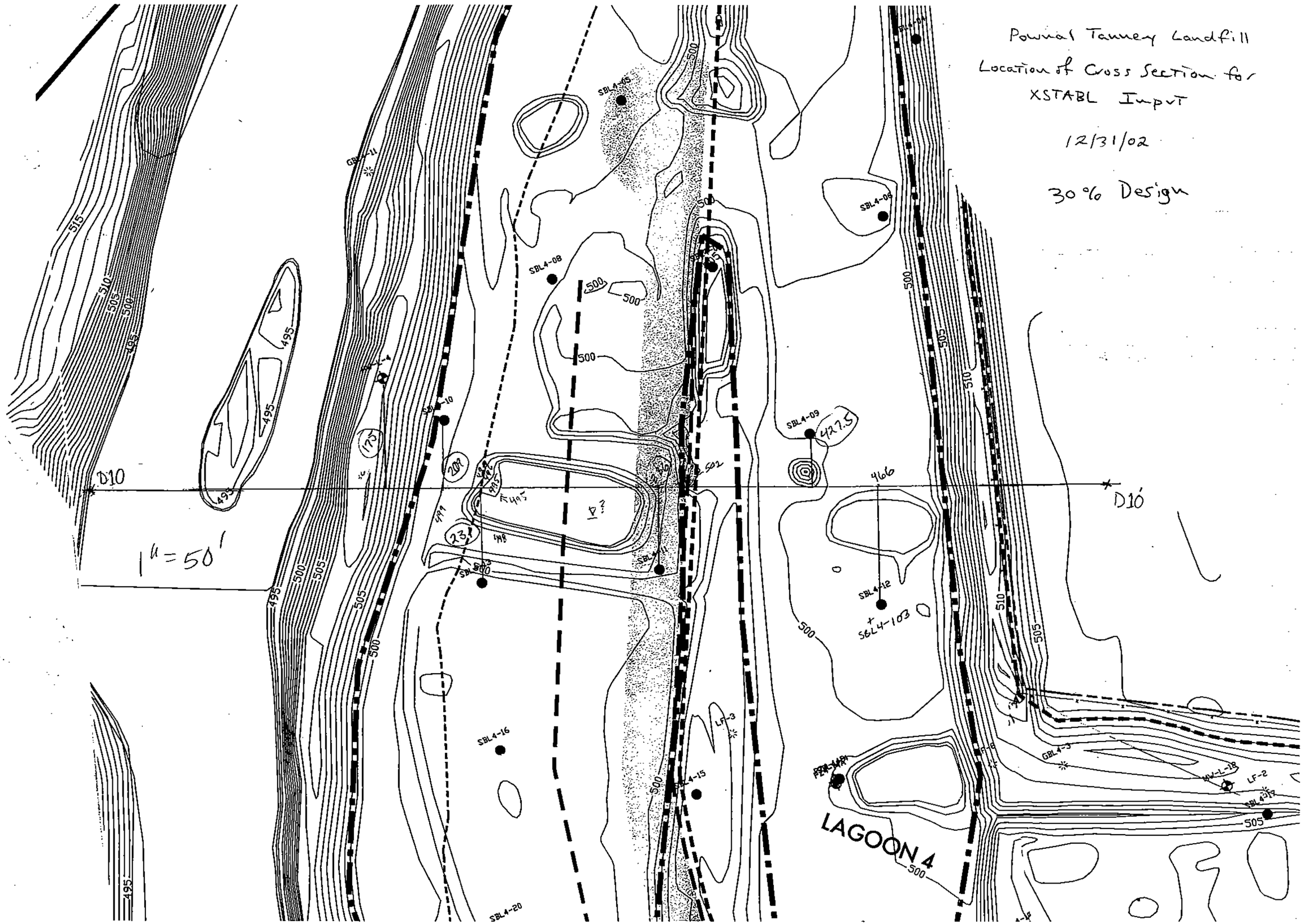
A

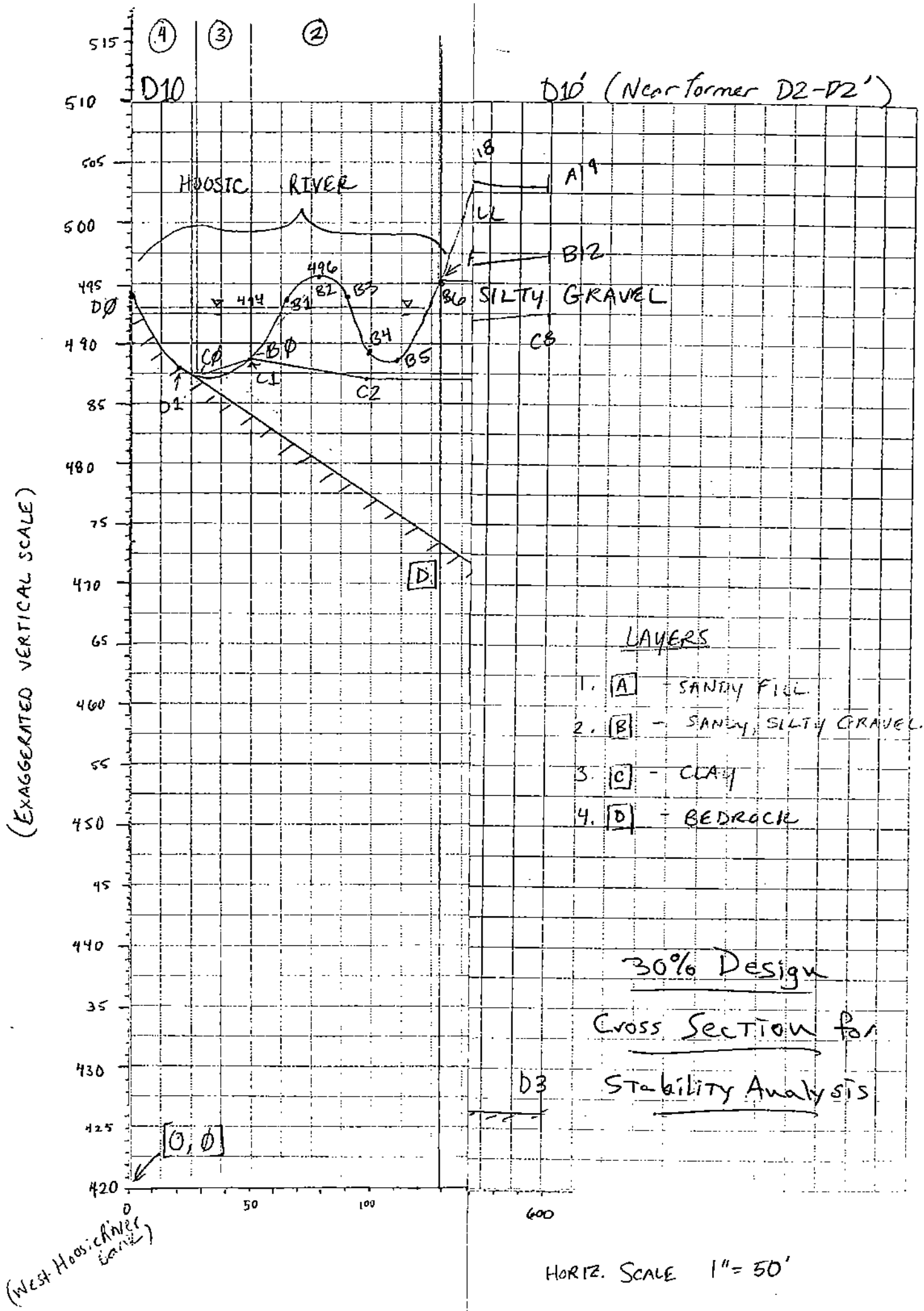
Summary of XSTABL Stability Analysis Iterations

1/22/2003

30% Design

XSTABL File	Description of Input/Assumptions	Resulting Factor of Safety, FOS
PWNLRUN5	Rather than modeling the full length of CS D10-D10', the length of the cross section was cropped to focus the XSTABL evaluation on the landfill area; in this case, the length was shortened to extend from x = 130 ft. to the end of the end of the cross section (x = 600 ft.). 5 soil layers (cap material, waste sludge, silty sand, gravel, and clay) were modeled with the surface layer represented by the coordinates for the top of the cap. The unit weight of sludge was taken to be 96 pcf (from laboratory determinations). The unit weights used for granular materials were the averages of the wet unit weights given for each soil type in Table 6 of NAVFAC. The friction angle values (ϕ) were determined by using Figure 7 in the NAVFAC Manual to obtain ϕ using a dry unit weight value (different than the average of the wet weights) for each soil type. Therefore, in all subsequent runs, the ϕ was not based on N_{60} and σ'_v, as it was in runs 1 through 4, which have been omitted. Also, based on the results of the previous runs, the ranges specified for the failure surface initiation and termination points were condensed in this run (vs. previous runs) to concentrate more on the areas shown with circular failure surfaces in the output graphs for the previous runs.	1.66
PWNLRUN7	Same as above, but the ranges specified for the failure surface initiation and termination points were again condensed to concentrate on the areas shown with circular failure surfaces in the output graph in the previous run. Also, the length of the cross section was further cropped to focus more on the landfill area; in this case, the length was shortened to extend from x = 250 ft. to the end of the end of the cross section (x = 600 ft.). In addition, the layer coordinates for the existing ground surface (the silty sand layer underlying the sludge) were modified to reflect a topography change proposed as part of the cap construction (i.e., flattened out the raised, berm area below the western portion of the cap).	2.031
PWNLRUN10	Same as above (5 layers, cropped length of CS, flattened lagoon topography), but the strength value, "C", for the sludge was changed from 382 to 270 in an attempt to approximate the FOS nearest to 1.5. In addition, the segment length used by the program to evaluate failure surfaces was changed from a user-specified value (previously 7-foot length segments) to a default program selected value (2-foot segments).	1.559


Pownal Tannery Landfill
Location of Cross Section for
XSTABL Input
12/31/02
30% Design
1" = 50'
D10
D10'
LAGOON 4
SBL4-05
SBL4-06
SBL4-08
SBL4-09
SBL4-10
SBL4-11
SBL4-12
SBL4-103
SBL4-15
SBL4-16
SBL4-20
GBL4-3
LF-2
LF-3
MW-L-18
515
510
505
500
495
466
427.5
175
209
23



D10
D10' (Near former D2-D2')
HOOSIC RIVER
SILTY GRAVEL
A
B12
C8
D3
D1
C1
C2
B1
B2
B3
B4
B5
B6
C0
B0
D0
494
496
LAYERS
1. A - SANDY FILL
2. B - SANDY, SILTY GRAVEL
3. C - CLAY
4. D - BEDROCK
30% Design
Cross Section for
Stability Analysis
(EXAGGERATED VERTICAL SCALE)
(West Hoosic River bank)
HORIZ. SCALE 1" = 50'

Pownal Cap Design
12/31/02 30%
1/01/03

Defining Subsurface Layers on C.S. D10-D10'
[X, y] values using 420' elev. and west river bank @ water interface as origin (0, 0)

Layer 1. [A] - Sandy fill

points
A0 = [130, 75]
A1 = [157, 88.8]
A2 = [167, 86.7]
A3 = [188, 79.7]
A4 = [210, 75.7]
A5 = [232, 73]
A6 = [245, 72]
A7 = [307, 71.8]
A8 = [324, 73.2]
A9 = [336, 73.9]
A10 = [364, 82]
A11 = [375, 84]
A12 = [392, 83.3]
A13 = [428, 80.1]
A14 = [493, 79.9]
A15 = [502, 82.2]
A16 = [524, 90.9]
A17 = [543, 85]
A18 = [563, 83.7]
A19 = [600, 83]

2. [B] - Sandy, silty gravel

B0 = [50, 68.7]
B1 = [65, 73.5]
B2 = [80, 75.5]
B3 = [92, 73.8]
B4 = [100, 69.2]
B5 = [112, 68.5]
→ B6 = [130, 75]
B7 = [176, 75]
B8 = [212, 71.8]
B9 = [232, 69]
B10 = [336, 66.9]
B11 = [470, 74]
B12 = [600, 77.4]

3. [C] = Clay

C0 = [29, 67.1]
→ C1 = [50, 68.7]
C2 = [99, 67]
C3 = [147, 66.8]
C4 = [212, 65]
C5 = [231, 63.5]
C6 = [336, 63.9]
C7 = [470, 70]
C8 = [600 72.5]

4. [D] = Bedrock

D0 = [0, 74]
D1 = [20, 68]
D2 = [470, 7.1]
D3 = [600, 6.4]

Pournal Cap Design
1/01/03 30%

Water surface Coordinates:

Layer: Water (phreatic surface)

W1 = [0, 494] y = 74
W2 = [183, 494.25] y = 74.25
W3 = [216, 494.5] y = 74.5
W4 = [254, 494.75] y = 74.75
W5 = [287, 495] y = 75
W6 = [324, 495.25] y = 75.25
W7 = [367, 495.5] y = 75.5
W8 = [400, 495.75] y = 75.75
W9 = [440, 496] y = 76
W10 = [481, 496.25] y = 76.25
W11 = [518, 496.5] y = 76.5
W12 = [554, 496.75] y = 76.75
W13 = [592, 497] y = 77
W14 = [600, 497.1] y = 77.1

Adjusted for [0,0] → 420 in C.S. D10-D10'

Sludge Layer & Surface Layer Coordinates: (soil type 1 or 2)

E1 = [355, 500] y = 80
E2 = [400, 516] y = 96
E3 = [455, 517.14] y = 97.14
E4 = [514, 516] y = 96
E5 = [530, 510] y = 90

Adjusted (see above)

Top of Cap Coordinates: (soil type 1)

F1 = [368.5, 83.5]
F2 = [400, 92.2]
F3 = [456, 94.4]
F4 = [515.7, 92.2]
F5 = A16 = [524, 90.9]

XSTABL File: PWNLRUN5 1-09-** 11:49

```
*****************************************
*              X S T A B L              *
*                                       *
*        Slope Stability Analysis       *
*               using the               *
*            Method of Slices           *
*                                       *
*        Copyright (C) 1992 Ä 98        *
*   Interactive Software Designs, Inc.  *
*        Moscow, ID 83843, U.S.A.       *
*                                       *
*          All Rights Reserved          *
*                                       *
*  Ver. 5.202                96 Ä 1641  *
*****************************************
```

Problem Description : Revised Global 4 with Cap 1/09/03

30% Design

SEGMENT BOUNDARY COORDINATES

---

17 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	130.0	75.0	157.0	88.8	3
2	157.0	88.8	167.0	86.7	3
3	167.0	86.7	188.0	79.7	3
4	188.0	79.7	210.0	75.7	3
5	210.0	75.7	232.0	73.0	3
6	232.0	73.0	245.0	72.0	3
7	245.0	72.0	307.0	71.8	3
8	307.0	71.8	324.0	73.2	3
9	324.0	73.2	336.0	73.9	3
10	336.0	73.9	355.0	80.0	3
11	355.0	80.0	400.0	96.0	1
12	400.0	96.0	455.0	97.1	1
13	455.0	97.1	514.0	96.0	1
14	514.0	96.0	530.0	90.0	1
15	530.0	90.0	543.0	85.0	3
16	543.0	85.0	563.0	83.7	3
17	563.0	83.7	600.0	83.0	3

25 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	364.0	82.0	368.5	83.5	2
2	368.5	83.5	400.0	92.2	2
3	400.0	92.2	456.0	94.4	2
4	456.0	94.4	515.7	92.2	2
5	515.7	92.2	524.0	90.9	2
6	355.0	80.0	364.0	82.0	3
7	364.0	82.0	375.0	84.0	3
8	375.0	84.0	392.0	83.3	3
9	392.0	83.3	428.0	80.1	3
10	428.0	80.1	493.0	79.9	3
11	493.0	79.9	502.0	82.2	3
12	502.0	82.2	524.0	90.9	3
13	524.0	90.9	530.0	90.0	3
14	130.0	75.0	176.0	74.9	4
15	176.0	74.9	212.0	71.8	4
16	212.0	71.8	232.0	69.0	4
17	232.0	69.0	336.0	66.9	4
18	336.0	66.9	470.0	74.0	4
19	470.0	74.0	600.0	77.4	4
20	130.0	67.0	147.0	66.8	5
21	147.0	66.8	212.0	65.0	5
22	212.0	65.0	231.0	63.5	5
23	231.0	63.5	336.0	63.9	5
24	336.0	63.9	470.0	70.0	5
25	470.0	70.0	600.0	72.5	5

ISOTROPIC Soil Parameters
---

5 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	122.5	122.5	.0	36.00	.000	.0	0
2	96.0	96.0	382.0	.00	.000	.0	0
3	115.0	115.0	.0	34.00	.000	.0	1
4	140.0	140.0	.0	37.00	.000	.0	1
5	116.4	116.5	724.0	.00	.000	.0	1

1 Water surface(s) have been specified

Unit weight of water = 62.40 (pcf)

Water Surface No. 1 specified by 2 coordinate points

****
PHREATIC SURFACE,
****

Point No.	x-water (ft)	y-water (ft)
1	130.00	73.00
2	600.00	77.10

BOUNDARIES THAT LIMIT SURFACE GENERATION HAVE BEEN SPECIFIED

LOWER limiting boundary of 2 segments:

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)
1	130.0	53.5	470.0	7.1
2	470.0	7.1	600.0	6.4

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

80 trial surfaces will be generated and analyzed.

10 Surfaces initiate from each of 8 points equally spaced along the ground surface between x = 250.0 ft
and x = 300.0 ft

Each surface terminates between x = 440.0 ft
and x = 500.0 ft

Unless further limitations were imposed, the minimum elevation at which a surface extends is y = 10.0 ft

5.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS

The first segment of each failure surface will be inclined within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED BISHOP METHOD * * * * *

The most critical circular failure surface
is specified by 44 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	285.71	71.87
2	289.25	68.34
3	292.95	64.97
4	296.79	61.76
5	300.76	58.73
6	304.87	55.89
7	309.11	53.22
8	313.45	50.75
9	317.91	48.48
10	322.46	46.41
11	327.10	44.54
12	331.81	42.88
13	336.60	41.44
14	341.44	40.21
15	346.34	39.19
16	351.28	38.40
17	356.24	37.82
18	361.23	37.47
19	366.23	37.34
20	371.23	37.44
21	376.22	37.76
22	381.19	38.30
23	386.13	39.06
24	391.03	40.04
25	395.89	41.24
26	400.68	42.66
27	405.41	44.28
28	410.06	46.12
29	414.63	48.16
30	419.09	50.41
31	423.46	52.85
32	427.71	55.48
33	431.84	58.30
34	435.83	61.30
35	439.70	64.48
36	443.41	67.83
37	446.97	71.34
38	450.37	75.00
39	453.61	78.81
40	456.67	82.77
41	459.55	86.85
42	462.25	91.06
43	464.76	95.39
44	465.55	96.90

**** Simplified BISHOP FOS = 1.660 ****

The following is a summary of the TEN most critical surfaces

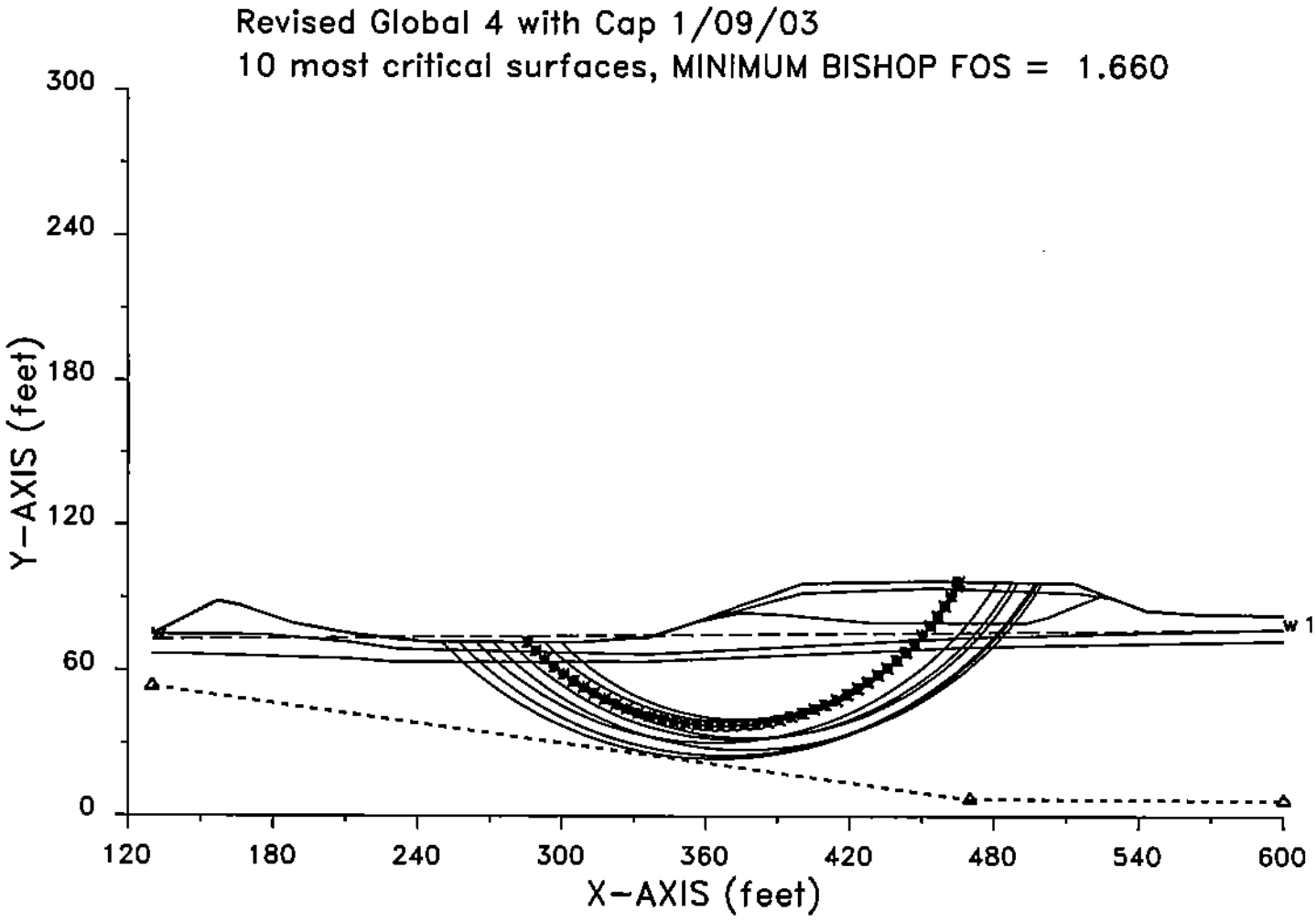
Problem Description : Revised Global 4 with Cap 1/09/03

	FOS (BISHOP)	Circle Center x-coord (ft)	Circle Center y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)
1.	1.660	366.59	149.35	112.00	285.71	465.55	1.632E+07
2.	1.666	373.60	164.02	132.35	278.57	487.38	2.217E+07
3.	1.668	370.06	147.57	108.14	292.86	465.56	1.508E+07
4.	1.669	367.47	178.76	153.55	257.14	497.01	2.951E+07
5.	1.670	368.10	179.55	154.55	257.14	498.31	2.984E+07
6.	1.671	373.90	142.23	102.07	300.00	465.33	1.370E+07
7.	1.671	363.12	168.93	138.48	264.29	481.20	2.410E+07
8.	1.676	376.25	173.22	145.77	271.43	500.03	2.668E+07
9.	1.677	378.50	161.12	128.74	285.71	489.78	2.109E+07
10.	1.677	364.43	183.95	160.09	250.00	498.39	3.180E+07

* * * END OF FILE * * *

PWNLRUN5 1-09-•• 11:49

30% Design



XSTABL File: PWNLRUN7 1-09-** 12:38

```
*****************************************
*              X S T A B L              *
*                                       *
*        Slope Stability Analysis       *
*               using the               *
*            Method of Slices           *
*                                       *
*         Copyright (C) 1992 Ä 98       *
*   Interactive Software Designs, Inc.  *
*        Moscow, ID 83843, U.S.A.       *
*                                       *
*          All Rights Reserved          *
*                                       *
*  Ver. 5.202                96 Ä 1641  *
*****************************************
```

Problem Description : Landfill Stability Run 2 1/09/03

30 % Design

SEGMENT BOUNDARY COORDINATES

---

8 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	250.0	80.0	355.0	80.0	3
2	355.0	80.0	400.0	96.0	3
3	400.0	96.0	455.0	97.1	1
4	455.0	97.1	514.0	96.0	1
5	514.0	96.0	530.0	90.0	1
6	530.0	90.0	543.0	85.0	3
7	543.0	85.0	563.0	83.7	3
8	563.0	83.7	600.0	83.0	3

14 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	364.0	80.0	400.0	92.2	2
2	400.0	92.2	456.0	94.4	2
3	456.0	94.4	515.7	92.2	2
4	515.7	92.2	524.0	90.9	2
5	355.0	80.0	493.0	79.9	3
6	493.0	79.9	502.0	82.2	3
7	502.0	82.2	524.0	90.9	3
8	524.0	90.9	530.0	90.0	3
9	250.0	68.5	336.0	66.9	4
10	336.0	66.9	470.0	74.0	4
11	470.0	74.0	600.0	77.4	4
12	250.0	63.5	336.0	63.9	5
13	336.0	63.9	470.0	70.0	5
14	470.0	70.0	600.0	72.5	5

ISOTROPIC Soil Parameters
---

5 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	122.5	122.5	.0	36.00	.000	.0	0
2	96.0	96.0	382.0	.00	.000	.0	0
3	115.0	115.0	.0	34.00	.000	.0	1
4	140.0	140.0	.0	37.00	.000	.0	1
5	116.4	116.5	724.0	.00	.000	.0	1

1 Water surface(s) have been specified

Unit weight of water = 62.40 (pcf)

Water Surface No. 1 specified by 2 coordinate points

****
PHREATIC SURFACE,
****

Point No.	x-water (ft)	y-water (ft)
1	250.00	73.00
2	600.00	77.10

BOUNDARIES THAT LIMIT SURFACE GENERATION HAVE BEEN SPECIFIED

LOWER limiting boundary of 2 segments:

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)
1	250.0	37.4	470.0	7.1
2	470.0	7.1	600.0	6.4

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

80 trial surfaces will be generated and analyzed.

10 Surfaces initiate from each of 8 points equally spaced along the ground surface between x = 350.0 ft
and x = 400.0 ft

Each surface terminates between x = 405.0 ft
and x = 500.0 ft

Unless further limitations were imposed, the minimum elevation at which a surface extends is y = 10.0 ft

7.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS

The first segment of each failure surface will be inclined within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

****
** Factor of safety calculation for surface # 51 **
** failed to converge within FIFTY iterations **
**
** The last calculated value of the FOS was 33.9814 **
** This will be ignored for final summary of results **
****

```
Circular surface (FOS= 33.9814) is defined by: xcenter =    439.98
ycenter =    149.86   Init. Pt. =    385.71   Seg. Length =   7.00
-------------------------------------------------------------------

    ************************************************************
    **     Factor of safety calculation for surface #    58    **
    **     failed to converge within FIFTY iterations          **
    **                                                         **
    **    The last calculated value of the FOS was  20.9944    **
    **    This will be ignored for final summary of results    **
    ************************************************************

Circular surface (FOS= 20.9944) is defined by: xcenter =    430.23
ycenter =    142.76   Init. Pt. =    385.71   Seg. Length =   7.00
-------------------------------------------------------------------

    ************************************************************
    **     Factor of safety calculation for surface #    61    **
    **     failed to converge within FIFTY iterations          **
    **                                                         **
    **    The last calculated value of the FOS was  64.4037    **
    **    This will be ignored for final summary of results    **
    ************************************************************

Circular surface (FOS= 64.4037) is defined by: xcenter =    443.63
ycenter =    150.45   Init. Pt. =    392.86   Seg. Length =   7.00
-------------------------------------------------------------------

    ************************************************************
    **     Factor of safety calculation for surface #    62    **
    **     failed to converge within FIFTY iterations          **
    **                                                         **
    **    The last calculated value of the FOS was  29.8402    **
    **    This will be ignored for final summary of results    **
    ************************************************************

Circular surface (FOS= 29.8402) is defined by: xcenter =    438.94
ycenter =    233.53   Init. Pt. =    392.86   Seg. Length =   7.00
-------------------------------------------------------------------

    ************************************************************
    **     Factor of safety calculation for surface #    66    **
    **     failed to converge within FIFTY iterations          **
    **                                                         **
    **    The last calculated value of the FOS was  80.6643    **
    **    This will be ignored for final summary of results    **
    ************************************************************
```

Circular surface (FOS= 80.6643) is defined by: xcenter = 445.15
ycenter = 140.84 Init. Pt. = 392.86 Seg. Length = 7.00

****

ERROR # 28

****

In automatically generating a failure surface, it has been found that more than 100 points are needed to define this surface. The program is limited to a maximum of 100 points. To meet this criterion, please INCREASE the specified length of the line segments.

****

****

*** The above error occurred in attempting ***
*** to generate surface # 1 from the ***
*** initiation point located at x = 400.00 ***

****

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED BISHOP METHOD * * * * *

The most critical circular failure surface is specified by 11 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	350.00	80.00
2	356.91	78.86
3	363.89	78.40
4	370.89	78.60
5	377.83	79.48
6	384.66	81.02
7	391.31	83.22
8	397.71	86.04
9	403.82	89.46
10	409.57	93.46
11	412.86	96.26

**** Simplified BISHOP FOS = 2.031 ****

```
**********************************************************************
**                                                                  **
**  Out of the     70 surfaces generated and analyzed by XSTABL,    **
**       5 surfaces were found to have MISLEADING FOS values.       **
**                                                                  **
**********************************************************************
```

The following is a summary of the TEN most critical surfaces

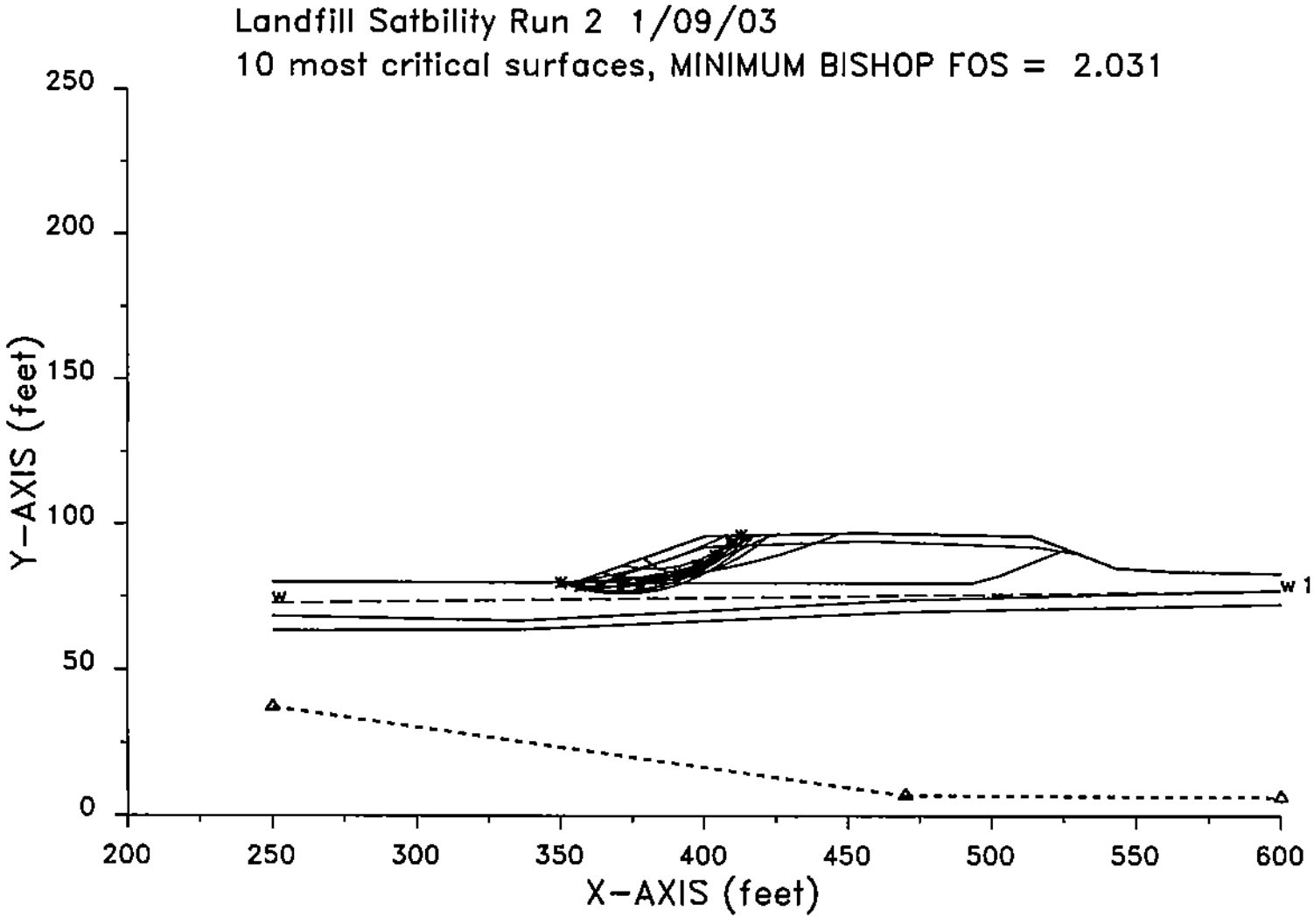
Problem Description : Landfill Stability Run 2 1/09/03

	FOS (BISHOP)	Circle Center x-coord (ft)	Circle Center y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)
1.	2.031	365.25	151.06	72.68	350.00	412.86	1.673E+06
2.	2.086	381.97	140.99	60.34	364.29	422.65	1.271E+06
3.	2.114	334.54	243.27	164.07	357.14	407.07	1.520E+06
4.	2.117	377.64	136.82	55.16	364.29	414.95	9.829E+05
5.	2.239	369.47	142.78	65.73	350.00	415.88	2.017E+06
6.	2.313	360.71	211.49	130.78	357.14	422.84	2.839E+06
7.	2.399	371.39	138.96	62.72	350.00	417.28	2.244E+06
8.	2.490	381.72	129.58	44.93	371.43	411.71	6.006E+05
9.	2.650	363.31	304.77	224.09	357.14	447.08	6.844E+06
10.	2.807	391.56	101.39	18.39	378.57	408.86	2.278E+05

* * * END OF FILE * * *

PWNLRUN7 1-09-** 12:38

30% Design



XSTABL File: PWNLRN7A 1-15-** 11:24

```
*******************************************
*              X S T A B L                *
*                                         *
*        Slope Stability Analysis         *
*              using the                  *
*           Method of Slices              *
*                                         *
*        Copyright (C) 1992 Ä 98          *
*   Interactive Software Designs, Inc.    *
*        Moscow, ID 83843, U.S.A.         *
*                                         *
*          All Rights Reserved            *
*                                         *
*  Ver. 5.202                96 Ä 1641    *
*******************************************
```

Problem Description : Landfill Stability Run 2a 1/15/03

30% Design

SEGMENT BOUNDARY COORDINATES

---

8 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	250.0	80.0	355.0	80.0	3
2	355.0	80.0	400.0	96.0	3
3	400.0	96.0	455.0	97.1	1
4	455.0	97.1	514.0	96.0	1
5	514.0	96.0	530.0	90.0	1
6	530.0	90.0	543.0	85.0	3
7	543.0	85.0	563.0	83.7	3
8	563.0	83.7	600.0	83.0	3

14 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	364.0	80.0	400.0	92.2	2
2	400.0	92.2	456.0	94.4	2
3	456.0	94.4	515.7	92.2	2
4	515.7	92.2	524.0	90.9	2
5	355.0	80.0	493.0	79.9	3
6	493.0	79.9	502.0	82.2	3
7	502.0	82.2	524.0	90.9	3
8	524.0	90.9	530.0	90.0	3
9	250.0	68.5	336.0	66.9	4
10	336.0	66.9	470.0	74.0	4
11	470.0	74.0	600.0	77.4	4
12	250.0	63.5	336.0	63.9	5
13	336.0	63.9	470.0	70.0	5
14	470.0	70.0	600.0	72.5	5

ISOTROPIC Soil Parameters
---

5 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	122.5	122.5	.0	36.00	.000	.0	0
2	96.0	96.0	382.0	.00	.000	.0	0
3	115.0	115.0	.0	34.00	.000	.0	1
4	140.0	140.0	.0	37.00	.000	.0	1
5	116.4	116.5	724.0	.00	.000	.0	1

1 Water surface(s) have been specified

Unit weight of water = 62.40 (pcf)

Water Surface No. 1 specified by 2 coordinate points

****
PHREATIC SURFACE,
****

Point No.	x-water (ft)	y-water (ft)
1	250.00	73.00
2	600.00	77.10

BOUNDARIES THAT LIMIT SURFACE GENERATION HAVE BEEN SPECIFIED

LOWER limiting boundary of 2 segments:

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)
1	250.0	37.4	470.0	7.1
2	470.0	7.1	600.0	6.4

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

80 trial surfaces will be generated and analyzed.

```
  10 Surfaces initiate from each of   8 points equally spaced
along the ground surface between  x =    350.0 ft
                             and  x =    400.0 ft


Each surface terminates between   x =    405.0 ft
                             and  x =    500.0 ft


Unless further limitations were imposed, the minimum elevation
at which a surface extends is  y =     10.0 ft


* * * * *  DEFAULT SEGMENT LENGTH SELECTED BY XSTABL  * * * * *

    2.0 ft line segments define each trial failure surface.


---------------------
ANGULAR RESTRICTIONS
---------------------

  The first segment of each failure surface will be inclined
  within the angular range defined by :

          Lower angular limit :=   -45.0 degrees
          Upper angular limit :=  (slope angle - 5.0) degrees



**************************************************************
**     Factor of safety calculation for surface #    51     **
**     failed to converge within FIFTY iterations           **
**                                                          **
**    The last calculated value of the FOS was  32.4840     **
**    This will be ignored for final summary of results     **
**************************************************************

Circular surface (FOS= 32.4840) is defined by: xcenter =    439.57
ycenter =    153.25   Init. Pt. =    385.71   Seg. Length =   2.00
--------------------------------------------------------------------


**************************************************************
**     Factor of safety calculation for surface #    61     **
**     failed to converge within FIFTY iterations           **
**                                                          **
**    The last calculated value of the FOS was  56.1618     **
**    This will be ignored for final summary of results     **
**************************************************************
```

```
Circular surface (FOS= 56.1618) is defined by: xcenter =    442.46
      ycenter =    152.98   Init. Pt. =    392.86   Seg. Length =   2.00
      ---------------------------------------------------------------


     ************************************************************
     **     Factor of safety calculation for surface #    62     **
     **     failed to converge within FIFTY iterations           **
     **                                                          **
     **    The last calculated value of the FOS was  30.7100     **
     **    This will be ignored for final summary of results     **
     ************************************************************


     Circular surface (FOS= 30.7100) is defined by: xcenter =    439.09
     ycenter =    242.66   Init. Pt. =    392.86   Seg. Length =   2.00
     ---------------------------------------------------------------


     ************************************************************
     **     Factor of safety calculation for surface #    66     **
     **     failed to converge within FIFTY iterations           **
     **                                                          **
     **    The last calculated value of the FOS was  76.7911     **
     **    This will be ignored for final summary of results     **
     ************************************************************


     Circular surface (FOS= 76.7911) is defined by: xcenter =    444.75
     ycenter =    143.97   Init. Pt. =    392.86   Seg. Length =   2.00
     ---------------------------------------------------------------


     ***************************************************************************
     ERROR # 28
     ***************************************************************************
     In automatically generating a failure surface, it has been found that
     more than 100 points are needed to define this surface.  The program
     is limited to a maximum of 100 points.  To meet this criterion,
     please INCREASE the specified length of the line segments.
     ***************************************************************************


          ************************************************
          ***   The above error occurred in attempting   ***
          ***     to generate surface #    1 from the    ***
          ***  initiation point located at x =   400.00  ***
          ************************************************


     Factors of safety have been calculated by the :

     * * * * *   SIMPLIFIED BISHOP METHOD   * * * * *
```

The most critical circular failure surface
is specified by 35 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	350.00	80.00
2	351.97	79.68
3	353.95	79.40
4	355.94	79.18
5	357.93	79.00
6	359.93	78.88
7	361.93	78.81
8	363.93	78.79
9	365.93	78.82
10	367.93	78.90
11	369.92	79.03
12	371.91	79.21
13	373.90	79.44
14	375.88	79.73
15	377.85	80.06
16	379.82	80.45
17	381.77	80.88
18	383.71	81.36
19	385.64	81.89
20	387.55	82.48
21	389.45	83.11
22	391.33	83.78
23	393.19	84.51
24	395.04	85.28
25	396.86	86.10
26	398.67	86.97
27	400.45	87.88
28	402.20	88.83
29	403.94	89.83
30	405.64	90.88
31	407.32	91.97
32	408.97	93.09
33	410.59	94.27
34	412.18	95.48
35	413.16	96.26

**** Simplified BISHOP FOS = 2.007 ****

****
**
** Out of the 70 surfaces generated and analyzed by XSTABL, **
** 4 surfaces were found to have MISLEADING FOS values. **
**
****

The following is a summary of the TEN most critical surfaces

Problem Description : Landfill Stability Run 2a 1/15/03

	FOS (BISHOP)	Circle Center x-coord (ft)	Circle Center y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)
1.	2.007	363.75	157.34	78.55	350.00	413.16	1.706E+06
2.	2.113	329.32	259.92	181.31	357.14	407.08	1.590E+06
3.	2.144	380.92	147.19	66.01	364.29	423.23	1.387E+06
4.	2.167	368.28	148.31	70.72	350.00	416.17	2.015E+06
5.	2.178	376.26	143.21	61.09	364.29	415.39	1.078E+06
6.	2.307	370.30	143.99	67.14	350.00	417.62	2.222E+06
7.	2.374	358.21	224.56	143.80	357.14	423.55	3.127E+06
8.	2.561	380.22	136.29	51.21	371.43	412.12	6.716E+05
9.	2.688	389.99	103.52	18.96	378.57	407.40	2.095E+05
10.	2.713	361.03	323.89	243.16	357.14	448.33	7.501E+06

* * * END OF FILE * * *

XSTABL File: PWNLRN10 1-09-** 12:49

```
*******************************************
*              X S T A B L                *
*                                         *
*        Slope Stability Analysis         *
*               using the                 *
*            Method of Slices             *
*                                         *
*         Copyright (C) 1992 Ä 98         *
*   Interactive Software Designs, Inc.    *
*        Moscow, ID 83843, U.S.A.         *
*                                         *
*          All Rights Reserved            *
*                                         *
*  Ver. 5.202                 96 Ä 1641   *
*******************************************
```

Problem Description : Landfill Stability Run 5 1/09/03

SEGMENT BOUNDARY COORDINATES

---

8 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	250.0	80.0	355.0	80.0	3
2	355.0	80.0	400.0	96.0	3
3	400.0	96.0	455.0	97.1	1
4	455.0	97.1	514.0	96.0	1
5	514.0	96.0	530.0	90.0	1
6	530.0	90.0	543.0	85.0	3
7	543.0	85.0	563.0	83.7	3
8	563.0	83.7	600.0	83.0	3

14 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	364.0	80.0	400.0	92.2	2
2	400.0	92.2	456.0	94.4	2
3	456.0	94.4	515.7	92.2	2
4	515.7	92.2	524.0	90.9	2
5	355.0	80.0	493.0	79.9	3
6	493.0	79.9	502.0	82.2	3
7	502.0	82.2	524.0	90.9	3
8	524.0	90.9	530.0	90.0	3
9	250.0	68.5	336.0	66.9	4
10	336.0	66.9	470.0	74.0	4
11	470.0	74.0	600.0	77.4	4
12	250.0	63.5	336.0	63.9	5
13	336.0	63.9	470.0	70.0	5
14	470.0	70.0	600.0	72.5	5

ISOTROPIC Soil Parameters
---

5 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	122.5	122.5	.0	36.00	.000	.0	0
2	96.0	96.0	270.0	.00	.000	.0	0
3	115.0	115.0	.0	34.00	.000	.0	1
4	140.0	140.0	.0	37.00	.000	.0	1
5	116.4	116.5	724.0	.00	.000	.0	1

1 Water surface(s) have been specified

Unit weight of water = 62.40 (pcf)

Water Surface No. 1 specified by 2 coordinate points

****
PHREATIC SURFACE,
****

Point No.	x-water (ft)	y-water (ft)
1	250.00	73.00
2	600.00	77.10

BOUNDARIES THAT LIMIT SURFACE GENERATION HAVE BEEN SPECIFIED

LOWER limiting boundary of 2 segments:

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)
1	250.0	37.4	470.0	7.1
2	470.0	7.1	600.0	6.4

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

80 trial surfaces will be generated and analyzed.

10 Surfaces initiate from each of 8 points equally spaced along the ground surface between x = 350.0 ft
and x = 400.0 ft

Each surface terminates between x = 405.0 ft
and x = 500.0 ft

Unless further limitations were imposed, the minimum elevation at which a surface extends is y = 10.0 ft

* * * * * DEFAULT SEGMENT LENGTH SELECTED BY XSTABL * * * * *

2.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS

The first segment of each failure surface will be inclined within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

```
**************************************************************
**     Factor of safety calculation for surface #    51     **
**     failed to converge within FIFTY iterations           **
**                                                          **
**    The last calculated value of the FOS was  31.4980     **
**    This will be ignored for final summary of results     **
**************************************************************
```

```
Circular surface (FOS= 31.4980) is defined by: xcenter =    439.57
ycenter =    153.25   Init. Pt. =    385.71   Seg. Length =   2.00
-------------------------------------------------------------------


    ***************************************************************
    **     Factor of safety calculation for surface #    61     **
    **     failed to converge within FIFTY iterations           **
    **                                                          **
    **    The last calculated value of the FOS was  52.7487     **
    **    This will be ignored for final summary of results     **
    ***************************************************************


Circular surface (FOS= 52.7487) is defined by: xcenter =    442.46
ycenter =    152.98   Init. Pt. =    392.86   Seg. Length =   2.00
-------------------------------------------------------------------


    ***************************************************************
    **     Factor of safety calculation for surface #    62     **
    **     failed to converge within FIFTY iterations           **
    **                                                          **
    **    The last calculated value of the FOS was  22.2822     **
    **    This will be ignored for final summary of results     **
    ***************************************************************


Circular surface (FOS= 22.2822) is defined by: xcenter =    439.09
ycenter =    242.66   Init. Pt. =    392.86   Seg. Length =   2.00
-------------------------------------------------------------------


    ***************************************************************
    **     Factor of safety calculation for surface #    66     **
    **     failed to converge within FIFTY iterations           **
    **                                                          **
    **    The last calculated value of the FOS was  74.0715     **
    **    This will be ignored for final summary of results     **
    ***************************************************************


Circular surface (FOS= 74.0715) is defined by: xcenter =    444.75
ycenter =    143.97   Init. Pt. =    392.86   Seg. Length =   2.00
-------------------------------------------------------------------


*****************************************************************************
ERROR # 28
*****************************************************************************
In automatically generating a failure surface, it has been found that
more than 100 points are needed to define this surface.  The program
is limited to a maximum of 100 points.  To meet this criterion,
please INCREASE the specified length of the line segments.
*****************************************************************************
```

```
************************************************
***   The above error occurred in attempting   ***
***     to generate surface #    1 from the    ***
***  initiation point located at x =   400.00  ***
************************************************
```

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED BISHOP METHOD * * * * *

The most critical circular failure surface
is specified by 33 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	364.29	83.30
2	366.23	82.83
3	368.19	82.41
4	370.15	82.06
5	372.13	81.76
6	374.12	81.52
7	376.11	81.35
8	378.11	81.23
9	380.11	81.18
10	382.11	81.18
11	384.10	81.25
12	386.10	81.37
13	388.09	81.56
14	390.08	81.80
15	392.05	82.11
16	394.02	82.48
17	395.97	82.90
18	397.91	83.39
19	399.84	83.93
20	401.75	84.53
21	403.64	85.19
22	405.50	85.90
23	407.35	86.67
24	409.17	87.50
25	410.97	88.38
26	412.73	89.31
27	414.47	90.30
28	416.18	91.34
29	417.86	92.43
30	419.50	93.57
31	421.11	94.76
32	422.68	96.00
33	423.23	96.46

**** Simplified BISHOP FOS = 1.559 ****

****
** **
** Out of the 70 surfaces generated and analyzed by XSTABL, **
** 4 surfaces were found to have MISLEADING FOS values. **
** **
****

The following is a summary of the TEN most critical surfaces

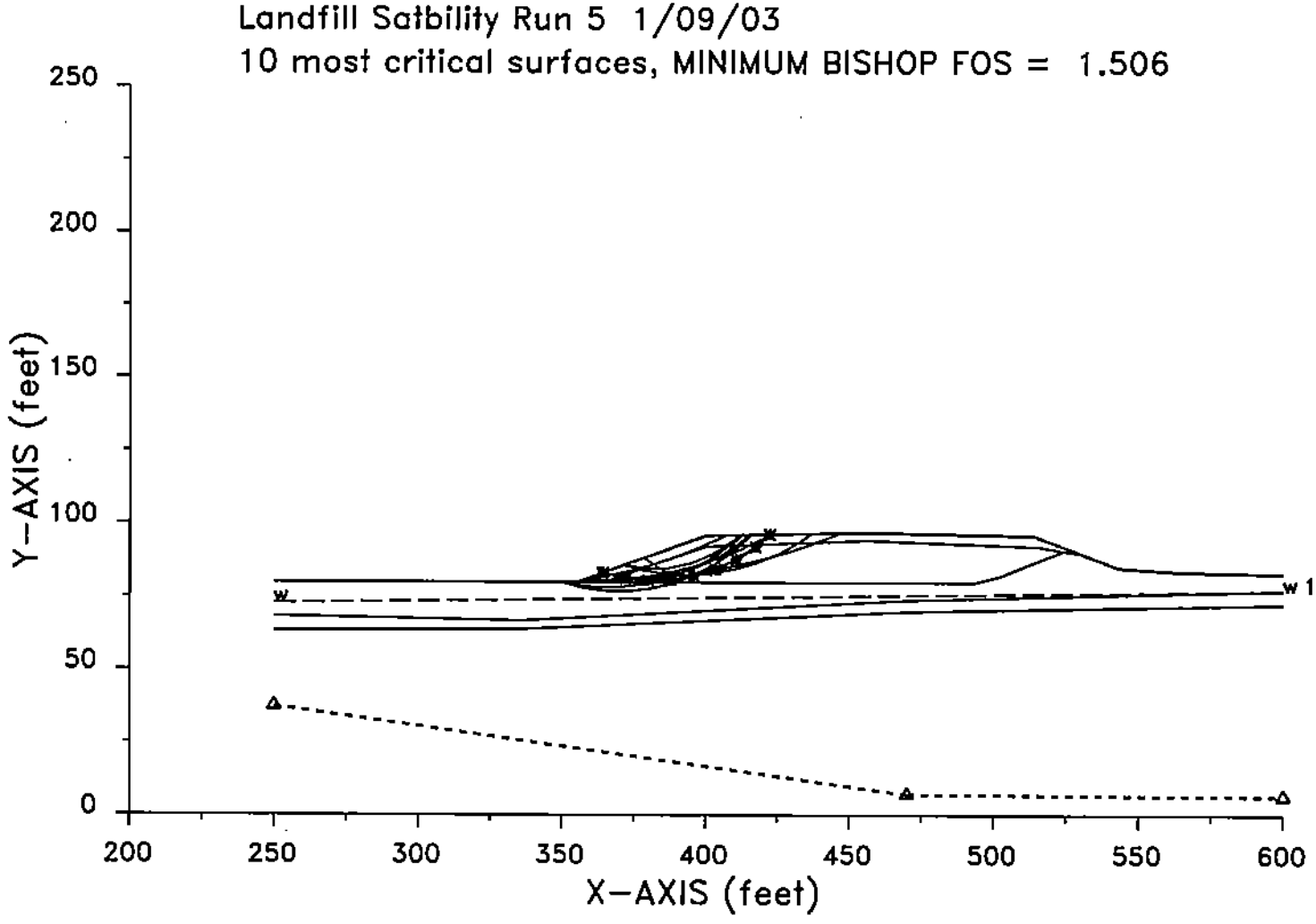
Problem Description : Landfill Stability Run 5 1/09/03

	FOS (BISHOP)	Circle Center x-coord (ft)	Circle Center y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)
1.	1.559	380.92	147.19	66.01	364.29	423.23	1.009E+06
2.	1.598	376.26	143.21	61.09	364.29	415.39	7.909E+05
3.	1.654	363.75	157.34	78.55	350.00	413.16	1.406E+06
4.	1.751	358.21	224.56	143.80	357.14	423.55	2.306E+06
5.	1.918	368.28	148.31	70.72	350.00	416.17	1.784E+06
6.	1.919	380.22	136.29	51.21	371.43	412.12	5.033E+05
7.	1.975	361.03	323.89	243.16	357.14	448.33	5.460E+06
8.	1.984	389.99	103.52	18.96	378.57	407.40	1.546E+05
9.	2.062	394.33	102.73	21.31	378.57	414.65	2.360E+05
10.	2.095	370.30	143.99	67.14	350.00	417.62	2.018E+06

* * * END OF FILE * * *

PWNLRN10 1-09-** 12:46

30% Design



XSTBL Geometry Input
90% Design
Pownal Tannery Site
Sept. 2003
Note: Geometry from 30% design was revised using final Landfill surface and stabilized waste grades from 90% design drawing dated 8/03
LAYERS
1. A - SANDY FILL
2. B - SANDY, SILTY GRAVEL
3. C - CLAY
4. D - BEDROCK
SCALE
1" = 50'
(EXAGGERATED VERTICAL SCALE)
HOOSIC RIVER
LAGOON H
LAGOON 4A
Access Road
Beg. C5
SANDY FILL
SANDY, SILTY GRAVEL
CLAY
BEDROCK
D10
[0,0]
509
496
494
493
502.5
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A11
A12
A13
A14
A15
A17
A18
A19
B0
B1
B2
B3
B4
B5
B6
B7
B8
B9
B10
B11
B12
C0
C1
C2
C3
C4
C5
C6
C7
C8
D0
D1
D2
D3
E1
F1
SBL4-10
SBL4-13
SBL4-11
SBL4-09
SBL4-12
SBL4-103
MW-2-4
515
510
505
500
495
490
85
480
75
470
65
460
55
450
45
440
35
430
425
420
0
50
100
150
200
250
300
350
400
450
500
550
600

Pownal Superfund Site
90% Design
Section for XSTABL Input
Cap Surface
September 2003

GV-1

GV-2

GV-3

GV-5

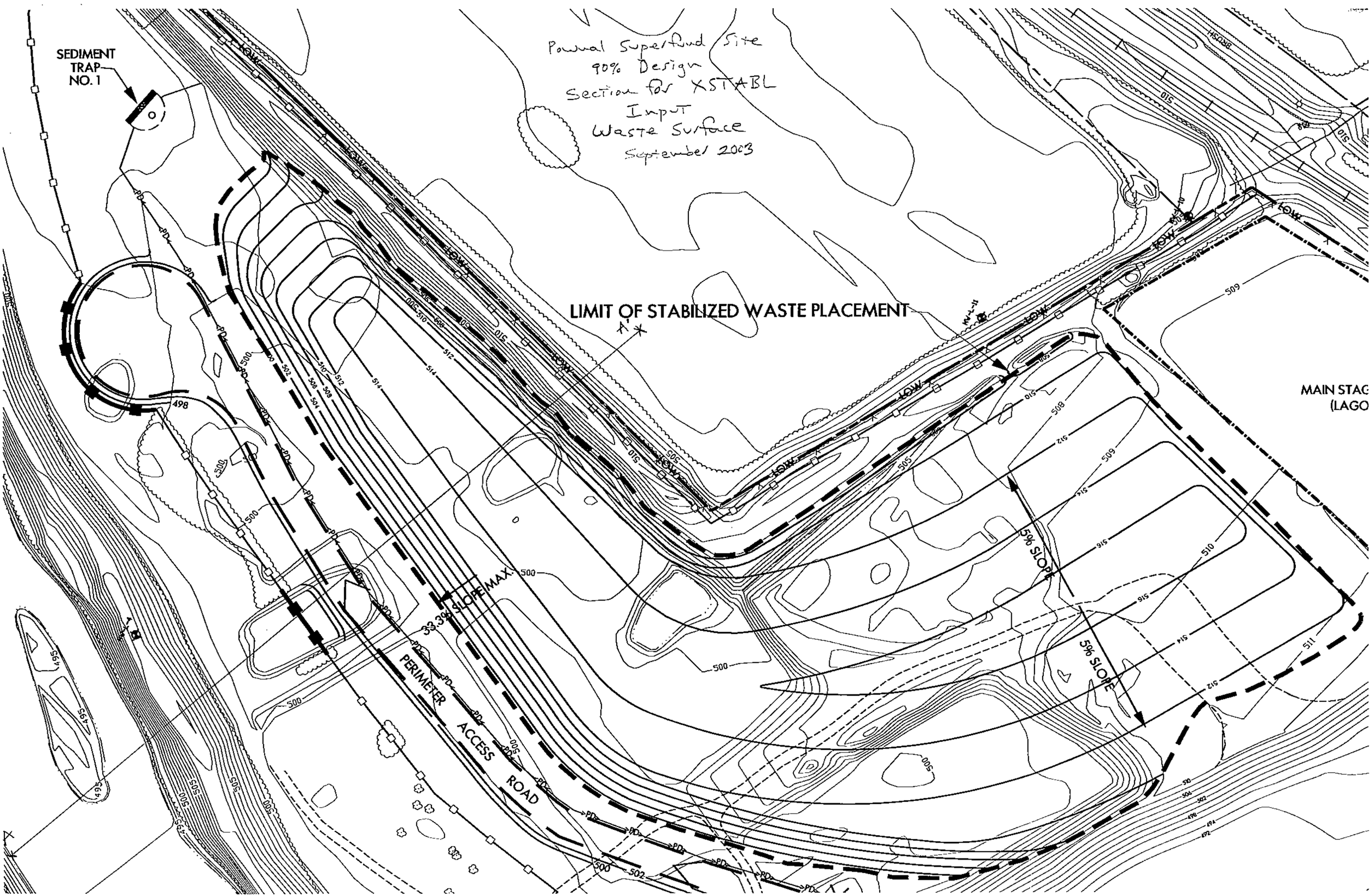
CULVERT NO. 1

A

A'

B

B'



Pownal Superfund Site
90% Design
Section for XSTABL
Input
Waste Surface
September 2003
SEDIMENT TRAP NO. 1
LIMIT OF STABILIZED WASTE PLACEMENT
MAIN STAG
(LAGO
33.3% SLOPE MAX.
5% SLOPE
5% SLOPE
PERIMETER ACCESS ROAD

XSTABL File: PWNLRN5A 9-10-** 11:40

```
*****************************************
*              X S T A B L              *
*                                       *
*        Slope Stability Analysis       *
*               using the               *
*            Method of Slices           *
*                                       *
*         Copyright (C) 1992 Ã 98       *
*   Interactive Software Designs, Inc.  *
*        Moscow, ID 83843, U.S.A.       *
*                                       *
*          All Rights Reserved          *
*                                       *
*  Ver. 5.202                96 Ã 1641  *
*****************************************
```

Problem Description : 90% Global with new LF and waste C

90% Design

SEGMENT BOUNDARY COORDINATES

---

23 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	130.0	75.0	157.0	88.8	3
2	157.0	88.8	167.0	86.7	3
3	167.0	86.7	188.0	79.7	3
4	188.0	79.7	210.0	75.7	3
5	210.0	75.7	232.0	73.0	3
6	232.0	73.0	245.0	72.0	3
7	245.0	72.0	275.0	72.0	3
8	275.0	72.0	290.0	76.0	3
9	290.0	76.0	305.0	82.0	3
10	305.0	82.0	325.0	82.0	3
11	325.0	82.0	340.0	78.0	1
12	340.0	78.0	350.0	80.0	1
13	350.0	80.0	398.0	96.0	1
14	398.0	96.0	436.0	98.0	1
15	436.0	98.0	454.0	98.0	1
16	454.0	98.0	487.0	96.0	1
17	487.0	96.0	517.0	86.0	3
18	517.0	86.0	523.0	86.0	3
19	523.0	86.0	530.0	88.0	3
20	530.0	88.0	535.0	89.0	3
21	535.0	89.0	543.0	85.0	3
22	543.0	85.0	563.0	84.0	3
23	563.0	84.0	600.0	83.0	3

21 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	361.0	80.1	397.0	92.0	2
2	397.0	92.0	422.0	94.0	2
3	422.0	94.0	468.0	94.0	2
4	468.0	94.0	492.0	92.0	2
5	492.0	92.0	513.0	85.1	2
6	350.0	80.0	361.0	80.0	3
7	361.0	80.0	497.0	85.0	3
8	497.0	85.0	513.0	85.0	3
9	513.0	85.0	517.0	86.0	3
10	130.0	75.0	176.0	74.9	4
11	176.0	74.9	212.0	71.8	4
12	212.0	71.8	232.0	69.0	4
13	232.0	69.0	336.0	66.9	4
14	336.0	66.9	470.0	74.0	4
15	470.0	74.0	600.0	77.4	4
16	130.0	67.0	147.0	66.8	5
17	147.0	66.8	212.0	65.0	5
18	212.0	65.0	231.0	63.5	5
19	231.0	63.5	336.0	63.9	5
20	336.0	63.9	470.0	70.0	5
21	470.0	70.0	600.0	72.5	5

ISOTROPIC Soil Parameters
---

5 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	122.5	122.5	.0	36.00	.000	.0	0
2	96.0	96.0	100.0	.00	.000	.0	0
3	115.0	115.0	.0	34.00	.000	.0	1
4	140.0	140.0	.0	37.00	.000	.0	1
5	116.4	116.5	724.0	.00	.000	.0	1

1 Water surface(s) have been specified

Unit weight of water = 62.40 (pcf)

Water Surface No. 1 specified by 2 coordinate points

****
PHREATIC SURFACE,
****

Point No.	x-water (ft)	y-water (ft)
1	130.00	73.00
2	600.00	77.10

BOUNDARIES THAT LIMIT SURFACE GENERATION HAVE BEEN SPECIFIED

LOWER limiting boundary of 2 segments:

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)
1	130.0	53.5	470.0	7.1
2	470.0	7.1	600.0	6.4

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

80 trial surfaces will be generated and analyzed.

10 Surfaces initiate from each of 8 points equally spaced along the ground surface between x = 150.0 ft
and x = 300.0 ft

Each surface terminates between x = 440.0 ft
and x = 500.0 ft

Unless further limitations were imposed, the minimum elevation at which a surface extends is y = 10.0 ft

10.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS

The first segment of each failure surface will be inclined within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED BISHOP METHOD * * * * *

The most critical circular failure surface
is specified by 29 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	235.71	72.71
2	242.79	65.64
3	250.33	59.08
4	258.30	53.04
5	266.66	47.56
6	275.38	42.66
7	284.41	38.37
8	293.72	34.71
9	303.25	31.69
10	312.97	29.34
11	322.83	27.65
12	332.78	26.64
13	342.77	26.31
14	352.77	26.66
15	362.71	27.70
16	372.56	29.41
17	382.28	31.80
18	391.80	34.84
19	401.10	38.52
20	410.12	42.83
21	418.83	47.75
22	427.18	53.26
23	435.13	59.31
24	442.66	65.90
25	449.71	72.99
26	456.26	80.54
27	462.29	88.53
28	467.75	96.90
29	467.89	97.16

**** Simplified BISHOP FOS = 1.783 ****

The following is a summary of the TEN most critical surfaces

Problem Description : 90% Global with new LF and waste C

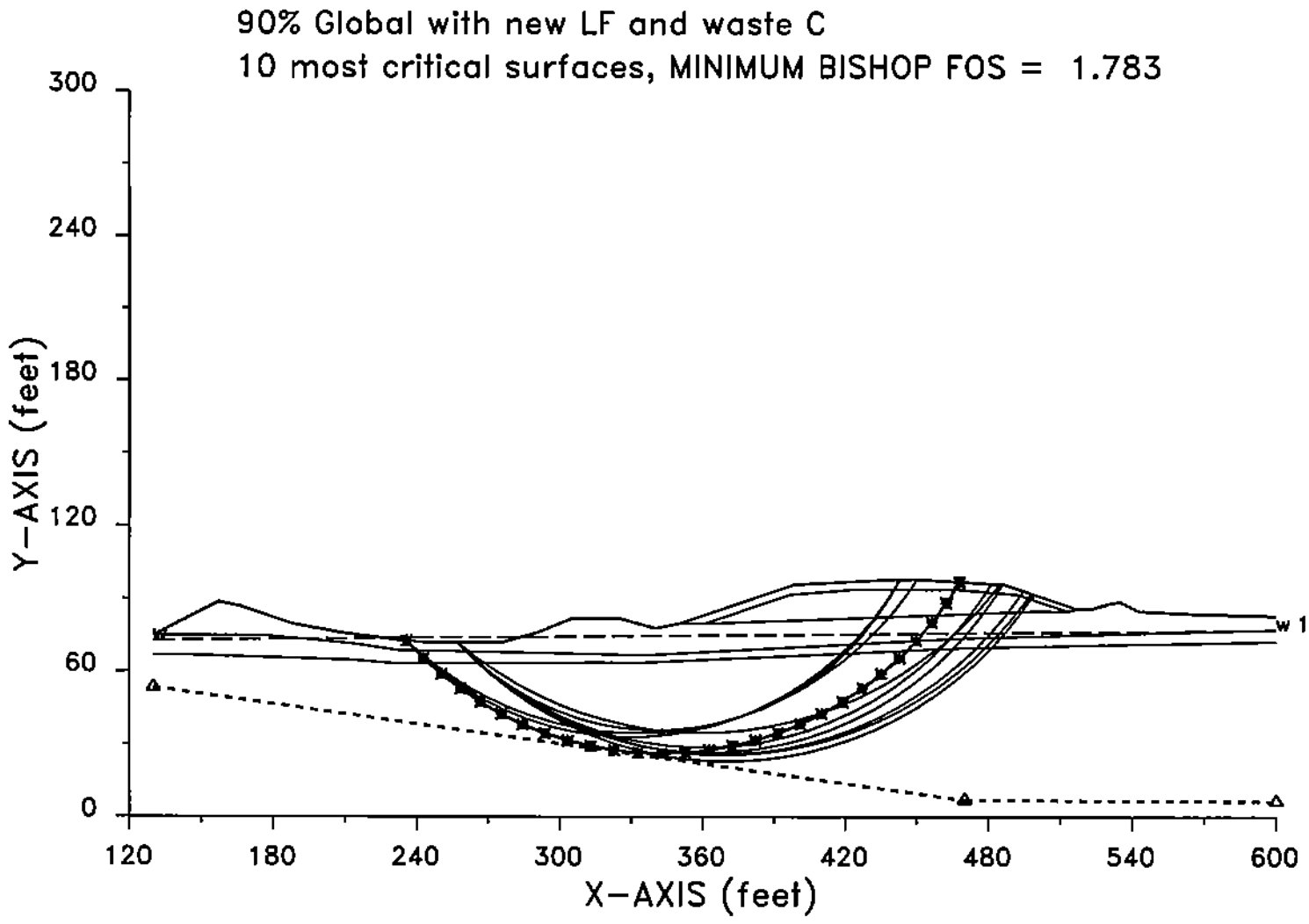
FOS	Circle Center	Radius	Initial	Terminal	Resisting

	(BISHOP)	x-coord (ft)	y-coord (ft)	(ft)	x-coord (ft)	x-coord (ft)	Moment (ft-lb)
1.	1.783	342.58	172.56	146.25	235.71	467.89	2.741E+07
2.	1.807	362.29	171.29	144.62	257.14	485.70	2.661E+07
3.	1.815	359.63	171.98	143.17	257.14	481.18	2.572E+07
4.	1.851	367.02	179.83	153.95	257.14	494.43	2.930E+07
5.	1.865	370.07	177.86	154.79	257.14	498.85	3.019E+07
6.	1.880	368.89	183.55	157.90	257.14	497.74	3.040E+07
7.	1.909	359.29	194.11	159.20	257.14	484.67	2.826E+07
8.	1.939	340.63	150.70	114.74	257.14	442.50	1.722E+07
9.	1.940	332.11	176.00	141.28	235.71	449.80	2.393E+07
10.	1.949	329.61	164.53	131.33	235.71	442.80	2.178E+07

* * * END OF FILE * * *

PWNLRN5A 9-10-•• 11:40

90% Design



XSTABL File: PWNLRN7C 9-10-** 11:53

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*****************************************
*              X S T A B L              *
*                                       *
*        Slope Stability Analysis       *
*               using the               *
*           Method of Slices            *
*                                       *
*         Copyright (C) 1992 Ã 98       *
*   Interactive Software Designs, Inc.  *
*        Moscow, ID 83843, U.S.A.       *
*                                       *
*          All Rights Reserved          *
*                                       *
*  Ver. 5.202                96 Ã 1641  *
*****************************************
```

Problem Description : 90% Global with new LF and waste C

90% Design

SEGMENT BOUNDARY COORDINATES

---

23 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	130.0	75.0	157.0	88.8	3
2	157.0	88.8	167.0	86.7	3
3	167.0	86.7	188.0	79.7	3
4	188.0	79.7	210.0	75.7	3
5	210.0	75.7	232.0	73.0	3
6	232.0	73.0	245.0	72.0	3
7	245.0	72.0	275.0	72.0	3
8	275.0	72.0	290.0	76.0	3
9	290.0	76.0	305.0	82.0	3
10	305.0	82.0	325.0	82.0	3
11	325.0	82.0	340.0	78.0	1
12	340.0	78.0	350.0	80.0	1
13	350.0	80.0	398.0	96.0	1
14	398.0	96.0	436.0	98.0	1
15	436.0	98.0	454.0	98.0	1
16	454.0	98.0	487.0	96.0	1
17	487.0	96.0	517.0	86.0	3
18	517.0	86.0	523.0	86.0	3
19	523.0	86.0	530.0	88.0	3
20	530.0	88.0	535.0	89.0	3
21	535.0	89.0	543.0	85.0	3
22	543.0	85.0	563.0	84.0	3
23	563.0	84.0	600.0	83.0	3

21 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	361.0	80.1	397.0	92.0	2
2	397.0	92.0	422.0	94.0	2
3	422.0	94.0	468.0	94.0	2
4	468.0	94.0	492.0	92.0	2
5	492.0	92.0	513.0	85.1	2
6	350.0	80.0	361.0	80.0	3
7	361.0	80.0	497.0	85.0	3
8	497.0	85.0	513.0	85.0	3
9	513.0	85.0	517.0	86.0	3
10	130.0	75.0	176.0	74.9	4
11	176.0	74.9	212.0	71.8	4
12	212.0	71.8	232.0	69.0	4
13	232.0	69.0	336.0	66.9	4
14	336.0	66.9	470.0	74.0	4
15	470.0	74.0	600.0	77.4	4
16	130.0	67.0	147.0	66.8	5
17	147.0	66.8	212.0	65.0	5
18	212.0	65.0	231.0	63.5	5
19	231.0	63.5	336.0	63.9	5
20	336.0	63.9	470.0	70.0	5
21	470.0	70.0	600.0	72.5	5

ISOTROPIC Soil Parameters
---

5 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	122.5	122.5	.0	36.00	.000	.0	0
2	96.0	96.0	270.0	.00	.000	.0	0
3	115.0	115.0	.0	34.00	.000	.0	1
4	140.0	140.0	.0	37.00	.000	.0	1
5	116.4	116.5	724.0	.00	.000	.0	1

1 Water surface(s) have been specified

Unit weight of water = 62.40 (pcf)

Water Surface No. 1 specified by 2 coordinate points

****
PHREATIC SURFACE,
****

Point No.	x-water (ft)	y-water (ft)
1	130.00	73.00
2	600.00	77.10

BOUNDARIES THAT LIMIT SURFACE GENERATION HAVE BEEN SPECIFIED

LOWER limiting boundary of 2 segments:

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)
1	130.0	53.5	470.0	7.1
2	470.0	7.1	600.0	6.4

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

80 trial surfaces will be generated and analyzed.

10 Surfaces initiate from each of 8 points equally spaced along the ground surface between x = 300.0 ft
and x = 400.0 ft

Each surface terminates between x = 405.0 ft
and x = 450.0 ft

Unless further limitations were imposed, the minimum elevation at which a surface extends is y = 10.0 ft

5.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS

The first segment of each failure surface will be inclined within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

```
**************************************************************
**     Factor of safety calculation for surface #    71     **
**     failed to converge within FIFTY iterations           **
**                                                          **
**    The last calculated value of the FOS was  22.4603     **
**    This will be ignored for final summary of results     **
**************************************************************
```

Circular surface (FOS= 22.4603) is defined by: xcenter = 407.36
ycenter = 100.70 Init. Pt. = 400.00 Seg. Length = 5.00

```
**************************************************************
**     Factor of safety calculation for surface #    76     **
**     failed to converge within FIFTY iterations           **
**                                                          **
**    The last calculated value of the FOS was  22.1593     **
**    This will be ignored for final summary of results     **
**************************************************************
```

Circular surface (FOS= 22.1593) is defined by: xcenter = 405.61
ycenter = 101.79 Init. Pt. = 400.00 Seg. Length = 5.00

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED BISHOP METHOD * * * * *

The most critical circular failure surface
is specified by 17 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	357.14	82.38
2	362.10	81.75
3	367.09	81.35
4	372.08	81.19
5	377.08	81.26
6	382.07	81.57
7	387.04	82.12
8	391.98	82.89
9	396.88	83.90
10	401.73	85.14
11	406.51	86.60
12	411.21	88.29
13	415.83	90.20
14	420.36	92.32

15	424.78	94.66
16	429.09	97.20
17	429.82	97.67

**** Simplified BISHOP FOS = 1.664 ****

****
** **
** Out of the 80 surfaces generated and analyzed by XSTABL, **
** 2 surfaces were found to have MISLEADING FOS values. **
** **
****

The following is a summary of the TEN most critical surfaces

Problem Description : 90% Global with new LF and waste C

	FOS (BISHOP)	Circle Center x-coord (ft)	Circle Center y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)
1.	1.664	373.02	187.33	106.14	357.14	429.82	1.974E+06
2.	1.934	382.63	116.45	31.37	371.43	406.71	2.877E+05
3.	1.998	338.63	404.52	325.98	342.86	449.54	9.226E+06
4.	2.020	374.13	135.06	55.34	357.14	414.08	1.209E+06
5.	2.287	353.54	387.69	305.33	357.14	449.99	6.966E+06
6.	2.299	339.21	364.99	283.18	357.14	433.12	5.010E+06
7.	2.389	329.27	412.89	331.68	357.14	432.95	5.763E+06
8.	2.543	358.53	292.81	214.81	342.86	449.01	9.359E+06
9.	2.574	381.68	130.63	72.66	328.57	446.59	7.698E+06
10.	2.663	288.83	687.86	609.32	357.14	441.58	1.175E+07

* * * END OF FILE * * *

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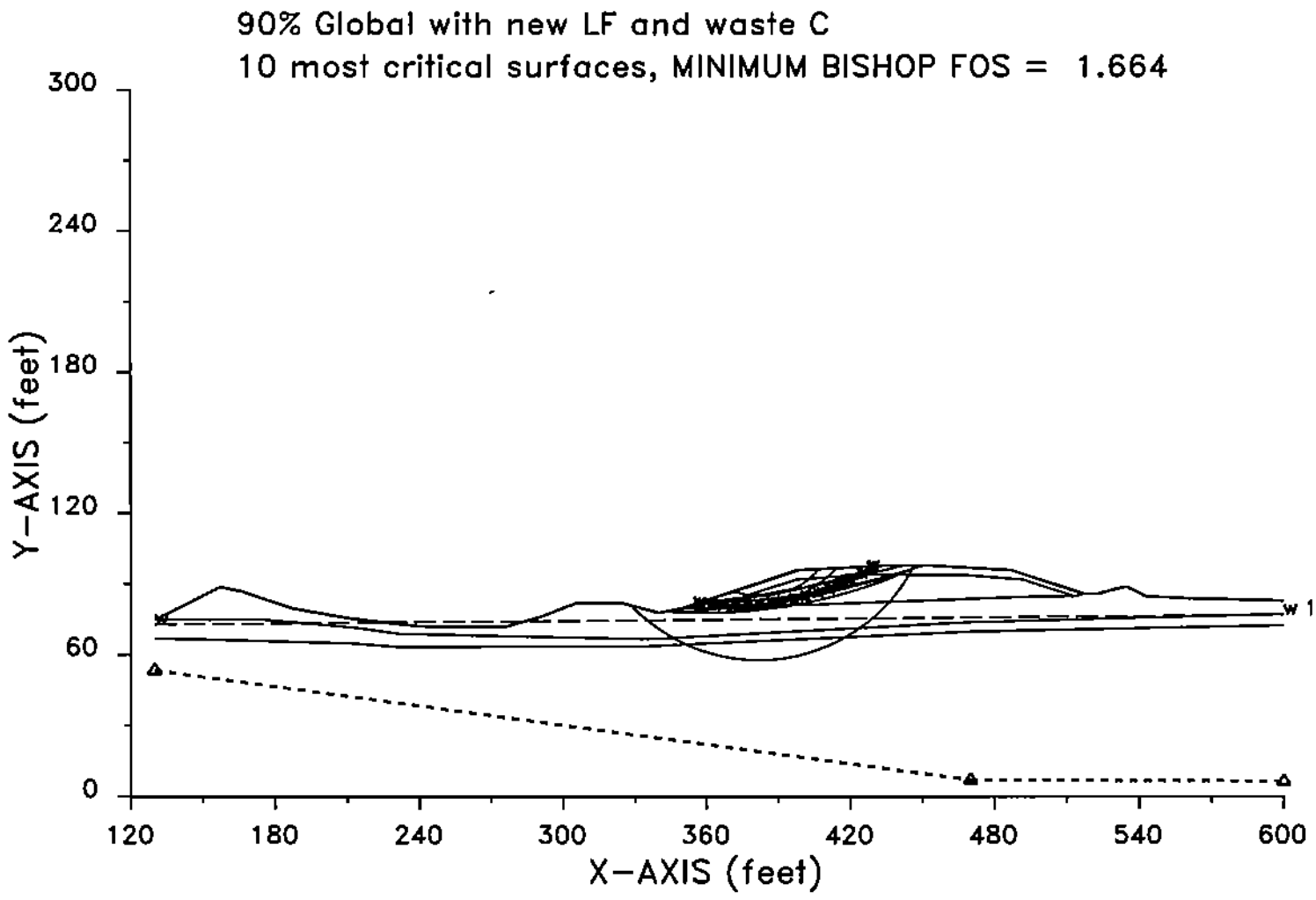

XSTABL File: PWNLRN7D 9-10-** 11:54

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*****************************************
*              X S T A B L              *
*                                       *
*        Slope Stability Analysis       *
*               using the               *
*            Method of Slices           *
*                                       *
*         Copyright (C) 1992 Ã 98       *
*   Interactive Software Designs, Inc.  *
*        Moscow, ID 83843, U.S.A.       *
*                                       *
*          All Rights Reserved          *
*                                       *
*  Ver. 5.202                96 Ã 1641  *
*****************************************
```

Problem Description : 90% Global with new LF and waste C

SEGMENT BOUNDARY COORDINATES

---

23 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	130.0	75.0	157.0	88.8	3
2	157.0	88.8	167.0	86.7	3
3	167.0	86.7	188.0	79.7	3
4	188.0	79.7	210.0	75.7	3
5	210.0	75.7	232.0	73.0	3
6	232.0	73.0	245.0	72.0	3
7	245.0	72.0	275.0	72.0	3
8	275.0	72.0	290.0	76.0	3
9	290.0	76.0	305.0	82.0	3
10	305.0	82.0	325.0	82.0	3
11	325.0	82.0	340.0	78.0	1
12	340.0	78.0	350.0	80.0	1
13	350.0	80.0	398.0	96.0	1
14	398.0	96.0	436.0	98.0	1
15	436.0	98.0	454.0	98.0	1
16	454.0	98.0	487.0	96.0	1
17	487.0	96.0	517.0	86.0	3
18	517.0	86.0	523.0	86.0	3
19	523.0	86.0	530.0	88.0	3
20	530.0	88.0	535.0	89.0	3
21	535.0	89.0	543.0	85.0	3
22	543.0	85.0	563.0	84.0	3
23	563.0	84.0	600.0	83.0	3

21 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	361.0	80.1	397.0	92.0	2
2	397.0	92.0	422.0	94.0	2
3	422.0	94.0	468.0	94.0	2
4	468.0	94.0	492.0	92.0	2
5	492.0	92.0	513.0	85.1	2
6	350.0	80.0	361.0	80.0	3
7	361.0	80.0	497.0	85.0	3
8	497.0	85.0	513.0	85.0	3
9	513.0	85.0	517.0	86.0	3
10	130.0	75.0	176.0	74.9	4
11	176.0	74.9	212.0	71.8	4
12	212.0	71.8	232.0	69.0	4
13	232.0	69.0	336.0	66.9	4
14	336.0	66.9	470.0	74.0	4
15	470.0	74.0	600.0	77.4	4
16	130.0	67.0	147.0	66.8	5
17	147.0	66.8	212.0	65.0	5
18	212.0	65.0	231.0	63.5	5
19	231.0	63.5	336.0	63.9	5
20	336.0	63.9	470.0	70.0	5
21	470.0	70.0	600.0	72.5	5

ISOTROPIC Soil Parameters
---

5 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	122.5	122.5	.0	36.00	.000	.0	0
2	96.0	96.0	250.0	.00	.000	.0	0
3	115.0	115.0	.0	34.00	.000	.0	1
4	140.0	140.0	.0	37.00	.000	.0	1
5	116.4	116.5	724.0	.00	.000	.0	1

1 Water surface(s) have been specified

Unit weight of water = 62.40 (pcf)

Water Surface No. 1 specified by 2 coordinate points

****
PHREATIC SURFACE,
****

Point No.	x-water (ft)	y-water (ft)
1	130.00	73.00
2	600.00	77.10

BOUNDARIES THAT LIMIT SURFACE GENERATION HAVE BEEN SPECIFIED

LOWER limiting boundary of 2 segments:

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)
1	130.0	53.5	470.0	7.1
2	470.0	7.1	600.0	6.4

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

80 trial surfaces will be generated and analyzed.

10 Surfaces initiate from each of 8 points equally spaced along the ground surface between x = 300.0 ft
and x = 400.0 ft

Each surface terminates between x = 405.0 ft
and x = 450.0 ft

Unless further limitations were imposed, the minimum elevation at which a surface extends is y = 10.0 ft

5.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS

The first segment of each failure surface will be inclined within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

```
**************************************************************
**     Factor of safety calculation for surface #    71     **
**     failed to converge within FIFTY iterations           **
**                                                          **
**    The last calculated value of the FOS was  21.7660     **
**    This will be ignored for final summary of results     **
**************************************************************

Circular surface (FOS= 21.7660) is defined by: xcenter =    407.36
ycenter =    100.70   Init. Pt. =    400.00   Seg. Length =   5.00
--------------------------------------------------------------------

**************************************************************
**     Factor of safety calculation for surface #    76     **
**     failed to converge within FIFTY iterations           **
**                                                          **
**    The last calculated value of the FOS was  22.1593     **
**    This will be ignored for final summary of results     **
**************************************************************

Circular surface (FOS= 22.1593) is defined by: xcenter =    405.61
ycenter =    101.79   Init. Pt. =    400.00   Seg. Length =   5.00
--------------------------------------------------------------------

    Factors of safety have been calculated by the :

    * * * * *   SIMPLIFIED BISHOP METHOD   * * * * *


      The most critical circular failure surface
      is specified by 17 coordinate points

           Point      x-surf      y-surf
            No.        (ft)        (ft)

             1        357.14       82.38
             2        362.10       81.75
             3        367.09       81.35
             4        372.08       81.19
             5        377.08       81.26
             6        382.07       81.57
             7        387.04       82.12
             8        391.98       82.89
             9        396.88       83.90
            10        401.73       85.14
            11        406.51       86.60
            12        411.21       88.29
            13        415.83       90.20
            14        420.36       92.32
```

15	424.78	94.66
16	429.09	97.20
17	429.82	97.67

**** Simplified BISHOP FOS = 1.555 ****

****
** **
** Out of the 80 surfaces generated and analyzed by XSTABL, **
** 2 surfaces were found to have MISLEADING FOS values. **
** **
****

The following is a summary of the TEN most critical surfaces

Problem Description : 90% Global with new LF and waste C

	FOS (BISHOP)	Circle Center x-coord (ft)	Circle Center y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)
1.	1.555	373.02	187.33	106.14	357.14	429.82	1.845E+06
2.	1.820	382.63	116.45	31.37	371.43	406.71	2.707E+05
3.	1.904	338.63	404.52	325.98	342.86	449.54	8.794E+06
4.	1.961	374.13	135.06	55.34	357.14	414.08	1.174E+06
5.	2.147	353.54	387.69	305.33	357.14	449.99	6.540E+06
6.	2.167	339.21	364.99	283.18	357.14	433.12	4.721E+06
7.	2.256	329.27	412.89	331.68	357.14	432.95	5.442E+06
8.	2.488	358.53	292.81	214.81	342.86	449.01	9.158E+06
9.	2.519	288.83	687.86	609.32	357.14	441.58	1.112E+07
10.	2.567	381.68	130.63	72.66	328.57	446.59	7.678E+06

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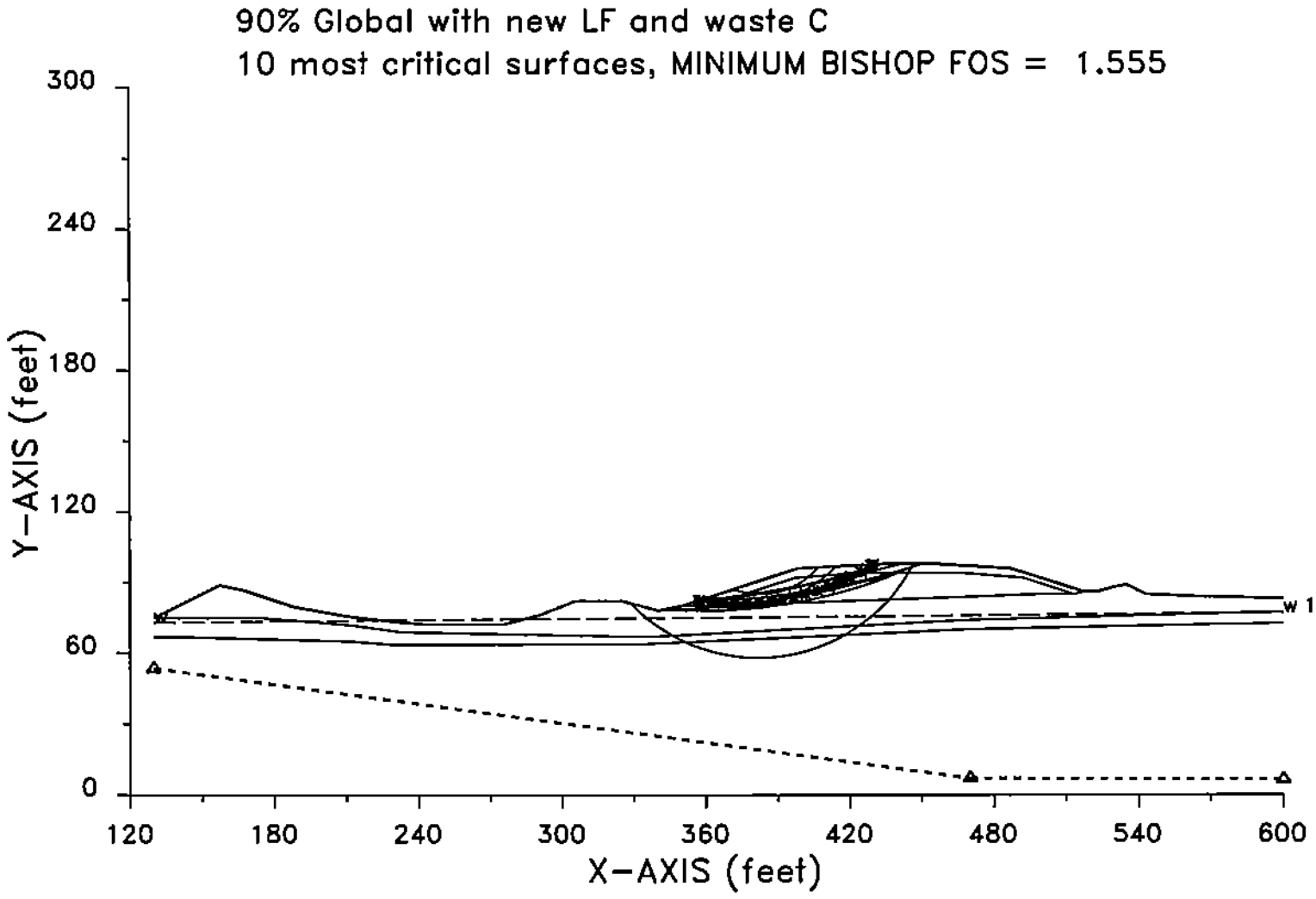

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*****************************************
*              X S T A B L              *
*                                       *
*        Slope Stability Analysis       *
*               using the               *
*            Method of Slices           *
*                                       *
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```

Problem Description : 90% Global, C=250 psf, Block

SEGMENT BOUNDARY COORDINATES

---

23 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	130.0	75.0	157.0	88.8	3
2	157.0	88.8	167.0	86.7	3
3	167.0	86.7	188.0	79.7	3
4	188.0	79.7	210.0	75.7	3
5	210.0	75.7	232.0	73.0	3
6	232.0	73.0	245.0	72.0	3
7	245.0	72.0	275.0	72.0	3
8	275.0	72.0	290.0	76.0	3
9	290.0	76.0	305.0	82.0	3
10	305.0	82.0	325.0	82.0	3
11	325.0	82.0	340.0	78.0	1
12	340.0	78.0	350.0	80.0	1
13	350.0	80.0	398.0	96.0	1
14	398.0	96.0	436.0	98.0	1
15	436.0	98.0	454.0	98.0	1
16	454.0	98.0	487.0	96.0	1
17	487.0	96.0	517.0	86.0	3
18	517.0	86.0	523.0	86.0	3
19	523.0	86.0	530.0	88.0	3
20	530.0	88.0	535.0	89.0	3
21	535.0	89.0	543.0	85.0	3
22	543.0	85.0	563.0	84.0	3
23	563.0	84.0	600.0	83.0	3

21 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	361.0	80.1	397.0	92.0	2
2	397.0	92.0	422.0	94.0	2
3	422.0	94.0	468.0	94.0	2
4	468.0	94.0	492.0	92.0	2
5	492.0	92.0	513.0	85.1	2
6	350.0	80.0	361.0	80.0	3
7	361.0	80.0	497.0	85.0	3
8	497.0	85.0	513.0	85.0	3
9	513.0	85.0	517.0	86.0	3
10	130.0	75.0	176.0	74.9	4
11	176.0	74.9	212.0	71.8	4
12	212.0	71.8	232.0	69.0	4
13	232.0	69.0	336.0	66.9	4
14	336.0	66.9	470.0	74.0	4
15	470.0	74.0	600.0	77.4	4
16	130.0	67.0	147.0	66.8	5
17	147.0	66.8	212.0	65.0	5
18	212.0	65.0	231.0	63.5	5
19	231.0	63.5	336.0	63.9	5
20	336.0	63.9	470.0	70.0	5
21	470.0	70.0	600.0	72.5	5

ISOTROPIC Soil Parameters
---

5 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	122.5	122.5	.0	36.00	.000	.0	0
2	96.0	96.0	250.0	.00	.000	.0	0
3	115.0	115.0	.0	34.00	.000	.0	1
4	140.0	140.0	.0	37.00	.000	.0	1
5	116.4	116.5	724.0	.00	.000	.0	1

1 Water surface(s) have been specified

Unit weight of water = 62.40 (pcf)

Water Surface No. 1 specified by 2 coordinate points

****
PHREATIC SURFACE,
****

Point No.	x-water (ft)	y-water (ft)
1	130.00	73.00
2	600.00	77.10

BOUNDARIES THAT LIMIT SURFACE GENERATION HAVE BEEN SPECIFIED

LOWER limiting boundary of 2 segments:

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)
1	130.0	53.5	470.0	7.1
2	470.0	7.1	600.0	6.4

A critical failure surface searching method, using a random technique for generating sliding BLOCK surfaces, has been specified.

The active and passive portions of the sliding surfaces are generated according to the Rankine theory.

500 trial surfaces will be generated and analyzed.

3 boxes specified for generation of central block base

* * * * * DEFAULT SEGMENT LENGTH SELECTED BY XSTABL * * * * *

Length of line segments for active and passive portions of sliding block is 2.0 ft

Box no.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Width (ft)
1	360.0	80.0	380.0	80.0	6.0
2	390.0	85.0	420.0	85.0	6.0
3	425.0	92.0	450.0	92.0	6.0

WARNING - limitation boundaries have been specified !,
These are ignored for RANKINE block analysis

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED JANBU METHOD * * * * *

The 10 most critical of all the failure surfaces examined
are displayed below - the most critical first

Failure surface No. 1 specified by 14 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	359.16	83.05
2	359.83	82.71
3	361.62	81.80
4	363.40	80.89
5	364.17	80.12
6	364.24	80.08
7	415.35	82.65
8	426.00	90.26
9	427.42	91.67
10	428.83	93.09
11	429.74	94.00
12	430.65	95.78
13	431.56	97.56
14	431.67	97.77

** Corrected JANBU FOS = 1.647 ** (Fo factor = 1.061)

Failure surface No. 2 specified by 12 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	362.16	84.05
2	362.84	83.70
3	364.62	82.80
4	366.41	81.89
5	367.47	80.82
6	397.87	82.92
7	426.16	92.06
8	427.57	93.47
9	428.10	94.00
10	429.00	95.78
11	429.91	97.56
12	429.97	97.68

** Corrected JANBU FOS = 1.673 ** (Fo factor = 1.049)

Failure surface No. 3 specified by 12 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	364.50	84.83
2	365.19	84.48
3	366.98	83.57
4	368.76	82.66
5	369.17	82.26
6	370.58	80.84
7	395.94	82.63
8	427.40	93.45
9	427.95	94.00
10	428.86	95.78
11	429.77	97.56
12	429.82	97.67

** Corrected JANBU FOS = 1.686 ** (Fo factor = 1.051)

Failure surface No. 4 specified by 8 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	357.60	82.53
2	357.99	82.34
3	359.78	81.43
4	361.56	80.52
5	411.25	84.07
6	430.85	94.66
7	431.75	96.44
8	432.45	97.81

** Corrected JANBU FOS = 1.691 ** (Fo factor = 1.050)

Failure surface No. 5 specified by 11 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	356.36	82.12
2	356.96	81.82
3	358.74	80.91
4	360.53	80.00
5	361.45	79.51
6	393.83	82.61
7	426.95	92.75
8	428.20	94.00
9	429.11	95.78
10	430.02	97.56
11	430.08	97.69

** Corrected JANBU FOS = 1.706 ** (Fo factor = 1.042)

Failure surface No. 6 specified by 9 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	358.87	82.96
2	359.54	82.61
3	361.32	81.70
4	363.11	80.80
5	363.19	80.72
6	408.27	82.18
7	440.52	94.69
8	441.43	96.47
9	442.20	98.00

** Corrected JANBU FOS = 1.719 ** (Fo factor = 1.047)

Failure surface No. 7 specified by 14 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	363.28	84.43
2	363.97	84.08
3	365.75	83.17
4	367.53	82.26
5	367.71	82.09
6	369.12	80.67
7	406.42	82.99
8	430.02	90.35
9	431.43	91.76
10	432.85	93.17
11	433.67	94.00
12	434.58	95.78
13	435.49	97.56
14	435.70	97.98

** Corrected JANBU FOS = 1.719 ** (Fo factor = 1.052)

Failure surface No. 8 specified by 13 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	360.79	83.60
2	361.47	83.25
3	363.25	82.34
4	365.03	81.43
5	365.37	81.10
6	401.29	83.51
7	426.16	90.97
8	427.58	92.38
9	428.99	93.80
10	429.19	94.00
11	430.10	95.78
12	431.01	97.56

13	431.10	97.74

** Corrected JANBU FOS = 1.721 ** (Fo factor = 1.047)

Failure surface No. 9 specified by 13 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	359.52	83.17
2	360.20	82.83
3	361.98	81.92
4	363.76	81.01
5	364.33	80.44
6	408.82	83.68
7	431.67	89.95
8	433.09	91.37
9	434.50	92.78
10	435.72	94.00
11	436.63	95.78
12	437.54	97.56
13	437.76	98.00

** Corrected JANBU FOS = 1.730 ** (Fo factor = 1.046)

Failure surface No.10 specified by 9 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	359.01	83.00
2	359.47	82.77
3	361.26	81.86
4	415.13	82.28
5	429.36	93.74
6	429.62	94.00
7	430.53	95.78
8	431.44	97.56
9	431.54	97.77

** Corrected JANBU FOS = 1.746 ** (Fo factor = 1.062)

The following is a summary of the TEN most critical surfaces

Problem Description : 90% Global, C=250 psf, Block

	Modified JANBU FOS	Correction Factor	Initial x-coord (ft)	Terminal x-coord (ft)	Available Strength (lb)
1.	1.647	1.061	359.16	431.67	1.941E+04

2.	1.673	1.049	362.16	429.97	1.745E+04
3.	1.686	1.051	364.50	429.82	1.685E+04
4.	1.691	1.050	357.60	432.45	1.916E+04
5.	1.706	1.042	356.36	430.08	2.021E+04
6.	1.719	1.047	358.87	442.20	2.127E+04
7.	1.719	1.052	363.28	435.70	1.877E+04
8.	1.721	1.047	360.79	431.10	1.803E+04
9.	1.730	1.046	359.52	437.76	2.011E+04
10.	1.746	1.062	359.01	431.54	1.873E+04

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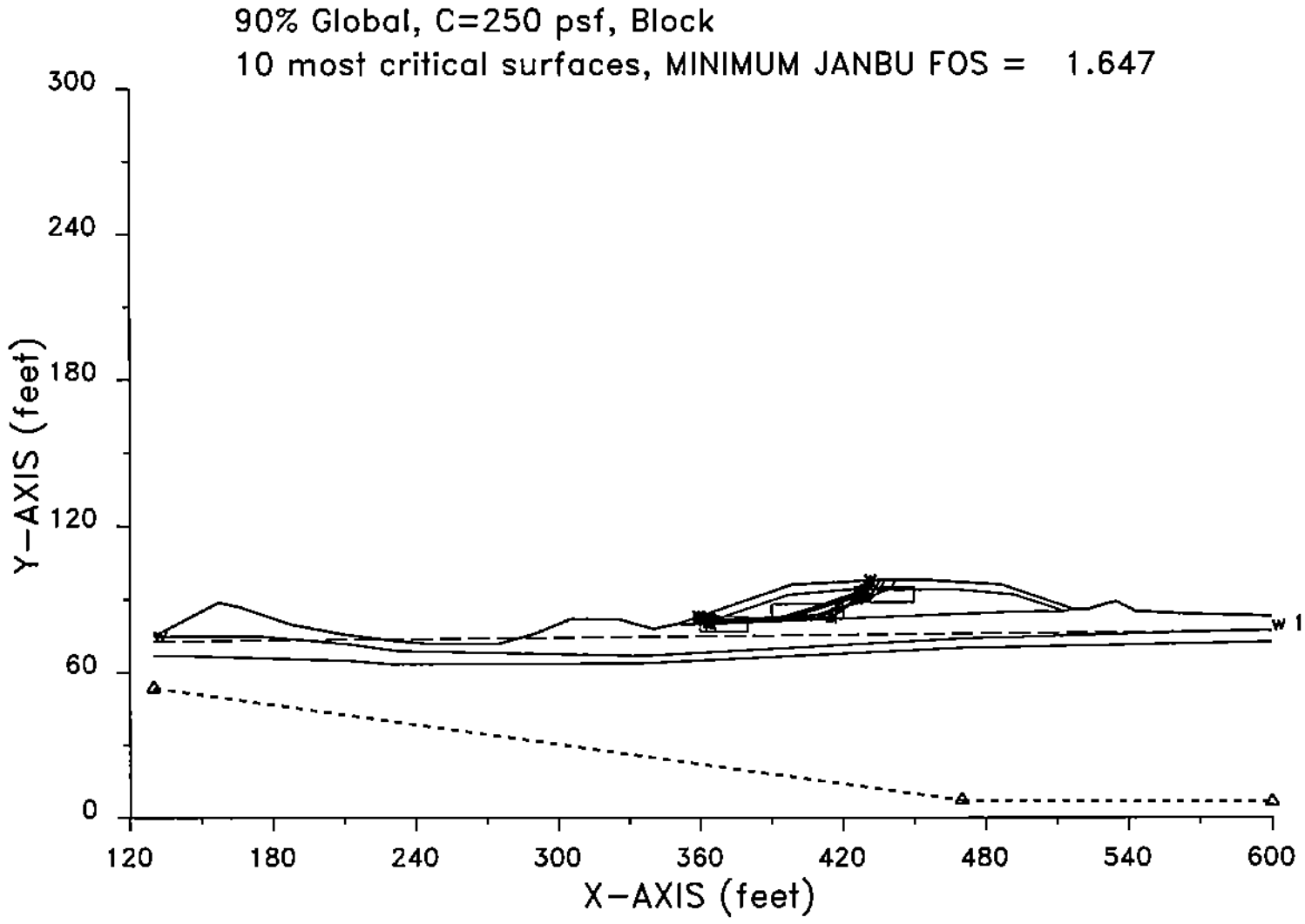

APPENDIX H-2

SHEET NO. 1 OF 1
PROJECT NO.
DATE 1/20/03
BY GAM
CHK'D FC

TRC
Customer-Focused Solutions

SUBJECT Pownal Tannery Landfill

Determine Minimum Friction Angle for Cover Soil, Sludge Landfill Cap, Pownal Tannery

Assume minimum FS = 1.5, Use Infinite Slope Analysis

ϕ = Internal angle of Friction Cover Soil

i = Angle of slope (18.43°)

Note: 18.43° = 3:1 slope

$$FS = \frac{\tan\phi}{\tan i}$$

$$1.5 = \frac{\tan\phi}{\tan(18.43°)}$$

$$\tan\phi = 1.5(0.333)$$

$$\tan\phi = 0.50$$

$$\phi = 26.57°$$

A

Table 11.3 Summary of Friction Angle Data for Use in Preliminary Design

	Friction Angles							
	Slope Angle of Repose		At Ultimate Strength		At Peak Strength			
					Medium Dense		Dense	
Classification	i(°)	Slope (vert. to hor.)	ϕ_{cv}(°)	tan ϕ_{cv}	ϕ(°)	tan ϕ	ϕ(°)	tan ϕ
Silt (nonplastic)	26 to 30	1 on 2 to 1 on 1.75	26 to 30	0.488 to 0.577	28 to 32	0.532 to 0.625	30 to 34	0.577 to 0.675
Uniform fine to medium sand	26 to 30	1 on 2 to 1 on 1.75	26 to 30	0.488 to 0.577	30 to 34	0.577 to 0.675	32 to 36	0.675 to 0.726
Well-graded sand	30 to 34	1 on 1.75 to 1 on 1.50	30 to 34	0.577 to 0.675	34 to 40	0.675 to 0.839	38 to 46	0.839 to 1.030
Sand and gravel	32 to 36	1 on 1.60 to 1 on 1.40	32 to 36	0.625 to 0.726	36 to 42	0.726 to 0.900	40 to 48	0.900 to 1.110

From B. K. Hough, *Basic Soils Engineering*. Copyright © 1957, The Ronald Press Company, New York.
Note. Within each range, assign lower values if particles are well rounded or if there is significant soft shale or mica content, higher values for hard, angular particles. Use lower values for high normal pressures than for moderate normal pressure.

problems involving man-made fills, it is difficult to either measure or estimate the friction angle of a sand on the basis of laboratory tests alone. For these reasons, extensive use is made in practice of correlations between the friction angle of a sand and the resistance of the natural sand deposit to penetration.

Figure 11.14 shows an empirical correlation between the resistance offered to the standard penetration spoon (Chapter 7) and the friction angle. Inevitably, any such correlation is crude. The actual friction angle may deviate by ±3° or more from the value given by the curve. The given relation is intended to apply for depths of overburden up to 40 ft, and is conservative for greater depths.

11.6 SUMMARY OF MAIN POINTS

1. The strength of soil can be represented by a Mohr envelope, which is a plot of τ_{ff} versus σ_{ff}. Generally the Mohr envelope of a granular soil is curved. For stresses less than 100 psi, the envelope usually is almost straight so that
$$\tau_{ff} = \sigma_{ff} \tan \phi$$
where ϕ is the friction angle corresponding to the peak point of the stress-strain curve.
2. The value of ϕ for any soil depends upon ϕ_μ and upon the amount of interlocking; i.e., the initial void ratio and σ_{ff}.
3. Where sand is being subjected to very large strains, ϕ_{cv} should be used in the failure law. Unless the sand is very loose, ϕ_{cv} will be less than ϕ. Where the sand is sliding over the surface of a structure, the friction angle will vary from ϕ_μ to ϕ_{cv}, depending on the smoothness of the surface.
4. A knowledge of the effect of composition helps guide the selection of materials to be used in man-made fills
5. Materials to be used in man-made fills should be tested using the actual range of confining pressures which will be encountered in the fill.
6. For many practical problems, the friction angle of an *in situ* sand deposit can be determined by indirect means, such as the standard penetration test.

PROBLEMS

11.1 Given the following triaxial test data, plot the results (*a*) in a Mohr diagram and (*b*) in a *p–q* diagram, and determine ϕ by each method.

Lambe, T., Whitman, R., 1969. "Soil Mechanics," John Wiley & Sons, New York

prepared by: GAM
checked: FC

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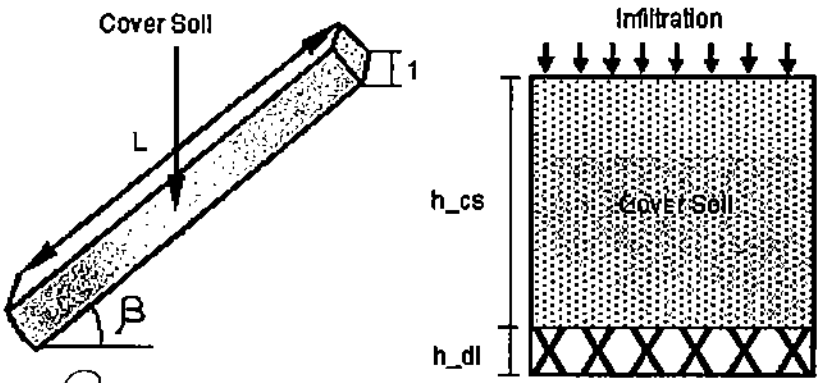
Cover Slope Stability - Design Calculator

Pownal Tannery Superfund Site
Sludge Consolidation Landfill
Side Slopes with Vegetative Cover Soil

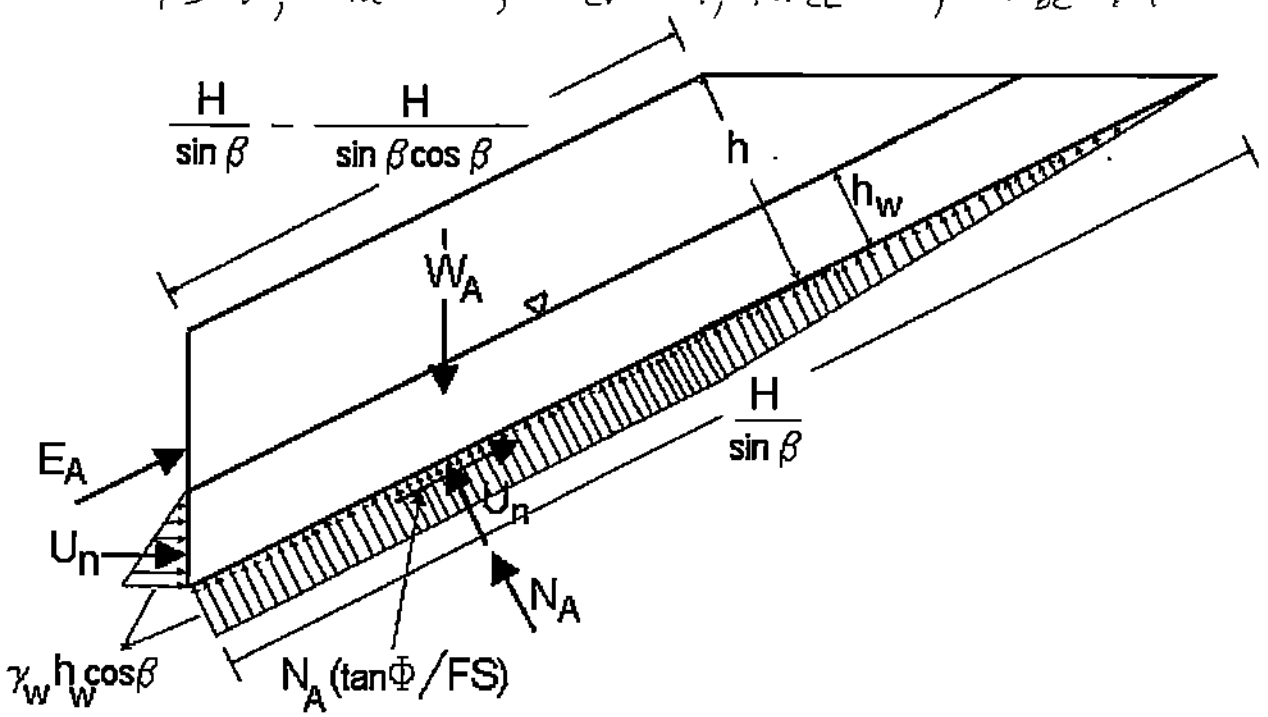
Problem Statement

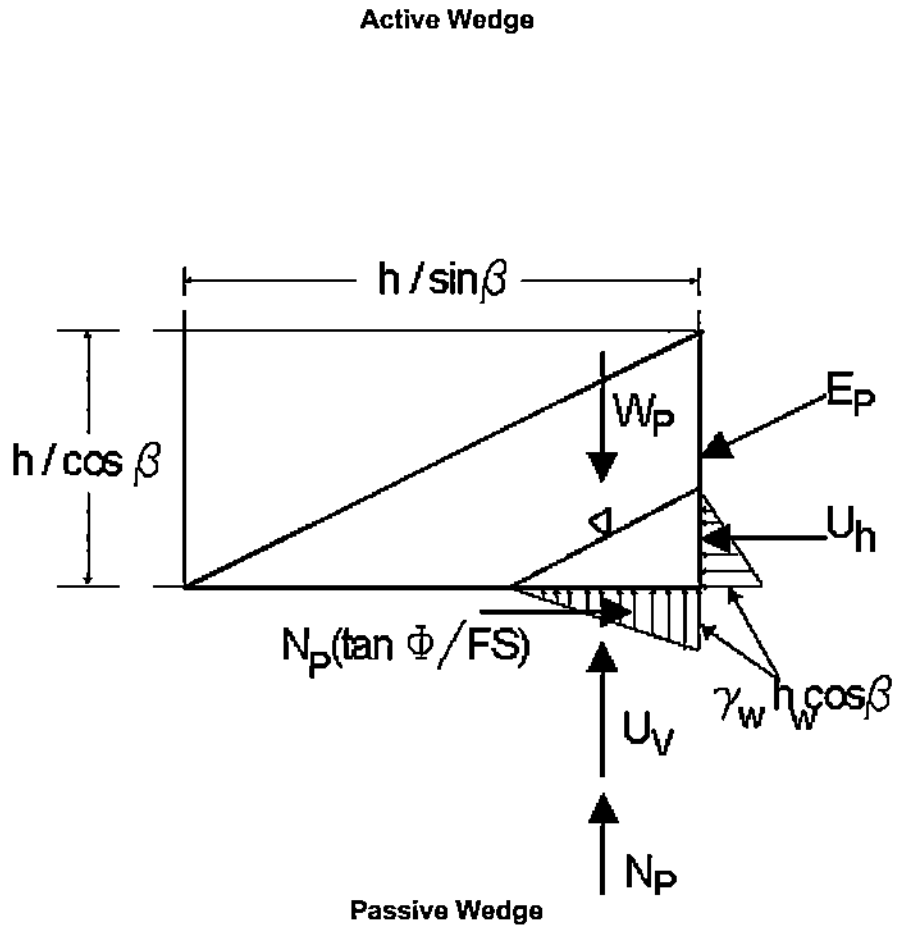


Assumptions for drainage Layer:

1) $\theta_{d+} = 6 \times 10^{-3}\ m^2/s$ from drainage layer design
2) $h_{dl} = 0.007\ m$ (typical thickness of a triplanar or heavy bi-planar geocomposite)
3. $FS_L = FS \times RF_{in} \times RF_{cr} \times RF_{cc} \times RF_{bc} = 6.55$

$FS = 2$, $RF_{in} = 1.2$, $RF_{cr} = 1.4$, $RF_{cc} = 1.2$, $RF_{bc} = 1.9$





Input Values

Design Input

Slope characteristics

Length of the slope (L)	12.85	m
Slope angle (ß)	18.43	degrees ← 3:1 slope

Height of soil layers

Height of cover soil (h_cs)	762	mm ← 24" cover soil, 6" top soil
Height of drainage layer (h_dl)	7	mm

Permeability of the soil layers

Permeability of the soil layers

Permeability of cover soil	.0001	cm/s
Design permeability of drainage layer	13	cm/s

$\frac{\theta_{ult}}{FS_t} = k\,t$

$\frac{6\times10^{-3}\,m^2}{5} = k\,(0.007\,m)$

$\frac{}{6.55}$

$k = 13$ cm/s

Rain intensity parameters

Precipitation	50	mm/hr
Run-off coefficient	0.4	

overestimate to ensure saturation of cover soil

Soil characteristics

Dry unit weight of cover soil	18.458	kN/m^3
Saturated unit weight of the cover soil	19.24	kN/m^3

Unit weight used in global stability analysis

Friction angles

Friction angle of the cover soil	30	degrees
Friction angle of the cover soil / underlying interface	23.8	degrees

(conservative value for cover soil)

Stability Calculation

↖ Required interface friction (adjusted until FS ≥ 1.5)

Solution

I. Normalized Input data

Gradient	0.316
Horizontal length	12.191 m
Height cover soil and drainage layer	0.769 m
Permeability of cover soil in m/s	1.00E-006 m/s
Design permeability of the drainage layer in m/s	0.13 m/s

II. Calculation of the Drainage Capacity

Precipitation from input	50 mm/hr
Actual runoff	46.4 mm/hr
Actual percolation	3.6 mm/hr
Actual flux	0.044 m^3/hr
Allowable flux	1.036 m^3/hr
Drainage Layer Capacity (DLC) (needs to be >1.0 to avoid saturation)	**23.599**

Geocomposite will keep cover soil in a drained state

III. Parallel Submergence Ratio (PSR)

Average height water table	2.97E-004 m
Parallel Submergence Ratio (PSR)	**0.000**

Stability Factor of Safety (FS)	**1.510**

OK

Material Selection

Follow the GFR link to view our extensive database of geosynthetic materials reprinted with permission of IFAI

GFR

Additional Assistance

If you would like to have Advanced Geotech Systems provide material specifications that meet your performance criteria, please fill in the following fields and click the submit button. All information is kept strictly confidential.

Name *

Company

Email Address *

Phone

Project Reference

Comments

*required fields

Submit Design Results

Sponsored by

The following companies can service any of your geomembrane protection material selection needs.

References

R. M. Koerner, and T-Y. Soong, 1998. "Analysis and Design of Veneer Cover Soils". Proceedings of 6th International Conference on Geosynthetics, Vol. 1, pp. 1-23, Atlanta, Georgia, USA.

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Prepared: GAM

Connection: Close

go to problem statement input values solution material selection contact help references

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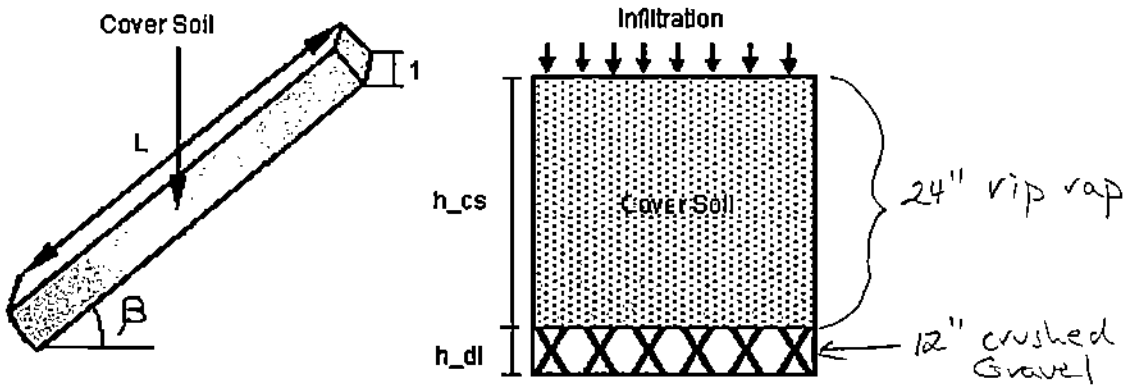
Cover Slope Stability - Design Calculator

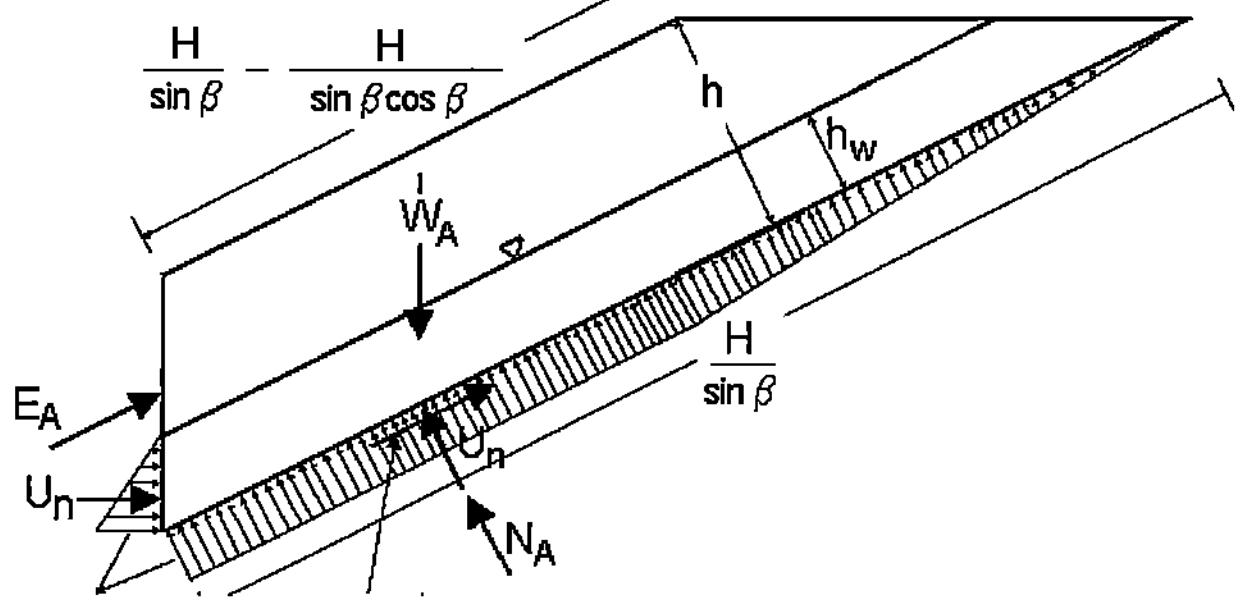
Pownal Tannery Superfund Site
Sludge Consolidation Landfill
Rip Rap Side Slopes with 12" Crushed Gravel
Undrained Conditions

Problem Statement

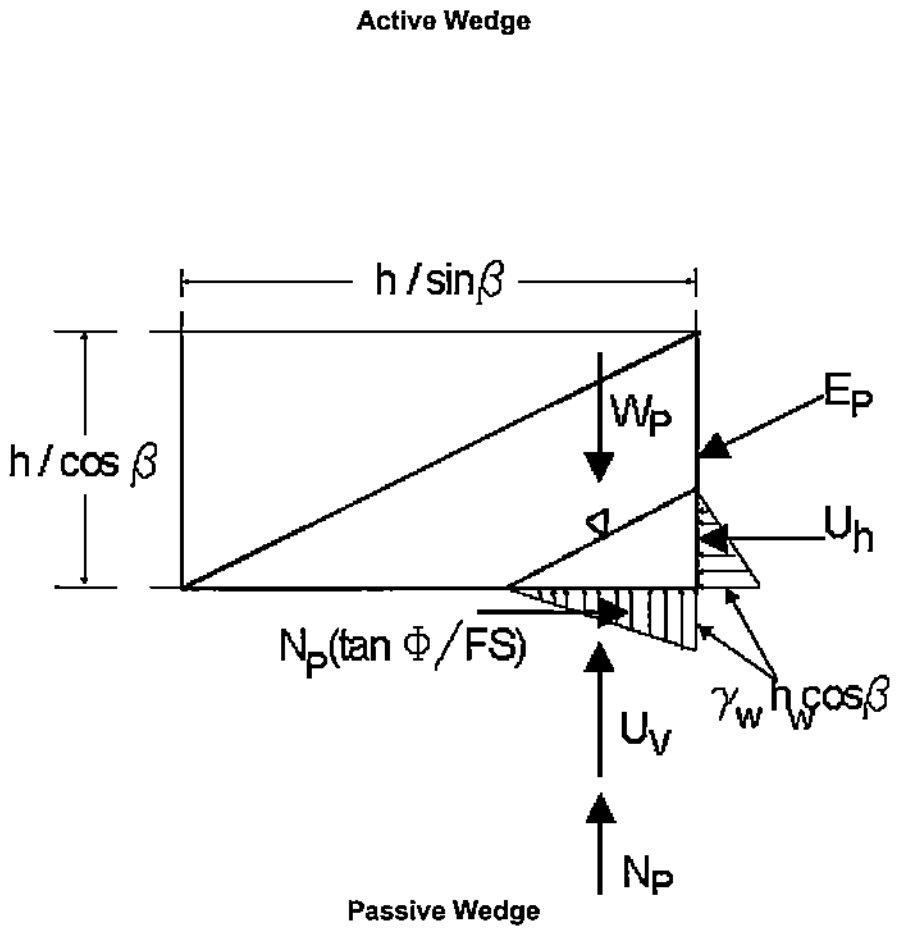


Assumptions:

1) Rip rap is free draining and will not develop seepage forces.
2) Crushed gravel will become saturated and develop seepage forces. Crushed gravel layer will act as drainage layer.
3) Keep precipitation at default (0.5mm/hr) and adjust permeability of crushed gravel until the layer is just saturated.
4) Adjust interface friction angle until FS ≥ 1.3



$\gamma_w h_w \cos\beta \quad < \quad N_A(\tan\Phi/FS)$



Input Values

Design Input

Slope characteristics

Length of the slope (L)	19.28	m	$L = \frac{60\ ft}{\cos 18.43^\circ}$
Slope angle (ß)	18.43	degrees	

Height of soil layers

Height of cover soil (h_cs)	609.6	mm	24" Rip Rap

Height of drainage layer (h_dl)	304.8	mm	12" Crushed Gravel
Permeability of the soil layers			
Permeability of cover soil	10	cm/s	← Rip Rap Assumed to be free draining
Design permeability of drainage layer	0.001	cm/s	← Adjusted Kdl until crushed Gravel Saturated
Rain intensity parameters			
Precipitation	0.5	mm/hr	Default value →
Run-off coefficient	0.6		← Assumes high run off through rip rap
Soil characteristics			
Dry unit weight of cover soil	20.5	kN/m^3	→ Rip Rap = 130 pcf
Saturated unit weight of the cover soil	20.5	kN/m^3	
Friction angles			
Friction angle of the cover soil	34	degrees	(conservative for riprap / crushed gravel)
Friction angle of the cover soil / underlying interface	25	degrees	← Adjusted until FS ≥ 1.3 (Required interface friction value)

Stability Calculation

Solution

I. Normalized Input data

Gradient	0.316
Horizontal length	18.291 m
Height cover soil and drainage layer	0.9144 m
Permeability of cover soil in m/s	1.00E-001 m/s
Design permeability of the drainage layer in m/s	1e-005 m/s

II. Calculation of the Drainage Capacity

Precipitation from input	0.5 mm/hr
Actual runoff	0.3 mm/hr
Actual percolation	0.2 mm/hr
Actual flux	0.004 m^3/hr
Allowable flux	0.003 m^3/hr
Drainage Layer Capacity (DLC) (needs to be >1.0 to avoid saturation)	**0.948**

III. Parallel Submergence Ratio (PSR)

12" Crushed Gravel just saturated

Average height water table	3.05E-001 m ←
Parallel Submergence Ratio (PSR)	**0.333**

Stability Factor of Safety (FS) **1.316** OK

Material Selection

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GFR

Additional Assistance

If you would like to have Advanced Geotech Systems provide material specifications that meet your performance criteria, please fill in the following fields and click the submit button. All information is kept strictly confidential.

Name *

Company

Email Address *

Phone

Project Reference

Comments

*required fields

Submit Design Results

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References

R. M. Koerner, and T-Y. Soong, 1998. "Analysis and Design of Veneer Cover Soils". Proceedings of 6th International Conference on Geosynthetics, Vol. 1, pp. 1-23, Atlanta, Georgia, USA.

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Checked: FC

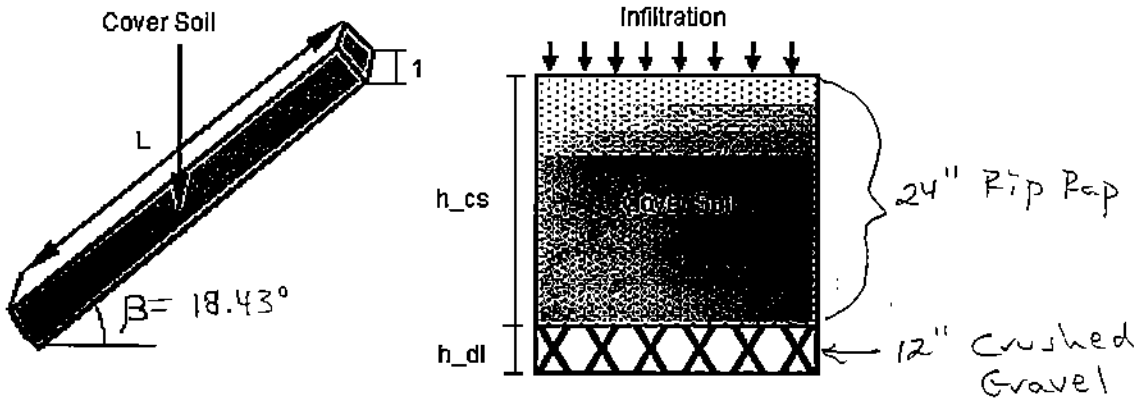
Prepared: GAM

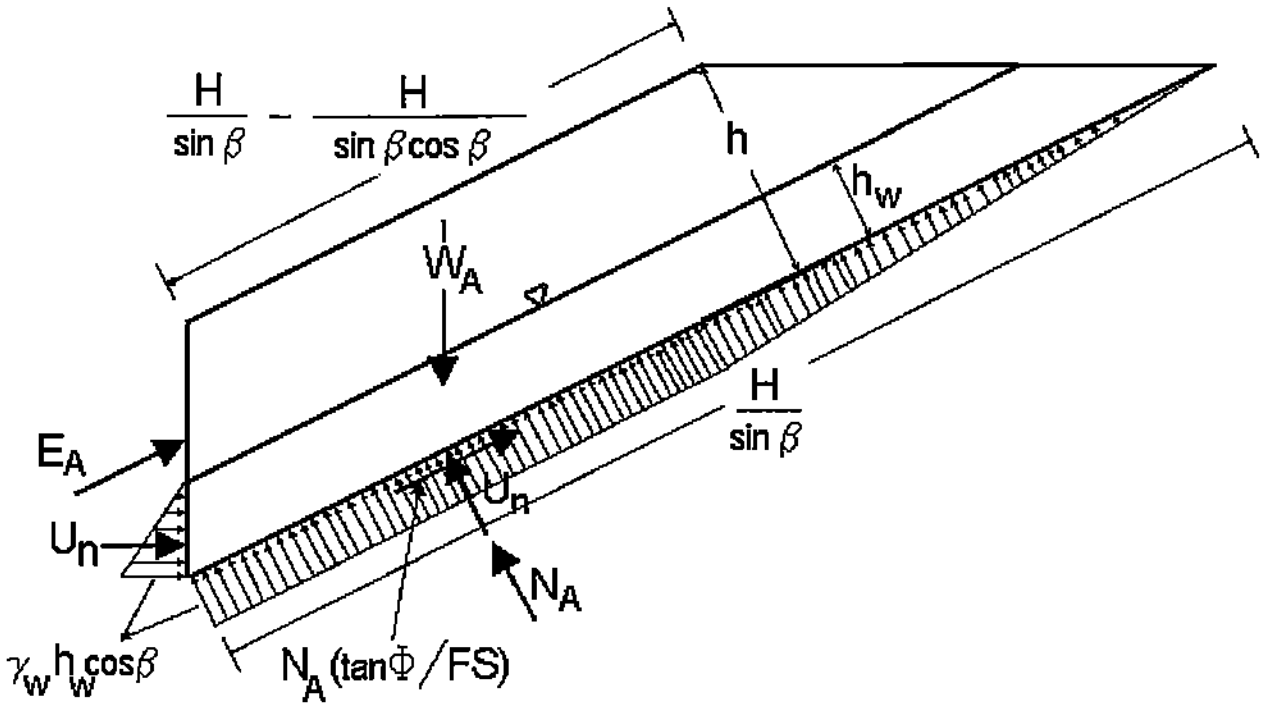
landfilldesign.com

Cover Slope Stability - Design Calculator

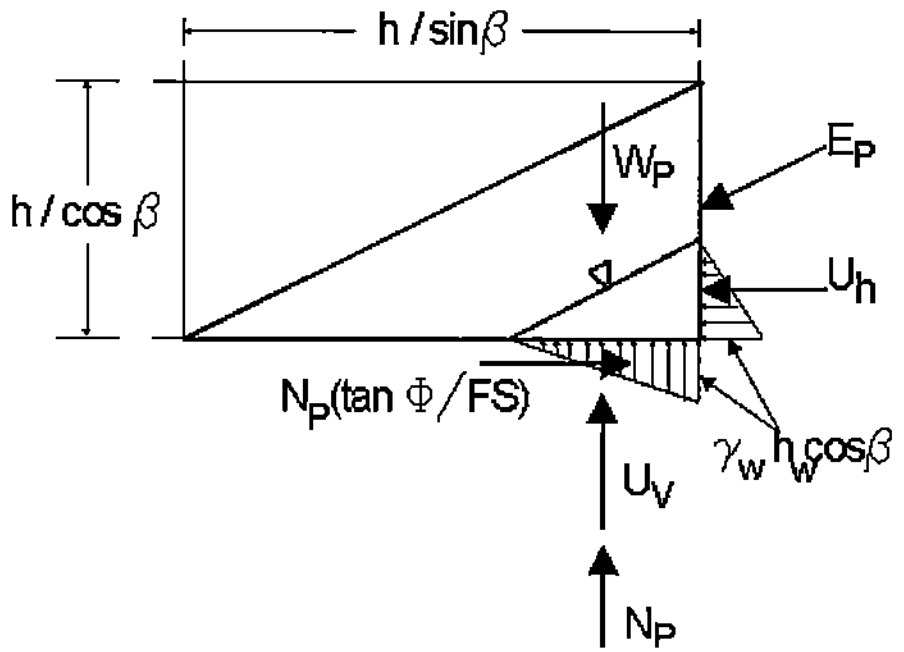
Powmal Tannery Superfund Site
Sludge Consolidation Landfill
Check of Undrained Conditions analysis for
Rip Rap Side Slopes with 12" Crushed Gravel

Problem Statement





Active Wedge



Passive Wedge

Input Values

Design Input

Slope characteristics

Length of the slope (L)	19.28	m
Slope angle (ß)	18.43	degrees

Height of soil layers

Height of cover soil (h_cs)	609.6	mm
Height of drainage layer (h_dl)	304.8	mm

Permeability of the soil layers

Permeability of cover soil	10	cm/s
Design permeability of drainage layer	.001	cm/s

Rain intensity parameters

Precipitation	50	mm/hr
Run-off coefficient	0.6	

Increased precipitation to evaluate effect on stability

Soil characteristics

Dry unit weight of cover soil	20.5	kN/m^3
Saturated unit weight of the cover soil		kN/m^3

	20.5	
Friction angles		
Friction angle of the cover soil	34	degrees
Friction angle of the cover soil / underlying interface	25	degrees

Stability Calculation

Solution

I. Normalized Input data

Gradient	0.316
Horizontal length	18.291 m
Height cover soil and drainage layer	0.9144 m
Permeability of cover soil in m/s	1.00E-001 m/s
Design permeability of the drainage layer in m/s	1e-005 m/s

II. Calculation of the Drainage Capacity

Precipitation from input	50 mm/hr
Actual runoff	30 mm/hr
Actual percolation	20 mm/hr
Actual flux	0.366 m^3/hr
Allowable flux	0.003 m^3/hr
Drainage Layer Capacity (DLC) (needs to be >1.0 to avoid saturation)	**0.009**

III. Parallel Submergence Ratio (PSR)

Average height water table	3.08E-001 m
Parallel Submergence Ratio (PSR)	**0.337**

Stability Factor of Safety (FS) **1.313** ok FS ≥ 1.3

Material Selection

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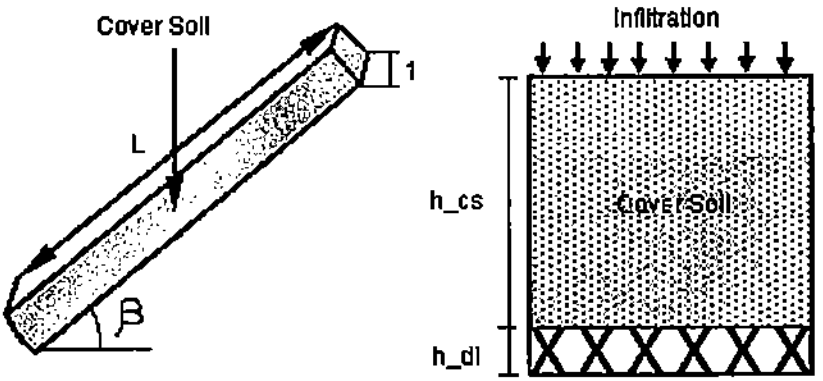
Checked: FC
Prepared: GAM

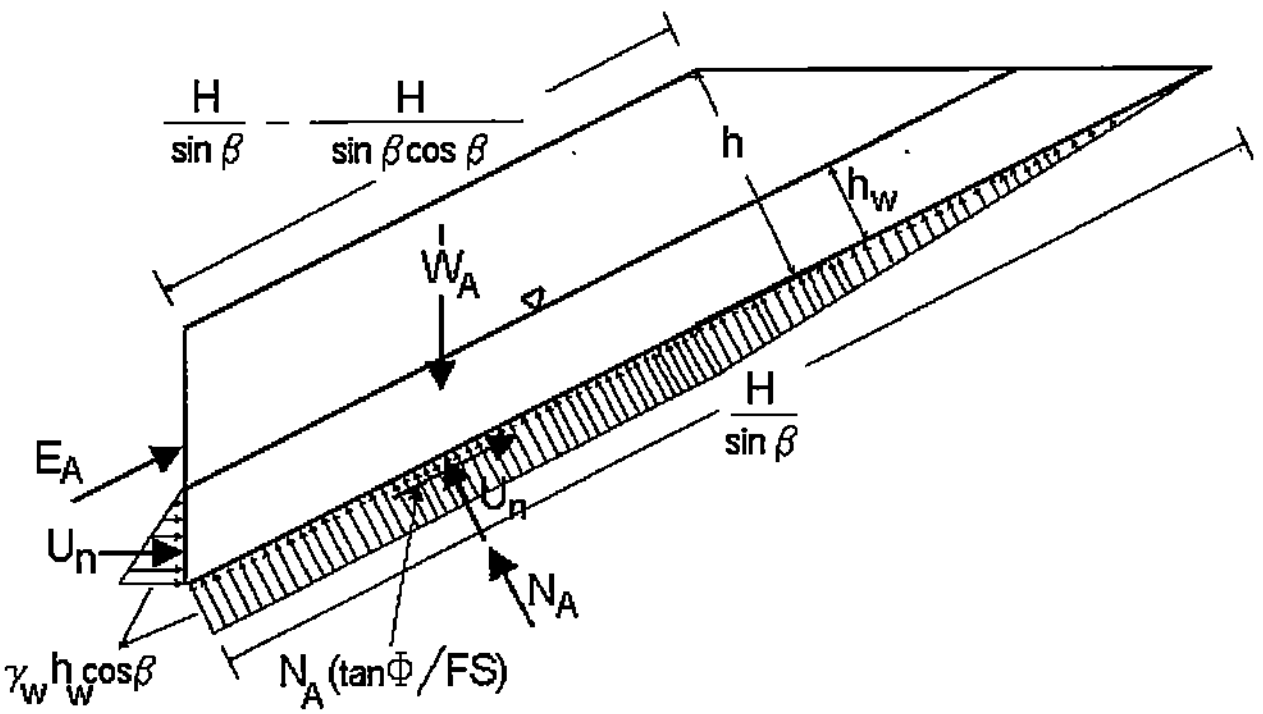
landfilldesign.com

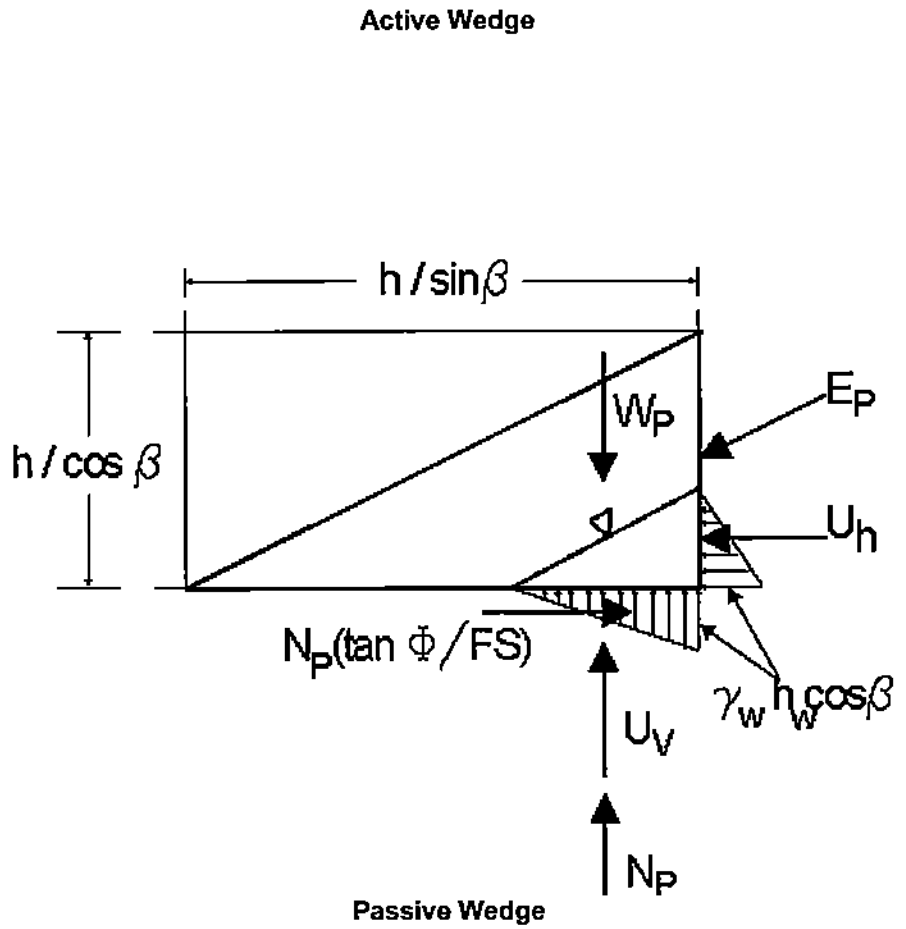
Cover Slope Stability - Design Calculator

Pownal Tannery Superfund Site
Sludge Consolidation Landfill
Rip Rap Side Slopes w/ 12" Crushed Gravel
Drained Conditions

Problem Statement







Input Values

Design Input

Slope characteristics

Length of the slope (L)	19.28	m
Slope angle (ß)	18.43	degrees

Height of soil layers

Height of cover soil (h_cs)	609.6	mm
Height of drainage layer (h_dl)	304.8	mm

Permeability of the soil layers

Permeability of the soil layers

Permeability of cover soil	10	cm/s	
Design permeability of drainage layer	.001	cm/s	Value from undrained analysis

Rain intensity parameters

Precipitation	.01	mm/hr	Low value input to force the cap to be in a drained condition
Run-off coefficient	0.6		

Soil characteristics

Dry unit weight of cover soil	20.5	kN/m^3	Rip Rap = 130 pcf
Saturated unit weight of the cover soil	20.5	kN/m^3	

Friction angles

Friction angle of the cover soil	34	degrees	Conservative for riprap
Friction angle of the cover soil / underlying interface	25	degrees	Required friction angle (adjusted until FS ≥ 1.5)

Stability Calculation

Solution

I. Normalized Input data

Gradient	0.316
Horizontal length	18.291 m
Height cover soil and drainage layer	0.9144 m
Permeability of cover soil in m/s	1.00E-001 m/s
Design permeability of the drainage layer in m/s	1e-005 m/s

II. Calculation of the Drainage Capacity

Precipitation from input	.01 mm/hr
Actual runoff	0.006 mm/hr
Actual percolation	0.004 mm/hr
Actual flux	0.000 m^3/hr
Allowable flux	0.003 m^3/hr
Drainage Layer Capacity (DLC) (needs to be >1.0 to avoid saturation)	**47.414**

III. Parallel Submergence Ratio (PSR)

Average height water table	6.43E-003 m
Parallel Submergence Ratio (PSR)	**0.007**

Stability Factor of Safety (FS) **1.546** ok.

Material Selection

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APPENDIX H-3

SHEET NO. 1 OF 1
PROJECT NO. 02136-0510-01N98
DATE 3/11/03
BY GAM
CHK'D FC

TRC
Customer-Focused Solutions

SUBJECT Pownal Tannery Landfill

Seismic Stability Analysis for Landfill and Cap

Determine peak ground acceleration (PGA) using USGS Seismic Hazard Mapping Project data (see attached print out by zip code and contour map)

Note: Peak acceleration with 2% probability of exceedance in 50 years is equivalent to a 90% probability of non-exceedance in 250 years

PGA = 0.12g Note: PGA = a_{max}

Use 50% of the peak horizontal ground acceleration as the seismic coefficient (k_s) in pseudo-static slope stability analyses. (see attached "Seismic Analysis and Design Considerations for Municipal Solid Waste Landfills", 1994)

$$k_s = 0.5 \frac{a_{max}}{g}$$

$$k_s = 0.5 (0.12)$$

$$k_s = 0.06$$ (Minimum k_s value, more conservative k_s values used in calculations)

Perform a simplified site response analysis to adjust the peak acceleration for local soil conditions (free field peak acceleration) and for the influence of the landfill. Using Figure 4.5 of RCRA Seismic Design Guidance document (attached):

Free Field Peak Acceleration a_{max} = 0.18g

$k_s = 0.5(0.18) = 0.09$ ← use for global and side wall veneer analysis

Peak Acceleration at Crest of land fill: a_{max} = 0.24g

$k_s = 0.5(0.24) = 0.12$ ← use for top cap veneer stability

A

d

The input zip-code is 05261.

ZIP CODE	5261		
LOCATION	42.7970 Lat.	-73.2250 Long.	
DISTANCE TO NEAREST GRID POINT	2.0692 kms		
NEAREST GRID POINT	42.8 Lat.	-73.2 Long.	

Probabilistic ground motion values, in %g, at the Nearest Grid point are:

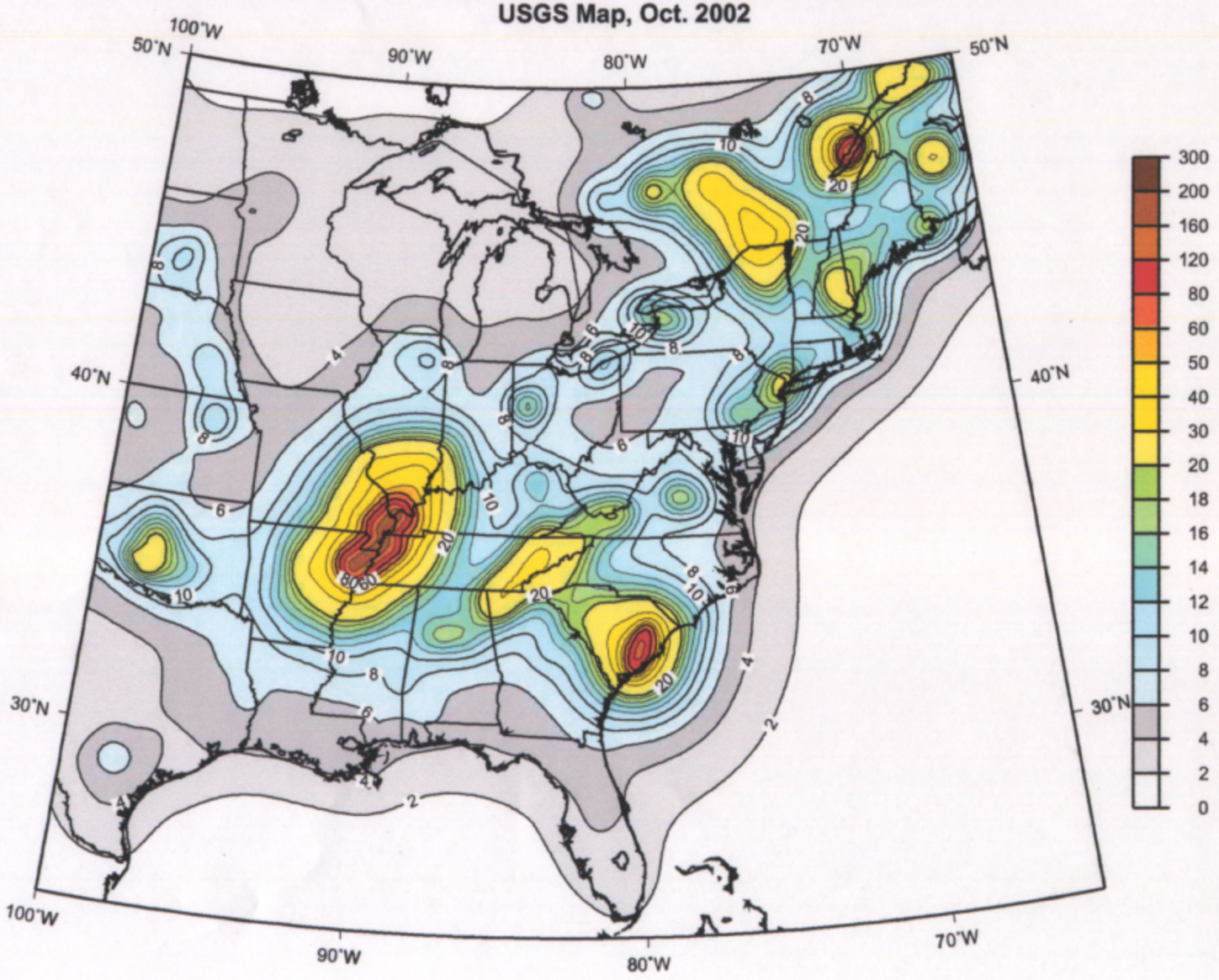
	10%PE in 50 yr	5%PE in 50 yr	2%PE in 50 yr
PGA	4.261891	6.769863	12.106860 ← PGA for Powwal
0.2 sec SA	10.228210	15.840640	26.539511
0.3 sec SA	8.218229	12.559100	21.719910
1.0 sec SA	3.317175	5.373018	9.066104

- -

The input zip-code is .
Zip code is zero and we go to the end and stop.

PROJECT INFO: Home Page
SEISMIC HAZARD: Hazard by Zip Code

Peak Acceleration (%g) with 2% Probability of Exceedance in 50 Years
USGS Map, Oct. 2002



Your map is for ground motions having a 2% probability of exceedance in 50 years. Are those values the same as those for 10% in 250?

Yes, basically. This conclusion will be illustrated by using an approximate rule-of-thumb for calculating Return Period (RP).

A typical seismic hazard map may have the title, "Ground motions having 90 percent probability of not being exceeded in 50 years." The 90 percent is a "non-exceedance probability"; the 50 years is an "exposure time." An equivalent alternative title for the same map would be, "Ground motions having 10 percent probability of being exceeded in 50 years." A typical shorthand to describe these ground motions is to say that they are 475-year return-period ground motions. This means the same as saying that these ground motions have an annual probability of occurrence of 1/475 per year. "Return period" is thus just the inverse of the annual probability of occurrence (of getting an exceedance of that ground motion).

To get an approximate value of the return period, RP, given the exposure time, T, and exceedance probability, r = 1 - non-exceedance probability, NEP, (expressed as a decimal, rather than a percent), calculate

RP = T / r* Where r* = r(1 + 0.5r).

r* is an approximation to the value -loge (NEP).

In the above case, where r = 0.10, r* = 0.105 which is approximately = -loge (0.90) = 0.10536 Thus, approximately, when r = 0.10, RP = T / 0.105

Consider the following table.

				Rule of Thumb		Exact
NEP	T	r	r*	Calculation	RP	RP
0.90	50	0.10	0.105	50 / 0.105	476.2	474.6
0.90	100	0.10	0.105	100 / 0.105	952.4	949.1
0.90	250	0.10	0.105	250 / 0.105	2381.0	2372.8

In this table, the exceedance probability is constant for different exposure times. Compare the results of the above table with those shown below, all for the same exposure time, with differing exceedance probabilities.

				Rule of Thumb		Exact
NEP	T	r	r*	Calculation	RP	RP
0.90	50	0.10	0.105	50 / 0.105	476.2	474.6
0.95	50	0.05	0.05125	50 / 0.05125	975.6	974.8
0.98	50	0.02	0.0202	50 / 0.0202	2475.2	2475.9

Comparison of the last entry in each table allows us to see that ground motion values having a 2% probability of exceedance in 50 years should be approximately the same as those having 10% probability of being exceeded in 250 years: The annual exceedance probabilities differ by about 4%. Corresponding ground motions should differ by 2% or less in the EUS and 1 percent or less in the WUS, based upon typical relations between ground motion and return period.

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Seismic Analysis and Design Considerations For Municipal Solid Waste Landfills

Sponsored by the
New York Association
for Solid Waste Management

In cooperation with the
New York State
Department of Environmental Conservation

and the
United States Environmental Protection
Agency

EPA

March 2-3, 1994

Sheraton Saratoga Springs
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Saratoga Springs, New York

SECTION 6

258.14 SEISMIC IMPACT ZONES: SLOPE STABILITY AND DEFORMATION ANALYSIS

The large accelerations associated with seismic events can induce significant forces that may lead to momentary instability within the Municipal Solid Waste (MSW) landfill. In turn, this instability can lead to deformation of the landfill elements, to permanent damage, or eventually to the catastrophic failure. However, it should be mentioned, that significant seismic related damage of MSW landfills has not been reported so far. Several studies dealing with landfill behavior during the 1979 Loma Prieta earthquake (M = 7.1) (Orr and Finch, 1990; Buranek and Prasad, 1991; Sharma and Goyal, 1991; Johnson et al., 1991) reported only minor damage, even for the landfills located on relatively weak San Francisco Bay mud. Damage was mostly limited to cracking of landfill covers and disruption of surficial piping systems. However, no geomembrane-lined landfills were impacted by the Loma Prieta event. At least two modern, geosynthetically-lined landfills were impacted during the 1994 Northridge Earthquake (M = 6.8). However, preliminary studies revealed no major damage (EERC, 1994; Kavazanjian, 1994).

Numerous methods and procedures are currently available to evaluate slope stability (see e.g., recent state-of-the-art report by Duncan, 1992). Most of the methods available are, in some form, suitable for seismic stability analyses. They can be used in conjunction with several different approaches for seismic analysis, of which the following two represent the current state-of-practice: (1) the pseudo-static factor of safety approach, and (2) the permanent seismic deformation approach. Both of these conventional approaches to seismic stability assessment are based on the principles of limit equilibrium analysis.

In the pseudo-static factor of safety approach, a seismic coefficient is specified to represent the effect of the inertial forces imposed by the earthquake upon the potential failure mass and a factor of safety is defined in the conventional manner as the ratio of the ultimate shear strength of the slope elements to the maximum shear stresses induced in those elements by seismic and static loadings. The main drawback of the pseudo-static factor of safety approach lies in its inability to rationally relate the value of the seismic coefficient to the characteristics of the design earthquake. Use of the peak acceleration (expressed as a fraction of gravity) as the seismic coefficient has been shown to give excessively conservative assessments of slope stability.

In contrast to the pseudo-static factor of safety approach, in the permanent seismic deformation approach cumulative seismic deformations are calculated on the basis of the acceleration time history of the failure mass and the acceleration that results in a factor of safety of 1.0 in a limit equilibrium analysis, termed the yield acceleration. Permanent seismic deformations are calculated using the approach suggested by Newmark (1965), depicted in Figure 6.1, wherein acceleration pulses in the time history that exceed the yield acceleration are double integrated to yield cumulative relative displacement. In a Newmark analysis, permanent displacement is assumed only to accumulate in one direction (the downslope direction). The yield acceleration in the other (upslope) direction is assumed to exceed the peak acceleration of the failure mass.

In practice, both the pseudo-static factor of safety and permanent seismic deformation approaches can be combined in the unified seismic slope stability and deformation analysis which is outlined in Subsection 6.2.

6.1 Key Material Properties

To perform seismic slope stability analysis, estimates of the unit weight and (dynamic) shear strength parameters of various components of the landfill are needed. Unfortunately, a fair amount of uncertainty often exists as to the value of these parameters. Evaluation of the material properties required for slope stability analysis can be a difficult task. This is due to both the paucity of field and laboratory measurements of MSW properties, the cost and difficulty in making project-specific field measurements, and the heterogeneous nature of MSW. The following information is currently available for estimating key material properties of MSW:

- The unit weight of MSW can be estimated from Table 6.1 (Fassett et al., 1994) based on actual operational practice. It should be noted that significantly higher MSW unit weights have been reported (Richardson and Reynolds, 1991) that result from the use of an unusually high percentage of daily cover soil. The unit weights in Table 6.1 do not account for the increase in density with depth that occurs in MSW due to its compressibility or to changes that occur with time. The variation of density with depth can have a significant influence on the results of static and dynamic stability and seismic response analyses. Figure 6.2 (Earth Technology, 1988) shows the density-depth relationship developed for one southern California landfill on the basis of field measurements of density and laboratory measurements of waste compressibility.

- The interface friction angle between geosynthetic components, e.g., geomembrane and geotextile from static laboratory tests may be used for dynamic analyses. Some investigations have reported slight differences between static and dynamic interface strengths (Kavazanjian et al., 1991). Others have reported that interface shear strengths appear to be independent of the frequency content and number of cycles of motion (Yegian and Lahlaf, 1992). However, considering the uncertainties inherent to other material properties, it appears that the shear strength measured in laboratory direct shear tests may be used to represent the dynamic interface shear strength. This observation is based on laboratory tests performed on a shake table and equated to conventional static direct shear interface friction tests.

- The dynamic shear strength of clays is influenced by the amplitude of the seismic deviator stress, the number of applied cycles, and the plasticity of the clay (Makdisi and Seed, 1978). In most cases (e.g. unsaturated compacted clay), the static shear strength may be used as the shear strength for dynamic analyses. For saturated soft clays, the dynamic shear strength can conservatively be assumed to equal approximately 80% of the static undrained strength.

- The cyclic shear strength of dry sands can be assumed to equal the static shear strength of the sand. In saturated sands, seismic loading can significantly alter the dynamic shear strength. Evaluation of the potential for shear strength reduction in a saturated sand subject to dynamic loading may require sophisticated cyclic laboratory testing. Alternatively, a residual shear strength may be assigned to the sand based upon either undrained laboratory tests or in situ test results. Use of residual shear strengths in a dynamic stability assessment can result in a very conservative assessment of the pseudo-static factor of safety and/or yield acceleration.

- The shear strength of MSW can be based upon the data in Figure 6.3 (Singh and Murphy, 1990) This figure represents a compilation of filed and laboratory test results and shear strengths backfigured from field observations of unsatisfactory performance of MSW landfills. Laboratory and field tests have consistently shown shear strengths in excess of a cohesion of 200 psf (10 kPa) and a friction angle of 20 degrees (Landva and Clark, 1990 and Richardson and Reynolds, 1991). Observations of the satisfactory performance of landfill slopes in major

earthquakes indicates that the dynamic shear strength of MSW may be significantly greater than the static shear strength. Figure 6.4 (Siegel et al., 1990) shows combinations of cohesion, friction angle, and yield acceleration that resulted a pseudo-static factor of safety of 1.0 in back analyses of the slopes of a southern California landfill observed to have performed satisfactorily in a major earthquake.

It is strongly recommended that all stability analyses be performed as parametric studies to clearly identify the sensitivity of the performance of the landfill to the material properties used in the analysis. If the performance appears very dependent on a given parameter, then additional laboratory or field testing may be required to better define the in-situ properties.

6.2 Analysis

The first prerequisite for performing a seismic slope stability analysis is to perform the static analysis. After solving the static problem, the seismic stability analysis is carried out using the same basic model(s) of landfill and containment system used in the static analysis and the following steps:

Step 1: Reinterpret cross-sections analyzed in static analysis and assign dynamic strength parameters where appropriate. In cases where it is not clear whether drained or undrained shear strength parameters are appropriate for the dynamic analysis, follow guidelines presented in Duncan (1992).

Step 2: Determine the appropriate seismic coefficient, k_s. There are many different views on how to define and determine k_s (e.g., Seed and Martin, 1966; Marcuson, 1981). The most reasonable definition appears to be one that regards the seismic coefficient as an empirical factor. This definition recognizes the limitations of the pseudo-static slope stability analysis in representing the actual effects of an earthquake on the landfill. Unfortunately, this definition provides no guidance in selection of an appropriate value of k_s. Seed (1979) reports that slopes and embankments designed with a minimum pseudo-static factor of safety of 1.15 using a seismic coefficient of 0.15 have experienced "acceptable" deformations in earthquakes of all magnitudes and intensities. However, the definition of acceptable deformations appears to include deformations of several feet in some cases. Based upon Newmark analyses using 387 strong motion records and 6 artificial accelerograms and upon their experience with seismic response analyses of slopes and embankments, Hynes and Franklin (1984) concluded that slopes

and embankments with a yield acceleration greater than or equal to half the peak ground acceleration would experience permanent seismic deformations of less than one foot (0.3 meters) in any earthquake. Based upon the work of Hynes and Franklin, it appears that k_s should be determined as $k_s = 0.5\ a_{max}/g$, where a_{max} is peak horizontal acceleration at the ground surface for analyses of the liner system and at the top of the landfill for analyses of the cover system. a_{max} can be determined either using the Idriss (1990) chart presented in Figure 4.2 or from the results of a site response analysis.

Step 3: Perform the pseudo-static stability analysis. If the minimum factor of safety, FS_{min}, exceeds 1.0, the seismic stability analysis is completed.

Step 4: If the pseudo-static factor of safety is less than 1.0, perform a Newmark deformation analysis. This is done with the following three steps:

1) Determine yield acceleration. The yield acceleration is usually determined by pseudo-static analyses using a trial and error procedure in which the seismic coefficient is varied until $FS_{min} = 1.0$ is obtained.

2) Calculate the permanent seismic deformation using either simplified design charts or a formal Newmark time-history analysis.

3) Compare the calculated permanent seismic deformation to the allowable maximum permanent displacement, u_{max}. Seed and Bonaparte (1992) report that u_{max} values of 0.5 to 1.0 feet (0.15 to 0.3 meters) are typically used in practice for design of geosynthetic liner systems. For cover systems, where permanent seismic deformations are readily observed in post-earthquake inspections and damage to components are easily repaired, larger permanent deformations may be considered acceptable. In fact, some state regulatory agencies consider seismic deformations of the landfill cover system primarily a maintenance problem.

Several investigators have presented simplified charts based upon the results of Newmark deformation analyses for estimating permanent seismic deformations. Makdisi and Seed (1978) developed the chart shown in Figure 6.5 from the results of two-dimensional finite element analyses of embankments. This chart includes the effect of amplification of seismic motions by an embankment and provides upper and lower bounds on the permanent deformation as a function of magnitude. Hynes and Franklin (1984) developed the chart shown in Figure 6.6

from classical Newmark "sliding block on a plane" analyses. These investigators did not consider amplification or magnitude effects. Due to the uncertainties in using a simplified design chart and the characteristics and limitations of the above analyses, the use of the upper bound curves from Makdisi and Seed (Figure 6.5) for analysis of the waste mass and liner system and the *mean* + σ curves from Hynes and Franklin (Figure 6.6) for analysis of the cover system is recommended for simplified deformation analysis.

If seismic response analysis has been performed, a formal Newmark seismic deformation analysis can be performed by using the acceleration or shear stress time histories from the response analysis. To evaluate the permanent displacement of the landfill mass, the average acceleration time history of mass above the geomembrane-geotextile interface should be used. The average acceleration time history may be calculated as the average of the acceleration time history of each layer above the interface weighted according to the relative unit weight and thickness of each layer. Alternatively, the average acceleration time history may be calculated from the shear stress at the interface divided by the total vertical stress above the interface, as described by Repetto et al. (1993).

To calculate the permanent deformations of the landfill final cover, the average time history of the cover layers of the shear stress time history at the cover waste interface divided by the total vertical stress at the interface should be used in the Newmark analysis. Particularly for landfills in the eastern United States, where the earthquake acceleration time history may contain relatively enriched high frequencies, the formal Newmark deformation analyses may yield significantly lower seismic deformations than the simplified Newmark analyses using Figures 6.5 and 6.6.

6.3 Additional Considerations

Stability of the underlying foundation soil is an important consideration in evaluating the overall performance of the landfill, particularly if a layer (or layers) in the foundation is susceptible to liquefaction, as illustrated in Figure 6.7. The potential for a liquefaction induced flow failure may be analyzed using limit equilibrium analyses by employing residual shear strengths in the potentially liquefiable zones. In this type of post-earthquake stability assessment, the seismic coefficient should be set equal to zero (Marcuson et al., 1990). If the residual shear strength is conservatively assessed using minimum values of SPT blow counts (or CPT tip resistance) within the potentially liquefiable layer(s), a factor of safety of 1.1 may be considered as acceptable. Evaluation of seismic settlement potential, as described in Section 5.3, still must be conducted to assess the impact of liquefaction on the landfill. It may be convenient to treat

the final cover of the landfill as an infinite slope. In this case, the pseudo-static factor of safety and yield acceleration for the cover may be assessed using the following general equations for the stability of an infinite slope proposed by Matasović (1991):

$$FS = \frac{c/(\gamma \cdot z \cdot \cos^2\beta) + \tan\varphi\left[1 - \gamma_w(z-d_w)/(\gamma \cdot z)\right] - k_s \cdot \tan\beta \cdot \tan\varphi}{k_s + \tan\beta} \qquad (6.1)$$

$$K_y = \frac{c/(\gamma \cdot z \cdot \cos^2\beta) + \tan\varphi\left[1 - \gamma_w(z-d_w)/(\gamma \cdot z)\right] - \tan\beta}{1 + \tan \cdot \beta \tan\varphi} \qquad (6.2)$$

where FS = factor of safety, K_y = yield acceleration, k_s = seismic coefficient, γ =unit weight of slope material(s), γ_w= unit weight of water, c = cohesion, φ =angle of internal friction of the assumed failure interface or surface, z = depth to the assumed failure interface or surface, and d_w = depth to the water table (assumed parallel to the slope). The above equations yield the factor of safety and yield acceleration explicitly for both cohesive ($c \neq 0$) and cohesionless soils (c = o). If there is no downslope seepage, the depth to the water table, d_w, should be set equal to the depth to the assumed failure plane, z.

6.4 References

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analyses are performed in an iterative manner. The maximum shear strain from one run is used to evaluate the equivalent modulus and damping for the next run and continuing to convergence.

Input to one-dimensional equivalent linear site response analyses typically includes the shear wave velocity and mass density or small-strain shear modulus for each soil layer, curves relating the representative shear strain to a modulus reduction factor and the fraction of critical damping for each soil type (modulus reduction and damping curves), the representative shear strain factor (the fraction of the maximum shear strain assumed to correspond to the representative shear strain) and an input acceleration-time history. Other input parameters include the density and shear wave velocity of the underlying bedrock. The acceleration-time history may be input as the motion at a hypothetical bedrock outcrop or at the bedrock-soil interface at the base of the soil column. Results of the analysis provide shear stress- and acceleration-time histories for each layer within the soil profile.

An alternative to the equivalent linear method of site response analysis is truly non-linear site response analysis (Lee and Finn, 1978; Matasovi and Vucetic, 1993). In a truly non-linear analysis, the actual hysteretic stress-strain behavior of each element of soil (or waste) is calculated in the time domain. Equivalent linear analysis are typically performed in the frequency domain, employing the principal of superposition to calculate the time history of ground motions. Non-linear site response analyses require a description of the hysteretic stress strain behavior of the soil (or waste), the mass density profile of the material, and an input acceleration time history. Truly non-linear site response analyses hold the promise of a more accurate representation of the seismic behavior of soil deposits and solid waste landfills. However, at the present time, truly non-linear site response analyses are still primarily a research tool and have yet to be widely employed in engineering practice.

4.1.1 Simplified Analysis

Whereas structural analyses typically require information on the spectral content of ground motions, and thus require a complete time history to characterize the design motion, geotechnical analyses frequently only require knowledge of either the peak ground acceleration or the peak ground acceleration and the earthquake magnitude. Several investigators have related the peak ground acceleration from a hypothetical bedrock outcrop, such as presented on the USGS maps, to the peak ground acceleration at a specific site as a function of the local soil conditions based upon the results of one-dimensional site response analysis and observations of ground motions during earthquakes. The top plot on Figure 4.4 shows an early relationship developed by Seed and Idriss (1982) for a variety of local soil conditions. This plot was developed using SHAKE, a computer program for equivalent linear one-dimensional site response analyses developed at the University of California, Berkeley (Schnabel et al., 1972).

Experience from recent earthquakes has shown that the curves in the top plot of Figure 4.4 can significantly under-predict site amplification effects in many situations. The plot on the bottom of Figure 4.4 shows a recent curve developed by Idriss (1990) for soft soil sites. This plot was developed from both SHAKE analysis and from field observations of soft soil site response in two recent earthquakes.

Observations of the response of the OII landfill, Los Angeles, in recent earthquakes (Hushmand Associates, 1994) and the results of truly non-linear one-dimensional seismic response analyses of landfills (Kavazanjian and Matasovi, 1995) indicate that the Idriss (1990) soft soil-site amplification curve may also provide an appropriate representation of the potential for typical peak acceleration amplification at solid waste landfills. Data obtained at the OII landfill during four recent earthquakes is plotted in Figure 4.5 along with the soft soil site field data and recommended curve from Idriss (1990). Also plotted on this figure are the results of non-linear analyses of landfill seismic response performed by Kavazanjian and Matasovi (1995) using waste parameters backfigured from strong motion records obtained at the OII landfill in the 17 January 1994 M 6.7 Northridge earthquake (peak acceleration at the landfill crest equal to 0.24 g).

Some of the non-linear landfill response analyses results plotted on Figure 4.5 at 0.3 g and 0.5 g bedrock acceleration fall significantly above the Idriss (1990) curve. However, the results that fall above the Idriss curve are from low amplitude (less than 0.1 g) accelerograms recorded at large distances from the earthquake source (greater than 50 kilometers) that were scaled up to large accelerations representative of near field conditions. Therefore, the large amplification factors computed for these cases may not be representative of the amplification potential from real earthquakes. On this basis, Kavazanjian and Matasovi (1995) concluded that the Idriss (1990) soft soil amplification curve provides a reasonable representation of the average peak acceleration amplification potential at the top of solid waste landfills.

Figure 4.6, from Singh and Sun (1995), present the results of their theoretical analyses for the amplification potential of a 100 ft (30 m)- high refuse fill along with a summary of the upper bound for observations of amplification at the crest of earth dams in earthquakes by Harder (1991). These investigators suggest that the observational data on earth dams may also provide an upper bound on the amplification potential of waste fills. The earth dam curve corresponds closely to the upper range of the analytical results of Kavazanjian and Matasovi (1995) presented in Figure 4.5.

The soft soil site curve developed by Idriss and presented in Figure 4.5, the analytical data developed by Kavazanjian and Matasovi (1995) and presented in Figure 4.5, and the observatinal data presented in Figure 4.6 may be used in a three-step simplified procedure developed by GeoSyntec (1994) to perform a simplified site response analyses for the purpose of adjusting the

peak acceleration from the USGS map (or from a site-specific analysis for the MHA in lithified earth) for the influence of local soil conditions (to obtain the free field peak acceleration at a project site) and for the influence of the landfill (to obtain the peak acceleration at the crest of the landfill). The three-step procedure is as follows:

Step 1: *Classify the Site.* Classify the site as special study, soft, medium stiff, stiff, or rock on the basis of the average shear wave velocity for the top 30 meters (100 feet) of soil and the following table (Borcherdt, 1994):

CLASSIFICATION	AVERAGE SHEAR WAVE VELOCITY	
Special Study	Less than 100 m/s	(330ft/s)
Soft	100 to 200 m/s	(330 to 660 ft/s)
Medium Stiff	200 to 375 m/s	(600 to 1,230 ft/s)
Stiff	375 to 700 m/s	(1,230 to 2,300 ft/s)
Rock	Greater than 700 m/s	(2,300 ft/s)

Poznań Grey Clay →

Note that special study soils also include liquefiable soils, quick and highly sensitive clays, peats, highly organic clays, very high plasticity clays (PI>75%), and soft soil deposits more than 37 meters (120 feet) thick.

Step 2: *Estimate the Free field Acceleration.* Estimate the potential amplification of the bedrock motions by the local soil deposit based upon the soil profile classification. For soft soils, use the curve in Figure 4.5 recommended by Idriss (1990) to estimate the free field peak ground acceleration from the peak bedrock acceleration. For medium stiff soils, use an acceleration equal to the average of the rock site acceleration and the soft soil site acceleration from Idriss' curve in Figure 4.5 for peak bedrock accelerations less than or equal to 0.4 g. For medium stiff soils when the peak bedrock acceleration exceeds 0.4 g and for stiff sites for all acceleration levels, assume the free field peak ground acceleration at the site is equal to the peak bedrock acceleration. For Special Study soil sites, Figure 4.5 should not be used. Instead, site specific seismic response analyses such as those described in the next section of this guidance document should be conducted.

Step 3: *Estimate the Peak Acceleration at the Top of the Landfill.* Estimate the potential amplification of the peak acceleration of the landfill mass using the analytical data in Figure 4.5 and the earth dam amplification curve in Figure 4.6. The decision as to whether to use the upper bound of the analytical data and/or the earth dams observations or to use a value closer to the median of the analytical data in Figure 4.5

is a matter of engineering judgment. As a general rule, if the predominant period of either the design earthquake or the foundation soil matches the predominant period of the landfill, the upper bound data should be used. The predominant period of the landfill and the foundation may be evaluated using equation 4.1. For relatively thin fills (less than 33 ft (10 m) founded on soft soils or subject to long period motions from distant earthquakes and for thick fills (over 165 ft (50 m)) founded on rock subject to high frequency motions from nearby earthquakes, the median analytical data (corresponding roughly to the Idriss soft soil curve) may be appropriate. The free field ground acceleration developed in Step 2 is used in place of the peak bedrock acceleration on the abscissa of Figures 4.5 and 4.6, and the acceleration at the top of the landfill is obtained from the ordinate of the appropriate figure.

The three-step procedure presented above is a simplified, decoupled analysis that ignores interaction between the waste mass and the ground. Analyses of the coupled response of landfills and foundation soils indicates that this simplified, decoupled analysis will yield a conservative upper bound estimate of the combined amplification potential of a landfill and its foundation (Bray, et al., 1995; GeoSyntec, 1994).

The peak acceleration at the top of the landfill estimated in Step 3 may be used in seismic performance analyses of the landfill cover and surface water drainage systems and in evaluation of other facilities constructed on top of the landfill (e.g., flare station or storage tanks). The acceleration calculated in Step 3 is not, however, the appropriate peak acceleration for use in seismic stability and deformation potential calculations of the waste mass. For seismic stability and deformation potential evaluations of the waste mass, the average acceleration of the assumed failure mass, and not the acceleration at the top of the landfill, is the relevant response quantity, as the average acceleration is directly proportional to the seismically-induced inertia forces and to the seismic shear stresses induced at the base of the failure mass (Repetto et al., 1993).

Makdisi and Seed (1978) developed a "typical" curve relating the ratio of peak average acceleration to peak ground acceleration to the depth of the failure surface for earth dams founded on rock. Kavazanjian and Matasovi (1995) demonstrated that the Makdisi and Seed (1978) earth dams curve provides a reasonable representation of the profile of average acceleration versus depth in solid waste landfills over 50 ft (15 m) thick. Figure 4.7 (Kavazanjian and Matasovi, 1995) compares nine different solid waste landfill non-linear seismic response analyses, encompassing waste fills from 50 to 300 ft (15 to 90 m) thick to the representative profile developed by Makdisi and Seed. Based upon a maximum average acceleration ratio at the base of the landfill of 0.45, as indicated by Figure 4.7, and upon a maximum amplification factor of 2.0 from Figure 4.5 for a peak bedrock acceleration of 0.1 g or greater, Kavazanjian and Matasovi (1995) concluded that the free field peak ground acceleration calculated for the landfill

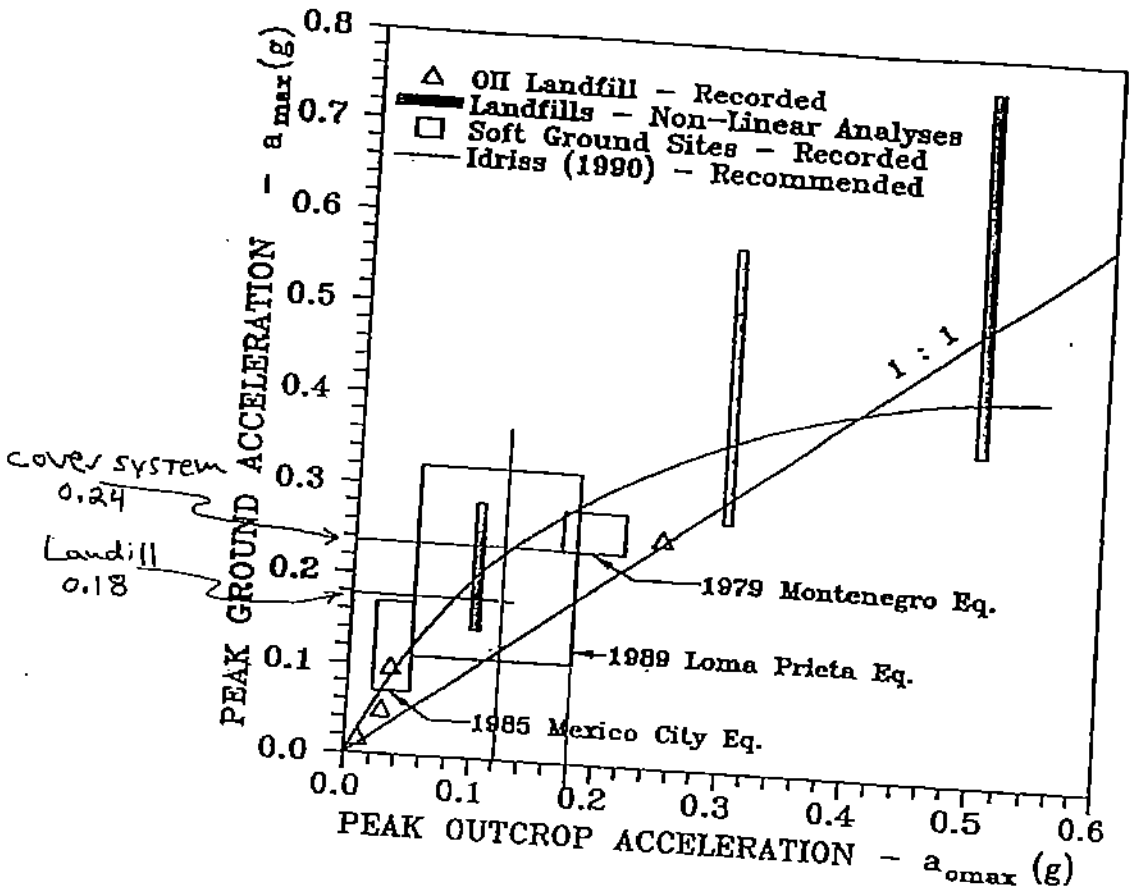

Figure 4.5 Observed Variations of Peak Horizontal Accelerations on Soft Soil and MSW Sites in Comparison to Rock Sites (Kavazanjian and Matasović, 1994).

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Problem Description : Seismic Landfill Stability Run 7F

SEGMENT BOUNDARY COORDINATES

---

8 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	250.0	80.0	355.0	80.0	3
2	355.0	80.0	400.0	96.0	3
3	400.0	96.0	455.0	97.1	1
4	455.0	97.1	514.0	96.0	1
5	514.0	96.0	530.0	90.0	1
6	530.0	90.0	543.0	85.0	3
7	543.0	85.0	563.0	83.7	3
8	563.0	83.7	600.0	83.0	3

14 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	364.0	80.0	400.0	92.2	2
2	400.0	92.2	456.0	94.4	2
3	456.0	94.4	515.7	92.2	2
4	515.7	92.2	524.0	90.9	2
5	355.0	80.0	493.0	79.9	3
6	493.0	79.9	502.0	82.2	3
7	502.0	82.2	524.0	90.9	3
8	524.0	90.9	530.0	90.0	3
9	250.0	68.5	336.0	66.9	4
10	336.0	66.9	470.0	74.0	4
11	470.0	74.0	600.0	77.4	4
12	250.0	63.5	336.0	63.9	5

13	336.0	63.9	470.0	70.0	5
14	470.0	70.0	600.0	72.5	5

ISOTROPIC Soil Parameters
---

5 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	122.5	122.5	.0	36.00	.000	.0	0
2	96.0	96.0	382.0	.00	.000	.0	0
3	115.0	115.0	.0	34.00	.000	.0	1
4	140.0	140.0	.0	37.00	.000	.0	1
5	116.4	116.5	724.0	.00	.000	.0	1

1 Water surface(s) have been specified

Unit weight of water = 62.40 (pcf)

Water Surface No. 1 specified by 2 coordinate points

****
PHREATIC SURFACE,
****

Point No.	x-water (ft)	y-water (ft)
1	250.00	73.00
2	600.00	77.10

A horizontal earthquake loading coefficient
of .090 has been assigned

A vertical earthquake loading coefficient
of .000 has been assigned

BOUNDARIES THAT LIMIT SURFACE GENERATION HAVE BEEN SPECIFIED

LOWER limiting boundary of 2 segments:

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)
1	250.0	37.4	470.0	7.1
2	470.0	7.1	600.0	6.4

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

80 trial surfaces will be generated and analyzed.

10 Surfaces initiate from each of 8 points equally spaced along the ground surface between x = 350.0 ft
and x = 400.0 ft

Each surface terminates between x = 405.0 ft
and x = 500.0 ft

Unless further limitations were imposed, the minimum elevation at which a surface extends is y = 10.0 ft

* * * * * DEFAULT SEGMENT LENGTH SELECTED BY XSTABL * * * * *

2.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS

The first segment of each failure surface will be inclined within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

****

-- WARNING -- WARNING -- WARNING -- WARNING -- (# 48)

****

Negative effective stresses were calculated at the base of a slice. This warning is usually reported for cases where slices have low self weight and a relatively high "c" shear strength parameter. In such cases, this effect can only be eliminated by reducing the "c" value.

****

USER SELECTED option to maintain strength greater than zero

****
ERROR # 28
****
In automatically generating a failure surface, it has been found that more than 100 points are needed to define this surface. The program is limited to a maximum of 100 points. To meet this criterion, please INCREASE the specified length of the line segments.
****

****
*** The above error occurred in attempting ***
*** to generate surface # 1 from the ***
*** initiation point located at x = 400.00 ***
****

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED BISHOP METHOD * * * * *

The most critical circular failure surface is specified by 35 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	350.00	80.00
2	351.97	79.68
3	353.95	79.40
4	355.94	79.18
5	357.93	79.00
6	359.93	78.88
7	361.93	78.81
8	363.93	78.79
9	365.93	78.82
10	367.93	78.90
11	369.92	79.03
12	371.91	79.21
13	373.90	79.44
14	375.88	79.73
15	377.85	80.06
16	379.82	80.45
17	381.77	80.88
18	383.71	81.36
19	385.64	81.89
20	387.55	82.48
21	389.45	83.11
22	391.33	83.78
23	393.19	84.51
24	395.04	85.28

25	396.86	86.10
26	398.67	86.97
27	400.45	87.88
28	402.20	88.83
29	403.94	89.83
30	405.64	90.88
31	407.32	91.97
32	408.97	93.09
33	410.59	94.27
34	412.18	95.48
35	413.16	96.26

**** Simplified BISHOP FOS = 1.543 ****

The following is a summary of the TEN most critical surfaces

Problem Description : Seismic Landfill Stability Run 7F

	FOS (BISHOP)	Circle Center x-coord (ft)	Circle Center y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)
1.	1.543	363.75	157.34	78.55	350.00	413.16	1.699E+06
2.	1.558	380.92	147.19	66.01	364.29	423.23	1.385E+06
3.	1.608	329.32	259.92	181.31	357.14	407.08	1.544E+06
4.	1.644	376.26	143.21	61.09	364.29	415.39	1.076E+06
5.	1.645	368.28	148.31	70.72	350.00	416.17	2.004E+06
6.	1.740	370.30	143.99	67.14	350.00	417.62	2.209E+06
7.	1.744	358.21	224.56	143.80	357.14	423.55	3.119E+06
8.	1.799	361.03	323.89	243.16	357.14	448.33	7.488E+06
9.	1.840	415.84	145.05	92.55	350.00	494.65	1.144E+07
10.	1.895	379.00	276.23	196.68	357.14	459.99	8.397E+06

* * * END OF FILE * * *

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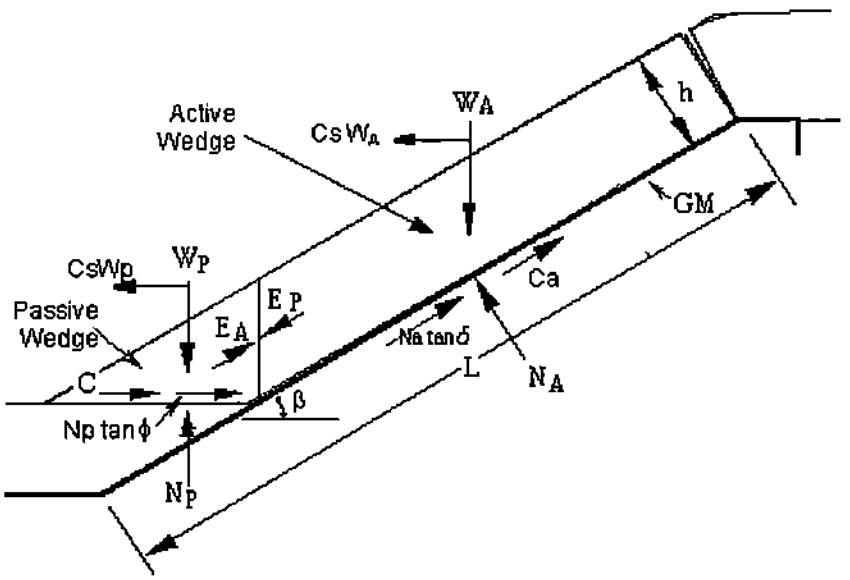
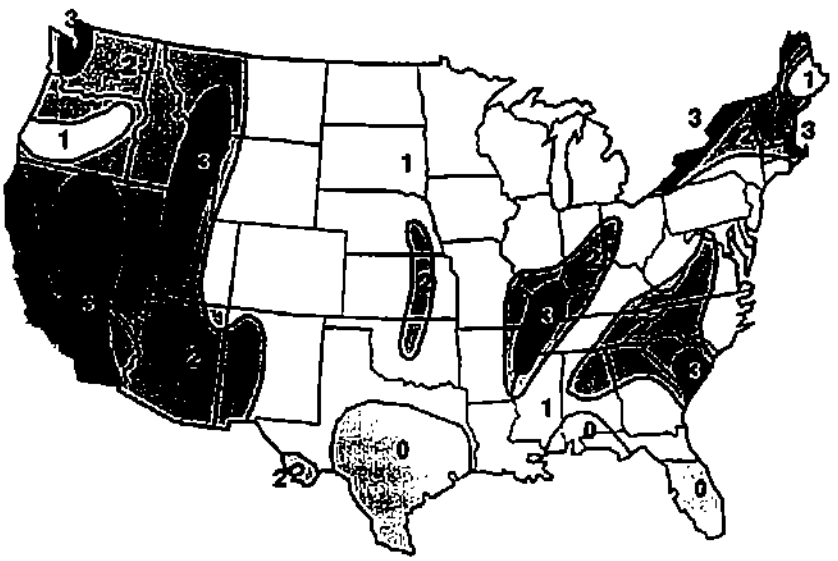
Slope Stability:Seismic Force - Design Calculator

Problem Statement

This slope stability calculator utilizes a pseudo-static analysis to determine the factor of safety (FS) of a geosynthetic lined slope. This calculator assumes that no seepage forces are present. The unit gradient calculator can be used to calculate the required transmissivity of the drainage geocomposite to assure adequate drainage.

Subtitle "D" of the U.S. EPA regulations requires a seismic analysis if the site has experienced a 0.1 g horizontal acceleration, or more, in the past 250 years. For the continental USA, this does not only include the western states, but major sections of the midwest and northeast as well. The map below shows the seismic coefficients for various zones in the USA.





Legend

Zone 0: No damage

Zone 1: Minor damage; corresponds to intensities V and VI on the modified Mercalli intensity scale

Zone 2: Moderate damage; corresponds to intensity VII on the modified Mercalli intensity scale

Zone 3: Major damage; corresponds to intensity VIII and higher on the modified Mercalli intensity scale

Seismic coefficients corresponding to each zone

Zone	Remark	Modified Mercalli Scale	Average Seismic Coefficient (Cs)
0	No damage	-	0
1	Minor damage	V and VI	0.03 to 0.07
2	Moderate damage	VII	0.13 ← site
3	Major damage	VIII and higher	0.27

Note: From simplified site response analysis $K_s = 0.09$ for side slope, use 0.13 (above) to be conservative.

Input Values

Design Inputs

Slope characteristics

Thickness of cover soil (h)	0.9144	m	(2 ft rip rap, 12" crushed gravel)
Slope angle (ß)	18.43	degrees	(3:1 slope)
Lenght of slope measured along geomembrane (L)	19.28	m	$L = \frac{60 ft}{\cos 18.43^\circ}$

Soil characteristics

Unit weight of the cover soil (g)	20.5	kN/m^3	Rip Rap & crushed gravel
Friction angle of the cover soil (F)	34	degrees	(conservative for chosen materials)
Cohesion of the cover soil (c)	0	kN/m^2	
Interface friction(d)		degrees	

	24.5	← Required friction angle (Adjusted until FS ≥ 1.1)
Interface adhesion (Ca)	0	kN/m²
Seismic characteristic		
Seismic coefficient (Cs)	0.13	g

Seismic Stability Calculation

Solution

Factor of Safety with seismic activity (FS) 1.100 FS ≥ 1.1 OK

Factor of Safety no seismic activity (FS) 1.613

Material Selection

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GFR

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References

R. M. Koerner, and T-Y. Soong, 1998. "Analysis and Design of Veneer Cover Soils". Proceedings of 6th International Conference on Geosynthetics, Vol. 1, pp. 1-23, Atlanta, Georgia, USA.

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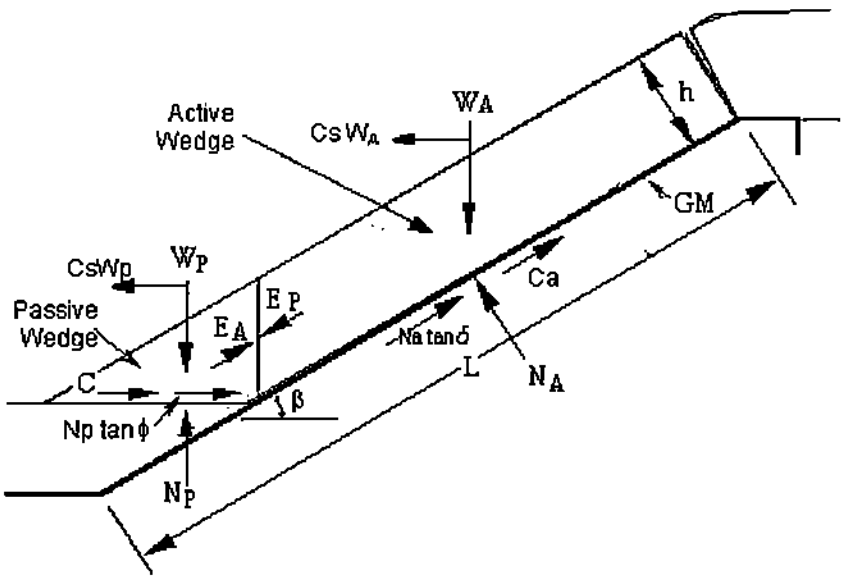
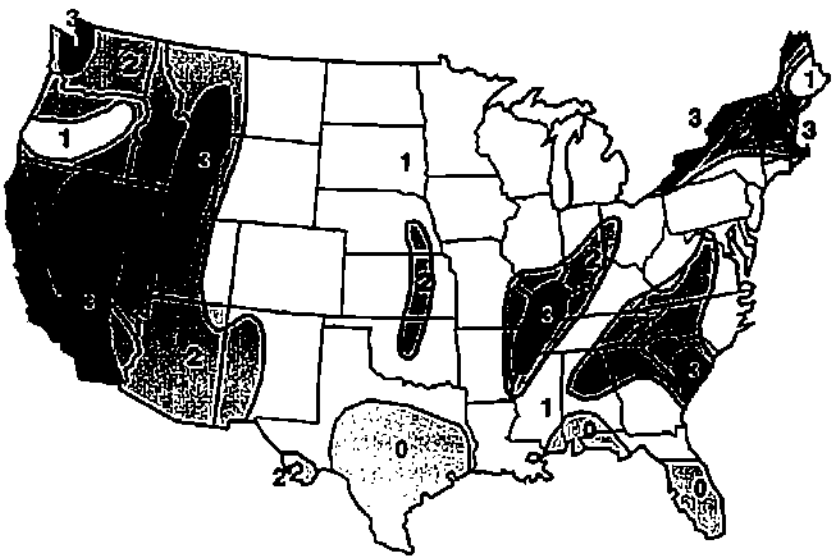
Slope Stability:Seismic Force - Design Calculator

Problem Statement

This slope stability calculator utilizes a pseudo-static analysis to determine the factor of safety (FS) of a geosynthetic lined slope. This calculator assumes that no seepage forces are present. The unit gradient calculator can be used to calculate the required transmissivity of the drainage geocomposite to assure adequate drainage.

Subtitle "D" of the U.S. EPA regulations requires a seismic analysis if the site has experienced a 0.1 g horizontal acceleration, or more, in the past 250 years. For the continental USA, this does not only include the western states, but major sections of the midwest and northeast as well. The map below shows the seismic coefficients for various zones in the USA.





Legend

Zone 0: No damage

Zone 1: Minor damage; corresponds to intensities V and VI on the modified Mercalli intensity scale

Zone 2: Moderate damage; corresponds to intensity VII on the modified Mercalli intensity scale

Zone 3: Major damage; corresponds to intensity VIII and higher on the modified Mercalli intensity scale

Seismic coefficients corresponding to each zone

Zone	Remark	Modified Mercalli Scale	Average Seismic Coefficient (Cs)
0	No damage	-	0
1	Minor damage	V and VI	0.03 to 0.07
2	Moderate damage	VII	0.13 ← site
3	Major damage	VIII and higher	0.27

Note: From simplified site response analysis $K_s = 0.12$ for crest of landfill, use 0.13 (above) to be conservative.

Input Values

Design Inputs

Slope characteristics

Thickness of cover soil (h)	0.762	m (2ft. cover soil, 6" topsoil)
Slope angle (ß)	2.86	degrees (5% slope on geomembrane)
Lenght of slope measured along geomembrane (L)	50.3	m (165ft on geomembrane)

Soil characteristics

Unit weight of the cover soil (g)	18.458	kN/m^3
Friction angle of the cover soil (F)	30	degrees (Assumed conservative value)
Cohesion of the cover soil (c)	0	kN/m^2
Interface friction(d)		degrees

	6	← Required friction angle
Interface adhesion (Ca)	0	kN/m²
Seismic characteristic		
Seismic coefficient (Cs)	0.13	g

Seismic Stability Calculation

Solution

Factor of Safety with seismic activity (FS) 1.121 FS ≥ 1.1 OK

Factor of Safety no seismic activity (FS) 4.650

Material Selection

Follow the GFR link to view our extensive database of geosynthetic materials reprinted with permission of IFAI

GFR

Additional Assistance

If you would like to have Advanced Geotech Systems provide material specifications that meet your performance criteria, please fill in the following fields and click the submit button. All information is kept strictly confidential.

Name *		Comments	
Company			
Email Address *			
Phone			
Project Reference			

*required fields

Submit Design Results

Sponsored by

The following companies can service any of your geomembrane protection material selection needs.

References

R. M. Koerner, and T-Y. Soong, 1998. "Analysis and Design of Veneer Cover Soils". Proceedings of 6lh International Conference on Geosynthetics, Vol. 1, pp. 1-23, Atlanta, Georgia, USA.

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APPENDIX H-4

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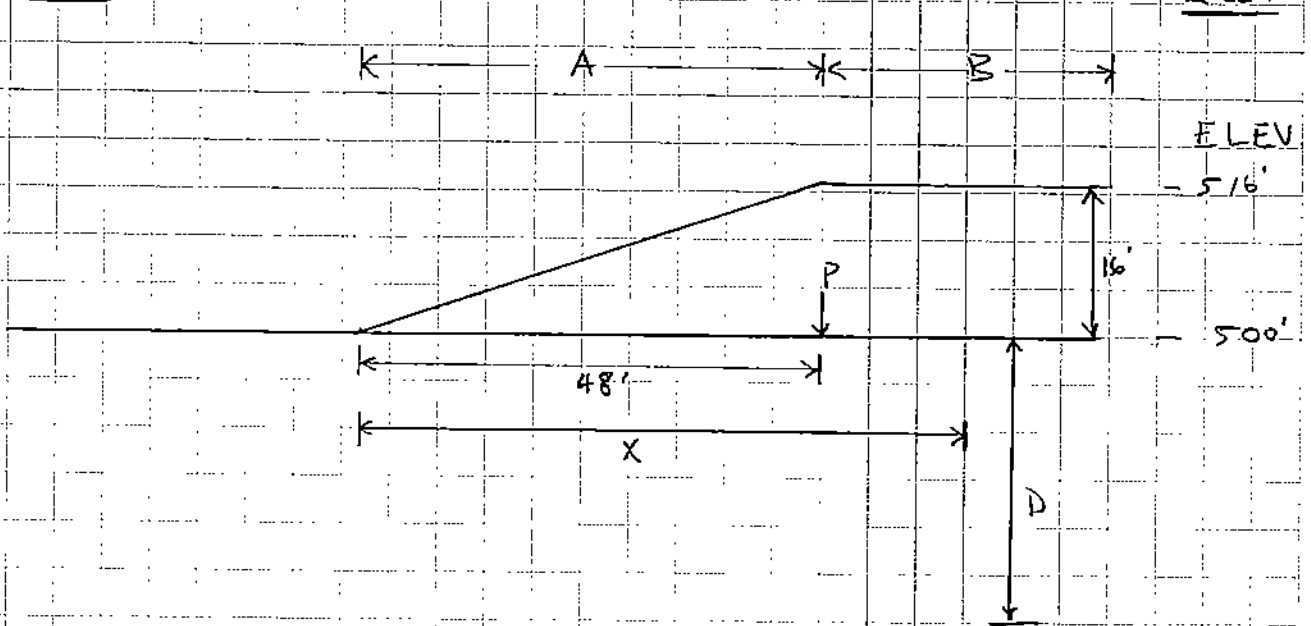
SUBJECT Pownal Tannery Landfill — Estimate Stress Increase

Estimate Stress Increase due to Landfill

- Use computer program GEOTEK and check using Boussinesq Influence Charts
- Generalize Landfill at north end of Lagoon 4.



Maximum Stress "P":

$\gamma_{cap} = 123$ pcf $\gamma_{sludge} = 96$ pcf Assume cap Thickness = 3'

$P = 3(123\text{ pcf}) + 13(96\text{ pcf}) = \underline{\underline{1617\text{ psf}}}$

$A = 48'$

$B = 120'$

$X = 108'$ to center of landfill

$D_o = 0'$ (existing surface of lagoon)

$D_f = 70'$ (Depth to bedrock)

A

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Customer-Focused Solutions

SUBJECT Pownal Tannery Landfill — Estimate Stress Increase

OUTPUT From GEOTEK Computer Program:

Depth	$\Delta\sigma_v$, psf
0	1617
5	1616.72
10	1614.79
15	1609.81
20	1600.75
25	1587.10
30	1568.76
35	1546.03
40	1519.44
45	1489.66
50	1457.40
55	1423.36
60	1388.15
65	1352.31
70	1316.28

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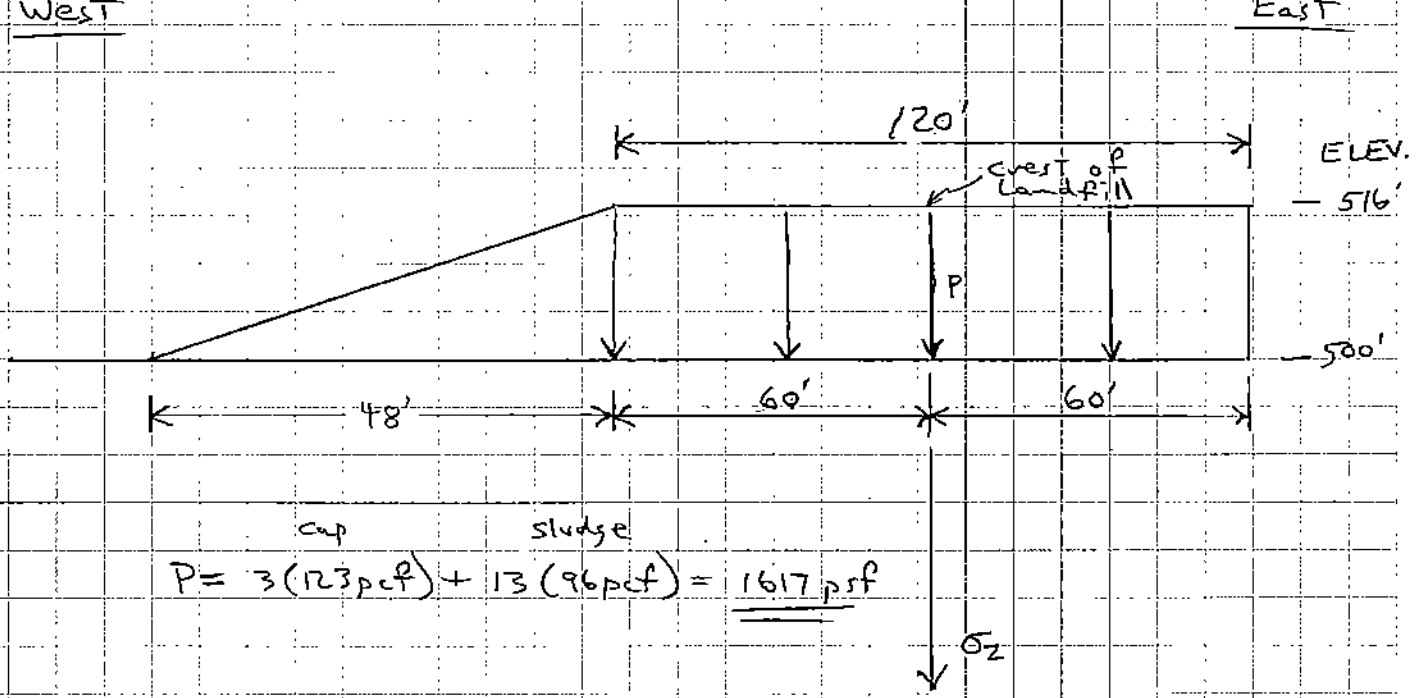
Customer-Focused Solutions

SUBJECT Estimate Stress Increase — Pownal Tannery Landfill

Calculate Increase in Stress Due To Landfill:

- Use Bassiness Influence Charts to check GEOTEK program
- Calculate increase in stress at top crest of landfill using the influence chart for a uniformly loaded rectangular area (Fig. 8.21) and the influence chart for a vertical stress under a long embankment (Fig. 8.23).



$P = 3(123\,pcf) + 13(96\,pcf) = \underline{1617\,psf}$

(cap, sludge)

Use Fig. 8.21 for rectangular area to east of crest.

$y = 300' +$
$x = 60'$
$z = 70'$

$m = \frac{x}{z}$ $\quad n = \frac{y}{z}$

$m = \frac{60'}{70'} = 0.86$ $\quad n = \frac{300'}{70'} = 4.29$

From Fig 8.21, $I = 0.19$

A

SHEET NO. 4 OF 7
PROJECT NO. 02136-0510
DATE 1/9/03
BY GAM
CHK'D ALS 10/21/03

TRC Customer-Focused Solutions

SUBJECT Powual Tannery Landfill — Estimate Stress Increase

Increase in stress due to rectangular area to east.

$\sigma_{z_1} = PI \times 2$

$\sigma_{z_1} = 1617\ psf\ (0.19) \times 2$

$= 614.46\ psf$

From Fig 8.23, calculate stress due to embankment

$a = 48'$ $\quad a/z = 0.69$

$b = 60'$

$q_o = 1617\ psf$ $\quad b/z = 0.86$

$z = 70'$

From Fig 8.23. $\Rightarrow$ $I = 0.435$

$\sigma_{z_2} = I \times q_o$

$= 0.435 \times 1617\ psf$

$\sigma_{z_2} = 703.40\ psf$

Total Increase in stress under landfill crest at 70' depth:

$\sigma_z = \sigma_{z_1} + \sigma_{z_2}$

$= 614.46 + 703.4\ psf$

$= 1317.86\ psf$

$1316.28 \cong 1317.86\ psf$ OK. To use GEOTEK

A

Pownal Tannery Landfill P. 5 of 7
Estimate Stress Increase

An Introduction to Geotechnical Engineering

ROBERT D. HOLTZ, PH.D., P.E.
University of Washington

WILLIAM D. KOVACS, PH.D., P.E.
University of Rhode Island

PRENTICE HALL, Englewood Cliffs, New Jersey 07632

(8-26)

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$\frac{+ 2)}{+ 1)}$

(8-27)

(8-28)
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a, respectively.
q. 8-27 may be

(8-30)

Fig. 8.21.

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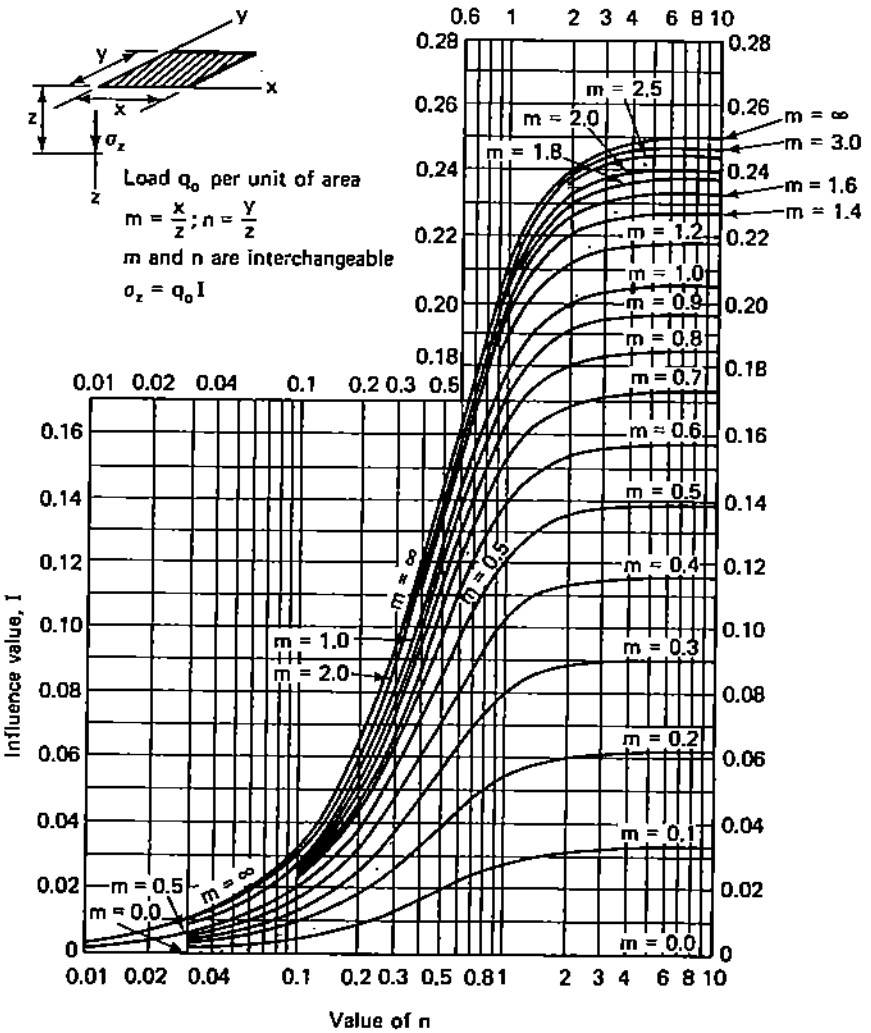

Fig. 8.21 Influence value for vertical stress under corner of a uniformly loaded rectangular area (after U.S. Navy, 1971).

Embankment (and

Pownal Tannery Landfill p. 7 of 7

Estimate Stress Increase

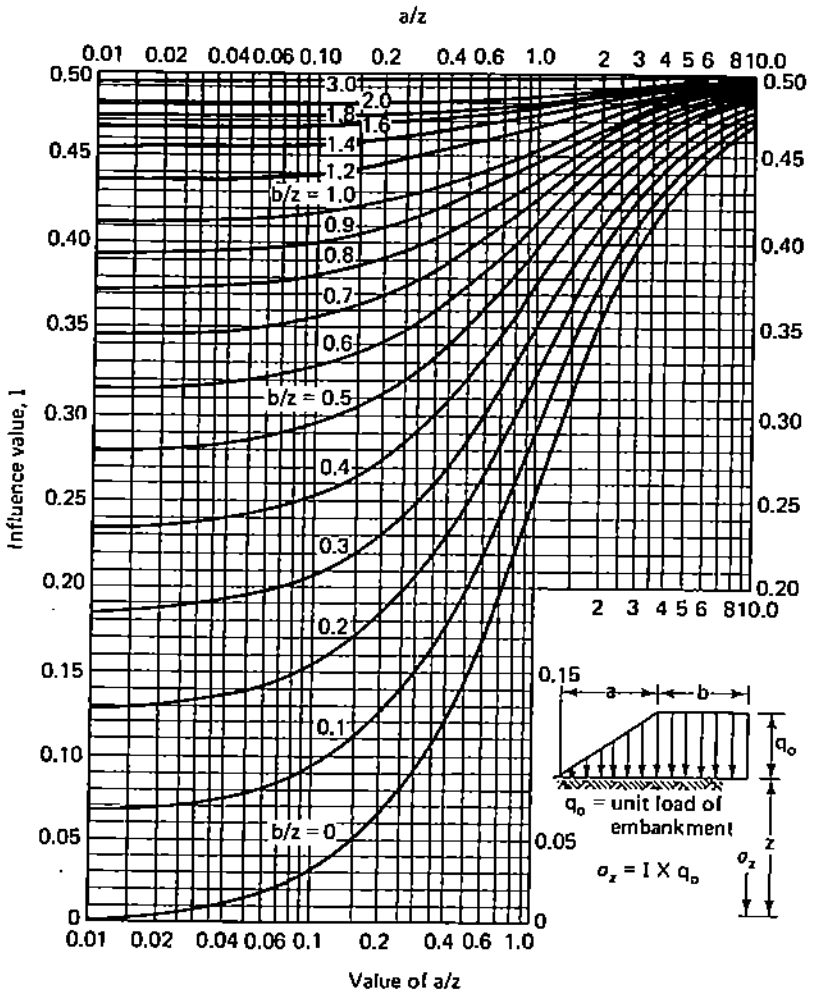

Fig. 8.23 Influence values for vertical stress under a very long embankment; length = ∞ (from U.S. Navy, 1971, after Osterberg, 1957).

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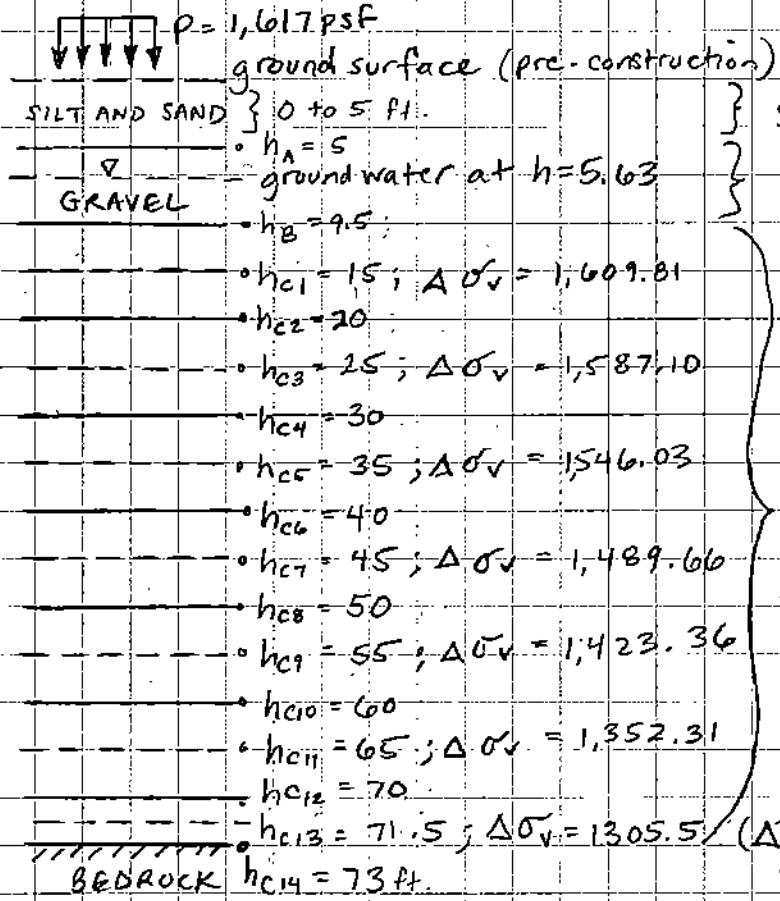
SUBJECT POWNAL CLAY/SETTLEMENT CALCS.

USE SBL4-103 as reference pt. for calcs.



Calculate Consolidation settlement for clays below cap:

Use modified compression index ($C_{c\epsilon}$) combined with pressures (Cassagrande's methods) to do calculation:

$$S_c = C_{c\epsilon} H_o \log\left(\frac{\sigma'_{vo} + \Delta\sigma_v}{\sigma'_{vo}}\right)$$; } set up spreadsheet to perform calculation

S_c = consolidation settlement for normally consolidated clays
$C_{c\epsilon}$ = modified compression index (use 0.105)
H_o = height of slice being evaluated in clay.
$\Delta\sigma_v$ = delta effective stress, psf
σ'_{vo} = existing vertical overburden stress, psf

A

SHEET NO. 2 OF 5

PROJECT NO.

DATE 1/17/03

BY ALS

CHK'D GAM

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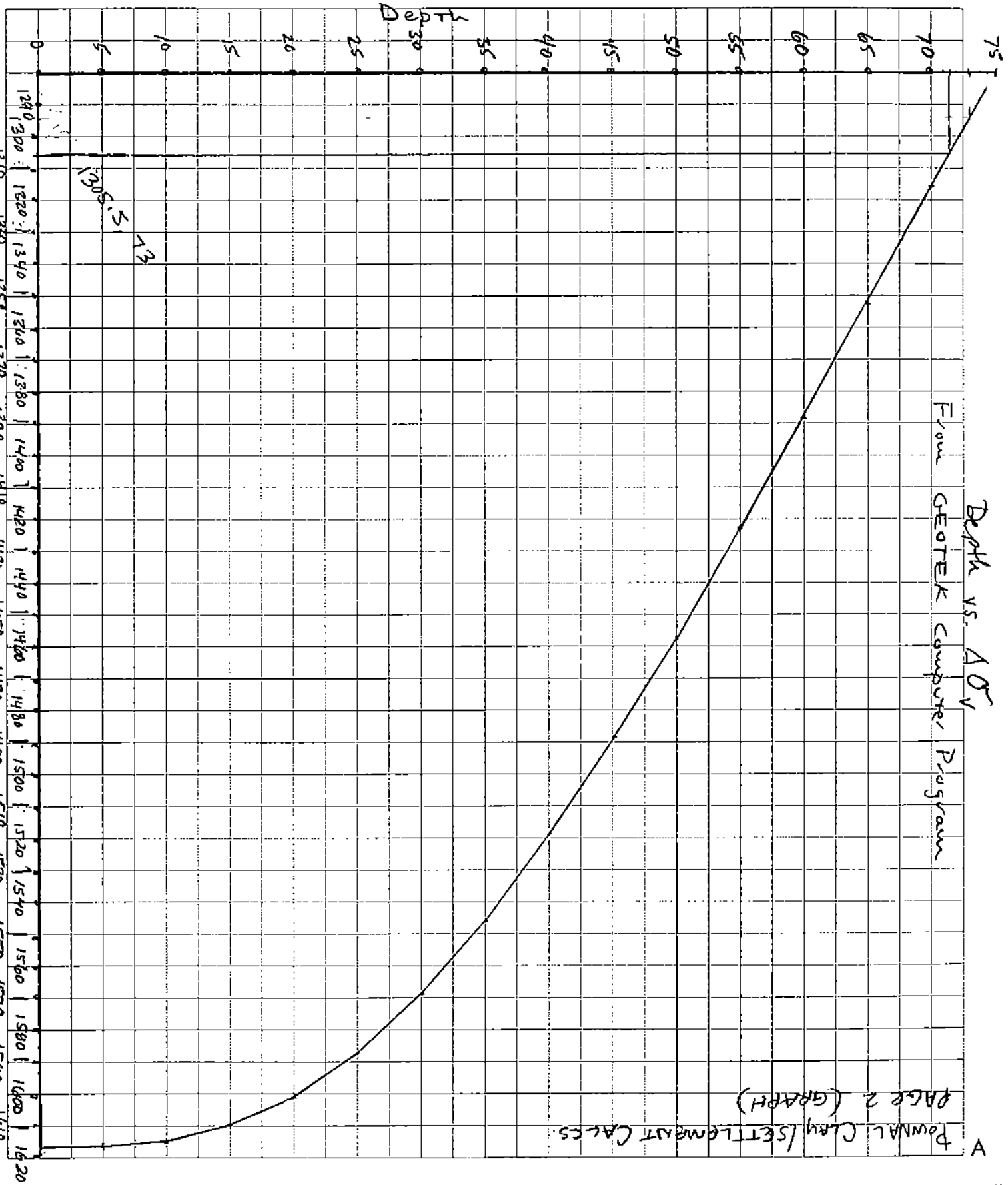
SUBJECT Pownal Clay/Settlement Calcs.



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SUBJECT POWNAL CLAY/SETTLEMENT CALCS,

Calculate vertical effective stress of layers overlying clay layer:

1) SILT & SAND LAYER, σ'_{vo}

$$\sigma'_{vo} = (H\gamma_{wet})_{silt+sand} = (5\,ft)(115\,pcf) = 575\,psf \text{ (at bottom of layer)}$$

2) GRAVEL LAYER, σ'_{vo}

$$\sigma'_{vo} = \sigma'_{v\,(silt+sand)} + (H\gamma_{wet})_{gravel} + (\gamma_{sat} - \gamma_{water})H_{gravel}$$

$$= 534.5 + (0.63 \times 140\,pcf) + (140 - 62.4\,pcf)(9.5 - 5.63)$$

$$= 622.7 + 77.6(3.87') = (622.7 + 300.31)\,psf$$

$$= 923.01\,psf \text{ (at bottom of layer)}$$

∴ Add 575 psf and 923.01 psf to all vertical effective stresses for clay layer(s).

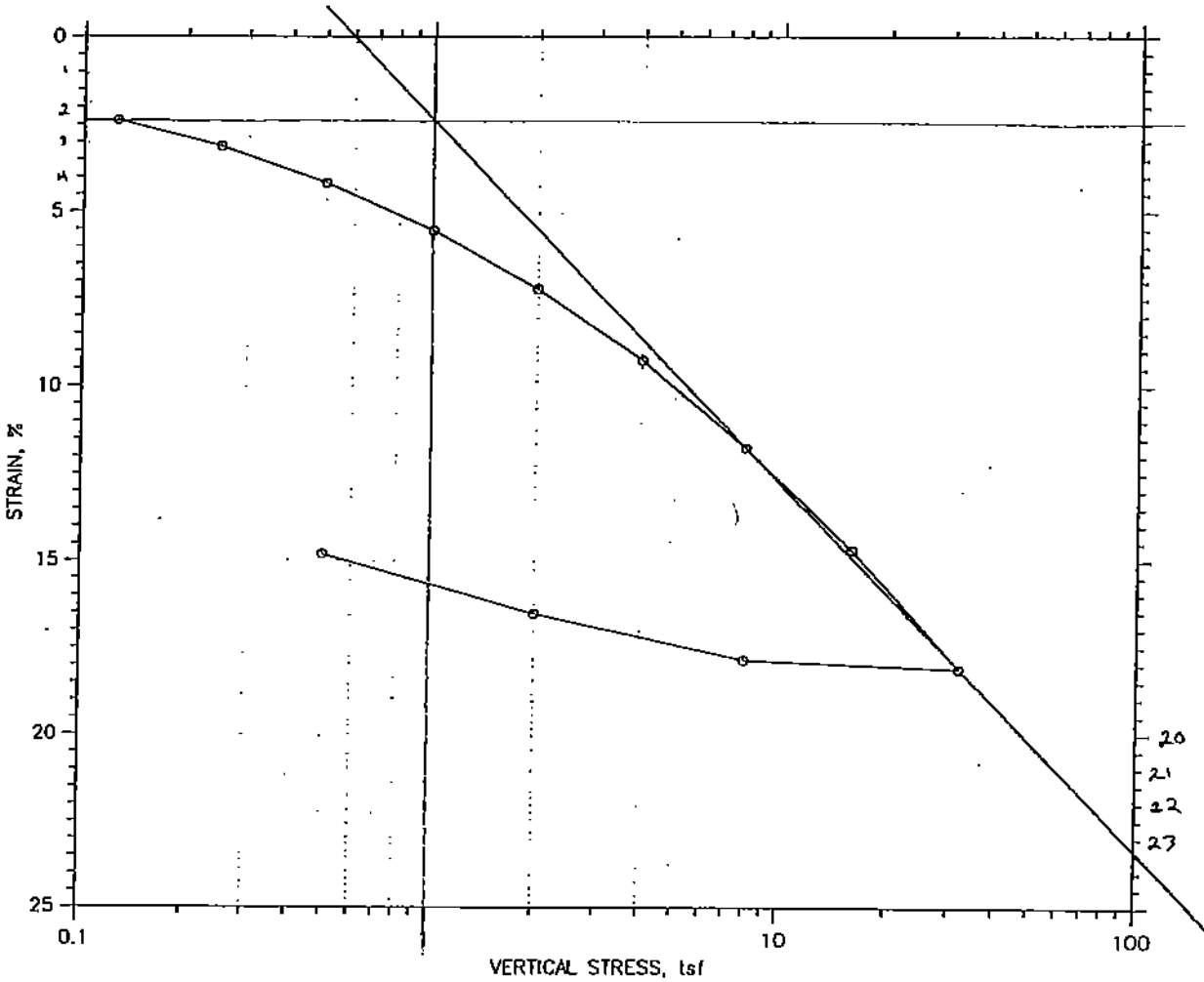
∴ (575 + 923.01) psf = 1,498.01 psf for overburden (silty sand + gravel layers)

∴ $\sigma'_{vo\,(clay,\,mid\text{-}layer)} = 1{,}498.01\,psf + \Delta H_{clay}(\gamma_{clay} - \gamma_{water})$

A

CONSOLIDATION TEST DATA

SUMMARY REPORT



$$C_{CE} = \frac{\Delta \varepsilon}{\log \frac{100}{1}} = \frac{0.234 - 0.024}{2} = \frac{0.21}{2} = 0.105$$

				Before Test	After Test
Overburden Pressure, tsf:			Water Content, %	35.62	25.18
Preconsolidation Pressure, tsf:			Dry Unit Weight, pcf	87.891	103.16
Compression Index:			Saturation, %	99.79	99.99
Diameter: 2.489 in	Height: 1 in		Void Ratio	1.01	0.71
LL: 0	PL: 0	PI: 0	GS: 2.83		

Project: Pownal Tannery	Location: ---	Project No.: GTX-4363
Boring No.: SBL-4	Tested By: fy	Checked By: jdt
Sample No.: 103	Test Date: 12/02/02	Depth: 25-27 ft
Test No.: C1	Sample Type: Tube	Elevation: ---
Description: Moist, gray clayey silt		
Remarks: ---		

Consolidation Settlement in Clay
Due to Landfill
Pownal Tannery Superfund Site

Depth Interval (ft.)	Depth at Midpoint (ft.)	C_{ce}	H_o (ft.)	O'_{vo} (psf)	$d(O_v)$ (psf)	S_c clay (ft.)	S_c clay (inches)
0 to 5	-	-	-	575	-	NA	NA
5 to 9.5	-	-	-	923.01	-	NA	NA
9.5 to 20	14.75	0.105	10.5	1781.7725	1609.81	0.308204	3.698448
20 to 30	25	0.105	10	2335.785	1587.1	0.236431	2.837176
30 to 40	35	0.105	10	2876.285	1546.03	0.196159	2.353904
40 to 50	45	0.105	10	3416.785	1489.66	0.165007	1.980081
50 to 60	55	0.105	10	3957.285	1423.36	0.140109	1.681306
60 to 70	65	0.105	10	4497.785	1352.31	0.119872	1.438469
70 to 73	71.5	0.105	3	4849.11	1305.5	0.032615	0.391376
						Total =	14.38076 inches

NA - not applicable

SHEET NO. ____ OF ____

PROJECT NO. 02136-0510-

DATE 6/19/03

BY GAM

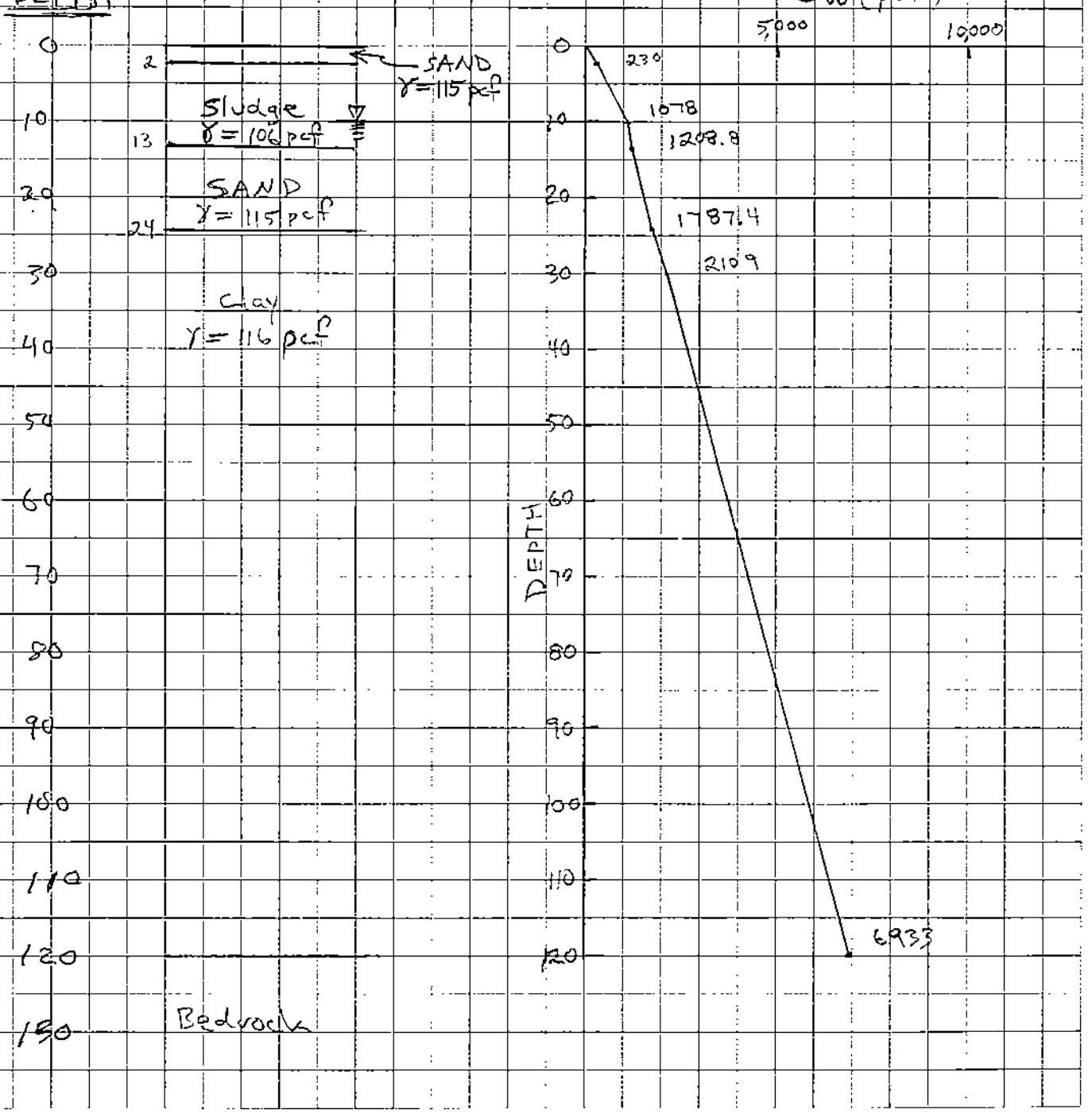
CHK'D N.P. 6/27/03

TRC

SUBJECT Pownal Tannery Superfund Site — Lagoon 3 Settlement

Determine existing effective stress at points "A" and "B" for use in settlement calculations.

Point A – Borings SBL3-102 and MW-109U were used to define subsurface soil units.



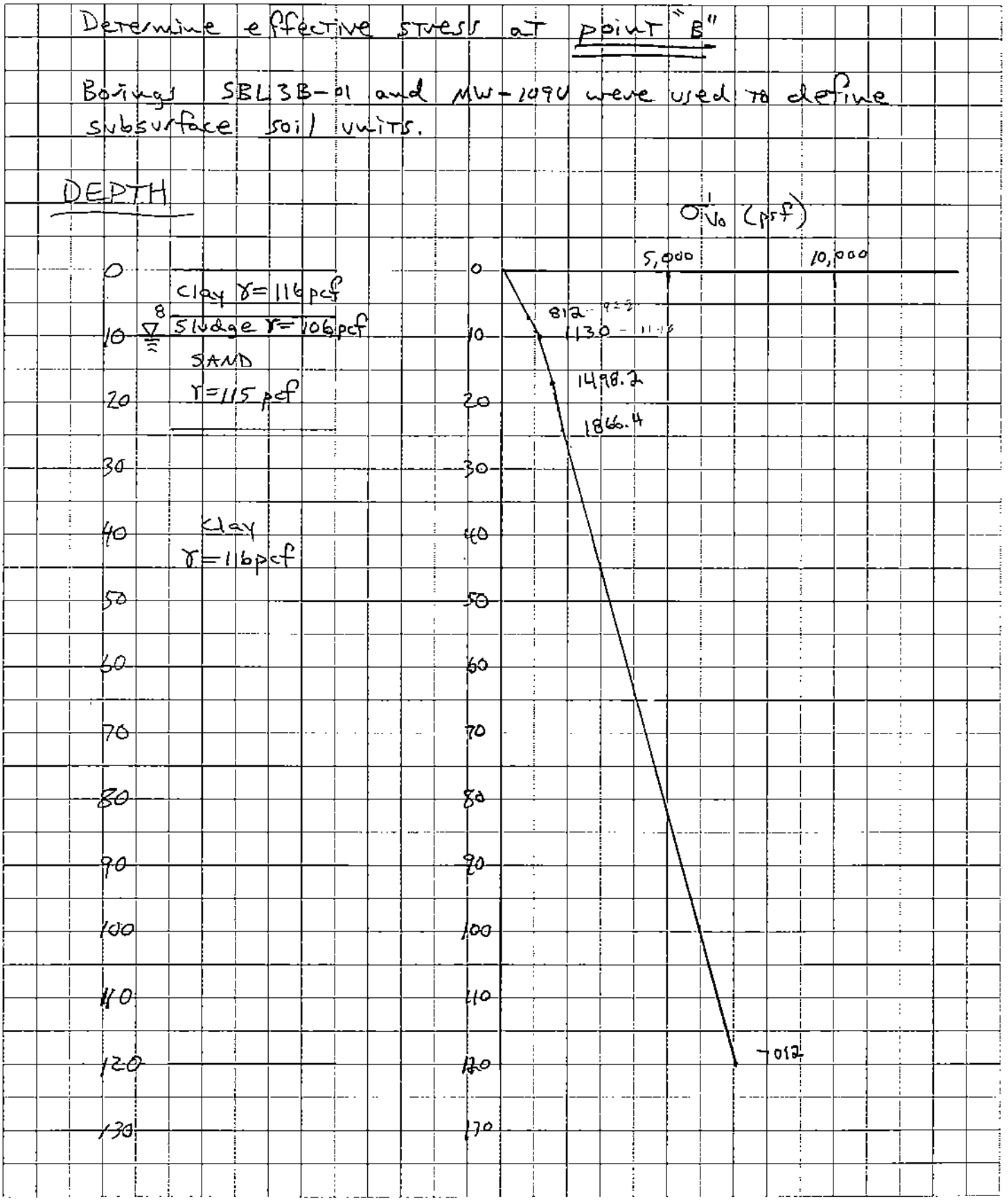
SHEET NO. _____ OF _____
PROJECT NO. 02136-0570
DATE 6/19/03
BY GAM
CHK'D M.P. 6/24/03

TRC

SUBJECT Lagoon 3 Settlement
Powual Tannery Superfund Site

Determine effective stress at point "B"

Borings SBL3B-01 and MW-109U were used to define subsurface soil units.



SHEET NO. _____ OF _____

PROJECT NO. 02136-0510

DATE 6/19/03

BY GAM

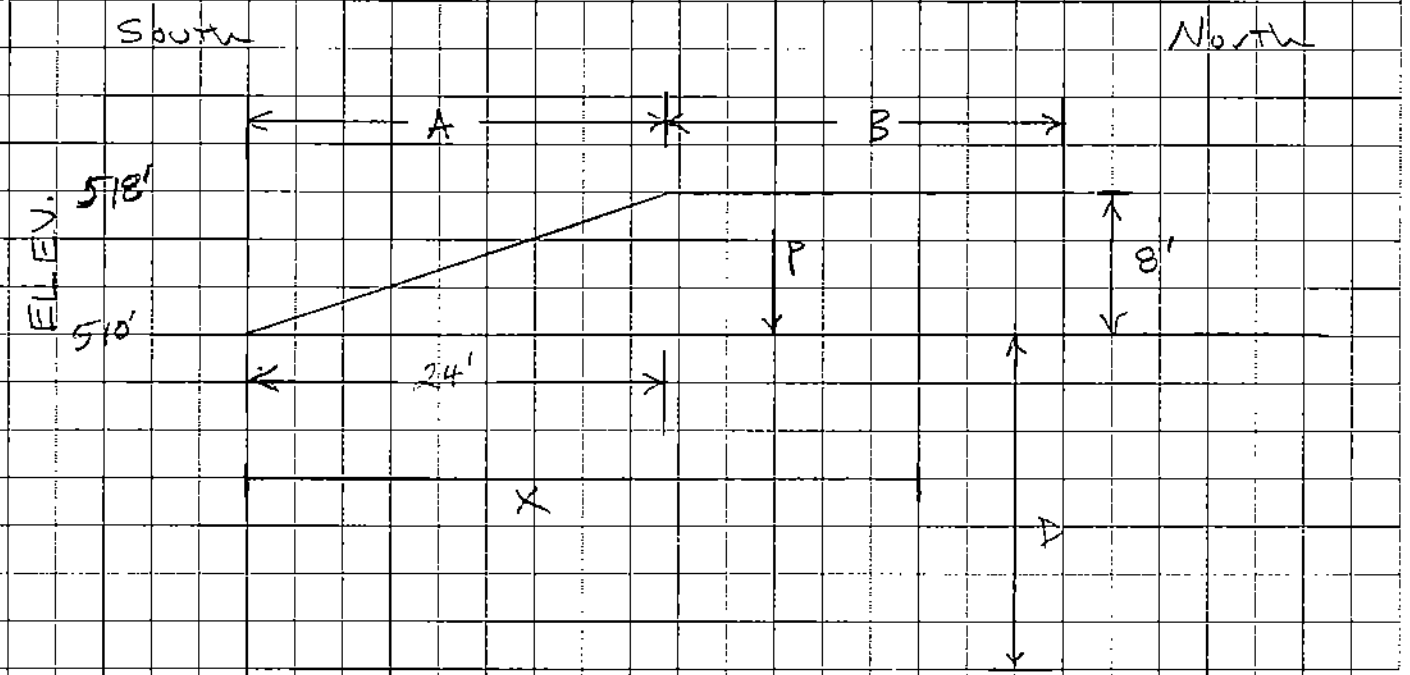
CHK'D M.P. 6/24/03

TRC

SUBJECT Lagoon 3 Settlement
Pownal Tannery Superfund Site

Calculate Stress Increase Due To Landfill

- Use computer program GEOTEK
- Generalize Landfill at east end of Lagoon 3.



A = 24'
B = 300'
D_o = 0' (Existing surface of Lagoon)
D_f = 120' (Depth to bedrock)

Maximum Stress (P) at point 'A': γ_{cap} = 123 pcf
γ_{sludge} = 96 pcf

$P = 3(123\ pcf) + 5'(96\ pcf) = \underline{\underline{849\ psf}}$

$X_A = 24' + 150' = 174'$

SHEET NO. _____ OF _____

PROJECT NO. 02136-0510

DATE 6/19/03

BY GAM

CHK'D M.P. 6/24/03

TRC

SUBJECT Lagoon 3 Settlement
Pownal Tannery Superfund Site

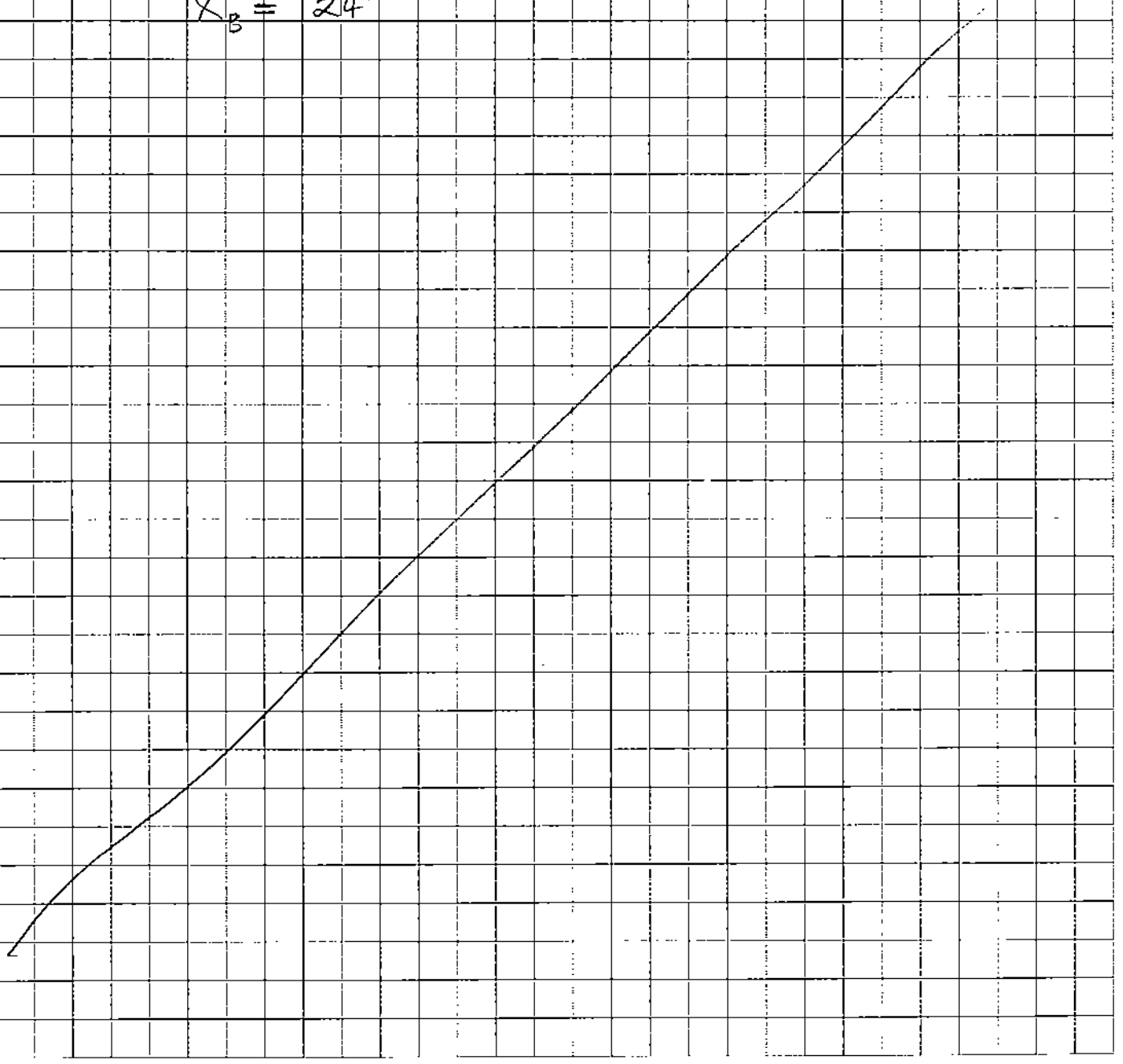
Maximum Stress (P) at point "B":

γ_{cap} = 123 pcf, γ_{sludge} = 96 pcf.

P = 7'(123 pcf) + 1'(96 pcf)

= 957 psf

X_B = 24'



SHEET NO. ____ OF ____

PROJECT NO. 02136-0510

DATE 6/19/03

BY GAM

CHK'D M.P. 6/24/03

TRC

SUBJECT Lagoon 3 Settlement
Annual Tannery Superfund Site

OUTPUT from GEOTEK for POINT "A" in Lagoon 3.

Depth	ΔSv
0	849
10	848.9
20	848.2
30	846.5
40	843.3
50	838.3
60	831.4
70	822.6
80	812.0
90	799.7
100	785.98
110	771.1
120	755.2

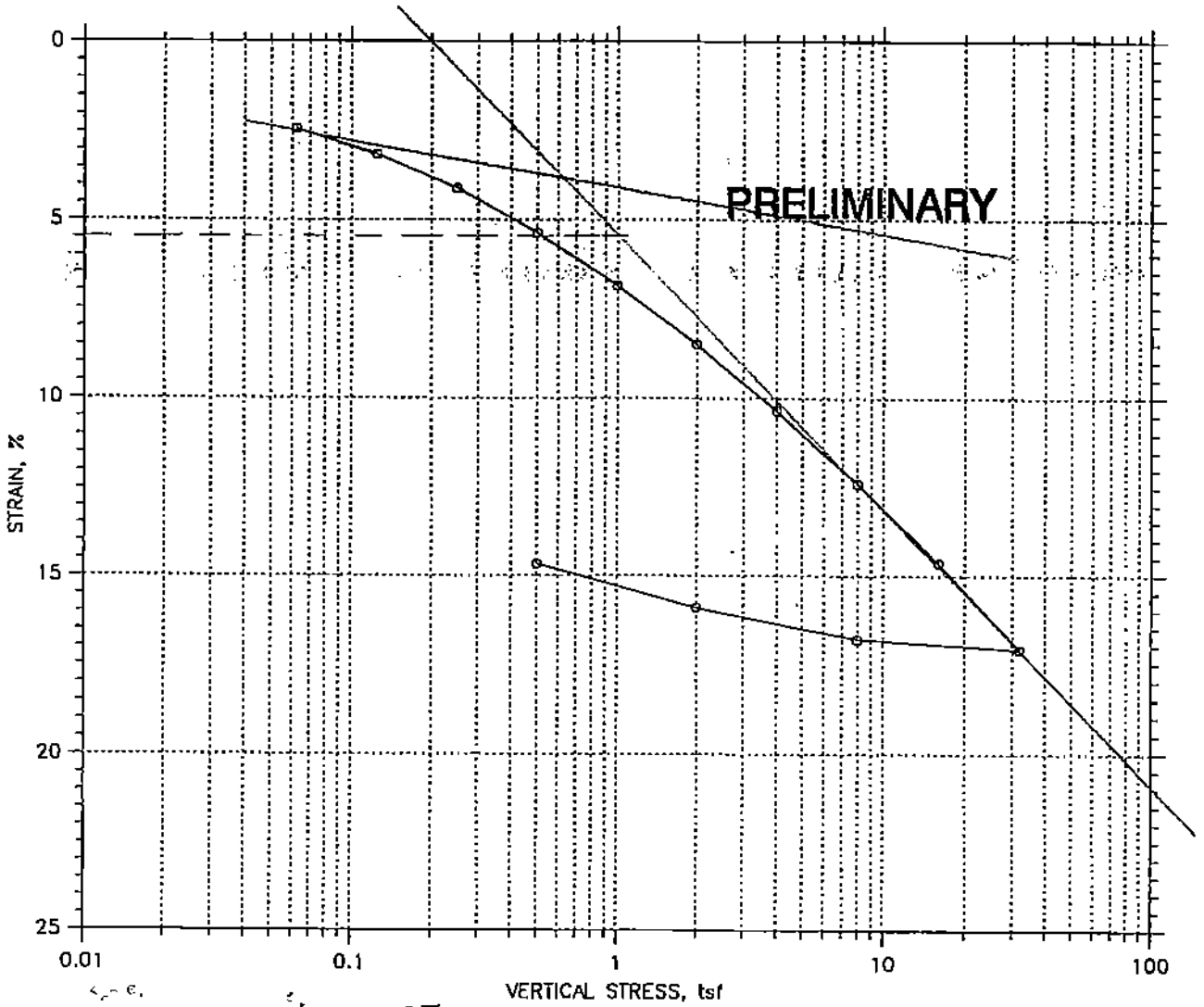
OUTPUT from GEOTEK for POINT "B" in Lagoon 3

Depth	ΔSv
0	957.0
10	836.7
20	745.3
30	683.8
40	642.7
50	613.9
60	592.9
70	576.7
80	563.7
90	552.9
100	543.6
110	535.3
120	527.8

Lagoon 3 Settlement

N.P 6/24/03

CONSOLIDATION TEST DATA
SUMMARY REPORT



$$C_{c\varepsilon} = \frac{\Delta\varepsilon}{\log\frac{100}{1}} = \frac{0.21 - 0.055}{2} = \frac{0.155}{2} = 0.0775$$

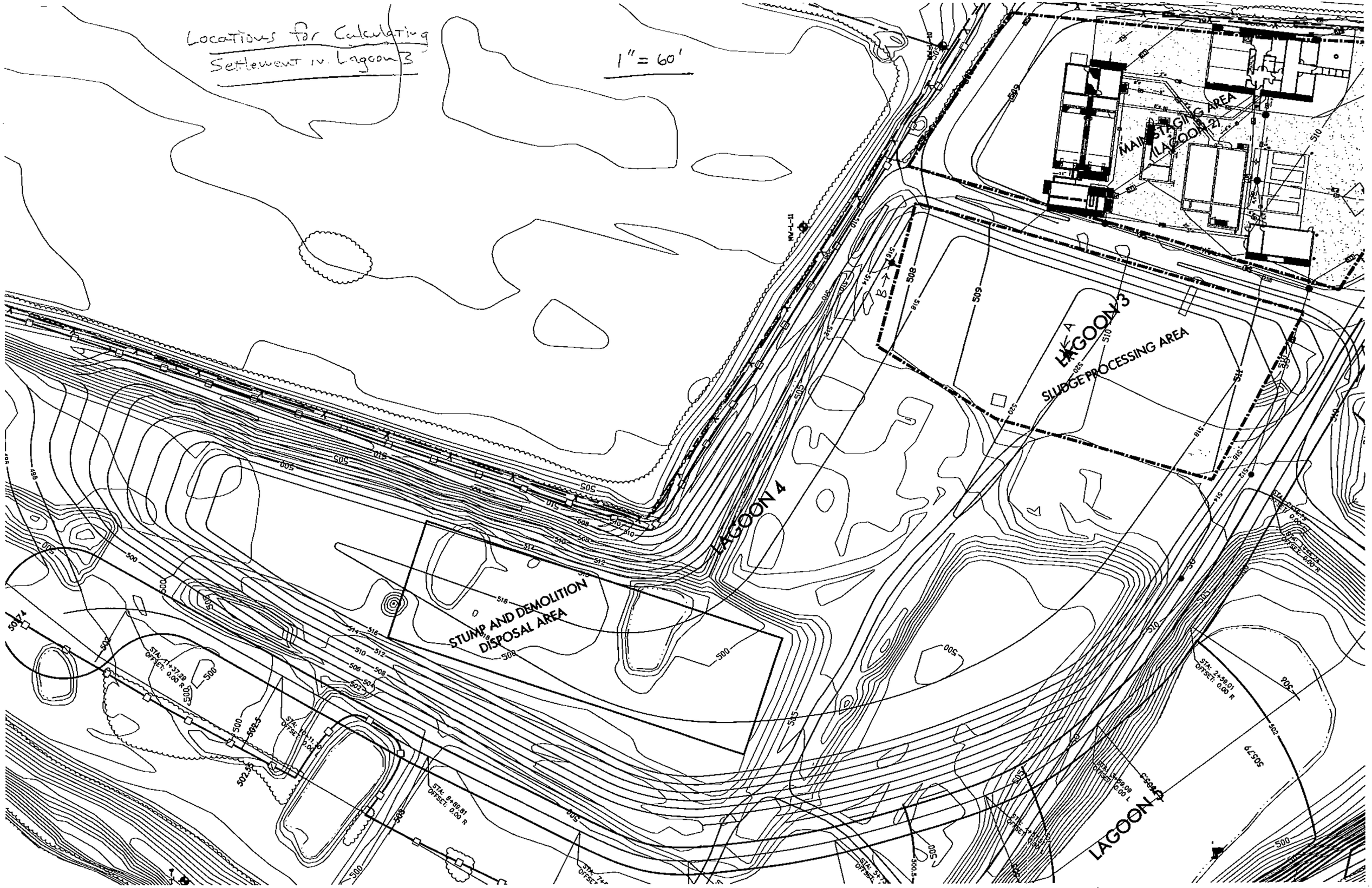
$C_{c\varepsilon} = 0.0775$

	Before Test	After Test
Overburden Pressure, tsf:	Water Content, %	26.51	17.62
Preconsolidation Pressure, tsf:	Dry Unit Weight, pcf	100.54	117.83
Compression Index:	Saturation, %	99.18	100.00
Diameter: 2.5 in / Height: 1 in	Void Ratio	0.76	0.50
LL: 0 / PL: 0 / PI: 0 / GS: 2.83			

Project: Pownal Tannery	Location: Pownal, VT	Project No.: GTX-4363
Boring No.: SBL-3	Tested By: fy	Checked By: jdt
Sample No.: 102	Test Date: 12/17/02	Depth: 6-8 ft
Test No.: C3	Sample Type: Tube	Elevation: ---
Description: Moist, dark gray clay with sand (Sludge from Lagoon 3)		
Remarks: ---		

Locations for Calculating Settlement in Lagoon 3

1" = 60'



Lagoon 3 Settlement

TRC ENVIRONMENTAL
Foot of John Street, Boott Mills South
Lowell, MA 01852
Telephone: (978) 970-5600
Fax: (978) 453-1995

BORING/WELL CONSTRUCTION LOG

POWNAL TANNERY, Pownal, VT

PROJECT NUMBER	02136-0220-01N93	BORING/WELL NUMBER	MW-109U
LOCATION	Pownal Tannery	DATE DRILLED	3/24/00
DRILLING CONTRACTOR	Earth Exploration	CASING TYPE/DIAMETER	4 inch steel casing.
DRILLING METHOD	Drive and Wash/4 inch steel	SCREEN TYPE/SLOT	10 foot 2 inch sch.40 PVC 0.006-slot screen.
SAMPLING METHOD	2 foot split-spoon (2" diam.)	FILTER PACK TYPE	#00 filter sand.
GROUND ELEVATION	510.80	SEAL TYPE	Medium bentonite chips.
TOP OF PVC	514.01	DEPTH TO WATER (Feet)	15.00
LOGGED BY	Jim Leonard	GROUND WATER ELEVATION	495.80
REMARKS	Field screening conducted with the use of a MicroFID flame-ionization detector.		

DEPTH (ft. BGL)	BLOW COUNTS	RECOVERY (feet)	SAMPLE ID.	U.S.C.S.	GRAPHIC LOG	LITHOLOGIC DESCRIPTION	FID (ppm)	RAS/DAS ID#	WELL DIAGRAM
1	7-13 19-25	12/24		SW GW		Light gray, dry, medium to coarse SAND and angular GRAVEL.	0		
2									
3	6-9 6-6	9/24		SW GW		Light gray, dry, medium to coarse SAND and angular GRAVEL.	0		
4									
5	6-9 5-4	6/24		SW GW		Brown, dry, medium to coarse SAND and angular GRAVEL.	0		Grout to surface. 2" sch.40 PVC riser
6									
7	5-6 15-7	3/24		SW GW		Brown, dry, medium to coarse SAND and angular GRAVEL, trace dark brown, medium SAND. Rock in tip.	0		
8									
9	7-6 11-14	8/24		SP SM		Gray/brown, dry, fine silty SAND.	0		Medium bentonite chips.
10				SP SM		Brown, dry, fine silty SAND, trace clay and angular gravel.			
11	13-12 13-11	24/24		SP SM		Black stained, dry, fine to medium silty SAND.	0		#00 filter sand
12									
13	8-8 6-5	14/24		SP SM		Light brown, moist, silty SAND, trace clay, trace black staining.	0		
14									
15	4-5 4-6	8/24		CL ML		Light brown, saturated, SILT and CLAY, little black staining at tip. ▼	0		
16									

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Lowell, MA 01852
Telephone: (978) 970-5600
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BORING/WELL CONSTRUCTION LOG

POWNAL TANNERY, Pownal, VT

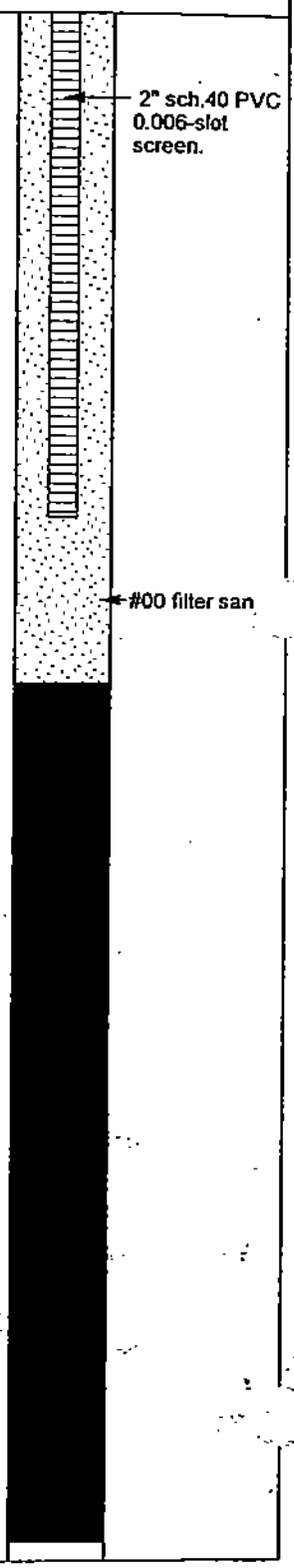
PROJECT NUMBER 02136-0220-01N93

BORING/WELL NUMBER MW-109U

DATE DRILLED 3/24/00

DEPTH (ft. BGL)	BLOW COUNTS	RECOVERY (feet)	SAMPLE ID.	U.S.C.S.	GRAPHIC LOG	LITHOLOGIC DESCRIPTION	FID (ppm)	RAS/DAS ID#
17	6-4 13-19	9/24		SP SM		Light brown, fine silty SAND, trace gravel, black staining at tip.	0	
18						Black stained, angular rock fragments and wash from borehole.		
19	11-11 10-6	6/24					0	
20								
21	19-21 17-13	12/24		GW		Light gray, angular and rounded gravel. Rock in tip.	0	
22						Light brown, SILT, little clay.		
23	18-11 19-17	12/24		CL ML			0	
24						Light brown, SILT, little clay.		
25	9-7 12-8	12/24		CL ML			0	
26						Light gray/brown, SILT, little clay.		
27	11-11 14-14	24/24		CL ML			0	
28						Gray, CLAY.		
29	5-4 5-5	12/24		CH			0	
30						Roller bit.		
31								
32								
33								
34								

WELL DIAGRAM



Lagoon 3 Settlement

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BORING/WELL CONSTRUCTION LOG

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PROJECT NUMBER 02136-0220-01N93

BORING/WELL NUMBER MW-109U

DATE DRILLED 3/24/00

DEPTH (ft. BGL)	BLOW COUNTS	RECOVERY (feet)	SAMPLE ID.	U.S.C.S.	GRAPHIC LOG	LITHOLOGIC DESCRIPTION	FID (ppm)	RAS/DAS ID#	WELL DIAGRAM
35									
36									
37									
38									
39						Gray, CLAY.			
40	7-7 11-12	24/24		CH			0		
41						Roller bit.			
42									
43									
44									
45									
46									
47									
48									
49						Gray, CLAY.			
50	4-4 6-6	24/24		CH			0		
51						Roller bit.			
52									

TRC ENVIRONMENTAL
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Lowell, MA 01852
Telephone: (978) 970-5600
Fax: (978) 453-1995

BORING/WELL CONSTRUCTION LOG

POWNAL TANNERY, Pownal, VT

PROJECT NUMBER 02136-0220-01N93

BORING/WELL NUMBER MW-109U

DATE DRILLED 3/24/00

DEPTH (ft. BGL)	BLOW COUNTS	RECOVERY (feet)	SAMPLE ID.	U.S.C.S.	GRAPHIC LOG	LITHOLOGIC DESCRIPTION	FID (ppm)	RAS/DAS ID#	WELL DIAGRAM
53									
54									
55									
56									
57									
58									
59									
60	0-0 1-2	24/24		CL SM		Gray, CLAY, with very fine silty sand lenses.	0		
61						Roller bit.			
62									
63									
64									
65									
66									
67									
68									
69									
70	0-0 2-3	24/24		CL SM		Gray, CLAY, with very fine silty sand lenses.	0		

Lagoon 3 Settlement

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BORING/WELL CONSTRUCTION LOG

POWNAL TANNERY, Pownal, VT

PROJECT NUMBER 02136-0220-01N93

BORING/WELL NUMBER MW-109U

DATE DRILLED 3/24/00

DEPTH (ft. BGL)	BLOW COUNTS	RECOVERY (feet)	SAMPLE ID.	U.S.C.S.	GRAPHIC LOG	LITHOLOGIC DESCRIPTION	FID (ppm)	RAS/DAS ID#	WELL DIAGRAM
71						Roller bit.			Medium bentonite chips.
72									
73									
74									
75									
76									
77									
78									
79						Gray, CLAY, with very fine silty sand lenses.			
80	2-2 2-3	24/24		CL SM			0		
81						Roller bit.			
82									
83									
84									
85									
86									
87									
88									
89									

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Fax: (978) 453-1995

BORING/WELL CONSTRUCTION LOG

POWNAL TANNERY, Pownal, VT

PROJECT NUMBER 02136-0220-01N93 **BORING/WELL NUMBER** MW-109U

DATE DRILLED 3/24/00

DEPTH (ft. BGL)	BLOW COUNTS	RECOVERY (feet)	SAMPLE ID.	U.S.C.S.	GRAPHIC LOG	LITHOLOGIC DESCRIPTION	FID (ppm)	RAS/DAS ID#	WELL DIAGRAM
90	0-0 3-3	24/24		CL SM		Gray, CLAY, with very fine silty sand lenses.	0		
91						Roller bit.			
92									
93									
94									
95									
96									
97									
98									
99									
100	0-0 2-3	24/24		CL SM		Gray, CLAY, with very fine silty sand lenses.	0		
101						Roller bit.			
102									
103									
104									
105									
106									
107									

Lagoon 3 Settlement

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BORING/WELL CONSTRUCTION LOG

POWNAL TANNERY, Pownal, VT

PROJECT NUMBER 02136-0220-01N93

BORING/WELL NUMBER MW-109U

DATE DRILLED 3/24/00

DEPTH (ft. BGL)	BLOW COUNTS	RECOVERY (feet)	SAMPLE ID.	U.S.C.S.	GRAPHIC LOG	LITHOLOGIC DESCRIPTION	FID (ppm)	RAS/DAS ID#	WELL DIAGRAM
108									
109						Gray, CLAY. Rock fragments in tip of spoon.			
110	13-11 11-23	12/24		CH			0		
111						Roller bit.			
112									
113									
114									
115									
116									
117									
118									
119									
120									
121						End of boring at top of rock.			

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BORING/WELL CONSTRUCTION LOG

POWNAL TANNERY, Pownal, VT

PROJECT NUMBER	02136-0220-01N93	**BORING/WELL NUMBER**	MW-110R
LOCATION	Pownal Tannery	**DATE DRILLED**	4/10/00
DRILLING CONTRACTOR	Earth Exploration	**CASING TYPE/DIAMETER**	4 inch steel casing.
DRILLING METHOD	Drive and Wash/4 inch steel	**SCREEN TYPE/SLOT**	10 foot 2 inch sch.40 PVC 0.006-slot screen.
SAMPLING METHOD	2 foot split-spoon (2" diam.)	**FILTER PACK TYPE**	#00 filter sand.
GROUND ELEVATION	505.70	**SEAL TYPE**	Medium bentonite chips.
TOP OF PVC	508.98	**DEPTH TO WATER (Feet)**	5.25
LOGGED BY	Kim Berry	**GROUND WATER ELEVATION**	500.45

REMARKS Field screening conducted with the use of a MicroFID flame-ionization detector.

DEPTH (ft. BGL)	BLOW COUNTS	RECOVERY (feet)	SAMPLE ID.	U.S.C.S.	GRAPHIC LOG	LITHOLOGIC DESCRIPTION	FID (ppm)	RAS/DAS ID#	WELL DIAGRAM
1			MW-110R/0.3-0.6			Concrete.		TRC-015	
2				GP					
3	21-24 17-17	12/24	MW-110R/3.0-6.0	GP		Brown, loose, dry, fine to coarse GRAVEL, angular rock fragments.	0		
4						Brick fragments.			
5	11-13 14-28	12/2		GP		Brown, loose, moist, fine to coarse GRAVEL, concrete and brick fragments.	1495	DAMT17 AQN88 MALS13	
6				GP		Black stained, loose, wet, fine to coarse GRAVEL, concrete and brick fragments.			Grout to surface.
7	80-7 5-4	6/24		GP			681		
8				GP		Black stained, loose, wet, fine to coarse GRAVEL, concrete and brick fragments.			
9	4-5 7-6	8/24		GP			583		2" sch.40 PVC riser
10				GP		Black stained, loose, wet, fine to coarse GRAVEL, concrete and brick fragments.			
11	5-6 5-7	18/24		SW GW		Black stained, loose, wet, coarse SAND and fine GRAVEL.	403		
12				SW GW					
13	11-17 17-24	18/24		SW GW		Black stained, loose, wet, coarse SAND and fine GRAVEL. Gray, metallic, weathered PHYLITE.	375		Medium bentonite chips.
14									
15	22-22 14-22	12/24				Gray, metallic, weathered PHYLITE.	374		
16						Roller bit.			

Lagoon 3 Settlement

TRC Environmental
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BORING/WELL CONSTRUCTION LOG
POWNAL TANNERY

PROJECT NUMBER	02136-0510-01N93	**BORING/WELL NUMBER**	SBL3-102
LOCATION		**DATE DRILLED**	12/4/02 - 12/5/02
DRILLING CONTRACTOR	Geologic	**CASING TYPE/DIAMETER**	No well installed.
DRILLING METHOD	Drive and Wash 4" Casing	**SCREEN TYPE/SLOT**	No well installed.
SAMPLING METHOD	2' Split Spoon (2"), 140 lb. hammer	**FILTER PACK TYPE**	No well installed.
GROUND ELEVATION		**SEAL TYPE**	Medium Bentonite Chips
TOP OF PVC		**DEPTH TO WATER (Feet)**	
LOGGED BY	A. Hamilton	**GROUND WATER ELEVATION**	

REMARKS Level B; Health & Safety monitoring coducted using PhotoVac 2020 PID & I.S. H2S/LEL Meter

DEPTH (ft. BGL)	BLOW COUNTS	RECOVERY (feet)	SAMPLE ID.	U.S.C.S.	GRAPHIC LOG	LITHOLOGIC DESCRIPTION	FID (ppm)	H2S/LEL (ppm/%)	WELL DIAGRAM
1	12-8 4-4	0.45/2	SBL3-102, 4-6'			Dark brown, dry, medium dense SAND, some silt. Top 0.1' organics, uniform sand.	ND	ND	
2						Dark brown, dry, medium dense SAND w/ silt, some coarse gravel. Black sludge w/ hair.			
3	4-10 14-4	1.4/2					110	12/ND	
4						Collect Shelby Tube. Recovery is < 9/29"			
5		9/29"					NA	NA	
6			SBL3-102, 6-8'			Collect Shelby Tube. Recovery is 27/29".			
7		27/29"					NA	NA	
8						Drive and Wash to 13 ft.			
9									
10							NA	NA	
11									
12									
13						Grayish brown, uniform, medium dense, fine SAND.			Grout to Surface
14									

Lagoon 3 Sediment

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BORING/WELL CONSTRUCTION LOG
POWNAL TANNERY

PROJECT NUMBER 02136-0510-01N93

BORING/WELL NUMBER SBL3-102

DATE DRILLED 12/4/02 - 12/5/02

DEPTH (ft. BGL)	BLOW COUNTS	RECOVERY (feet)	SAMPLE ID.	U.S.C.S.	GRAPHIC LOG	LITHOLOGIC DESCRIPTION	FID (ppm)	H2S/LEL (ppm/%)	WELL DIAGRAM
	6-7 20-43	1.3/2				Blackish-brown, coarse SAND.	ND	ND	
15						Drive and Wash to 20 ft.			
16									
17							NA	NA	
18									
19									
20						Rock fragments. Grayish-brown, wet, uniform, dense, fine SAND.			
21	18-17 29-27	1.0/2					ND	ND	
22						Grayish-brown, wet, uniform, very dense, fine SAND.			
23	31-29 35-35	1.7/2					ND	ND	
24						Rock fragments. Grayish-brown, very stiff, CLAY, trace sand and silt.			
25	14-8 15-16	1.8/2					ND	ND	
26						End of Boring.			

Lagoon 3 Settlement

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BORING/WELL CONSTRUCTION LOG

POWNAL TANNERY, Pownal, VT

PROJECT NUMBER	02136-0220-01N93	BORING/WELL NUMBER	SBL3B-01
LOCATION	Lagoon 3B	DATE DRILLED	3/27/00
DRILLING CONTRACTOR	Earth Exploration	CASING TYPE/DIAMETER	NA
DRILLING METHOD	Geoprobe	SCREEN TYPE/SLOT	NA
SAMPLING METHOD	Direct Push 4 foot PVC liner (2" diam.)	FILTER PACK TYPE	NA
GROUND ELEVATION	507.87	SEAL TYPE	NA
TOP OF CASING	NA	DEPTH TO WATER (Feet)	4.00
LOGGED BY	Sandy Weymouth	GROUND WATER ELEVATION	503.87

REMARKS: Field screening conducted with the use of a MicroFID flame-ionization detector.

DEPTH (ft. BGL)	BLOW COUNTS	RECOVERY (feet)	SAMPLE ID.	U.S.C.S.	GRAPHIC LOG	LITHOLOGIC DESCRIPTION	FID (ppm)	RAS/DAS ID#	WELL DIAGRAM
1			SBL3B-01/0.0-0.5			Gray, moist, CLAY, little silt and very fine sand, trace gravel, leaves/roots. (Fill)		DAMS26 ARE06 MANF86	
2	NA	2.6/4		CL			140		
3									
4									
5				CL					
6	NA	1.4/4					1200		
				CL		Gray, saturated, poorly sorted GRAVEL, little silt and clay. Overlying a thin layer of lyme(?). (Fill)			
7				OL		Black/gray, organic SILT, trace clay, hair, pieces of hide. (Fill)			
8									

Lagoon 3 Settlement

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BORING/WELL CONSTRUCTION LOG

POWNAL TANNERY, Pownal, VT

PROJECT NUMBER 02136-0220-01N93

BORING/WELL NUMBER SBL3B-01

DATE DRILLED 3/27/00

DEPTH (ft. BGL)	BLOW COUNTS	RECOVERY (feet)	SAMPLE ID.	U.S.C.S.	GRAPHIC LOG	LITHOLOGIC DESCRIPTION	FID (ppm)	RAS/DAS ID#	WELL DIAGRAM
			SBL3B-01/7.0-10.0	OL					Boring backfilled with bentonite
9				OL		Black saturated, organic SILT, little clay, trace very fine to fine sand. (Fill)		DAMS27 ARE07 MANF87	
10	NA	3.4/4					350		
				SW		Gray, saturated, well sorted. fine to medium SAND.			
11									
12				SW					
13									
				SW		Gray, saturated, well sorted fine to medium SAND.			
14	NA	2.8/4					0		
				SP GP		Black, poorly sorted, medium to coarse SAND, trace gravel.			
15				SP GP		Brown/gray, poorly sorted SAND and GRAVEL			
16						End of boring.			

Consolidation Settlement in Sludge and Clay
Due to Landfill
Pownal Tannery Superfund Site
Point A

Lagoon 3 Settlement

Depth Interval (ft.)	Depth at Midpoint (ft.)	C_{cs}	H_o (ft.)	O'_{vo} (psf)	$d(O_v)$ (psf)	S_c clay (ft.)	S_c clay (inches)
0 to 2	-	-	-	230	-	NA	NA
2 to 13	7.5	0.0775	11	813	849	0.264736	3.176829
13 to 24	18.5			1498.1		0	0
24 to 30	27	0.105	6	1948.2	847	0.098771	1.185252
30 to 40	35	0.105	10	2377	844.5	0.13863	1.663565
40 to 50	45	0.105	10	2913	839.5	0.115479	1.385751
50 to 60	55	0.105	10	3449	844.5	0.099874	1.19849
60 to 70	65	0.105	10	3985	826.5	0.085945	1.031337
70 to 80	75	0.105	10	4521	817	0.075751	0.909015
80 to 90	85	0.105	10	5057	806	0.067438	0.809259
90 to 100	95	0.105	10	5593	793	0.060463	0.72556
100 to 110	105	0.105	10	6129	778.5	0.054528	0.654334
110 to 120	115	0.105	10	6665	763	0.049425	0.593104

NA - not applicable

Total = **13.3325** **inches**

Consolidation Settlement in Sludge and Clay
Due to Landfill
Pownal Tannery Superfund Site
Point B

Lagoon 3 Settlement

Depth Interval (ft.)	Depth at Midpoint (ft.)	C_{ce}	H_o (ft.)	O'_{vo} (psf)	$d(O_v)$ (psf)	S_c clay (ft.)	S_c clay (inches)
0 to 8	-	-	-	812	-	NA	NA
8 to 10	9	0.0775	2	918	848.7	0.04407	0.528835
10 to 24	17			1498.2		NA	NA
24 to 30	27	0.105	6	2027.2	702.25	0.081382	0.97659
30 to 40	35	0.105	10	2456	663.2	0.109006	1.308067
40 to 50	45	0.105	10	2992	628.3	0.086922	1.043065
50 to 60	55	0.105	10	3528	603.4	0.071997	0.863965
60 to 70	65	0.105	10	4064	584.8	0.061307	0.735678
70 to 80	75	0.105	10	4600	570.2	0.053287	0.639444
80 to 90	85	0.105	10	5136	558.3	0.047056	0.564673
90 to 100	95	0.105	10	5672	548.3	0.042079	0.504946
100 to 110	105	0.105	10	6208	539.5	0.038001	0.456009
110 to 120	115	0.105	10	6744	531.5	0.034593	0.415111

NA - not applicable

Total = **8.036384** **inches**

APPENDIX H-5

GeoTesting Express
1145 Mass Avenue - Boxborough, MA 01719
(978) 635-0424 - Fax (978) 635-0266

LETTER OF TRANSMITTAL

TO:

Mr. Don Dwight
Metcalf & Eddy
30 Harvard Mill Square
Wakefield, MA 01888

DATE: 01/20/03	GTX NO: 4363
RE: Pownal Tannery Superfund Site Project	
Pages (excluding transmittal): 22	

We are sending you ☑ Attached ☐ Under separate cover via _____ the following items:
☑ Test results ☐ Proposal ☑ Report ☐ Samples ☐ Specifications ☐ Invoice
☐ Copy of letter ☐ Change order
☐ Other

COPIES	DATE	DESCRIPTION
1	01/20/03	**January 2003 Laboratory Test Reports**
		2 Grain Size Analyses (ASTM D 422) – with Hydrometer
		7 Grain Size Analyses (ASTM D 422) – sieve portion only
		2 Atterberg Limits (ASTM D 4318)

THESE ITEMS ARE TRANSMITTED as checked below:
☐ For approval ☐ Approved as submitted ☐ Resubmit _____ Copies for approval
☑ For your use ☐ Approved as noted ☐ Submit _____ Copies for distribution
☑ As requested ☐ Returned for corrections ☐ Return
☐ For review and comment
☐ For bids due _____, 20
☐ _____

REMARKS

_____

COPY TO Mr. Greg Mischel
TRC Environmental
Foot of John Street
Lowell, MA 01852

SIGNED _____

Joseph D. Tomei – Laboratory Manager

Geotechnical Test Report

Pownal Tannery Superfund Site Project

Pownal, VT

Prepared for:

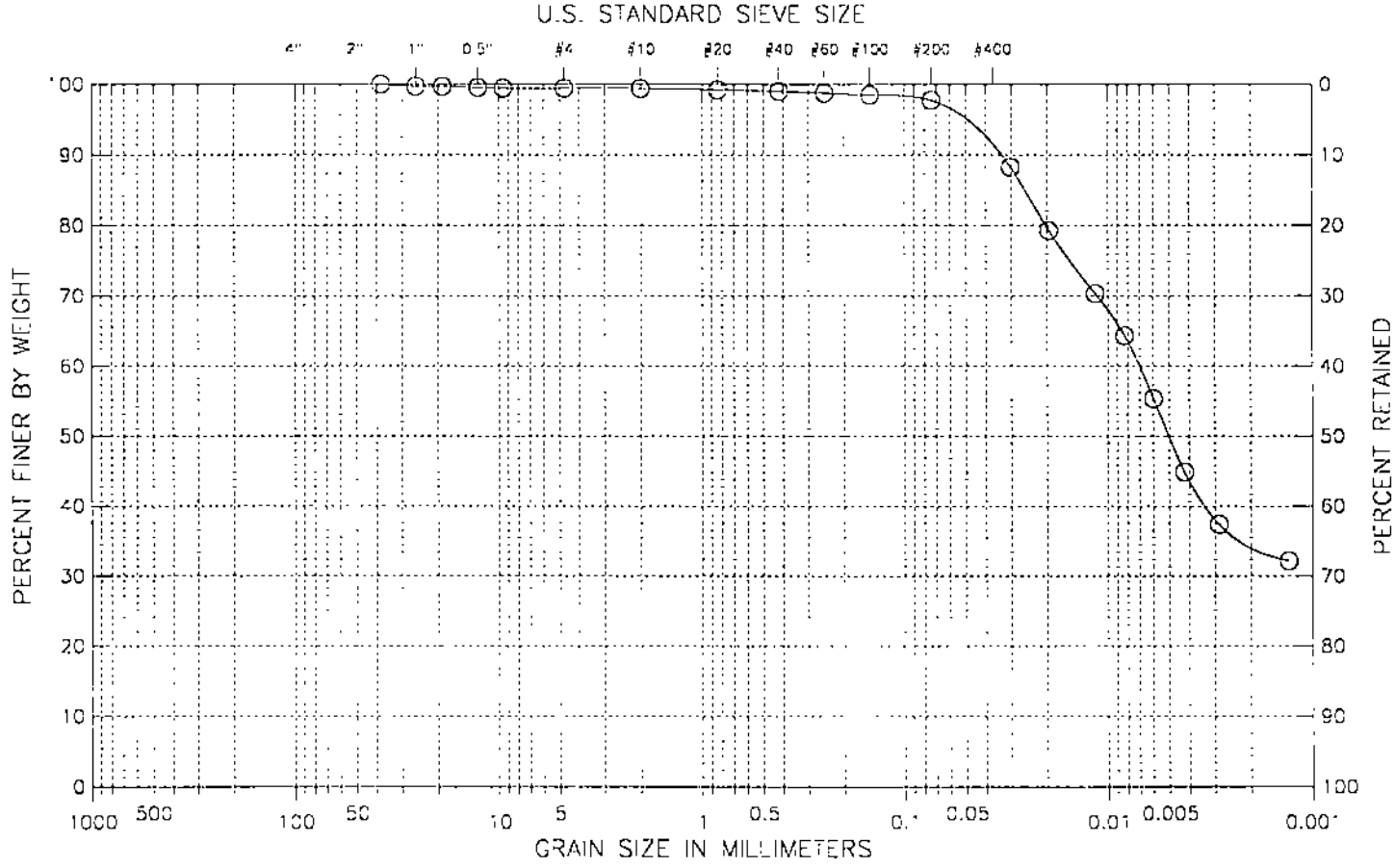
Metcalf & Eddy
Wakefield, MA

Prepared by:

GeoTesting Express, Inc.
Boxborough, MA

January 20, 2003

Boring No. : - - -	Project : Pownal Tannery Superfund Site
Sample No.: Bisson BS-C/S	Project No.: GTX-4363
Test Method ASTM D 422	Location: Pownal, VT
Filename : BISBSCS	Date : Mon Jan 20 2003



Classification :
(CL) lean clay
Visual Description :
Moist, light olive brown clay

Remarks :

Figure 1

GeoTesting Express, Inc. • Boxborough, MA • (978) 635-0424 • Fax (978) 635-0266

GEOTECHNICAL LABORATORY TEST DATA

Project : Pownal Tannery Superfund Site
Project No. : GTX-4363 Depth : ---
Boring No. : --- Test Date : 01/15/03
Sample No. : Bisson BS-C/S Test Method : ASTM D 422
Location : Pownal, VT
Soil Description : Moist, light olive brown clay
Remarks :

Filename : BISBSCS
Elevation : ---
Tested By : mjb
Checked By : jdL

HYDROMETER

Hydrometer ID : 343664
Weight of air-dried soil = 32.51 gm
Specific Gravity = 2.68

Hydroscopic Moisture Content :
Weight of Wet Soil = 0 gm
Weight of Dry Soil = 0 gm
Moisture Content = 0

Elapsed Time (min)	Reading	Temperature (deg. C)	Corrected Reading	Particle Size (mm)	Percent Finer (%)	Adjusted Particle Size
2.00	36.00	21.50	29.50	0.030	88	0.030
5.00	33.00	21.50	26.50	0.020	79	0.020
15.00	30.00	21.50	23.50	0.012	70	0.012
30.00	28.00	21.50	21.50	0.008	64	0.008
60.00	25.00	21.50	18.50	0.006	55	0.006
126.00	21.50	21.50	15.00	0.004	45	0.004
283.00	19.00	21.50	12.50	0.003	37	0.003
1382.00	17.50	21.00	10.75	0.001	32	0.001

GEOTECHNICAL LABORATORY TEST DATA

Project : Pownal Tannery Superfund Site
Project No. : GTX-4363
Boring No. : ---
Sample No. : Bisson BS-C/S
Location : Pownal, VT
Soil Description : Moist, light olive brown clay
Remarks :

Filename : BISBSCS
Depth : ---
Test Date : 01/15/03
Test Method : ASTM D 422
Elevation : ---
Tested by : njh
Checked by : jdt

COARSE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
1.5"	1.500	38.10	0.00	0.00	100
1"	1.012	25.70	39.00	39.00	100
0.75"	0.748	19.00	0.00	39.00	100
0.5"	0.500	12.70	21.00	60.00	100
0.375"	0.374	9.51	14.00	74.00	99

Total Dry Weight of Sample = 13570

FINE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
#4	0.187	4.75	0.00	0.00	99
#10	0.079	2.00	0.01	0.01	99
#20	0.033	0.84	0.10	0.11	99
#40	0.017	0.42	0.10	0.21	99
#60	0.010	0.25	0.12	0.33	99
#100	0.006	0.15	0.13	0.46	99
#200	0.003	0.07	0.37	0.83	99
Pan			47.51	48.34	0

Total Dry Weight of Sample = 162.93

D60 : 0.0259 mm
D50 : 0.0071 mm
D30 : 0.0050 mm
D15 : N/A
D10 : N/A

Soil Classification
ASTM Group Symbol : CL
ASTM Group Name : lean clay
AASHTO Group Symbol : A-6(12)
AASHTO Group Name : Clayey Soils

ATTERBERG LIMITS

PROJECT	PROJECT NUMBER	TESTED BY	BORING NUMBER
Pownal Tannery Superfund Site	GTX-4365	njh	---
LOCATION		CHECKED BY	SAMPLE NUMBER
Pownal, VT		jdl	Bisson BS-C/S
SAMPLE DESCRIPTION		DATE	FILENAME
Moist, light olive brown clay		Mon Jan 20 2003	BISBSCS

LIQUID LIMIT DETERMINATIONS

CONTAINER NUMBER	WT-14	K-11	K-2		
WT. WET SOIL + TARE	29.73	28.59	29.96		
WT. DRY SOIL + TARE	26.58	25.39	26.25		
WT. WATER	3.15	3.2	3.71		
TARE WT.	16.6	15.68	15.73		
WT. DRY SOIL	9.98	9.71	10.52		
WATER CONTENT, W_N (%)	31.56	32.96	35.27		
NUMBER OF BLOWS, N	33	27	16		
ONE-POINT LIQUID LIMIT, LI	32.64	33.26	33.41		

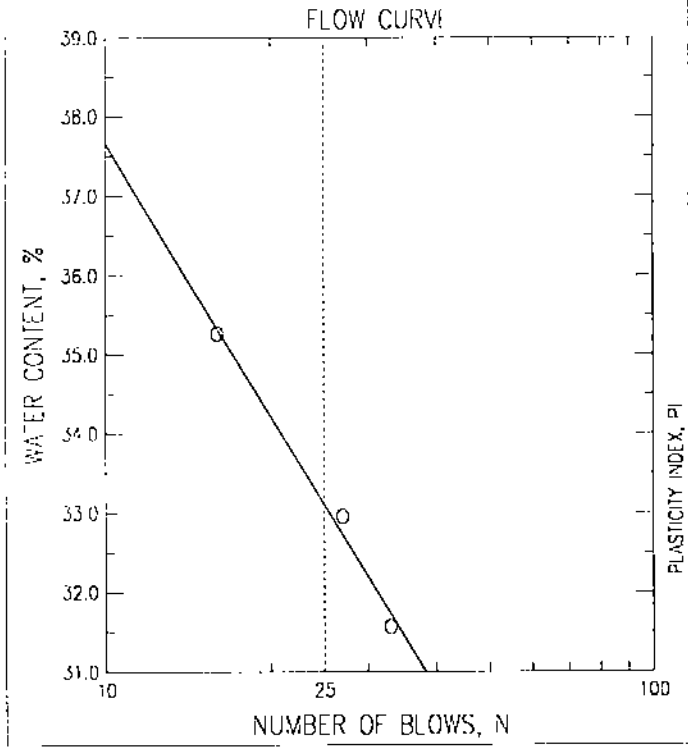
PLASTIC LIMIT DETERMINATIONS

CONTAINER NUMBER	K-6	T-8			
WT. WET SOIL + TARE	42.05	40.44			
WT. DRY SOIL + TARE	39.95	38.4			
WT. WATER	2.1	2.04			
TARE WT.	30.27	28.74			
WT. DRY SOIL	9.68	9.66			
WATER CONTENT (%)	21.69	21.12			

SUMMARY OF RESULTS

NATURAL WATER CONTENT, W (%)	18.2
LIQUID LIMIT, LL	33.1
PLASTIC LIMIT, PL	21.4
PLASTICITY INDEX, PI	11.7
LIQUIDITY INDEX, LI*	-0.27

*LI = (W - PL)/PI



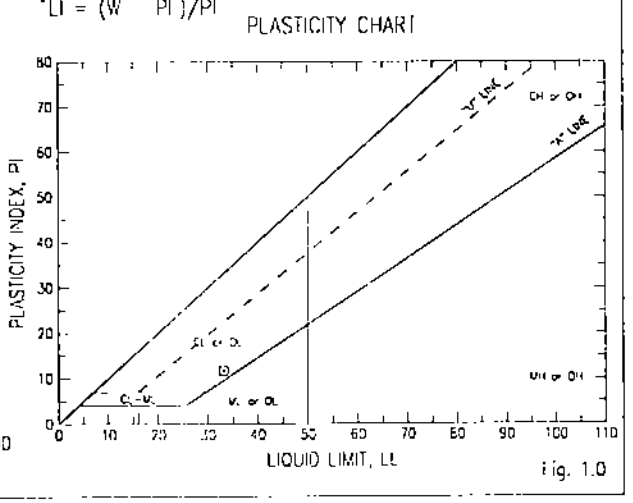
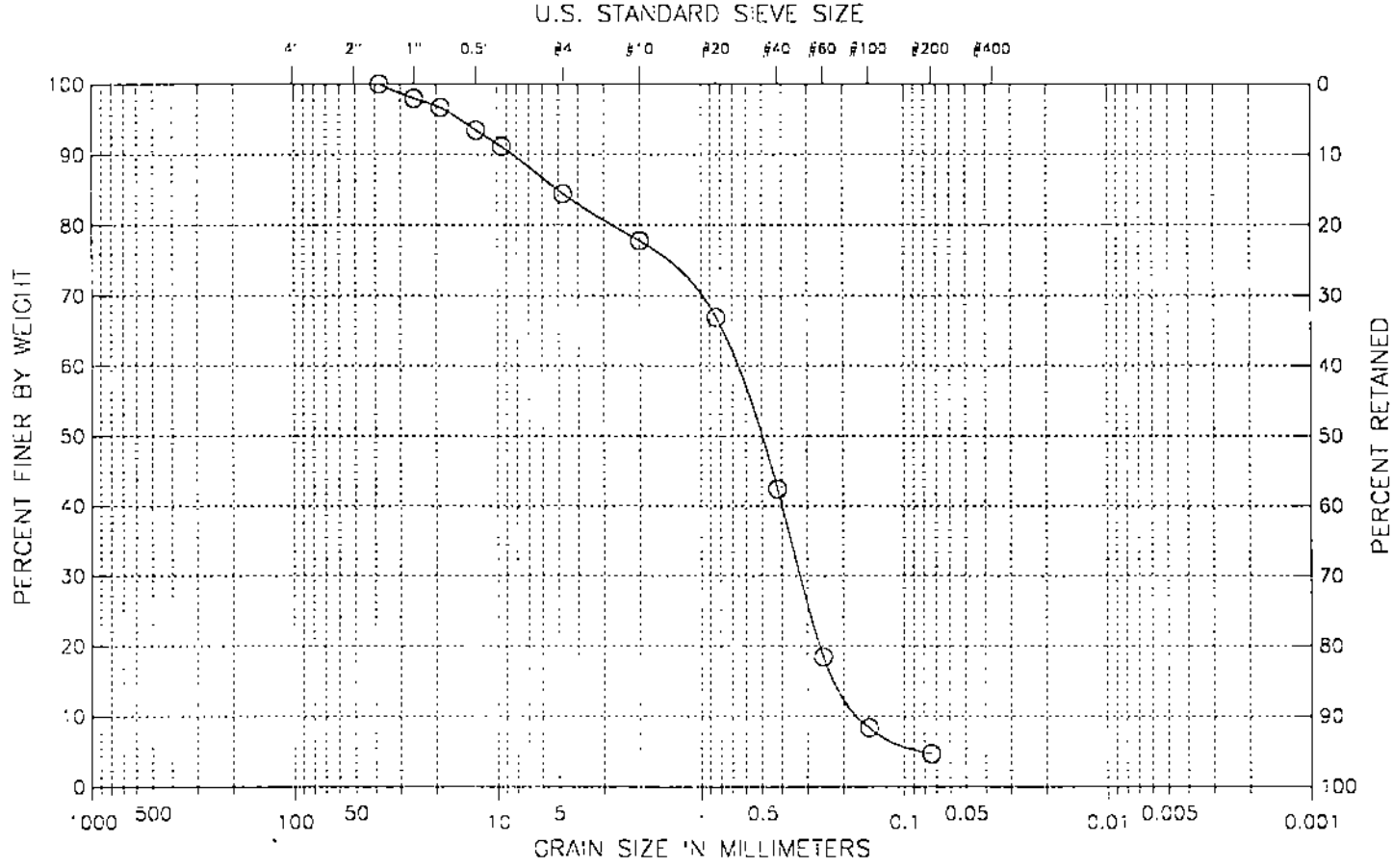


Fig. 1.0

Boring No. : ---	Project : Pownal Tannery Superfund Site
Sample No.: Bisson CS-CS	Project No.: GTX-4363
Test Method ASTM D 422	Location: Pownal, VT
Filename : BISCSCS	Date : Mon Jan 20 2003



Classification :
(SP) Poorly graded sand with gravel

Visual Description :
Dry, light yellowish brown sand with gravel

Remarks :

Figure 2

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GEOTECHNICAL LABORATORY TEST DATA

Project : Pownal Tannery Superfund Site
Project No. : GTX-4363
Boring No. : ---
Sample No. : Bisson CS CS
Location : Pownal, VT
Soil Description : Dry, light yellowish brown sand with gravel
Remarks :

Depth : ---
Test Date : 01/15/03
Test Method : ASTM D 422

Filename : BISCSCS
Elevation : ---
Tested by : njh
Checked by : jdt

COARSE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
1.5"	1.500	38.10	0.00	0.00	100
1"	1.012	25.70	215.00	215.00	9
0.75"	0.748	19.00	138.00	353.00	7
0.5"	0.500	12.70	340.00	693.00	34
0.375"	0.374	9.51	241.00	934.00	11

Total Dry Weight of Sample = 10553

FINE SIEVE SET

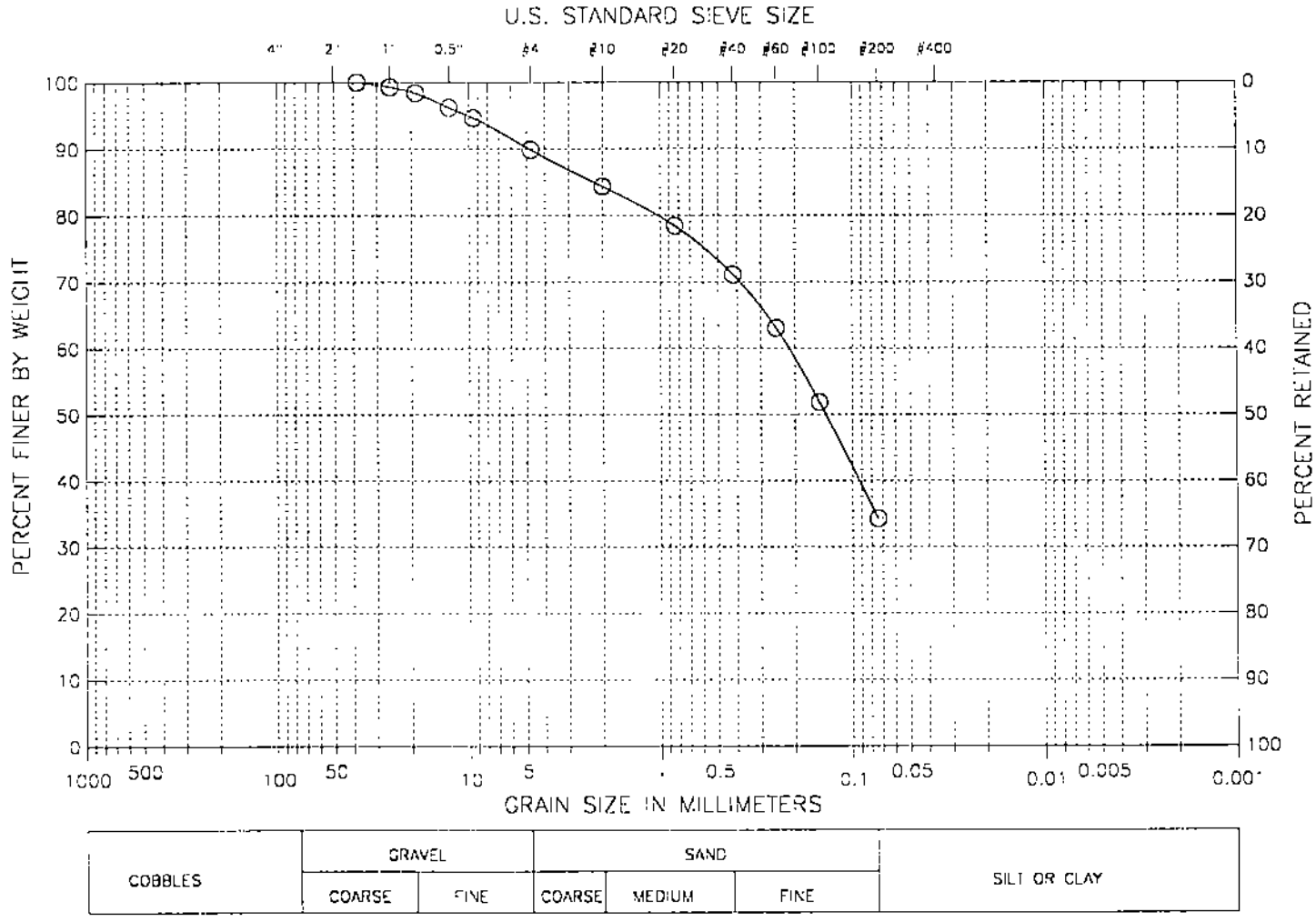
Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
#4	0.187	4.75	39.43	39.43	94
#10	0.079	2.00	39.28	78.71	74
#20	0.033	0.84	64.02	142.73	67
#40	0.017	0.42	144.13	286.86	42
#60	0.010	0.25	141.04	427.90	19
#100	0.006	0.15	59.25	487.15	9
#200	0.003	0.07	21.70	508.85	4
Pan			27.60	536.45	0

Total Dry Weight of Sample = 544.51

D85 = 5.0287 mm
D60 = 0.6916 mm
D50 = 0.5209 mm
D30 = 0.3211 mm
D15 = 0.2094 mm
D10 = 0.1620 mm

Soil Classification
ASTM Group Symbol : SP
ASTM Group Name : Poorly graded sand with gravel
AASHTO Group Symbol : A-1-b(0)
AASHTO Group Name : Stone Fragments, Gravel and Sand

Boring No. : - - -	Project : Pownal Tannery Superfund Site
Sample No.: Bisson VS-VS	Project No.: GTX-4363
Test Method ASTM D 422	Location: Pownal, VT
Filename : BISVSVS	Date : Mon Jan 20 2003



Classification :

Remarks :

Visual Description :
Moist, olive silty sand

Figure 3

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GEOTECHNICAL LABORATORY TEST DATA

Project : Pownal Tannery Superfund Site
Project No. : GTX-4363
Boring No. :
Sample No. : Bisson VS-VS
Location : Pownal, VT
Soil Description : Moist, olive silty sand
Remarks :

Depth : --
Test Date : 01/15/03
Test Method : ASTM D 422

Filename : BISVSVS
Elevation : ---
Tested by : njh
Checked by : jdr

COARSE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
1.5"	1.500	38.10	0.00	0.00	100
1"	1.012	25.70	60.00	60.00	99
0.75"	0.748	19.00	74.00	134.00	98
0.5"	0.500	12.70	181.00	315.00	96
0.375"	0.374	9.51	127.00	442.00	95

Total Dry Weight of Sample = 8299

FINE SIEVE SET

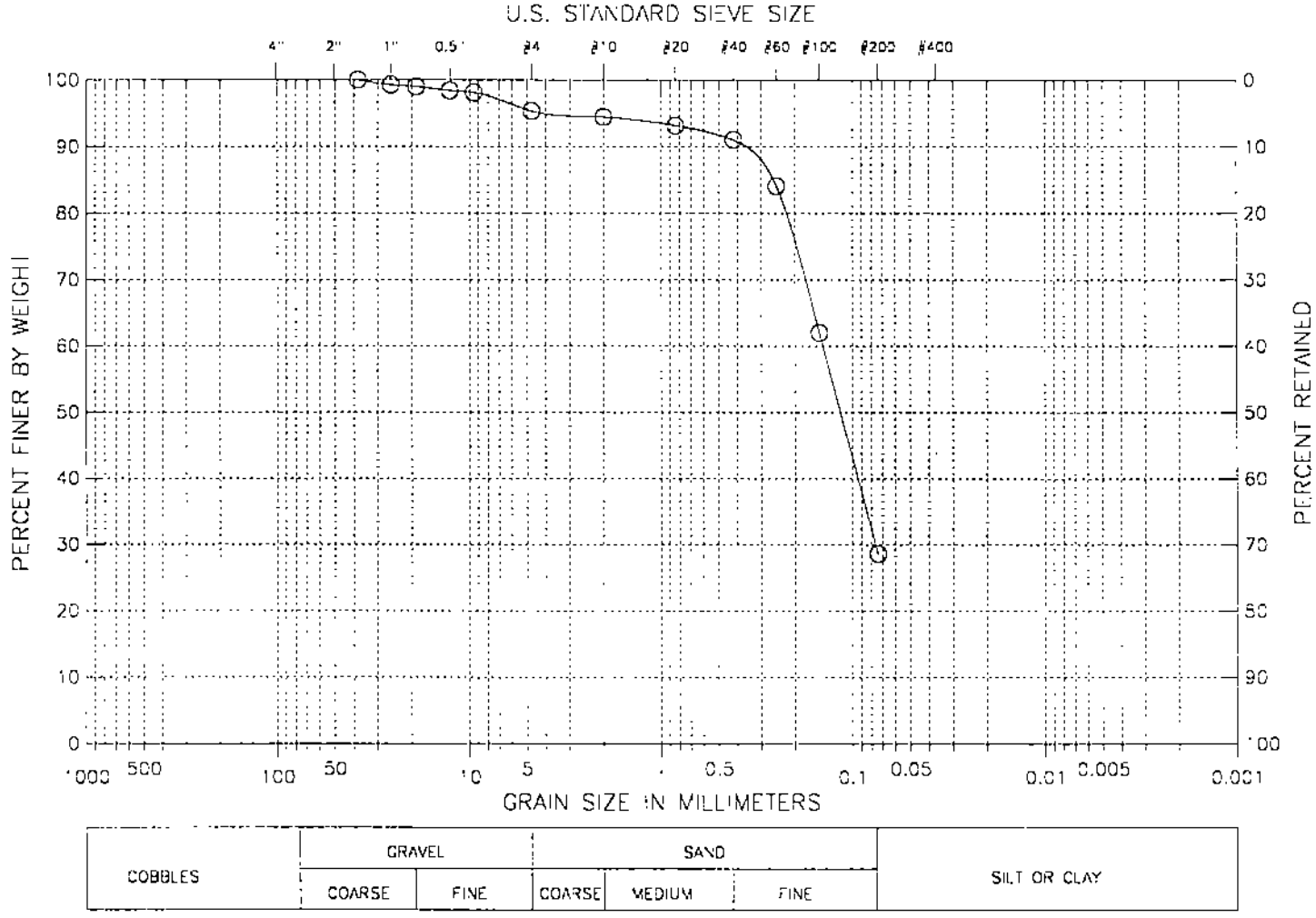
Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
#4	0.187	4.75	18.51	18.51	95
#10	0.079	2.00	21.38	39.89	89
#20	0.033	0.84	22.87	62.76	83
#40	0.017	0.42	28.40	91.16	77
#60	0.010	0.25	31.14	122.30	67
#100	0.006	0.15	43.31	165.61	56
#200	0.003	0.07	67.94	233.55	44
Pan			132.50	366.05	4

Total Dry Weight of Sample = 374.15

D85 : 9.2116 mm
D60 : 0.2172 mm
D50 : 0.1385 mm
D30 : N/A
D15 : N/A
D10 : N/A

Soil Classification
ASTM Group Symbol : N/A
ASTM Group Name : N/A
AASHTO Group Symbol : A-2-4(0)
AASHTO Group Name : Silty Gravel and Sand

	Boring No. : Burgess	Project : Pownal Tannery Superfund Site
	Sample No.: Brothers CS-SF	Project No.: GTX-4363
	Test Method ASTM D 422	Location: Pownal, VT
	Filename : BURGCSSF	Date : Mon Jan 20 2003



Classification :

Remarks :

Visual Description :
Moist, light yellowish brown silty sand

Figure 4

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GEOTECHNICAL LABORATORY TEST DATA

Project : Pownal Tannery Superfund Site
Project No. : GTX-4363
Boring No. : Burgess
Sample No. : Brothers CS-SF
Location : Pownal, VT
Soil Description : Moist, light yellowish brown silty sand
Remarks :

Filename : BURGCSSF
Depth : ---
Test Date : 01/15/03
Test Method : ASTM D 422
Elevation : ---
Tested by : mjb
Checked by : jdt

COARSE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
1.5"	1.500	38.10	0.00	0.00	100
1"	1.012	25.70	105.00	105.00	99
0.75"	0.748	19.00	39.00	144.00	99
0.5"	0.500	12.70	85.00	229.00	98
0.375"	0.374	9.51	41.00	270.00	98

Total Dry Weight of Sample = 14432

FINE SIEVE SET

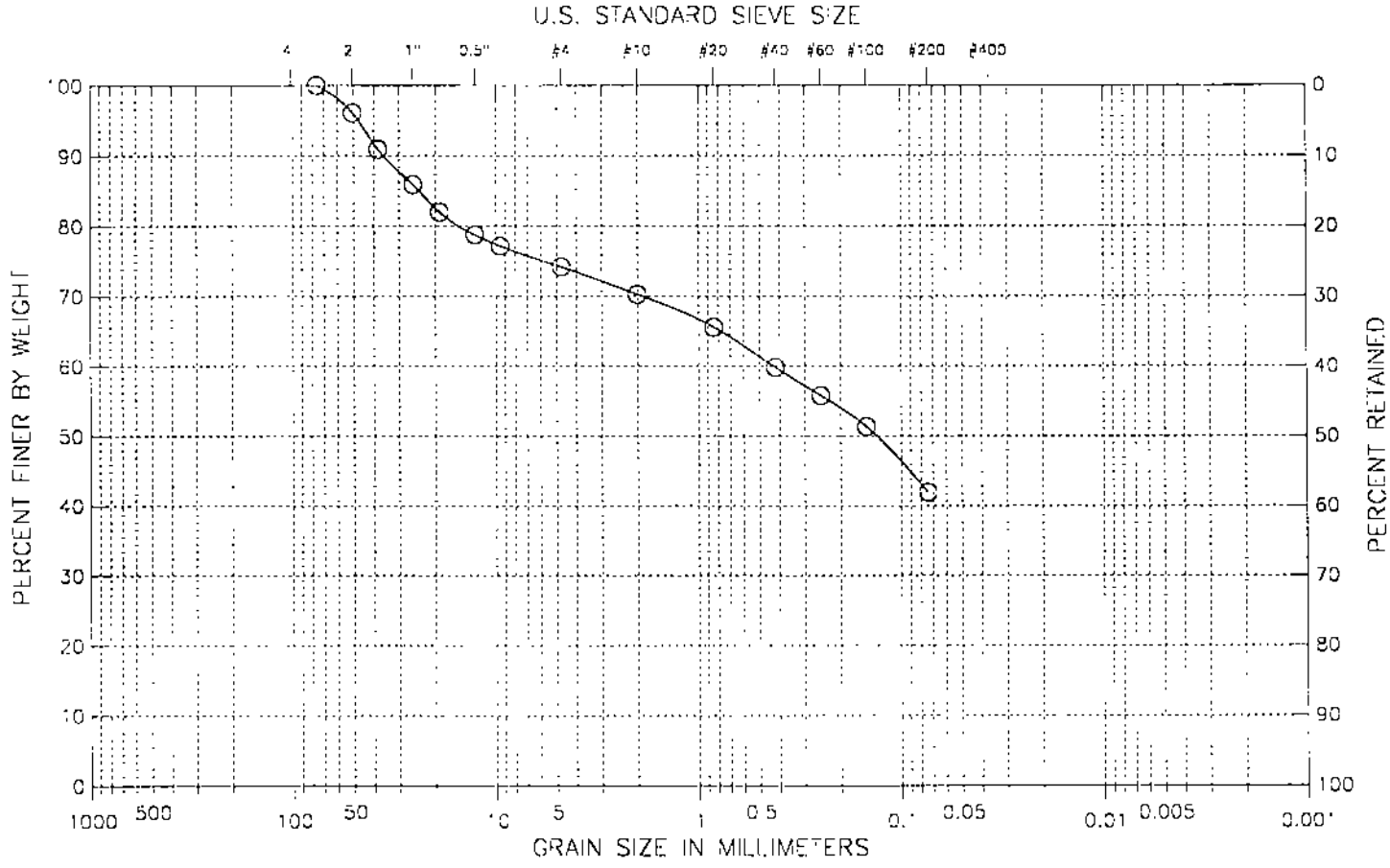
Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
#4	0.187	4.75	8.57	8.57	97
#10	0.079	2.00	2.62	11.19	96
#20	0.033	0.84	4.00	15.19	95
#40	0.017	0.42	6.48	21.67	93
#60	0.010	0.25	21.13	42.80	86
#100	0.006	0.15	67.38	110.18	64
#200	0.003	0.07	101.92	212.10	31
Pan			87.45	299.55	

Total Dry Weight of Sample = 307.73

D85 = 0.2073 mm
D60 = 0.1428 mm
D50 = 0.1158 mm
D30 = 0.0761 mm
D15 = N/A
D10 = N/A

Soil Classification
ASTM Group Symbol : N/A
ASTM Group Name : N/A
AASHTO Group Symbol : A-2-4(0)
AASHTO Group Name : Silty Gravel and Sand

Boring No. : Burgess	Project : Powna Tannery Superfund Site
Sample No.: Brainers VS-CB	Project No.: GTX-4363
Test Method ASTM D 422	Location: Pownal, VT
Filename : BURGVSCB	Date : Mon Jan 20 2003



Classification :

Remarks :

Visual Description :
Moist, light yellowish brown silty sand w/ gravel

Figure 5

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GEOTECHNICAL LABORATORY TEST DATA

Project : Pownal Tannery Superfund Site
Project No. : GTX-4363 Depth : ---
Boring No. : Burgess Test Date : 01/15/03
Sample No. : Brothers VS-CB Test Method : ASTM D 422
Location : Pownal, VT
Soil Description : Moist, light yellowish brown silty sand w/ gravel
Remarks :

Filename : BURGVSCB
Elevation : -
Tested by : njh
Checked by : jdt

COARSE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
3"	2.996	76.10	0.00	0.00	100
2"	2.000	50.80	532.00	532.00	96
1 5"	1.500	38.10	709.00	1241.00	91
1"	1.012	25.70	682.00	1923.00	86
0 75"	0.748	19.00	538.00	2461.00	82
0 5"	0.500	12.70	441.00	2902.00	79
0 375"	0.374	9.51	218.00	3120.00	77

Total Dry Weight of Sample = 13654

FINE SIEVE SET

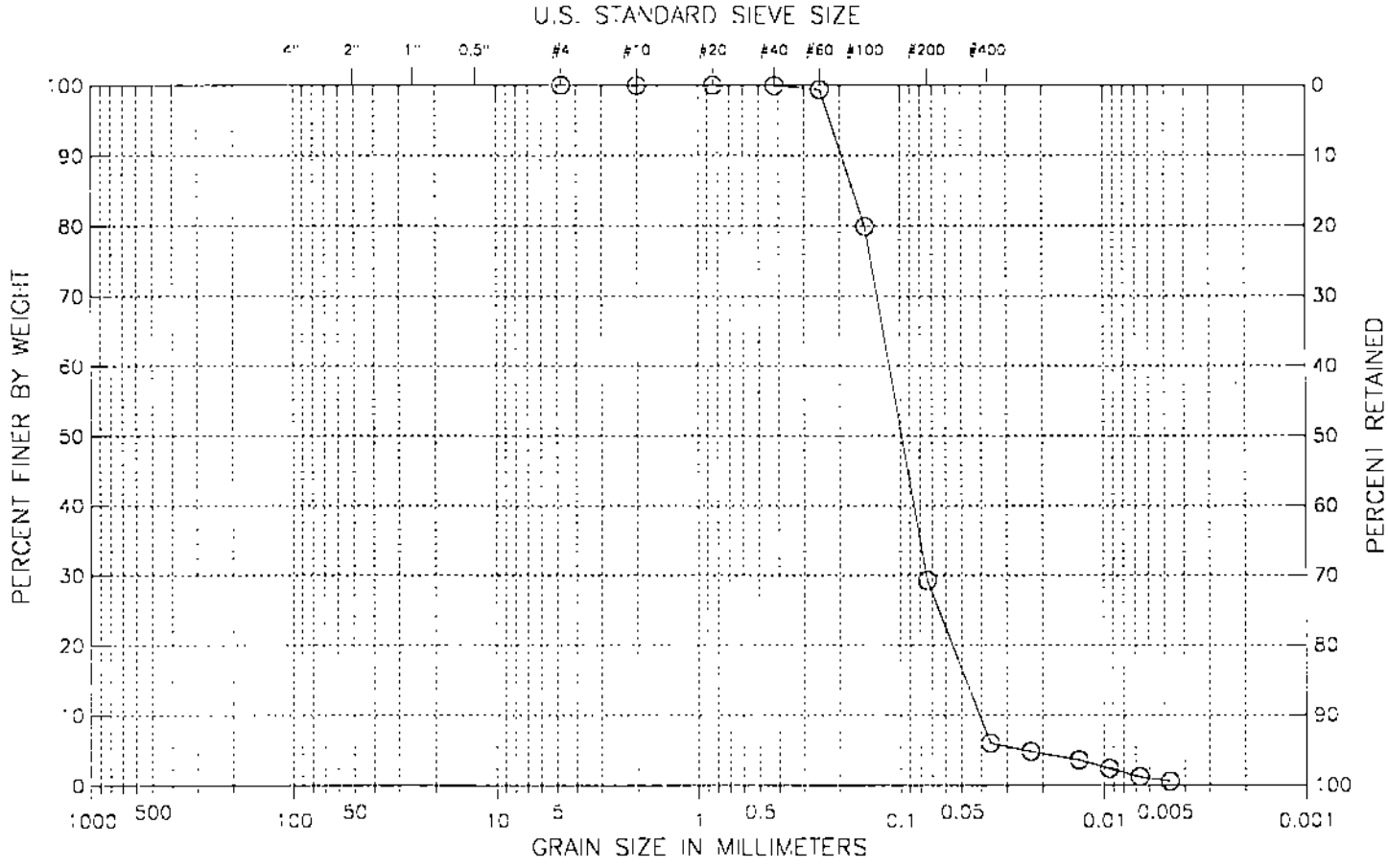
Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
#4	0.187	4.75	15.30	15.30	74
#10	0.079	2.00	20.77	35.57	70
#20	0.033	0.84	24.28	59.85	66
#40	0.017	0.42	29.63	89.48	60
#60	0.010	0.25	20.90	110.38	56
#100	0.006	0.15	22.88	133.26	51
#200	0.003	0.07	48.74	182.00	41
Pan			216.60	398.60	2

Total Dry Weight of Sample = 406.69

D85 = 23.9569 mm
D60 = 5.4287 mm
D50 = 0.1347 mm
D30 = N/A
D15 = N/A
D10 = N/A

Soil Classification
ASTM Group Symbol : N/A
ASTM Group Name : N/A
AASHTO Group Symbol : A-4(0)
AASHTO Group Name : Silty Soils

Boring No. : Chapel Road	Project : Powne Tannery Superfund Site
Sample No.: Denio-BS-S	Project No.: GTX-4363
Test Method ASTM D 422	Location: Pownal, VT
Filename : CHAPBSS	Date : Mon Jan 20 2003



Classification :
(SM) Silty sand
Visual Description :
Moist, pale yellow silty sand

Remarks :

Figure 6

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GEOTECHNICAL LABORATORY TEST DATA

Project : Pownal Tannery Superfund Site
Project No. : GTX-4363
Boring No. : Chapel Road
Sample No. : Denio BS-S
Location : Pownal, VT
Soil Description : Moist, pale yellow silty sand
Remarks :

Filename : CHAPDSS
Depth : ---
Test Date : 01/15/03
Test Method : ASTM D 422
Elevation : ---
Tested by : njh
Checked by : jdt

HYDROMETER

Hydrometer ID : 343664
Weight of air-dried soil = 12.1 gm
Specific Gravity = 2.68

Hydroscopic Moisture Content :
Weight of Wet Soil = 0 gm
Weight of Dry Soil = 0 gm
Moisture Content = 0

Elapsed Time (min)	Reading	Temperature (deg. C)	Corrected Reading	Particle Size (mm)	Percent Finer (%)	Adjusted Particle Size
2.00	9.00	21.50	2.50	0.036	6	0.036
5.00	8.50	21.50	2.00	0.023	5	0.023
15.00	8.00	21.50	1.50	0.013	4	0.013
30.00	7.50	21.50	1.00	0.009	2	0.009
60.00	7.00	21.50	0.50	0.007	1	0.007
121.00	7.00	21.00	0.25	0.005	1	0.005

FINE SIEVE SET

Sieve No.	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
#4	0.187	4.75	0.00	0.00	100
#10	0.079	2.00	0.01	0.01	100
#20	0.033	0.84	0.00	0.01	100
#40	0.017	0.42	0.01	0.02	100
#60	0.010	0.25	0.24	0.26	99
#100	0.006	0.15	8.04	8.30	95
#200	0.003	0.07	20.91	29.21	83
Pan			12.10	41.31	

Total Dry Weight of Sample = 168.35

D85 : 0.1706 mm
D60 : 0.1131 mm
D50 : 0.0985 mm
D30 : 0.0747 mm
D15 : 0.0476 mm
D10 : 0.0408 mm

Soil Classification
ASTM Group Symbol : SM
ASTM Group Name : Silty sand
AASHTO Group Symbol : A-2-4(0)
AASHTO Group Name : Silty Gravel and Sand

ATTERBERG LIMITS

PROJECT	PROJECT NUMBER	TESTED BY	BORING NUMBER
Pownal Tannery Superfund Site	GTX-4363	mh	Chapel Road
LOCATION		CHECKED BY	SAMPLE NUMBER
Pownal, VT		jdl	Denio-BS-S
SAMPLE DESCRIPTION		DATE	FILENAME
Moist, pale yellow silty sand		Mon Jan 20 2003	CHAPBSS

LIQUID LIMIT DETERMINATIONS					
CONTAINER NUMBER					
WT. WET SOIL + TARE					
WT. DRY SOIL + TARE					
WT. WATER					
TARE WT.					
WT. DRY SOIL					
WATER CONTENT, W_N (%)					
NUMBER OF BLOWS, N					
ONE-POINT LIQUID LIMIT, LL					

PLASTIC LIMIT DETERMINATIONS					
CONTAINER NUMBER					
WT. WET SOIL + TARE					
WT. DRY SOIL + TARE					
WT. WATER					
TARE WT.					
WT. DRY SOIL					
WATER CONTENT (%)					

Determined to be Non-plastic.

SUMMARY OF RESULTS	
NATURAL WATER CONTENT, W (%)	3.3
LIQUID LIMIT, LL	
PLASTIC LIMIT, PL	
PLASTICITY INDEX, PI	
LIQUIDITY INDEX, LI*	

*LI = (W - PI)/PI

PLASTICITY CHART

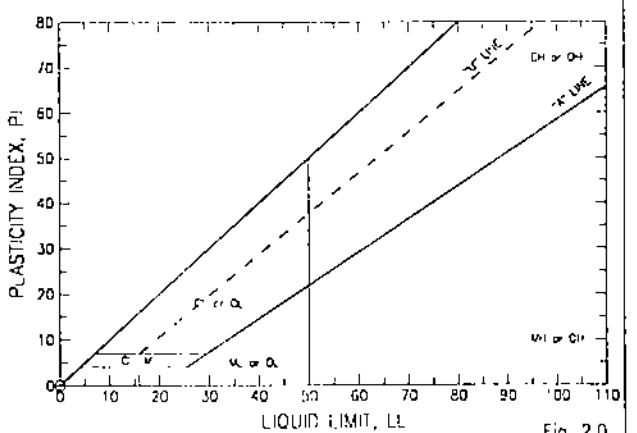
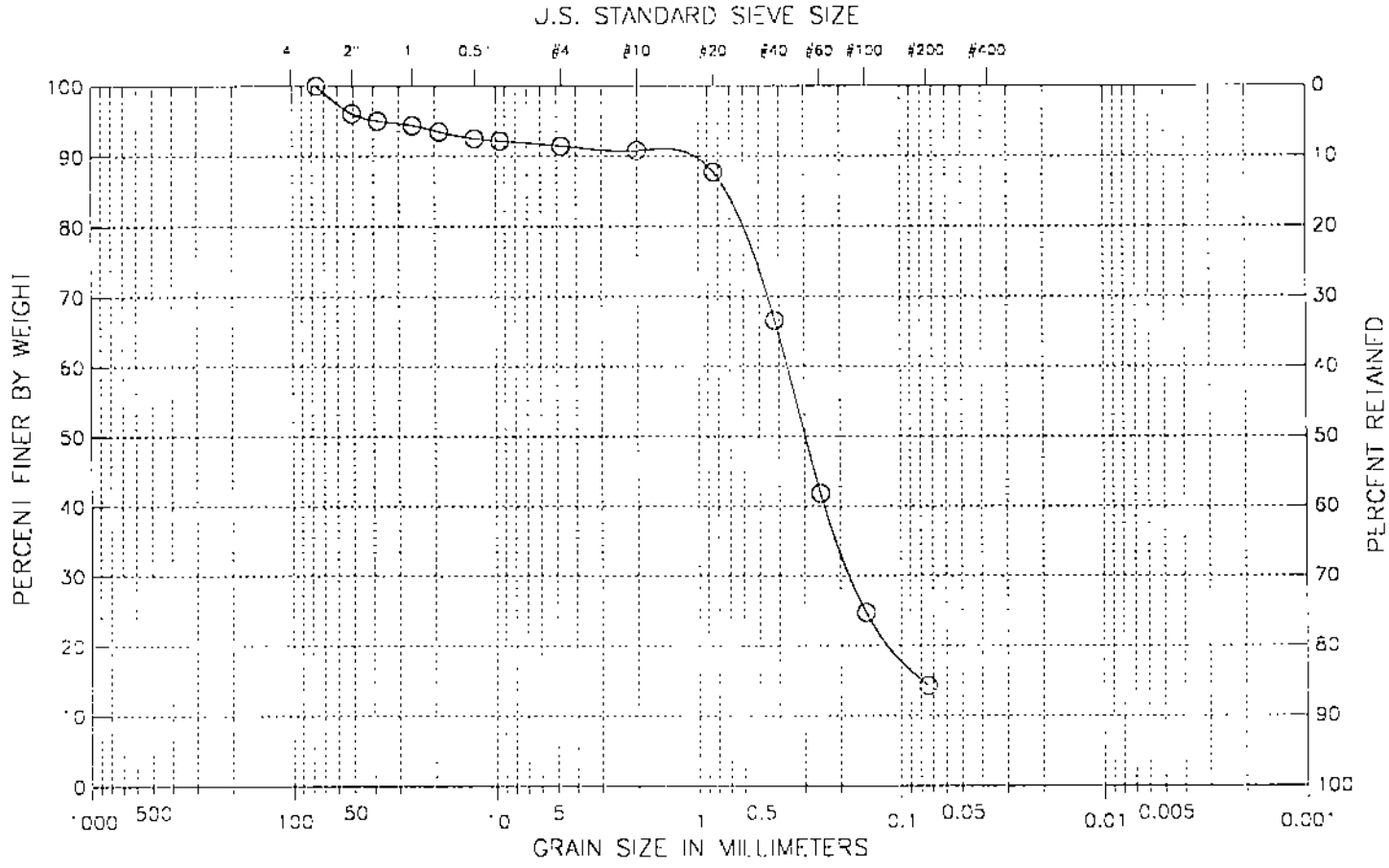


Fig. 2.0

Boring No. : Stromwater	Project : Pownal Tannery Superfund Site
Sample No.: VS-S	Project No.: GTX-4363
Test Method ASTM D 422	Location: Pownal, VT
Filename : STROVSS	Date : Mon Jan 20 2003



Classification :

Remarks :

Visual Description :
Moist, dark yellowish brown silty sand

Figure 7

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GEOTECHNICAL LABORATORY TEST DATA

Project : Fownal Tannery Superfund Site
Project No. : GTX-4363
Boring No. : Strohmanier
Sample No. : VS-S
Location : Fownal, VT
Soil Description : Moist, dark yellowish brown silty sand
Remarks :

Filename : STROVSS
Depth : ---
Test Date : 01/15/03
Test Method : ASTM D 422
Elevation : ---
Tested by : mjh
Checked by : jdt

COARSE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
3"	3.996	76.10	0.00	0.00	1[illegible]
2"	2.000	50.80	350.00	350.00	[illegible]
1.5"	1.500	38.10	94.00	444.00	[illegible]
1"	1.012	25.70	56.00	500.00	[illegible]
0.75"	0.748	19.00	80.00	580.00	[illegible]
0.5"	0.500	12.70	86.00	666.00	[illegible]
0.375"	0.374	9.51	30.00	696.00	[illegible]

Total Dry Weight of Sample = 8911

FINE SIEVE SET

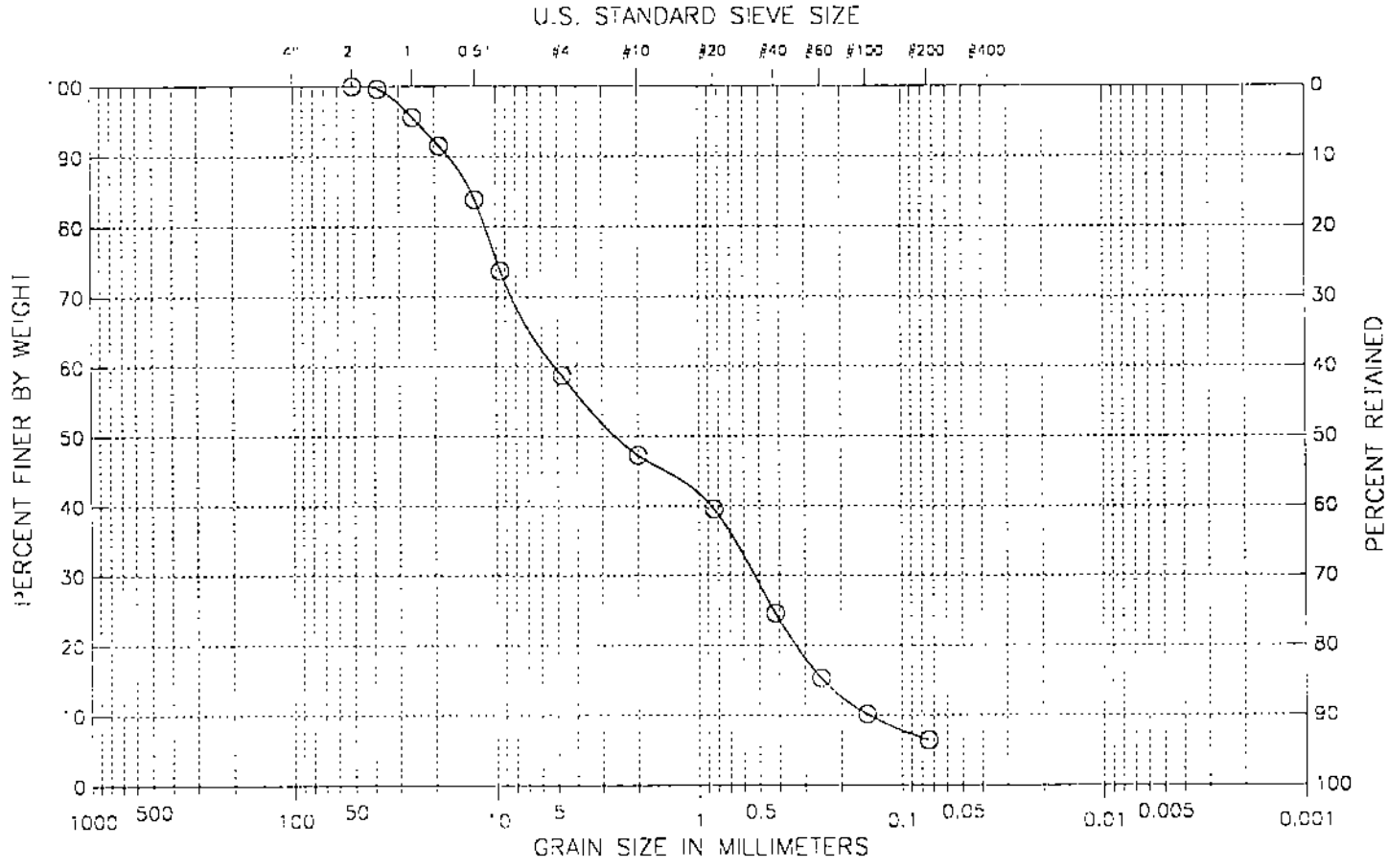
Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
#4	0.187	4.75	2.55	2.55	[illegible]
#10	0.079	2.00	2.37	4.92	[illegible]
#20	0.033	0.84	10.69	15.61	[illegible]
#40	0.017	0.42	74.14	89.75	[illegible]
#60	0.010	0.25	86.92	176.67	[illegible]
#100	0.006	0.15	59.91	236.58	[illegible]
#200	0.003	0.07	36.63	273.21	[illegible]
Pan			50.10	323.31	

Total Dry Weight of Sample = 111.56

D85 = 0.7687 mm
D60 = 0.3658 mm
D50 = 0.2967 mm
D30 = 0.1748 mm
D15 = 0.0776 mm
D10 = 0.0555 mm

Soil Classification
ASTM Group Symbol : N/A
ASTM Group Name : N/A
AASHTO Group Symbol : A-2-4(0)
AASHTO Group Name : Silty Gravel and Sand

Boring No. : Stromanier	Project : Powrel Tannery Superfund Site
Sample No: VS-SG	Project No.: GTX-4363
Test Method ASTM D 422	Location: Pownal, VT
Filename : STROVSSG	Date : Mon Jan 20 2003



Classification :

Remarks :

Visual Description :
Moist, light olive brown sand with silt & gravel

Figure 8

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GEOTECHNICAL LABORATORY TEST DATA

Project : Pownal Tannery Superfund Site
Project No. : GTX-4363
Boring No. : Strohmaier
Sample No. : VS-SG
Location : Pownal, VT
Soil Description : Moist, light olive brown sand with silt & gravel
Remarks :

Filename : STROVSSG
Elevation : --
Tested by : mjh
Checked by : jdt
Depth : --
Test Date : 01/15/03
Test Method : ASTM D 422

COARSE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
2"	2.000	50.80	0.00	0.00	1
1.5"	1.500	38.10	98.00	98.00	1
1"	1.012	25.70	1044.00	1142.00	9
0.75"	0.748	19.00	1040.00	2182.00	9
0.5"	0.500	12.70	1968.00	4150.00	8

Total Dry Weight of Sample = 25726

FINE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
0.375"	0.374	9.51	60.41	60.41	7
#4	0.187	4.75	88.54	148.95	7
#10	0.079	2.00	67.72	216.67	6
#20	0.033	0.84	45.88	262.55	4
#40	0.017	0.42	88.49	351.04	3
#60	0.010	0.25	54.94	405.98	1
#100	0.006	0.15	30.70	436.68	1
#200	0.003	0.07	21.81	458.49	0
Pan			38.07	496.56	0

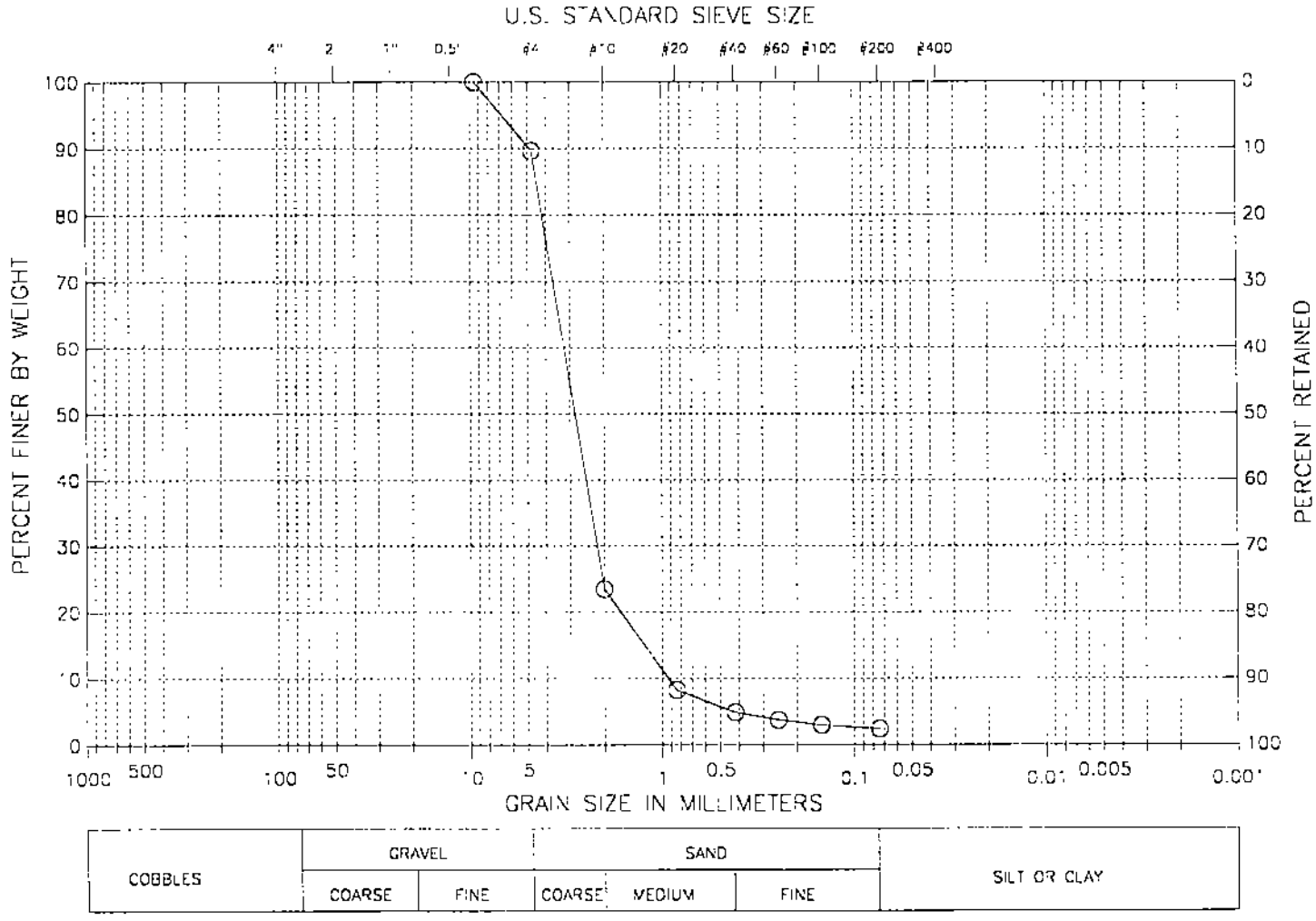
Total Dry Weight of Sample = 504.65

D85 13.4797 mm
D60 5.0429 mm
D50 2.6581 mm
D30 0.5403 mm
D15 0.2627 mm
D10 0.1458 mm

Soil Classification
ASTM Group Symbol : N/A
ASTM Group Name : N/A
AASHTO Group Symbol : A-1-a(0)
AASHTO Group Name : Stone Fragments, Gravel and Sand

Boring No. : W.E. Dailey
Sample No.: CS-WS
Test Method ASTM D 422
Filename : WEDACSWS

Project : Powra Tannery Superfund Site
Project No.: GTX-4363
Location: Pownal, VT
Date : Mon Jan 20 2003



Classification :
(SP) Poorly graded sand
Visual Description :
Wet, dark gray sand

Remarks :

Figure 9

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GEOTECHNICAL LABORATORY TEST DATA

Project : Pownal Tannery Superfund Site
Project No. : GTX-4363
Boring No. : W.E. Dailey
Sample No. : CS-WS
Location : Pownal, VT
Soil Description : Wet, dark gray sand
Remarks :

Filename : WEDACSWS
Elevation : ---
Tested by : ajh
Checked by : jdt
Depth : ---
Test Date : 01/15/03
Test Method : ASTM D 422

FINE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
0.375"	0.374	9.51	0.00	0.00	1
#4	0.187	4.75	54.03	54.03	
#10	0.079	2.00	346.09	400.12	
#30	0.033	0.84	79.61	479.73	
#40	0.017	0.42	17.33	497.06	
#60	0.010	0.25	6.02	503.08	1
#100	0.006	0.15	4.01	507.09	1
#200	0.003	0.07	3.11	510.20	1
Pan			12.51	522.71	0

Total Dry Weight of Sample = 531.05

D85 = 4.4692 mm
D60 = 3.2240 mm
D50 = 2.8291 mm
D30 = 2.1786 mm
D15 = 1.2166 mm
D10 = 0.9305 mm

Soil Classification
ASTM Group Symbol : SP
ASTM Group Name : Poorly graded sand
AASHTO Group Symbol : A-1-a(0)
AASHTO Group Name : Stone Fragments, Gravel and Sand

GeoTesting Express
1145 Mass Avenue - Boxborough, MA 01719
(978) 635-0424 - Fax (978) 635-0266

LETTER OF TRANSMITTAL

TO:

Mr. Don Dwight
Metcalf & Eddy
30 Harvard Mill Square
Wakefield, MA 01888

DATE: 05/06/03	GTX NO: 4363
RE: Pownal Tannery Superfund Site Project	
Pages (excluding transmittal): 4	

We are sending you ☒ Attached ☐ Under separate cover via _____ the following items:
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Lowell, MA 01852

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Fred Hooper - Laboratory Manager

Interface Shear Test Series by ASTM D 5321

Client:	Metcalf & Eddy	**Start Date:**	04/25/03
Project Name:	Pownal Tannery Superfund Site	**End Date:**	04/30/03
Project Location:	Pownal, VT	**Tested By:**	rmt
GTX #:	4363	**Checked By:**	fph/gtt

Test Profile / Setup Top to bottom: Series #2 (top to bottom); steel plate / SAND (Dailey CS-WS) / GEOMEMBRANE/ SAND (Bisson CS-CS) / textured steel plate

Soil ID/Description: Dailey CS-WS: Moist gray sand, Bisson CS-CS: Dry pale yellow sand

Soil Preparation: Compacted using moderate effort at as-received moisture content; Bisson CS-CS placed at 109 pcf at 0.6% moisture.

Compaction Characteristics ASTM D 1557:

Maximum Dry Density, pcf	Optimum Moisture Content, %
—	—

Geosynthetic Description / Preparation: Geomembrane: 40 mil textured black LLDPE. Test saturated for 15 minutes prior to shearing.

Test Equipment: Top box = 12 in x 12 in; Bottom box = 16 in x 12 in; Load cells and LVDTs connected to data acquisition system for shear force, normal load and horizontal displacement readings; Flat plate clamping device; surface area = 144 in^2

Test Condition: inundated

Horizontal Displacement, in/min: 0.04

Parameter	Point 1	Point 2	Point 3	Point 4	Point 5
Initial Moisture Content, %	2.3	2.3	2.3	—	—
Initial Dry Density, pcf	119.2	119.2	119.2	—	—
Percent Compaction, %	—	—	—	—	—
Normal Compressive Stress, psf	100	300	600	—	—
Peak Shear Stress, psf	68	178	339	—	—
Post Peak Shear Stress, psf	55	139	287	—	—
Final Moisture Content, %	16.2	11.1	16.0	—	—

NOTE:

Peak Friction Angle:	**28**	**degrees**
Peak Cohesion:	**14**	**psf**
Post Peak Friction Angle:	**24**	**degrees**
Post Peak Cohesion:	**20**	**psf**

Figure a. Shear Force vs. Horizontal Displacement

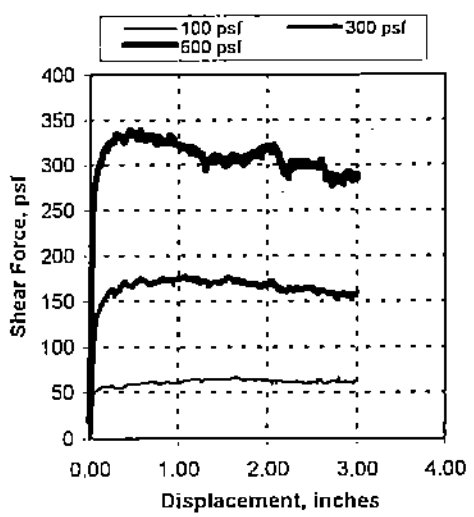
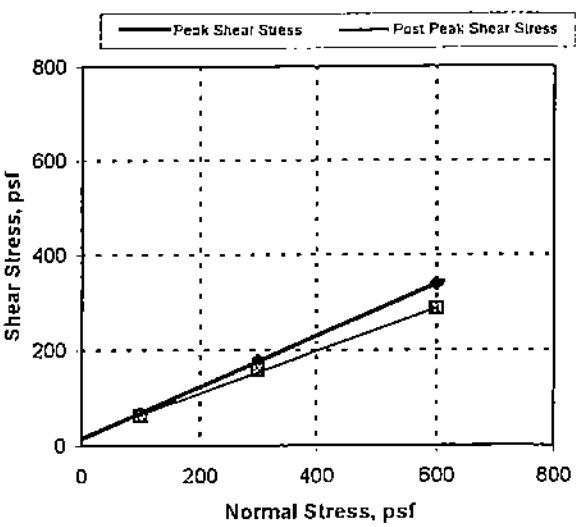


Figure b. Shear Stress vs. Normal Stress



Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material.

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Interface Shear Test Series by ASTM D 5321

Client:	Metcalf & Eddy	**Start Date:**	04/25/03
Project Name:	Pownal Tannery Superfund Site	**End Date:**	04/30/03
Project Location:	Pownal, VT	**Tested By:**	rmt
GTX #:	4363	**Checked By:**	fph/gtt

Test Profile / Setup Top to bottom: Series #1 (top to bottom); steel plate / SILT (Bisson VS-VS) / GEOCOMPOSITE/ SILT (Burgess Bros. VS-CB) / textured steel plate

Soil ID/Description: Bisson VS-VS: Slightly moist light yellowish brown silt, Burgess Bros. VS-CB: Moist

Soil Preparation: Compacted using moderate effort at as-received moisture content; Burgess Bros. VS-BC placed at 114 pcf and at 5.8% moisture.

Compaction Characteristics ASTM D 1557:

Maximum Dry Density, pcf	Optimum Moisture Content, %

Geosynthetic Description / Preparation: Geocomposite: GCMP DBL 250m/6oz (black double non-woven). Test saturated for 15 minutes prior to shearing.

Test Equipment: Top box = 12 in x 12 in; Bottom box = 16 in x 12 in; Load cells and LVDTs connected to data acquisition system for shear force, normal load and horizontal displacement readings; Flat plate clamping device; surface area = 144 in^2

Test Condition: inundated

Horizontal Displacement, in/min: 0.04

Parameter	Point 1	Point 2	Point 3	Point 4	Point 5
Initial Moisture Content, %	1.9	1.9	1.9	—	—
Initial Dry Density, pcf	106.9	106.9	106.9	—	—
Percent Compaction, %	—	—	—	—	—
Normal Compressive Stress, psf	100	300	600	—	—
Peak Shear Stress, psf	66	175	373	—	—
Post Peak Shear Stress, psf	55	139	270	—	—
Final Moisture Content, %	19.0	20.0	20.2	—	—

Note:

Peak Friction Angle:	**32**	**degrees**
Peak Cohesion:	**0**	**psf**
Post Peak Friction Angle:	**23**	**degrees**
Post Peak Cohesion:	**11**	**psf**

Figure a. Shear Force vs. Horizontal Displacement

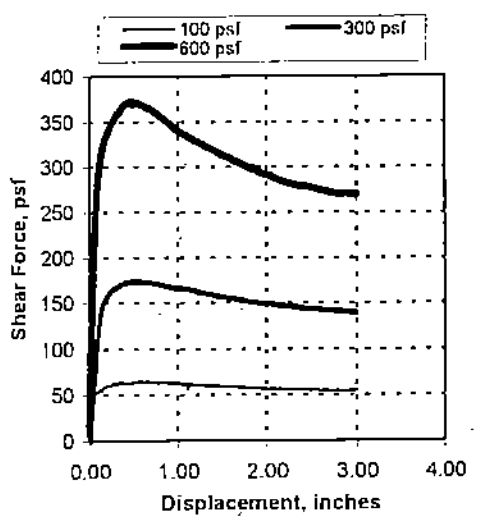
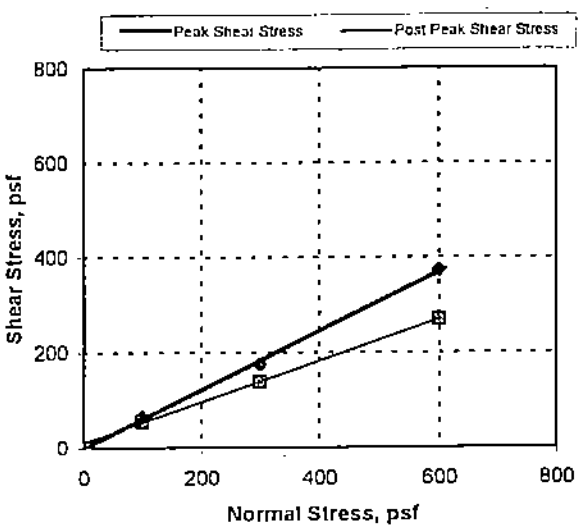


Figure b. Shear Stress vs. Normal Stress



Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material.

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Interface Shear Test Series by ASTM D 5321

Client:	Metcalf & Eddy	Start Date:	04/25/03
Project Name:	Pownal Tannery Superfund Site	End Date:	04/30/03
Project Location:	Pownal, VT	Tested By:	rmt
GTX #:	4363	Checked By:	fph/gtt

Test Profile / Setup Top to bottom: Series #3 (top to bottom); textured steel plate / GEOMEMBRANE / GEOCOMPOSITE / textured steel plate

Soil ID/Description: —

Soil Preparation: —

Compaction Characteristics ASTM D 1557:

Maximum Dry Density, pcf	Optimum Moisture Content, %
—	—

Geosynthetic Description / Preparation: Geomembrane: 40 mil textured black LLDPE. Geocomposite: GCMP DBL 250m/6oz (black double non-woven). Test saturated for 15 minutes prior to shearing.

Test Equipment: Top box = 12 in x 12 in; Bottom box = 16 in x 12 in; Load cells and LVDTs connected to data acquisition system for shear force, normal load and horizontal displacement readings; Flat plate clamping device; surface area = 144 in^2

Test Condition: inundated

Horizontal Displacement, in/min: 0.2

Parameter	Point 1	Point 2	Point 3	Point 4	Point 5
Initial Moisture Content, %	—	—	—	—	—
Initial Dry Density, pcf	—	—	—	—	—
Percent Compaction, %	—	—	—	—	—
Normal Compressive Stress, psf	100	300	600	—	—
Peak Shear Stress, psf	68	178	457	—	—
Post Peak Shear Stress, psf	55	139	287	—	—
Final Moisture Content, %	—	—	—	—	—

NOTE:

Peak Friction Angle:	**36**	**degrees**
Peak Cohesion:	**26**	**psf**
Post Peak Friction Angle:	**24**	**degrees**
Post Peak Cohesion:	**30**	**psf**

Figure a. Shear Force vs. Horizontal Displacement

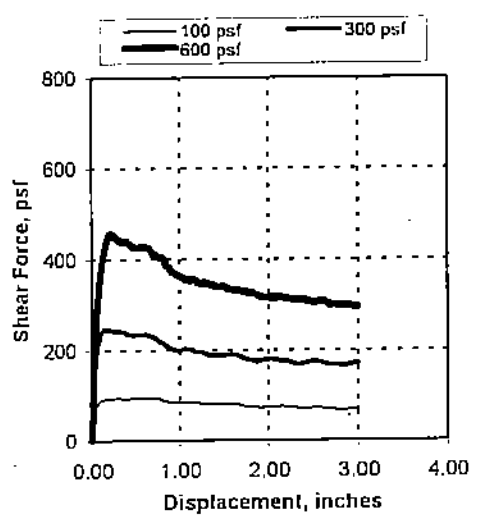
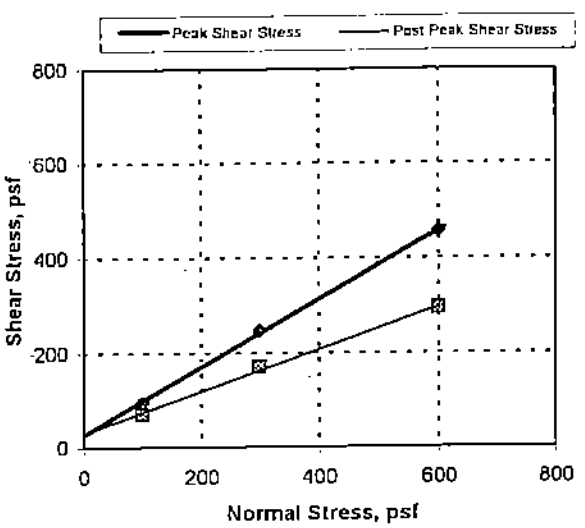


Figure b. Shear Stress vs. Normal Stress



Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material.

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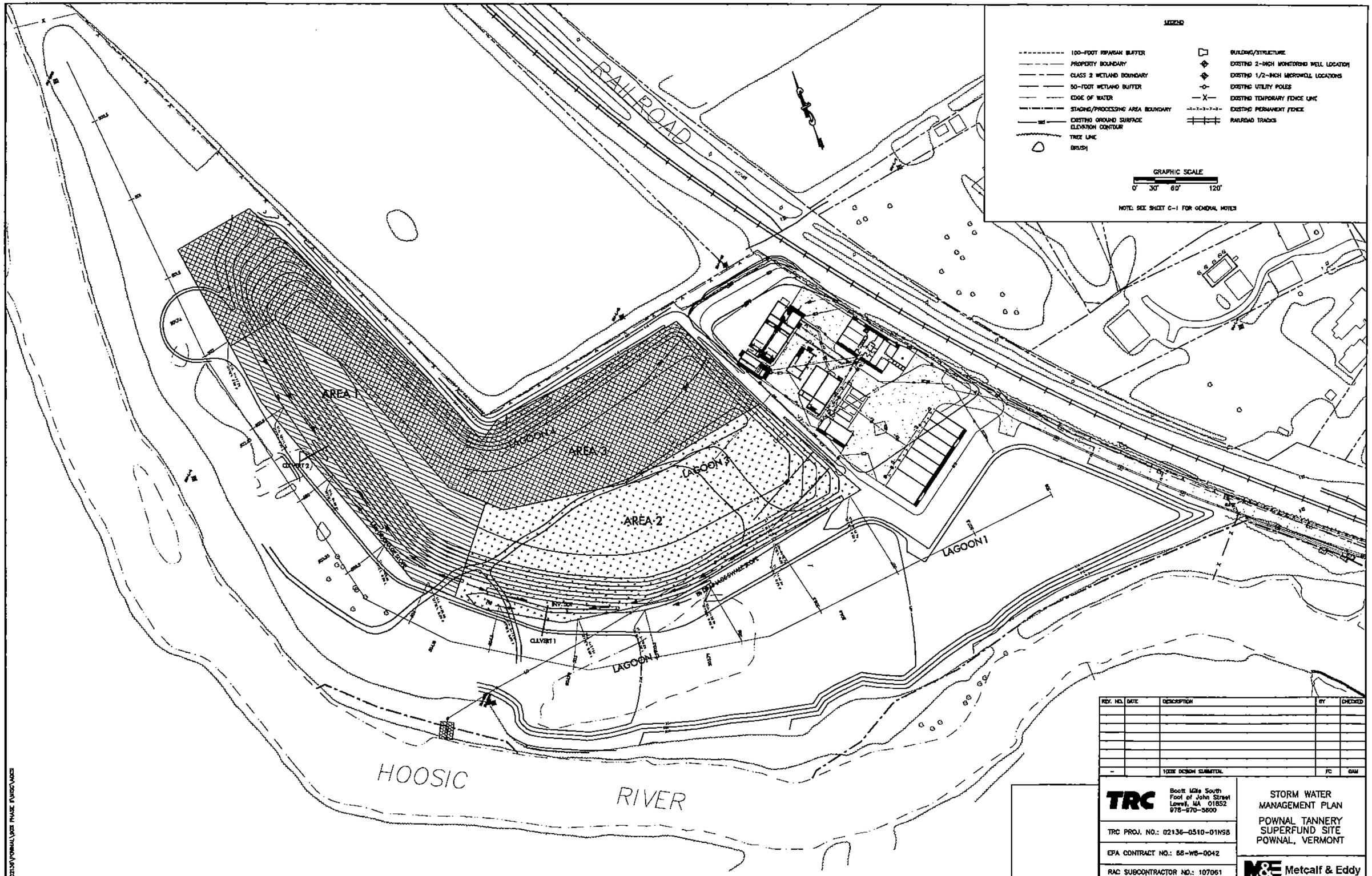
APPENDIX I

STORMWATER CALCULATIONS


LEGEND
100-FOOT RIPARIAN BUFFER
PROPERTY BOUNDARY
CLASS 2 WETLAND BOUNDARY
50-FOOT WETLAND BUFFER
EDGE OF WATER
STAGING/PROCESSING AREA BOUNDARY
EXISTING GROUND SURFACE ELEVATION CONTOUR
TREE LINE
BRUSH
BUILDING/STRUCTURE
EXISTING 2-INCH MONITORING WELL LOCATION
EXISTING 1/2-INCH MICROWELL LOCATIONS
EXISTING UTILITY POLES
EXISTING TEMPORARY FENCE LINE
EXISTING PERMANENT FENCE
RAILROAD TRACKS
GRAPHIC SCALE
0' 30' 60' 120'
NOTE: SEE SHEET C-1 FOR GENERAL NOTES
RAILROAD
AREA 1
AREA 2
AREA 3
LAGOON 1
LAGOON 2
LAGOON 3
LAGOON 4
CULVERT 1
CULVERT 2
HOOSIC
RIVER
REV. NO.
DATE
DESCRIPTION
BY
CHECKED
100% DESIGN SUBMITTAL
FC
GAM
TRC
Boott Mills South
Foot of John Street
Lowell, MA 01852
978-970-5600
TRC PROJ. NO.: 02136-0510-01N98
EPA CONTRACT NO.: 68-W8-0042
RAC SUBCONTRACTOR NO.: 107061
STORM WATER MANAGEMENT PLAN
POWNAL TANNERY SUPERFUND SITE
POWNAL, VERMONT
M&E Metcalf & Eddy

SHEET NO. 1 OF 12
PROJECT NO. 02136 - POWNAL
DATE
BY A.H.
CHK'D M.P. 6/25/03

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SUBJECT AREAS 1 & 2 RATIONAL METHOD

PROBLEM: DETERMINE PEAK FLOW OF AREA DRAINING TO THE S.W. CORNER OF THE LANDFILL ASSUMING WORST CASE (GEOMEMBRANE EXPOSED)

ASSUMPTIONS:

T_c = 10 MIN INITIAL ASSUMPTION
I = 5.74 IN/HR
n = 0.011 SMOOTH SURFACES (TABLE 3-1 TR-55)

SHEET FLOW
(L ≤ 300 LF)

$$T_T = \frac{0.933}{I^{0.4}} \left(\frac{nL}{\sqrt{S}} \right)^{0.6}$$

(1-2)
$$T_T = \frac{0.933}{(5.74\ \text{IN/HR})^{0.4}} \left(\frac{0.011\ (170\ \text{LF})}{\sqrt{0.02}} \right)^{0.6}$$

$$= 1.77\ \text{MIN}$$

(2-3)
$$T_T = \frac{0.933}{(5.74\ \text{IN/HR})^{0.4}} \left(\frac{0.011\ (31\ \text{LF})}{\sqrt{0.06}} \right)^{0.6}$$

$$= 0.565\ \text{MIN}$$

(3-4)
$$T_T = \frac{0.933}{(5.74\ \text{IN/HR})^{0.4}} \left(\frac{0.011\ (15\ \text{LF})}{\sqrt{0.33}} \right)^{0.6}$$

$$= 0.219\ \text{MIN}$$

$$T_{T(\text{SHEET})} = 2.55\ \text{MIN}$$

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SUBJECT RATIONAL METHOD

OPEN CHANNEL FLOW:

$$V = \frac{1.49}{n} R^{2/3} S^{1/2}$$

$$= \frac{1.49}{0.020} (0.401)^{2/3} (0.01)^{1/2}$$

$= 4.05$ FT/SEC ✓

$$T_{OPEN} = \frac{L}{60V}$$

$$T_{OPEN} = \frac{420 \text{ LF}}{60 (4.05 \text{ FT/SEC})}$$

$= 1.73$ MIN ✓

S = 1%
L = 420 LF
d = 0.5 FT
b = 4 FT
Z = 2
R = 0.401
n = 0.020 BARE SOIL

@ 20 CFS
d = 0.75
V = 5.07 FT/SEC

$= 1.38$ MIN

1.38 3.93 STILL USE 7.0

$T_{CONC} = 2.55 \text{ MIN} + 1.73 \text{ MIN} = 4.28$ MIN ✓ I = 7.0 IN/HR

USING I = 7.0 IN/HR

(1-2) $T_T = \frac{0.933}{(7.0 \text{ IN/HR})^{0.4}} \left(\frac{0.011 (120 \text{ LF})}{\sqrt{0.02}} \right)^{0.6} = 1.64$ MIN ✓

(2-3) $T_T = \frac{0.933}{(7.0 \text{ IN/HR})^{0.4}} \left(\frac{0.011 (31 \text{ LF})}{\sqrt{0.06}} \right)^{0.6} = 0.522$ MIN ✓

(3-4) $T_T = \frac{0.933}{(7.0 \text{ IN/HR})^{0.4}} \left(\frac{0.011 (15 \text{ LF})}{\sqrt{0.33}} \right)^{0.6} = 0.203$ MIN

$T_{SHEET} = 2.36$ MIN ✓

$T_{OPEN} = \frac{1.73 \text{ MIN}}{4.0 \text{ MIN}}$ USE I = 7.0 IN/HR

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SUBJECT RATIONAL METHOD

$Q = C I A$

$A = 3.3$ ACRES
$C = 0.95$
$I = 7.0$ IN/HR (@ 1% SLOPE DRAINAGE SWALE)

$Q = 0.95 (7.0 \text{ IN/HR})(3.3 \text{ Ac})$

$= 21.95$ CFS USE 22 CFS

FLOW TO CULVERT 2 = 7.3 CFS (1 ACRE)

FLOW TO CULVERT 1 = 14.7 CFS.

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SUBJECT RATIONAL METHOD

PROBLEM: DETERMINE PEAK FLOW OF AREA DRAINING TO THE SW CORNER OF THE LANDFILL ASSUMING COMPLETED CAP WITH ESTABLISHED VEG.

ASSUMPTIONS:

T_c = 10 MIN INITIAL ASSUMPTION
I = 5.74 IN/HR FROM IDF CURVE
n = 0.15 (SHORT PRAIRE GRASS TR-55 TABLE 3.1)

SHEET FLOW

(4300 LF)

(1-2) $T_T = \dfrac{0.933}{(5.74\ ^{IN}/_{HR})^{0.4}} \left(\dfrac{0.15\ (120\ LF)}{\sqrt{0.02}}\right)^{0.6}$

$= 8.495$ MIN ✓

(2-3) $T_T = \dfrac{0.933}{(5.74\ ^{IN}/_{HR})^{0.4}} \left(\dfrac{0.15\ (3')}{\sqrt{0.06}}\right)^{0.6}$

$= 2.71$ MIN ✓

(3-4) $T_T = \dfrac{0.933}{(5.74\ ^{IN}/_{HR})^{0.4}} \left(\dfrac{0.15\ (15')}{\sqrt{0.33}}\right)^{0.6}$

$= 1.05$ MIN ✓

T_{SHEET} = 12.26 MIN ✓

CHANNEL FLOW

$V = \dfrac{1.49}{0.041} (0.401)^{2/3} (0.01)^{1/2}$

$= 1.976$ FT/SEC ✓

$T_{OPEN} = \dfrac{420\ LF}{60\ (1.976\ FT/SEC)}$

T_{OPEN} = 3.54 MIN ✓

S = 1%
L = 420 LF
d = 0.5 FT
b = 4 FT
z = 2
R = 0.401
n = 0.041
d = 0.5 - 2.0 FT

$T_{conc.}$ = 12.26 MIN + 3.54 MIN = 15.8 MIN

USE I = 4.7 IN/HR

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SUBJECT RATIONAL METHOD

USING 4.7 IN/HR

SHEET (1-2) T_T = 9.20 MIN
(2-3) T_T = 2.94 MIN
(3-2) T_T = 1.14 MIN

SHEET = 13.28 MIN USE I = 5.2 IDF CURVE

$Q = CIA$ C = 0.25 - 0.35 HEAVY SOIL STEEP >7%
= 0.10 - 0.15 SANDY SOIL AVE 2-7%

ASSUMES 40% OF AREA RIPRAP WITH >7% SLOPE
60% OF AREA GRASS WITH 2-7% SLOPE

$ECA = (1.32\ AC)(0.35) + (1.98\ AC)(0.15)$
$= .759\ AC$

$Q = (0.759\ AC)(5.2\ IN/HR)$

$= 3.95\ CFS.$ USE 4.0 CFS

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SUBJECT RATIONAL METHOD

PROBLEM: DETERMINE PEAK FLOW OF AREA DRAINING TO SW CORNER OF THE LANDFILL ASSUMING BARE SOIL CONDITIONS.

SHEET FLOW

ASSUME
T_c = 15 MIN
I = 8 IN/HR

AREA I

$$T_{SHEET} = \frac{0.933}{(8\ IN/HR)^{0.4}} \left(\frac{0.011\ (300\ LF)}{\sqrt{0.005}} \right)^{0.6}$$

n = 0.011 BARE SOIL

= 4.07 MIN

SHALLOW CONC.

$V = k S_p^{0.5}$

SLOPE% = 1% = S_p

AREA II $V = 0.305 (0.01)^{.5}$

k = 0.305 TABLE 3-3 NEARLY BARE

= .0305 FT/SEC ✓

AREA III $V = 0.305 (.33)^{.5}$

= .176 FT/SEC

AREA IV $V = .305 (0.01)^{.5}$ ✓

= 0.0305 FT/SEC

AREA II $T = \frac{230\ LF}{60 (0.0305\ FT/SEC)}$ = 126 ✓ MIN

AREA III = $\frac{20\ LF}{60 (0.176\ FPS)}$ = 1.89 MIN 26.97 MIN

AREA IV = $\frac{260\ LF}{60 (0.305\ FPS)}$ = 142 ✓ MIN

4.5 HRS

TOTAL T = 270 MIN

FOR 3 HR DURATION STORM - CONSERVATIVE

USE I = 0.917 IN/HR

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SUBJECT RATIONAL METHOD

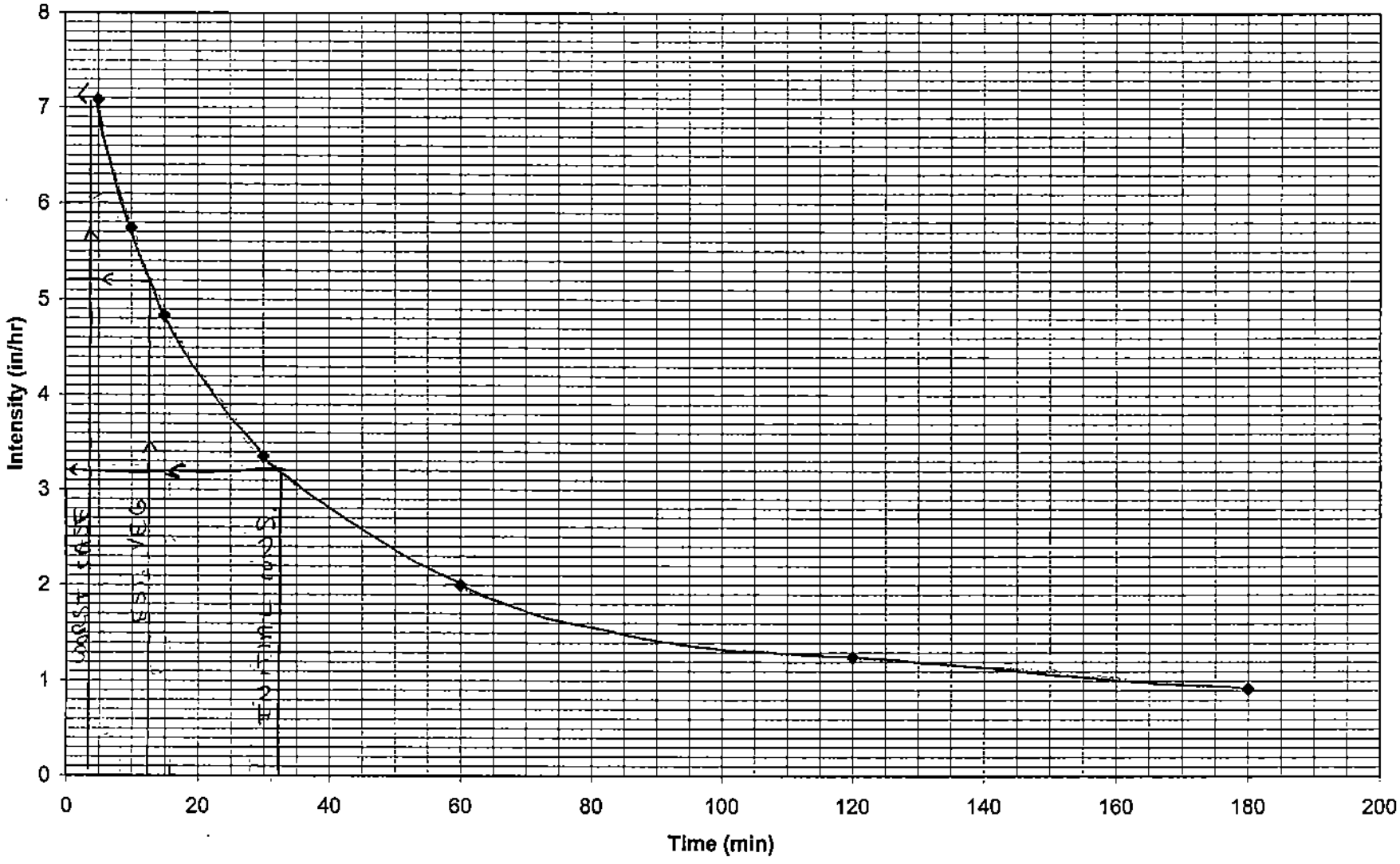
$Q = CIA$ C= 0.10 - 0.30 UNIMPROVED AREA,
$= (0.30)(.917\ IN/HR)(5.54\ AC.)$
$= 1.52\ CFS$

SUMMARY	DESCRIPTION	Q CFS
TRIAL 1	WORST CASE GEOMEMBRANE INSTALLED OVER 3.3 AC DRAINING TO SW CORNER	22
TRIAL 2	CAP IN PLACE WITH EST. VEG. OVER 3.3 AC DRAINING TO SW CORNER	4.0
TRIAL 3	INITIAL CONSTRUCTION CONDITIONS DRAINING TO SW CORNER OVER 5.54 AC. (WORST CASE)	1.52

A

HDF CURVE

Pownal, Vermont - 25 Year Frequency



Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

Table 3-1 Roughness coefficients (Manning's n) for sheet flow

Surface description	n 1/
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses 2/	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods: 3/	
Light underbrush	0.40
Dense underbrush	0.80

1 The n values are a composite of information compiled by Engman (1986).

2 Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.

3 When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overtop and Meadows 1976) to compute T_t:

$$T_t = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} s^{0.4}} \qquad \text{[eq. 3-3]}$$

where:

T_t = travel time (hr),
n = Manning's roughness coefficient (table 3-1)
L = flow length (ft)
P_2 = 2-year, 24-hour rainfall (in)
s = slope of hydraulic grade line (land slope, ft/ft)

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bankfull elevation.

Table 5-1. Manning's roughness coefficients. **

Lining Category	Lining Type	n - Value for Given Depth Ranges		
		0-0.15 m (0-0.5 ft)	0.15-0.60 m (0.5-2.0 ft)	> 0.60 m (> 2.0 ft)
Rigid	Concrete	0.015	0.013	0.013
	Grouted Riprap	0.040	0.030	0.028
	Stone Masonry	0.042	0.032	0.030
	Soil Cement	0.025	0.022	0.020
	Asphalt	0.018	0.016	0.016
Unlined	Bare Soil	0.023	0.020	0.020
	Rock Cut	0.045	0.035	0.025
Temporary*	Woven Paper Net	0.016	0.015	0.015
	Jute Net	0.028	0.022	0.019
	Fiberglass Roving	0.028	0.021	0.019
	Straw with Net	0.065	0.033	0.025
	Curled Wood Mat	0.066	0.035	0.028
	Synthetic Mat	0.036	0.025	0.021
Gravel Riprap	25 mm (1 in) D_{50}	0.044	0.033	0.030
	50 mm (2 in) D_{50}	0.066	0.041	0.034
Rock Riprap	150 mm (6 in) D_{50}	0.104	0.069	0.035
	300 mm (12 in) D_{50}	--	0.078	0.040

NOTE: Values listed are representative values for the respective depth ranges. Manning's roughness coefficients, n, vary with the flow depth.

* Some "temporary" linings become permanent when buried.
** Table reproduced from HEC-15 [30]

SOURCE : URBAN DRAINAGE DESIGN MANUAL
HYDRAULIC ENGINEERING CIRCULAR NO 22
US DOT
NOV. 96

Table 3-3. Intercept coefficients for velocity vs. slope relationship of equation 3-4. [a]

Land cover/flow regime	k
Forest with heavy ground litter; hay meadow (overland flow).	0.076
Trash fallow or minimum tillage cultivation; contour or strip cropped; woodland (overland flow).	0.152
Short grass pasture (overland flow).	0.213
Cultivated straight row (overland flow).	0.274
Nearly bare and untilled (overland flow); alluvial fans in western mountain regions.	0.305
Grassed waterway (shallow concentrated flow).	0.457
Unpaved (shallow concentrated flow).	0.491
Paved area (shallow concentrated flow); small upland gullies.	0.619

Example 3-2

Given: The following flow path characteristics:

Flow Segment	*Length (m)*	*Slope (m/m)*	*Segment Description*
1	*25*	*0.005*	*Short grass pasture*
2	*43*	*0.005*	*Short grass pasture*
3	*79*	*0.006*	*Grassed waterway*
4	*146*	*0.008*	*380 mm concrete pipe*

Find: *Railfall intensity, I, = 60 mm/hr. The time of concentration, t_c for the area.*

Solution:

Step 1. Calculate time of concentration for each segment.

Segment 1

Obtain Manning's n roughness coefficient from Table 3-2:

$n = 0.15$

Determine the sheet flow travel time using equation 3-3:

$T_u = (6.943/I^{0.4})\ (nL/S^{0.5})^{0.6} = [6.943/(60)^{0.4}]\ [(0.15)(25)/(0.005)^{0.5}]^{0.6} = 14.6$ min.

SOURCE: URBAN DRAINAGE DESIGN MANUAL
HYDRAULIC ENGINEERING CIRCULAR 22
NOV. 96

Table 3-1. Runoff coefficients for Rational formula. [10]

Type of Drainage Area	Runoff Coefficient, C*
Business:	
Downtown areas	0.70 - 0.95
Neighborhood areas	0.50 - 0.70
Residential:	
Single-family areas	0.30 - 0.50
Multi-units, detached	0.40 - 0.60
Multi-units, attached	0.60 - 0.75
Suburban	0.25 - 0.40
Apartment dwelling areas	0.50 - 0.70
Industrial:	
Light areas	0.50 - 0.80
Heavy areas	0.60 - 0.90
Parks, cemeteries	0.10 - 0.25
Playgrounds	0.20 - 0.40
Railroad yard areas	0.20 - 0.40
Unimproved areas	0.10 - 0.30
Lawns:	
Sandy soil, flat, 2%	0.05 - 0.10
Sandy soil, average, 2 - 7%	0.10 - 0.15
Sandy soil, steep, 7%	0.15 - 0.20
Heavy soil, flat, 2%	0.13 - 0.17
Heavy soil, average 2 - 7%	0.18 - 0.22
Heavy soil, steep, 7%	0.25 - 0.35
Streets:	
Asphaltic	0.70 - 0.95
Concrete	0.80 - 0.95
Brick	0.70 - 0.85
Drives and walks	0.75 - 0.85
Roofs	0.75 - 0.95

* Higher values are usually appropriate for steeply sloped areas and longer return periods because infiltration and other losses have a proportionally smaller effect on runoff in these cases.

SHEET NO. 1 OF 6

PROJECT NO. 02136 - POWNAL

DATE

BY A. H.

CHK'D M.P. 6/12/03

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SUBJECT AREA 3 RATIONAL METHOD

PROBLEM: DETERMINE PEAK FLOW OF AREA 3 THAT DRAINS TO THE NORTHERN TOE OF THE LANDFILL ASSUMING WORST CASE (GEOMEMBRAINE EXPOSED) CONDITIONS.

ASSUMPTIONS:

T_c = 10 MIN.

I = 5.74 IN/HR

n = 0.011 SMOOTH SURFACES (TABLE 3-1 TR-55)

SHEET FLOW:

($L \leq 300$ LF)

$$T_T = \frac{0.933}{I^{0.4}} \left(\frac{n L}{\sqrt{S}} \right)^{0.6}$$

(1-2) $$T_T = \frac{0.933}{(5.74 \text{ IN/HR})^{0.4}} \left(\frac{0.011 (112 \text{ LF})}{\sqrt{0.02}} \right)^{0.6}$$

$$= 1.70 \text{ MIN}$$

(2-3) $$T_T = \frac{0.933}{(5.74 \text{ IN/HR})^{0.4}} \left(\frac{0.011 (35 \text{ LF})}{\sqrt{0.057}} \right)^{0.6}$$

$$= 0.618 \text{ MIN}$$

(3-4) $$T_T = \frac{0.933}{(5.74 \text{ IN/HR})^{0.4}} \left(\frac{0.011 (20 \text{ LF})}{\sqrt{.33}} \right)^{0.6}$$

$$= 0.260 \text{ MIN}$$

T_{SHEET} = 2.58 MIN.

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SUBJECT RATIONAL METHOD

OPEN CHANNEL FLOW:

$$V = \frac{1.49}{n} R^{2/3} S^{1/2}$$

$$= \frac{1.49}{0.020} (0.565)^{2/3} (0.01)^{1/2}$$

$= 5.09$ FT/SEC ✓

$S = 1\%$
$L = 815$ LF
$d = 0.8$ FT
$b = 4$ FT
$Z = 3$
$R = 0.565$
$n = 0.020$ BARE SOIL

$$T_{OPEN} = \frac{L}{60V} = \frac{815 \text{ LF}}{60(5.09 \text{ FT/SEC})}$$

$T_{OPEN} = 2.67$ MIN ✓

$T_{CONC} = T_{SHEET} + T_{OPEN} = 2.58 \text{ MIN} + 2.67 \text{ MIN} = 5.25$ MIN ✓

CLOSE TO 5 MIN.

USE $I = 7.0$ IN/HR

USING $I = 7.0$ IN/HR

(1-2) $T_T = 1.57$ MIN ✓

(2-3) $T_T = 0.571$ ✓

(3-4) $T_T = 0.240$ ✓

2.38 MIN + 2.67 MIN = 5.05 CHECK

$Q = C I A$

$A = 2.61$ AC
$C = 0.95$

$= 0.95 (7.0 \text{ IN/HR}) (2.61 \text{ AC})$

$= \underline{17.36 \text{ CFS}}$ ✓

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SUBJECT RATIONAL METHOD

PROBLEM: DETERMINE PEAK FLOW OF AREA 3 DRAINING TO THE NORTHERN TOE OF THE LANDFILL ASSUMING COMPLETED CAP WITH ESTABLISHED VEG.

ASSUMPTIONS: T_c = 10 MIN INITIAL ASSUMPTION

I = 5.74 IN/HR

n = 0.15 (SHORT PRAIRE GRASS TR-55 TABLE 3.1)

SHEET FLOW (≤ 300 LF)

(1-2) $$T_T = \frac{0.933}{(5.74\ \text{IN/HR})^{0.4}} \left(\frac{0.15\ (112\ \text{LF})}{\sqrt{0.02}}\right)^{0.6}$$

$$= 8.15\ \text{MIN}$$

(2-3) $$T_T = \frac{0.933}{(5.74\ \text{IN/HR})^{0.4}} \left(\frac{0.15\ (35\ \text{LF})}{\sqrt{0.057}}\right)^{0.6}$$

$$= 2.96\ \text{MIN}$$

(3-4) $$T_T = \frac{0.933}{(5.74\ \text{IN/HR})^{0.4}} \left(\frac{0.15\ (20\ \text{LF})}{\sqrt{.333}}\right)^{0.6}$$

$$= 1.25\ \text{MIN}$$

$$T_{SHEET} = 12.36\ \text{MIN}$$

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SUBJECT RATIONAL METHOD

CHANNEL FLOW:

$$V = \frac{1.49}{0.041}(0.565)^{2/3}(0.01)^{1/2}$$

$= 2.48$ FT/SEC ✓

$S = 1\%$
$L = 815$ LF
$d = 0.8$ FT
$b = 4$ FT
$z = 3$
$R = 0.565$
$n = 0.041$

$$T_{OPEN} = \frac{815 \text{ LF}}{60(2.48 \text{ FT/SEC})}$$

$= 5.48$ MIN ✓

$T_{CONC} = 5.48$ MIN $+$ 12.36 MIN

$= 17.84$ MIN ✓ USE $I = 4.3$ IN/HR.

(1-2) $T_T = 9.15$ MIN
(2-3) $T_T = 3.32$ MIN
(3-4) $T_T = 1.40$ MIN

13.9 MIN $+ 5.48$ MIN $= 19.3$ MIN ✓ $I = 4.2$ IN/HR

$Q = CIA$ $C = 0.10 - 0.15$ SANDY SOIL AVE 2-7%

$= 0.15(4.2 \text{ IN/HR})(2.61 \text{ AC})$

$= 1.64$ CFS ✓

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SUBJECT RATIONAL METHOD

SUMMARY	DESCRIPTION	Q CFS
TRIAL 1	WORST CASE GEOMEMBRANE INSTALLED OVER 2.61 AC AREA DRAINING TO NORTH TOE	17.4 CFS
TRIAL 2	CAP IN PLACE WITH EST VEG OVER 2.61 AC AREA DRAINING TO NORTH TOE	1.64 CFS.

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SHEET NO. 1 OF 2
PROJECT NO. 02136 - POWNAL
DATE
BY A. H.
CHK'D n.?. 10/21/03

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SUBJECT CULVERT 3 RATIONAL METHOD

PROBLEM: DETERMINE PEAK FLOW OF AREA DRAINING TO THE DROP INLET ASSUMING EST. VEG. CONDITIONS

ASSUMPTIONS: T_C = 10 MIN.
I = 5.74 IN/HR
n = 0.15 (SHORT PRARE GRASS TR-55 TABLE 3.1)
S = 0.01
SHEET FLOW: L = 40 LF
(< 300 LF)

(1-2) $$T_T = \frac{0.933}{(5.74\ \text{IN/HR})^{0.5}} \left(\frac{0.15\,(40\ \text{LF})}{\sqrt{0.01}}\right)^{0.6}$$

$$= 3.77\ \text{MIN}$$

$$V = \frac{1.49}{0.15}(0.339)^{2/3}(0.01)^{1/2}$$

$$= 0.48\ \text{FT/SEC}$$

$$T_{OPEN} = \frac{220\ \text{LF}}{60\,(0.48\ \text{FT/SEC})}$$

$$T = 7.59$$

$$T_{CONC} = 7.59\ \text{MIN} + 3.77\ \text{MIN}$$

$$= 11.3\ \text{MIN}$$ INITIAL ASSUMPTION OK

USE I = 5.74 IN/HR

S = 1%
L = 220'
d = 0.5 FT
b = 2'
z = 3
R = 0.339
n = 0.15
(SHORT GRASS)

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SUBJECT RATIONAL METHOD

$A = 11{,}000$ SF $= .25$ ACRES

$C = 0.05 - 0.10$ LAWNS, SANDY SOIL FLAT

$Q = CIA$

$= 0.075\,(5.74\ \text{IN/HR})(0.25\ \text{AC})$ $\quad C = 0.075$

$= 0.11$ CFS

USE 0.2 CFS CONSERVATIVE

INCLUDING POND SUBAREAS 3–6

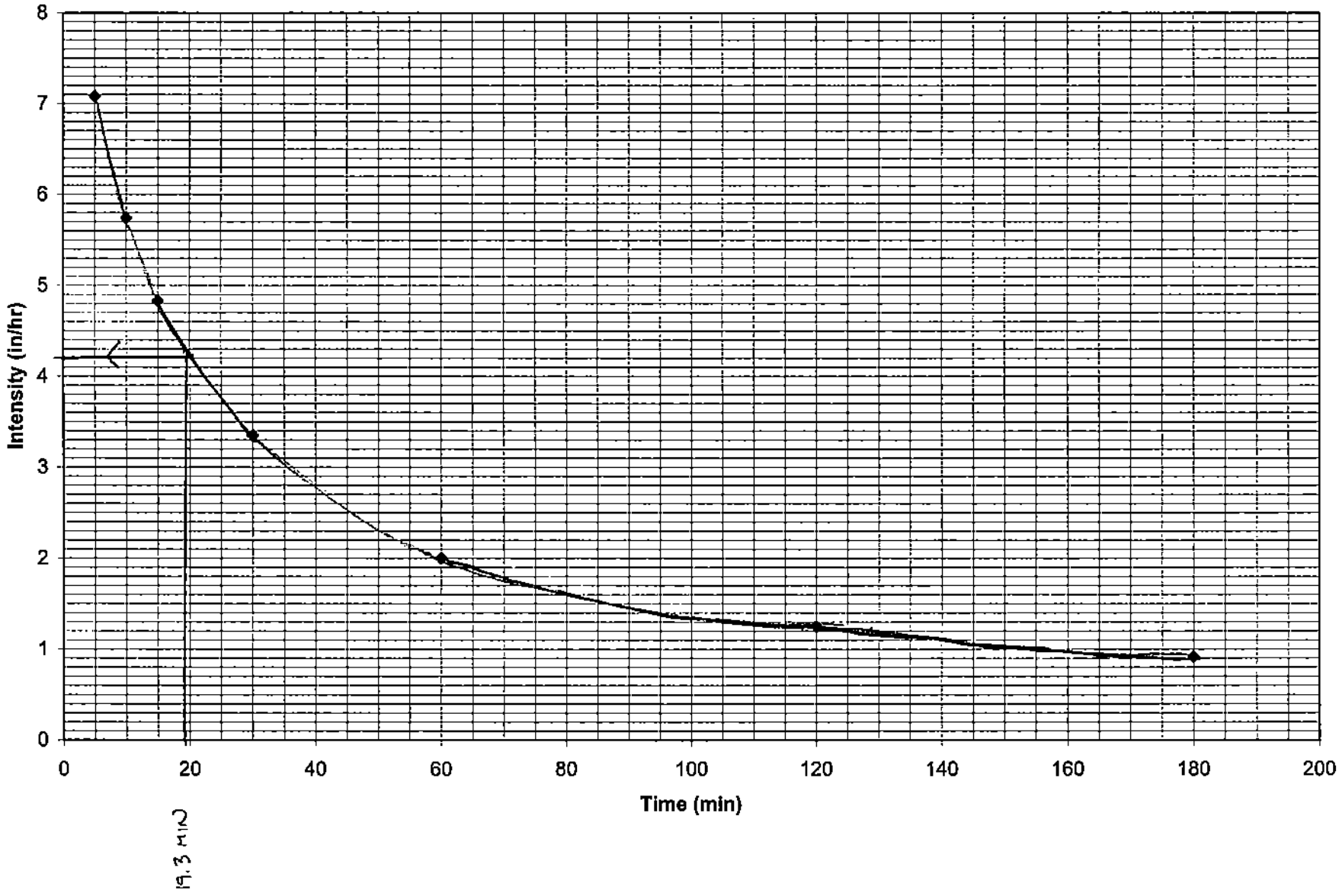
③ 0.7 CFS

④ 1.5 CFS

USE 2.4 CFS. USE 2.5

A

Pownal, Vermont - 25 Year Frequency



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SUBJECT DETERMINATION OF INTENSITY - DURATION - FREQ. CURVE

PROBLEM: DETERMINE INTENSITY - DURATION - FREQUENCY CURVE FOR POWNAL, VERMONT USING THE 25-YEAR RECURRENCE FREQUENCY.

SOURCE: RAINFALL FREQUENCY ATLAS OF THE UNITED STATES, TECHNICAL PAPER NO. 40.

RAINFALL (IN)	DURATION (HR)	INTENSITY (IN/HR)
1.6	0.5	3.20
2.0	1.0	2.00
2.5	2.0	1.25
2.75	3.0	0.917
3.5	6.0	0.588
4.0	12.0	0.333
4.8	24.0	0.20

SOURCE: 5- TO 60-MINUTE PRECIPITATION FREQUENCY FOR THE EASTERN AND CENTRAL U.S., NOAA TECHNICAL MEMORANDUM NWS HYDRO-35.

RAINFALL (IN)	DURATION (MIN)	FREQUENCY (YR)
0.38	5	2
0.72	5	100
0.70	15	2
1.50	15	100
1.10	60	2
2.75	60	100

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SUBJECT INTENSITY-DURATION-FREQ.

EQS. TO CONVERT TO INTERMEDIATE DURATIONS:

10 MIN = 0.59 (15 MIN VAL) + 0.41 (5-MIN VALUE)

30 MIN = 0.49 (60 MIN VAL.) + 0.51 (15 MIN VALUE)

EQS. TO CONVERT TO DIFFERENT FREQUENCY:

25 YR = 0.669 (100-YR) + 0.293 (2-YR)

INTERMEDIATE DURATION CALCS:

10 MIN 100-YR = 0.59 (1.50 IN) + 0.41 (0.72 IN)
= 1.18 IN

10 MIN 2-YR = 0.59 (0.70 IN) + 0.41 (0.38 IN)
= 0.5688 IN

30 MIN 100-YR = 0.49 (2.75 IN) + 0.51 (1.50 IN)
= 2.11 IN

30 MIN 2-YR = 0.49 (1.10 IN) + 0.51 (0.70 IN)
= 0.896 IN

CONVERSION TO 25-YR FREQUENCY:

25-YEAR 5MIN = 0.669 (0.72 IN) + 0.293 (0.38 IN)
= 0.593 IN INTENSITY = 7.08 IN/HR

25-YEAR 10MIN = 0.669 (1.18 IN) + 0.293 (0.5688 IN)
= 0.956 IN INTENSITY = 5.74 IN/HR

25-YEAR 15 MIN = 0.669 (1.50 IN) + 0.293 (0.70 IN)
= 1.21 IN INTENSITY = 4.83 IN/HR

25-YEAR 30MIN = 0.669 (2.11 IN) + 0.293 (0.896 IN)
= 1.67 IN I = 3.35 IN/HR

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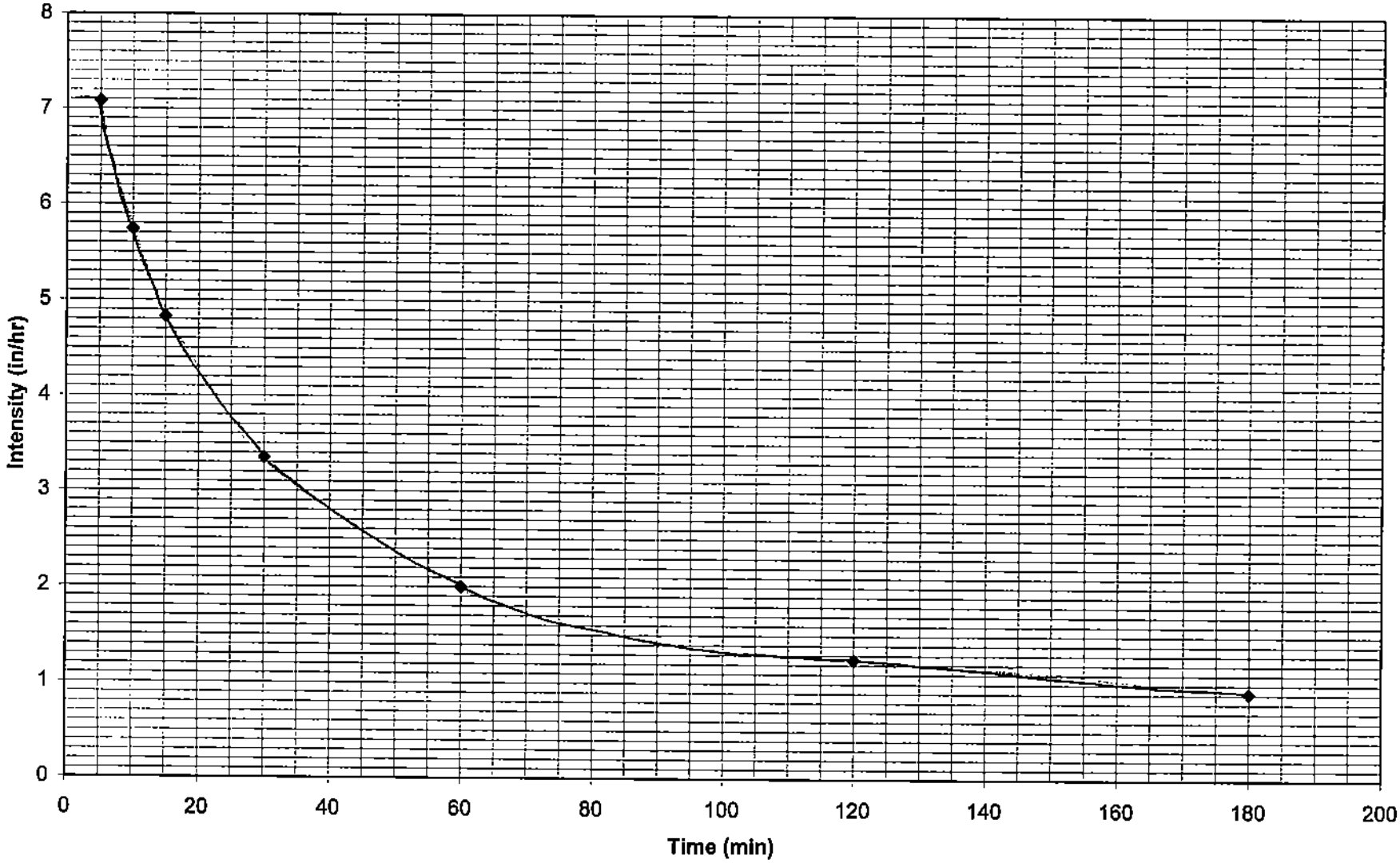
SUBJECT INTENSITY - DURATION - FREQ.

RAINFALL (IN)	DURATION (HR)	INTENSITY (IN/HR)
0.593	0.083	7.08
0.956	0.167	5.74
1.21	0.250	4.83
1.67	0.50	3.35

m.7 6/10/03

Pownal, Vermont - 25 Year Frequency



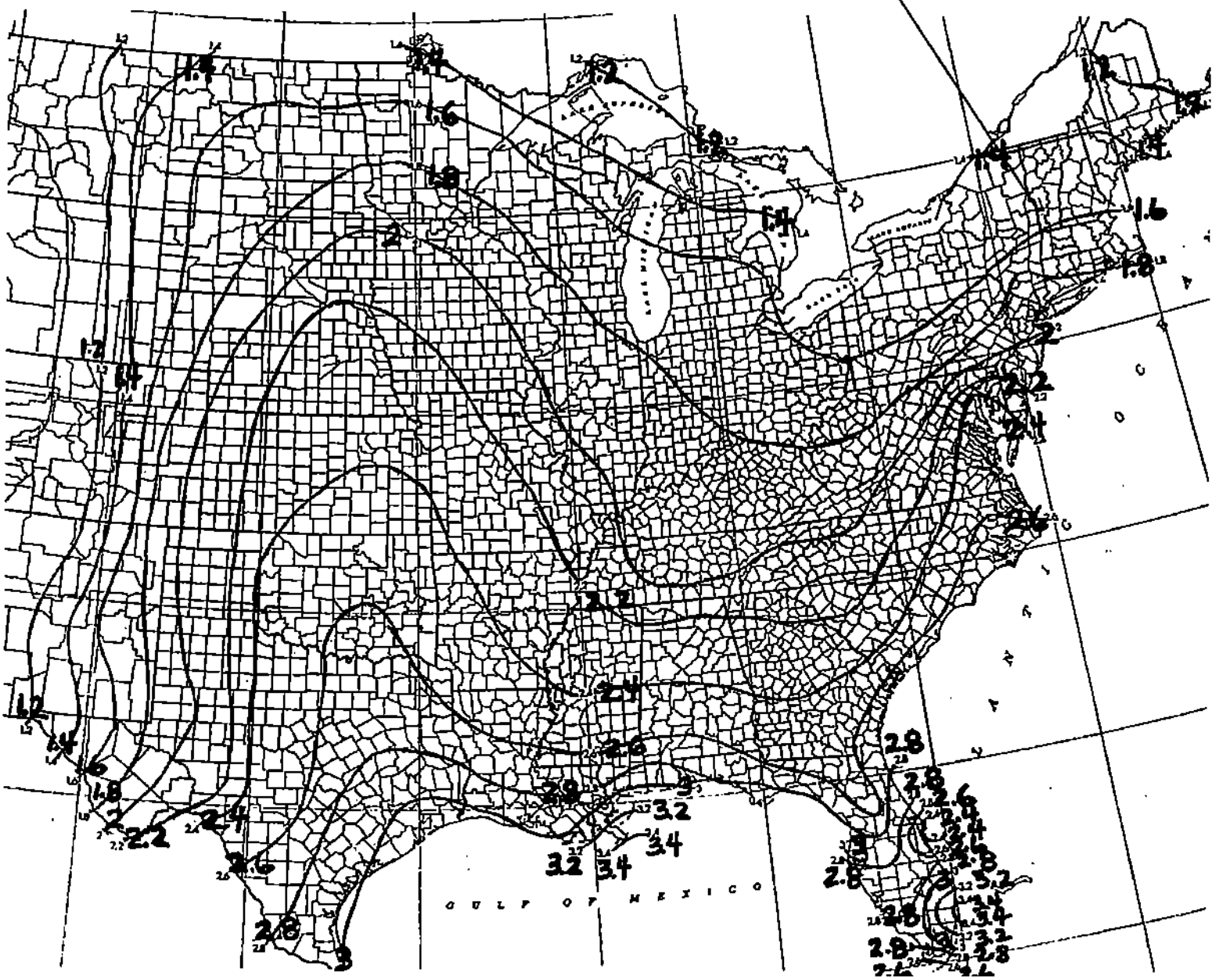
M.T. 6/18/03

Intensity-Duration Data
Pownal Vermont

Min	(in/hr) Intensity
5	7.08
10	5.74
15	4.83
30	3.35
60	2.00
120	1.25
180	0.917

A.3.6/10 b3

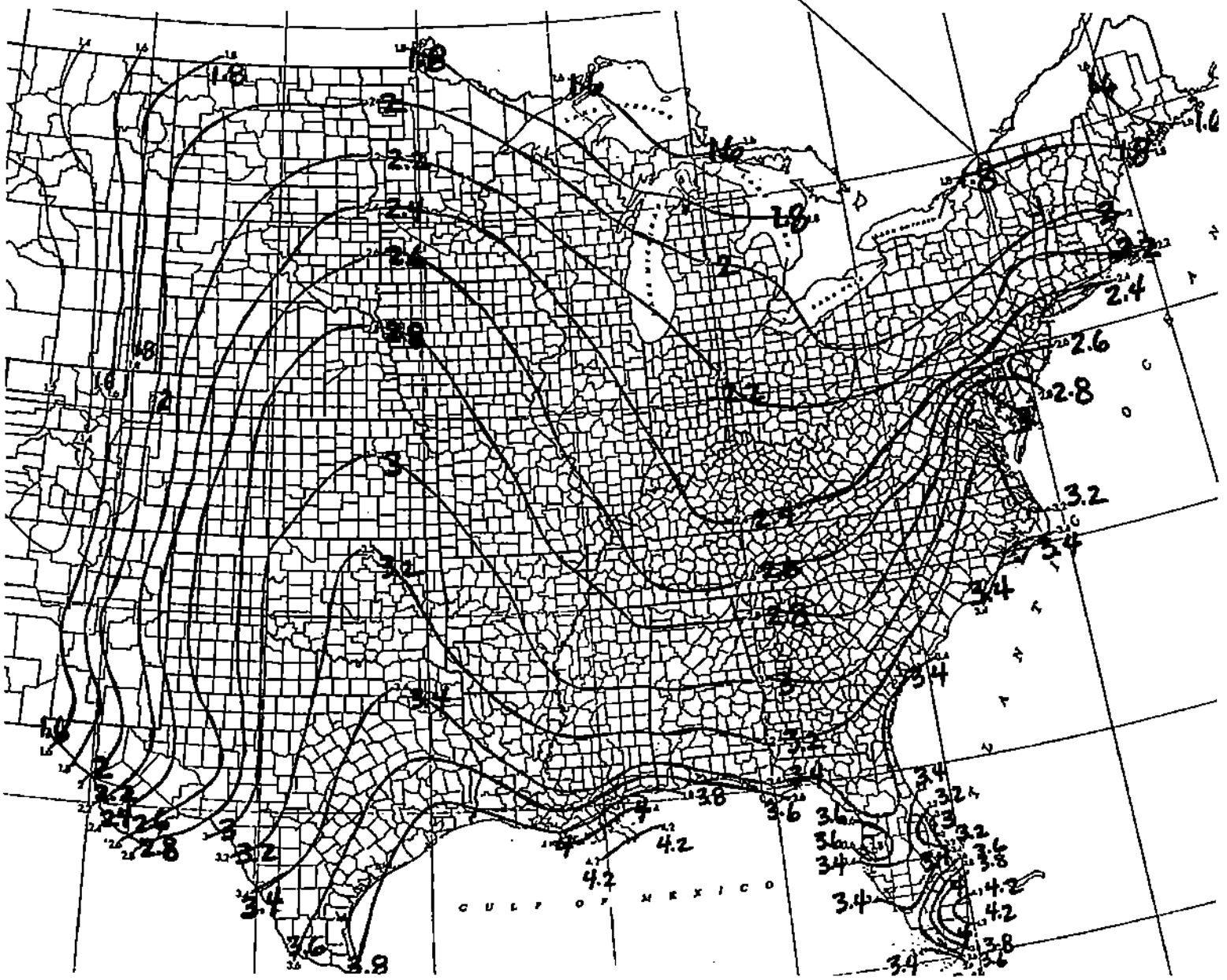
25-YEAR, 30 MIN 1.6 INCHES



INTENSITY = 3.2 IN/HR

MT 6/12/03

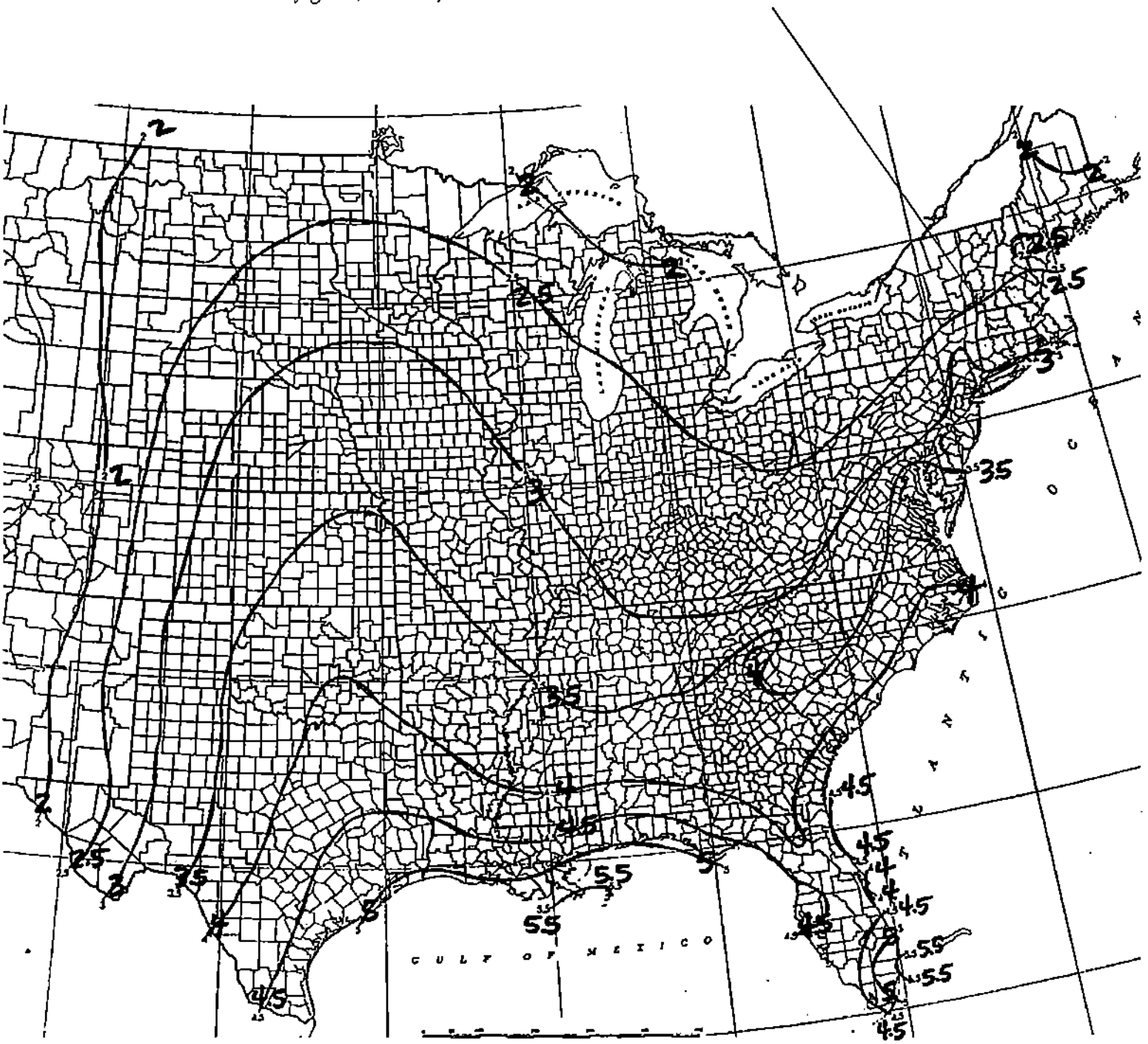
25-YEAR, 1 HR 2 INCHES



INTENSITY = 2 IN/HR

M.P. 6/16/03

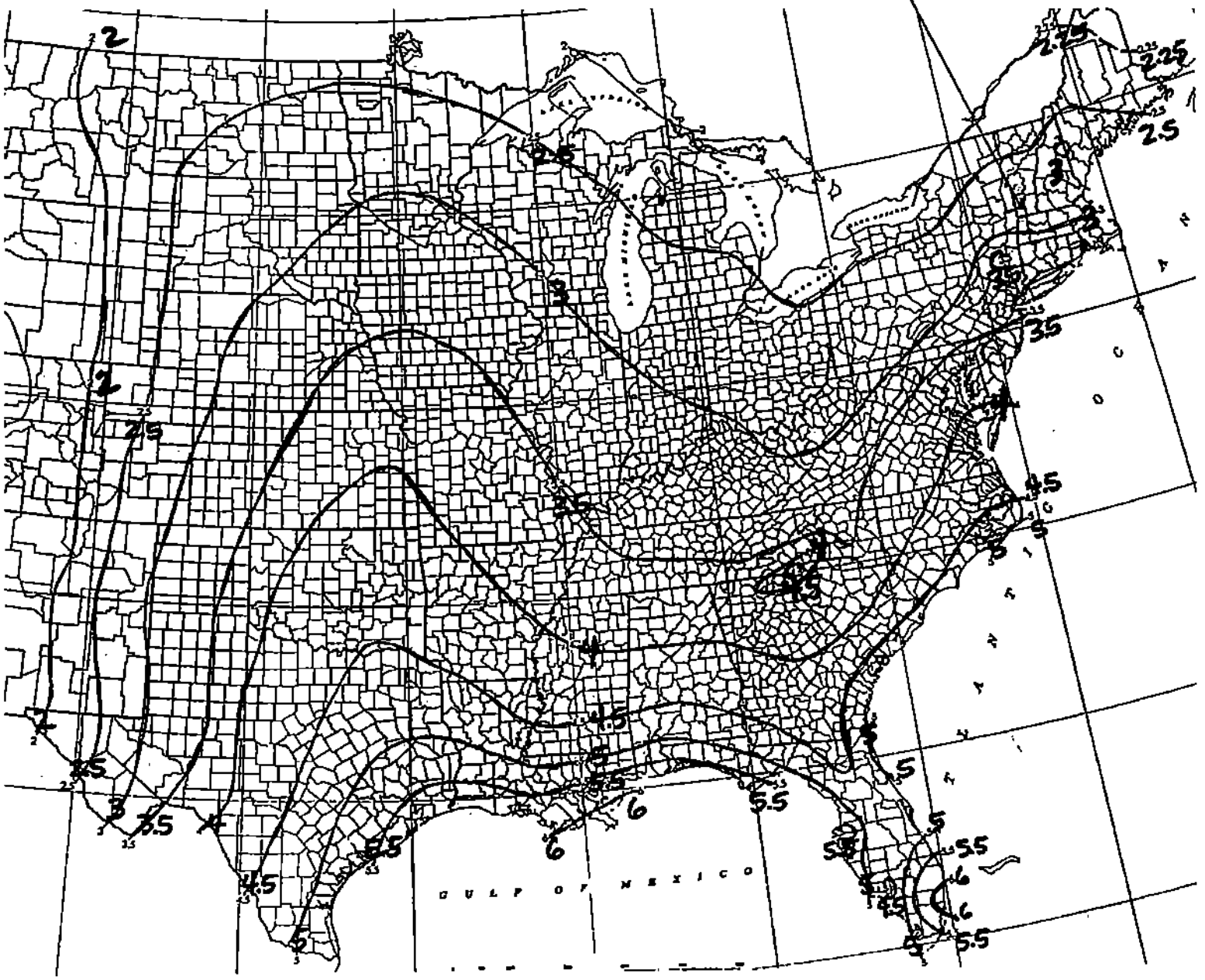
25 - YEAR, 2 HR 2.5 INCHES



INTENSITY = 1.25 IN/HR

MP, 6/12/03

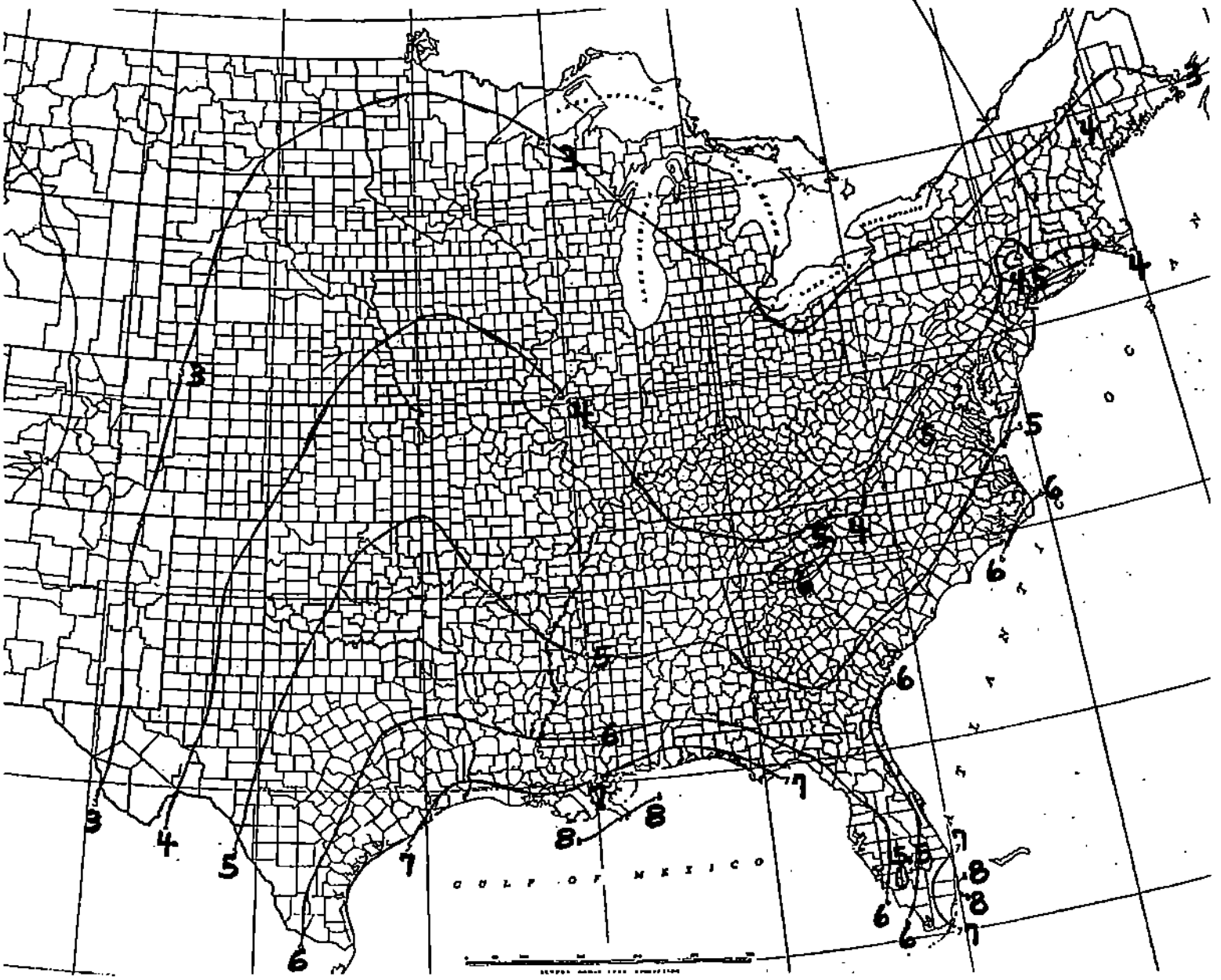
25-YEAR, 3HR 2.75 INCHES



INTENSITY = 0.933 IN/HR

M.P. 6/18/63

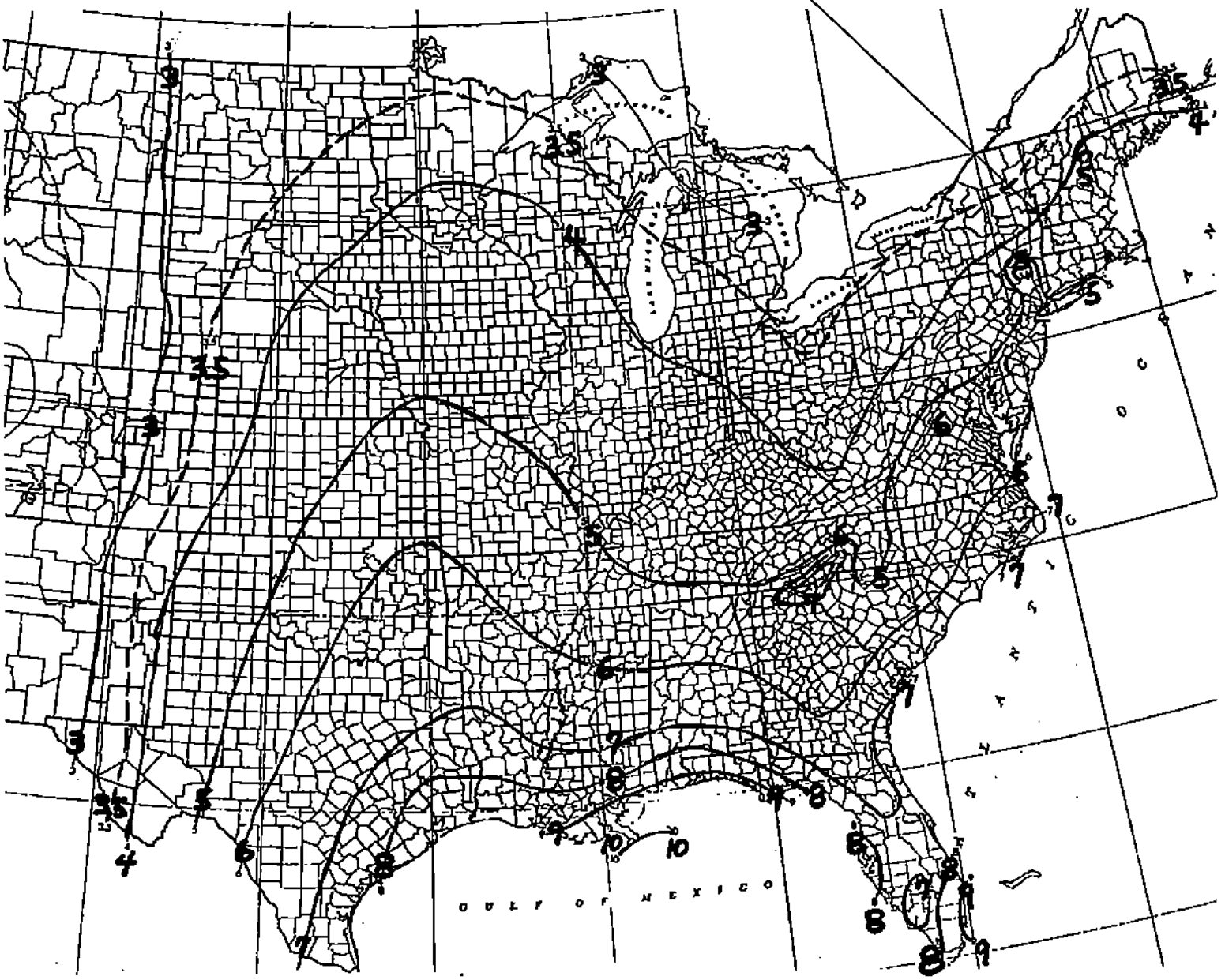
25 YEAR, 6 HR 3.5 INCHES



INTENSITY = 0.583 IN/HR

6/18/03

25 -YEAR, 12 HR 4 INCHES

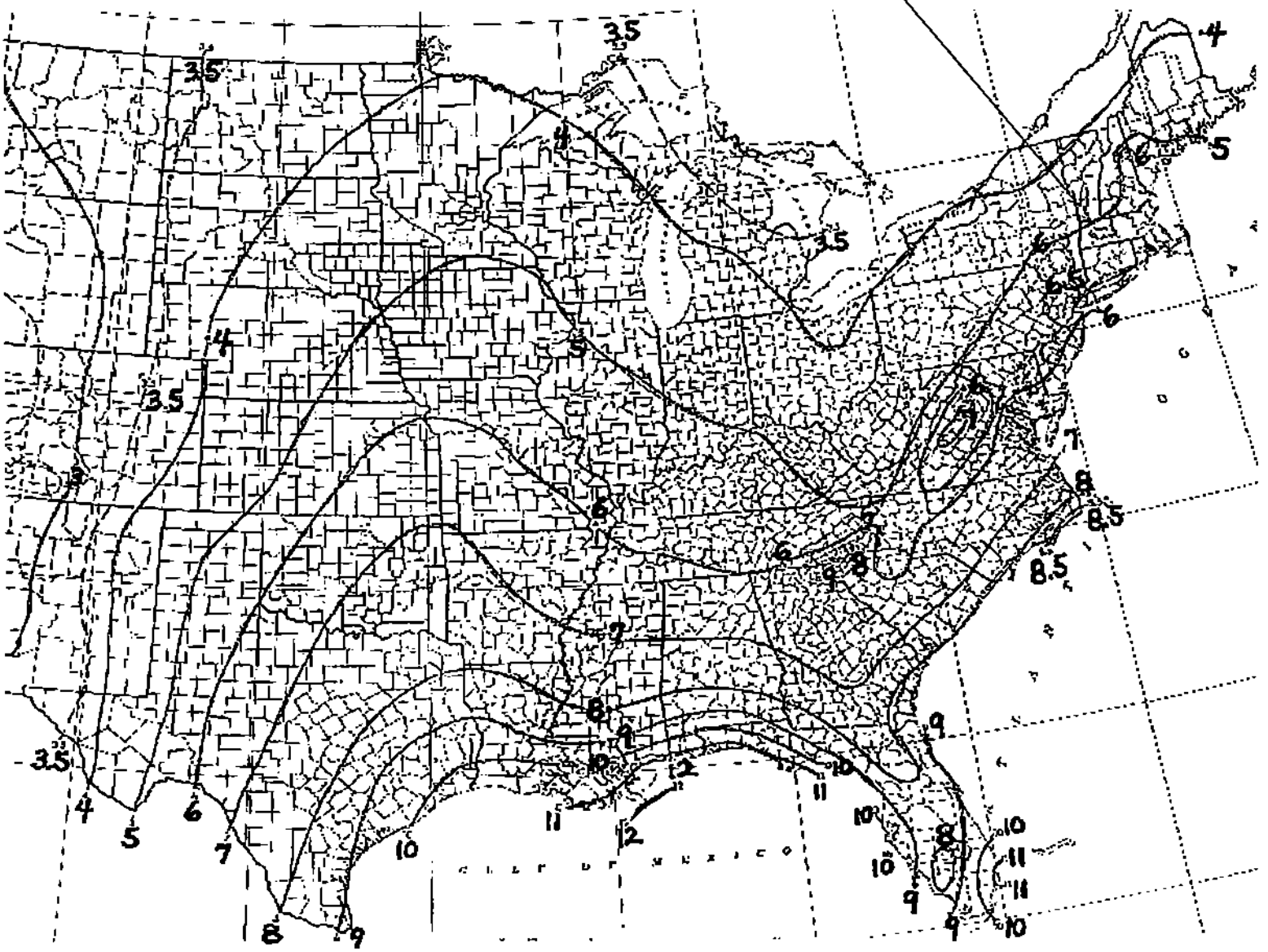


INTENSITY = 0.333 IN/HR

N.T 6/16/03

25-YEAR, 24 HR

4.8 INCHES



INTENSITY = 0.20 IN/HR

13 OF 21

SOURCE:

Rainfall Frequency Atlas Maps
(Central and Eastern U.S.)

These images were scanned from a copy of *TECHNICAL PAPER NO. 40*
RAINFALL FREQUENCY ATLAS OF THE UNITED STATES

<---------- Choose a link at the left to access

Link to Tech Paper No. 57 Normal Monthly Number of Days with Precipitation of 0.5, 1.0, 2.0, and 4.0 Inches or More

Scanned images of NOAA Atlas 2 for the Western U.S. are available from the Western Region Climate Center.

Precipitation Frequency Definition

Precipitation Frequency is a term used in the same manner as flood frequency; as in 100-year flood. But what does this mean, one big storm every 100 years? If we had "the 100-year storm" last year, does that mean that we have to wait 99 years for the next one? Well, no, it may happen next year, or not at all in the next 100 years.

100 - Year Event

An event which has a 1 percent chance of occurrence IN ANY YEAR; NOT ONE event every 100 years.

Use of Precipitation Frequency Values

Precipitation frequency estimates are used as basic design criteria for a wide variety of hydraulic structures such as culverts, roadway drainages, bridges and small dams. Current precipitation frequency studies for the continental United States are contained in studies that were completed from the early 1960s to the mid-1970s. These references provide information for durations from 5 minutes through 10 days, and for return periods of 2 years through 100 years. Furthermore, these documents provide an extreme precipitation climatology.

www.srh.noaa.gov/lub/wx/precip_index.htm

HRL Library Copy
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W23 REFERENCE FILE

NOAA Technical Memorandum NWS HYDRO-35

FIVE- TO 60-MINUTE PRECIPITATION FREQUENCY FOR THE EASTERN AND CENTRAL UNITED STATES

Silver Spring, Md.
June 1977

noaa NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION / National Weather Service

differences between adjacent grid points on the six maps were compared to discover any places where one map or set of maps showed increasing values where other maps or sets of maps were indicating decreasing values. This does not imply that values on all maps must move parallel to each other, but that nonparallel movement be examined to insure that the trends are intended by the analyst. A case of validated nonparallelism is illustrated in the Northern Plains States, where the ridge in the isopluvials shifts westward with increasing return period.

Intermediate Durations and Return Periods

10- and 30-Min Relations

The procedure discussed under "Methodology" was used to derive equations to estimate the 10-min values from 5- and 15-min, and 30-min values from 15- and 60-min values. The station data were first grouped geographically, and separate equations derived for each area and for the 2- and 100-yr return period. Neither geographical nor return period differences were significant, and one equation for the 10-min estimation and one equation for 30-min estimation were adopted. They are:

$$\text{10-min value} = 0.59\ (\text{15-min value}) + 0.41\ (\text{5-min value}) \quad (7)$$

$$\text{30-min value} = 0.49\ (\text{60-min value}) + 0.51\ (\text{15-min value}) \quad (8)$$

The graphical solution to these equations is shown in figure 10. The ordinate scale is linear. It is left unlabeled so that the user can label as appropriate for the range of data being used.

Intermediate Return Periods

A mathematical solution of the Gumbel equations for the partial duration series results in the following equations to compute values for selected return periods intermediate to the 2- and 100-yr values.

$$\text{5-yr} = 0.278\ (\text{100-yr}) + 0.674\ (\text{2-yr}) \quad (9)$$

$$\text{10-yr} = 0.449\ (\text{100-yr}) + 0.496\ (\text{2-yr}) \quad (10)$$

$$\text{25-yr} = 0.669\ (\text{100-yr}) + 0.293\ (\text{2-yr}) \quad (11)$$

$$\text{50-yr} = 0.835\ (\text{100-yr}) + 0.146\ (\text{2-yr}) \quad (12)$$

Interpretation of Results

Physiographic and Meteorological Effects

The center of low precipitation frequencies depicted in Northern Missouri is validated by the fact that this is also a center of low frequency of tornadoes (Fujita 1976) compared to the surrounding regions. High-intensity, short-duration rainfalls and tornadoes are both associated with convective storms. We do not know whether this anomaly is a shadow effect of the

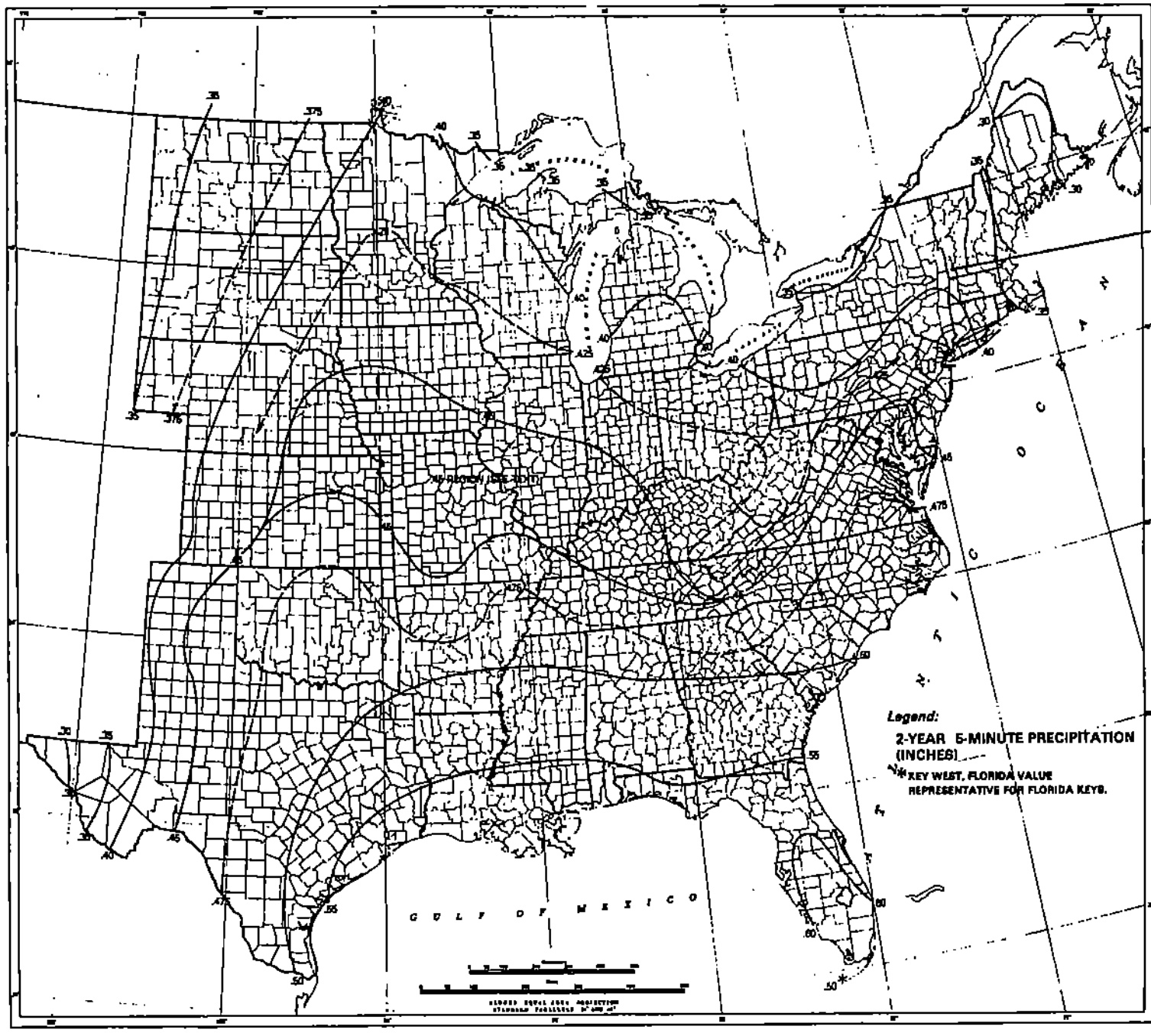

Figure 6.--2-year 5-minute precipitation (inches)--adjusted to partial-duration series.

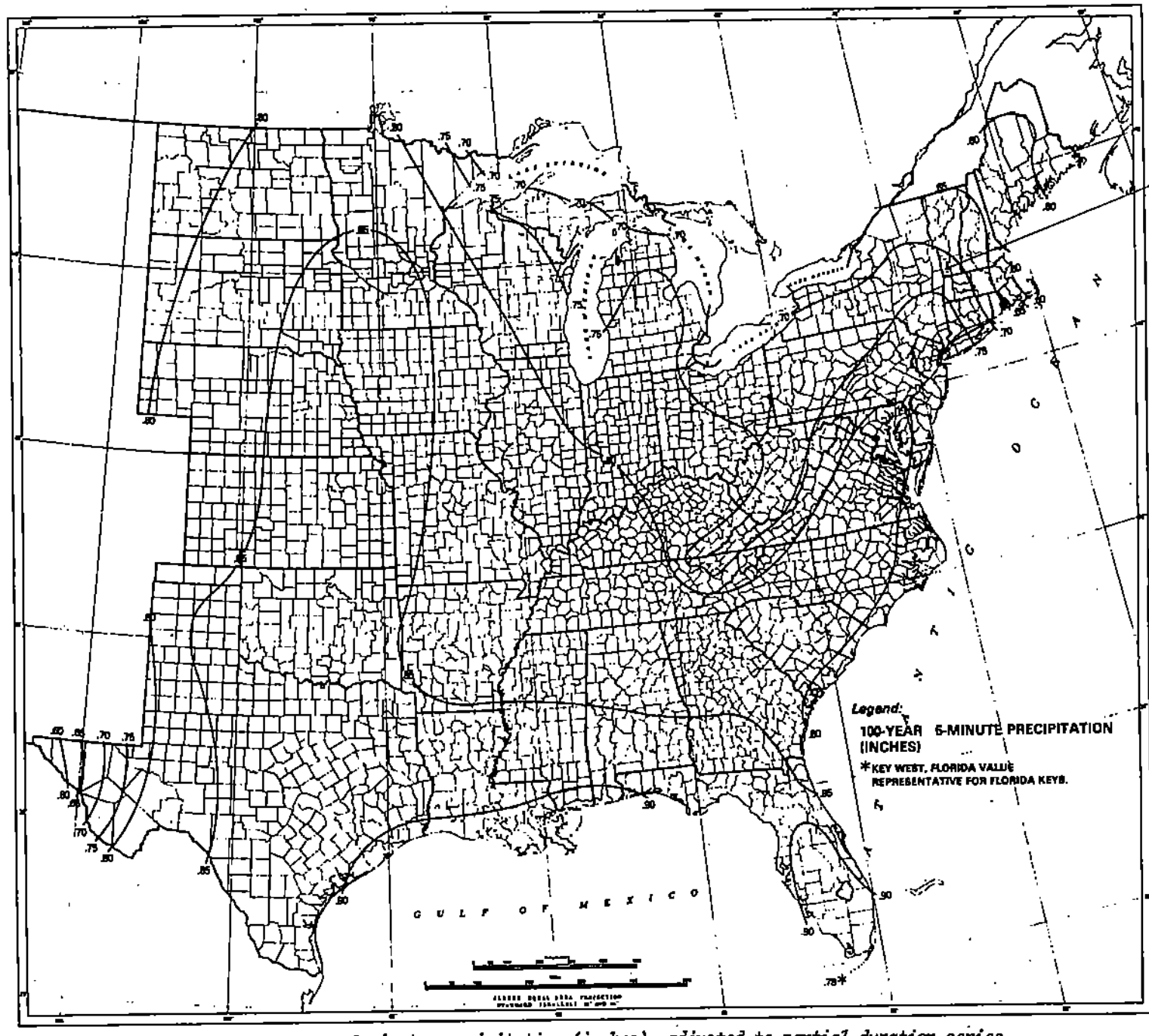

Figure 7.--100-year 5-minute precipitation (inches)--adjusted to partial-duration series.

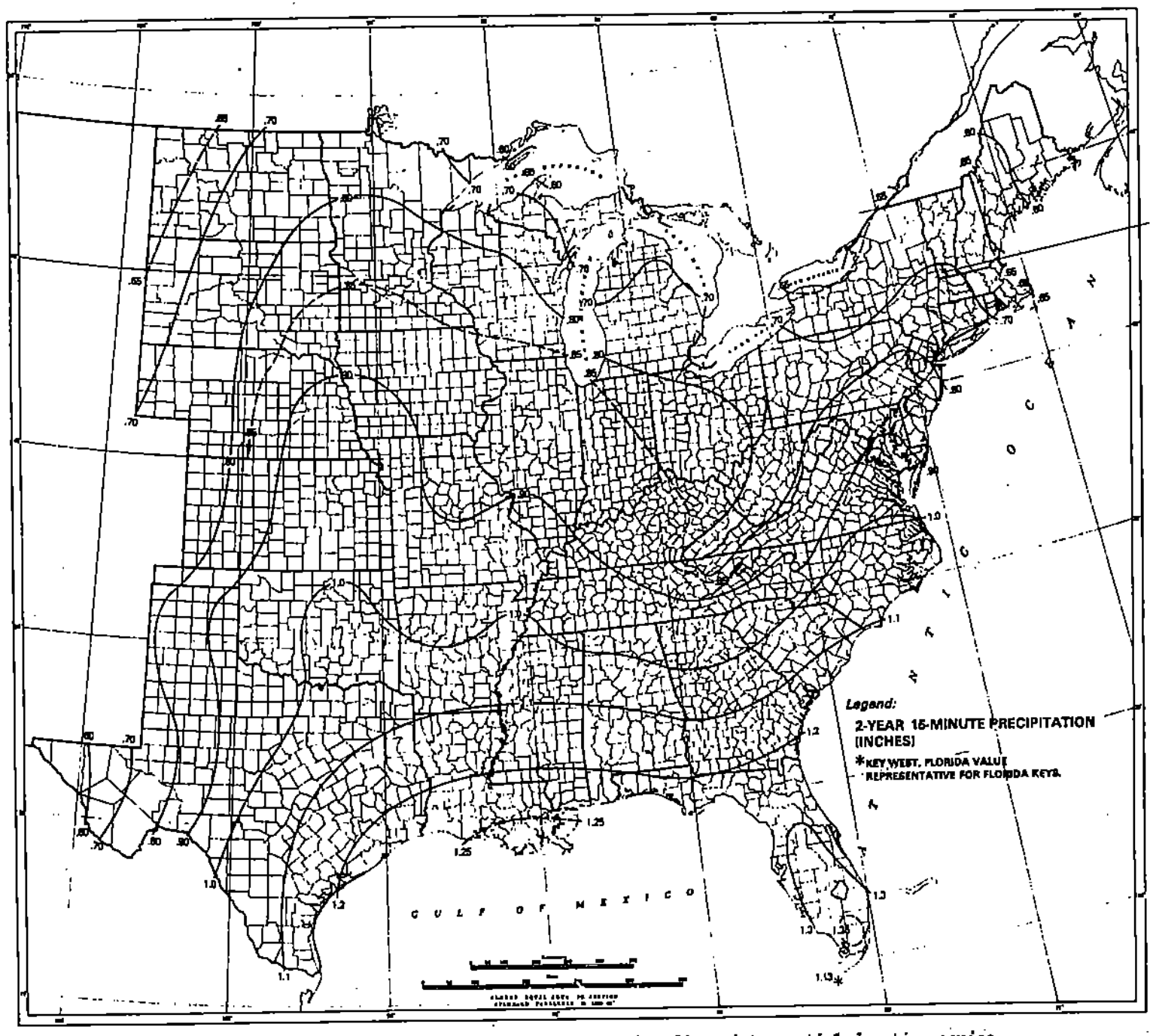

Figure 8.--2-year 15-min precipiatatation (inches)--adjusted to partial-duration series.

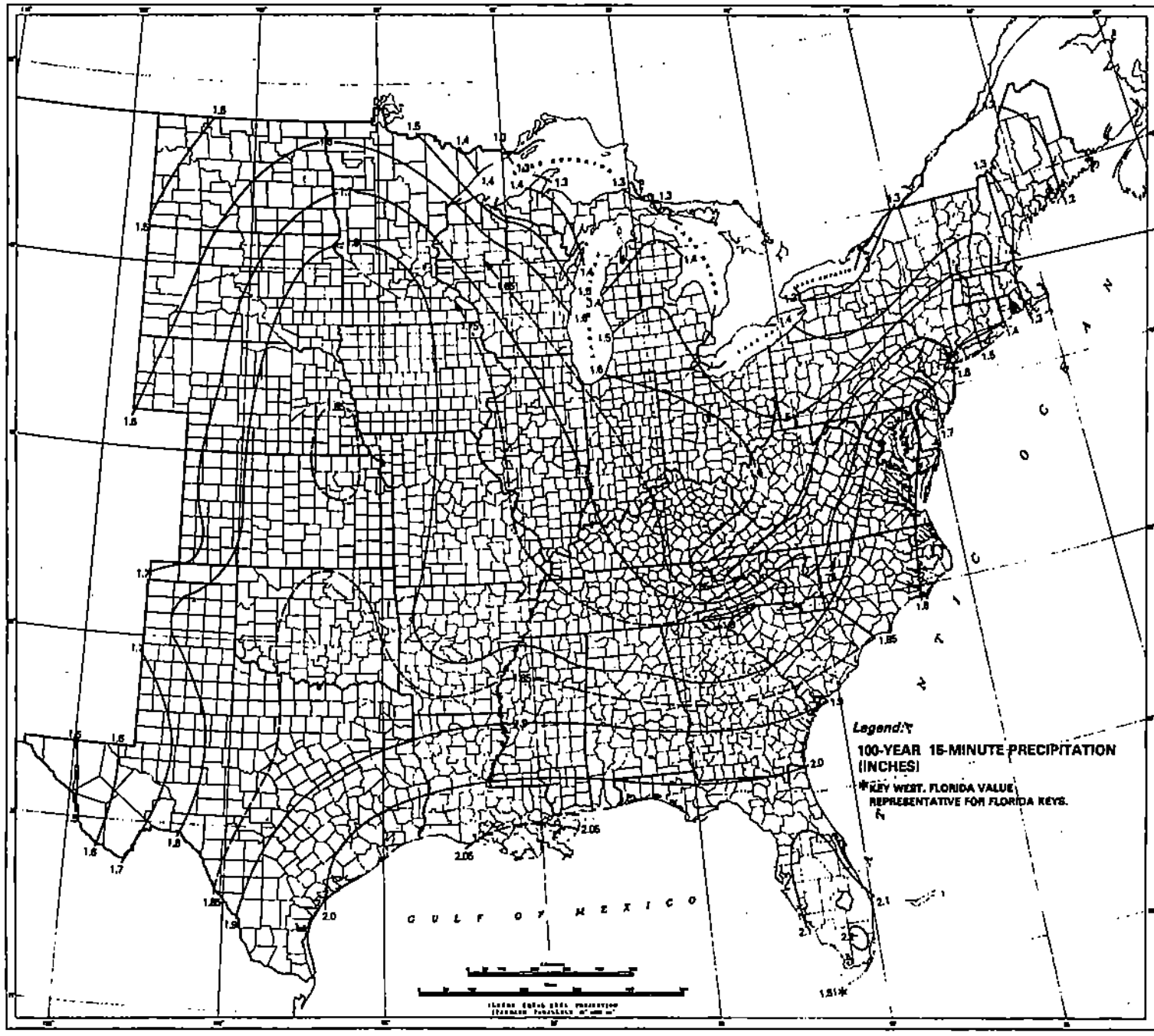

Figure 9.--100-year 15-minute precipitation (inches)--adjusted to partial-duration series.

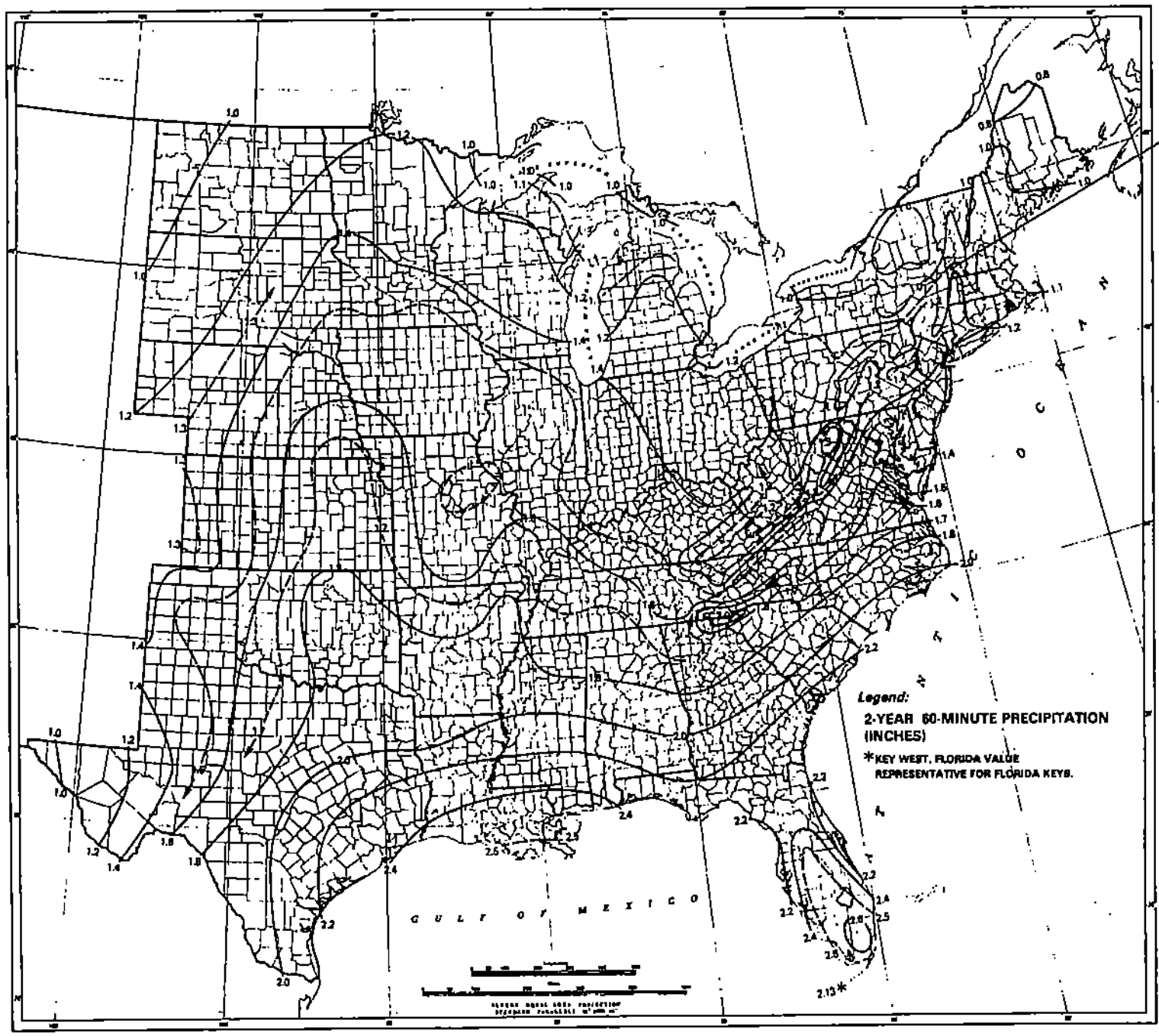

Figure 4.--2-year 60-min precipitation (inches)--adjusted to partial duration series.

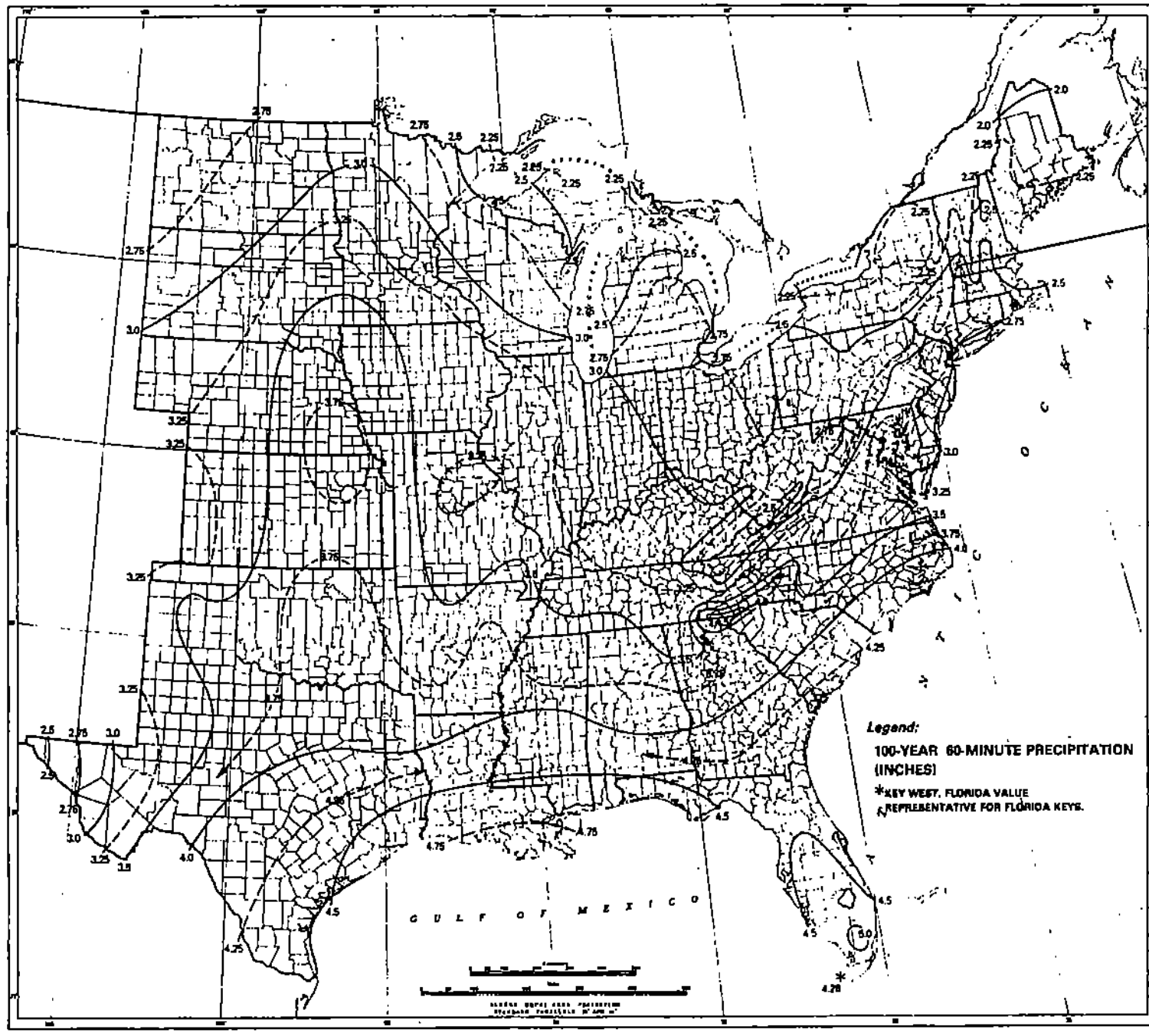

Figure 5.--100-year 60-minute precipitation (inches)--adjusted to partial duration series.

APPENDIX I-1

SHEET NO. 1 OF 3
PROJECT NO. 02136 - POWNAL
DATE 6/23/03
BY AH
CHK'D M.P. 10/21/03

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SUBJECT DOUBLE CULVERT
SW. CORNER SED. TRAP 2

CULVERT ELEVATION: 500.5 FT (INLET ELEVATION TO SED TRAP)

DRAINAGE AREA: 5 ACRES (WORST CASE)

VOLUME REQUIRED: 1800 CF/ACRE

1800 CF/ACRE x 5 ACRES = 9,000 CF

ELEV. H2O TABLE = 496 FT

EXCAVATION DEPTH = 3 FT BOTTOM ELEVATION = 497 FT

$\frac{9,000 \text{ CF}}{3 \text{ FT}} = 3,000 \text{ SF}$

MAINTAIN 30 FT WIDTH

LENGTH = 100 FT

LENGTH OF OUTLET = 6 x DRAINAGE ARE

= 30 FT

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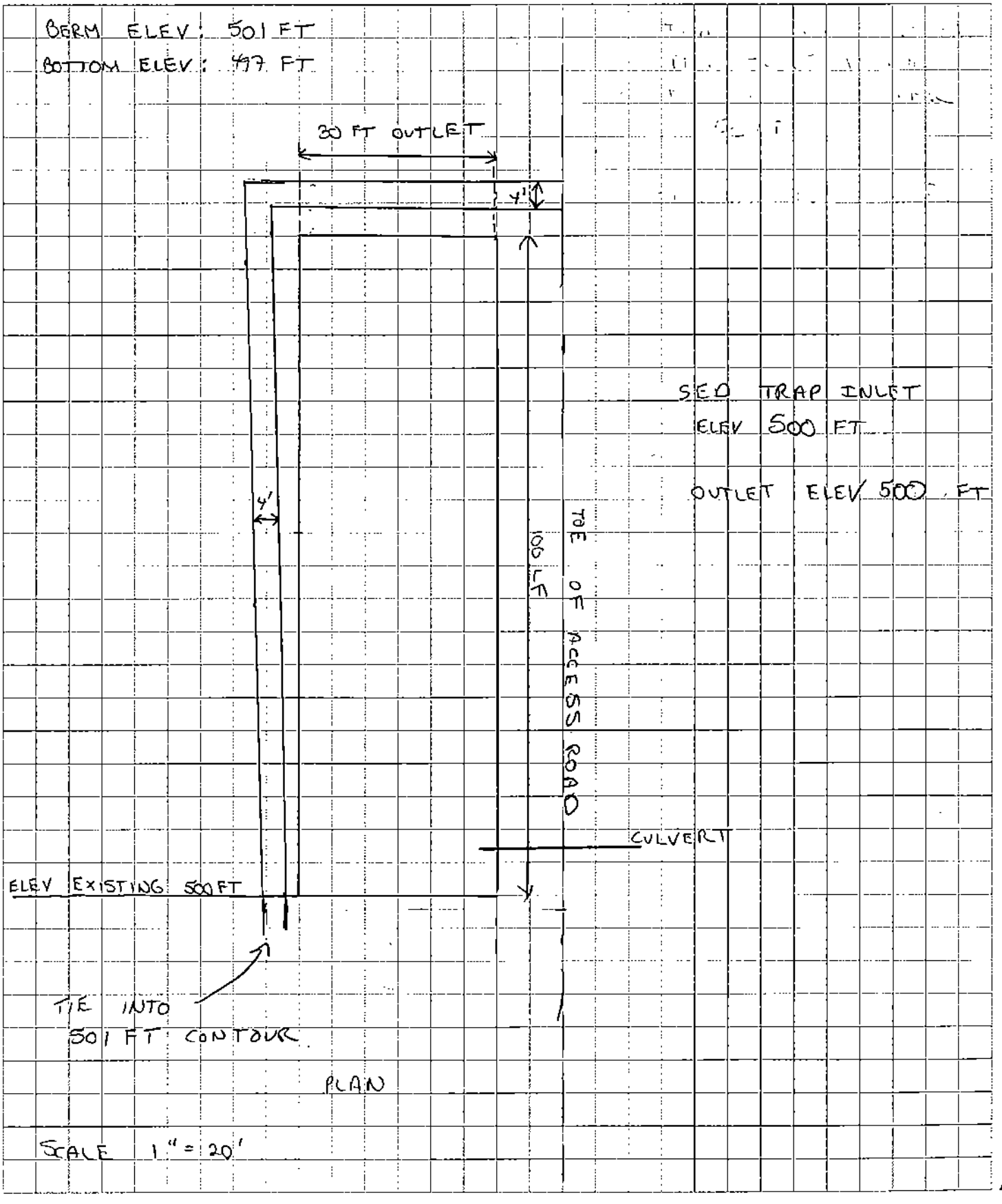
SUBJECT PLAN VIEW SW. CORNER SED TRAP



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SHEET NO. 3 OF 3

PROJECT NO. 02136 - POWNAL

DATE

BY A.H.

CHK'D M.P. 10/21/03

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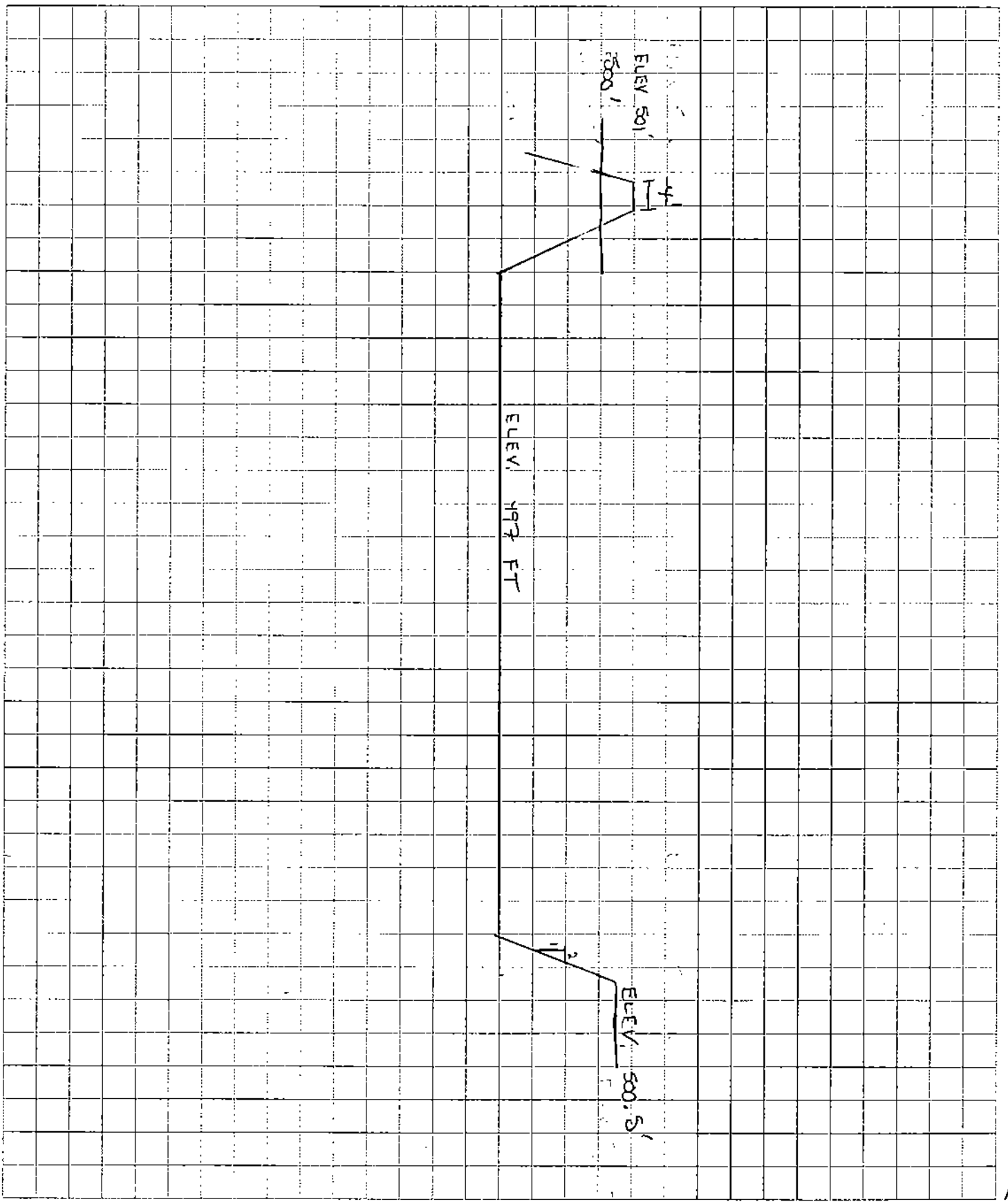
SUBJECT CROSS SECTION SW CORNER SED. TRAP



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SHEET NO. 1 OF _____

PROJECT NO. 92136 - POWNAL

DATE 6/23/03

BY AH.

CHK'D M.P. 10/21/03

TRC
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SUBJECT SINGLE CULVERT SED TRAP

→ CULVERT INLET 497.8 FT
50 LF @ .5% SLOPE

CULVERT ELEV = 497.55 FT

DRAINAGE AREA = 1 ACRE

VOLUME REQUIRED = 1,800 CF

DEPTH = 497.3 FT − 496 FT H20 ELEV.

= 1.3 FT

AREA = 1,385 SF

= 37' x 37' → HAVE ABOUT 37' x 50'
AVAILABLE IN EXISTING
DEPRESSION.
EXTEND AREA IF FILLED
IN DURING CONSTRUCTION
OF ACCESS RD.

25 YR 24 HR EVENT = 4.8"

OUTLET ELEV = 497.0 FT

OPTION 1 OUTLET:

RISER PIPE WITH OUTLET THRU. BERM
DIRECT DISCHARGE TO HOOSIC RIVER.
PROBLEM - POSSIBLE ESCAPE ROUTE FOR
CONSTRUCTION.

⇒ OPTION 2: EXCAVATE OUT A WIDER AREA TO
CREATE AN ONSITE STORMWATER
STORAGE AREA

REASON → STORMWATER MANAGEMENT FEATURE
MORE THAN SED TRAP

INSTALL ONCE CAP IS INPLACE

A

SHEET NO. _____ OF _____

PROJECT NO. _____

DATE _____

BY _____

CHK'D M.P. 10/2/03

TRC
Customer-Focused Solutions

SUBJECT RAIN VOLUME

25 YR STORM EVENT, 24 HR DURATION

4.8" = 0.40 FT

VOLUME = 0.4 FT X 43,560 SF

= 17,424 CF / 43,560 SF

= 0.4 ACRE FT

A

SHEET NO. _____ OF _____

PROJECT NO. _____

DATE _____

BY A.H.

CHK'D A.P. 10/21/02

TRC
Customer-Focused Solutions

SUBJECT NORTHERN TOE SED. TRAP 1

INLET ELEV. = 498 FT.

DRAINAGE AREA = 5 ACRES

VOLUME REQUIRED: 1800 CF/ACRE

= 9,000 CF

ASSUME G.W. ELEV. = 496'

9,000 CF / 2' = 4500

9,000 CF / 1.5' = 6,000

AREA = 67' x 67'

A

APPENDIX I-2

SHEET NO. _____ OF _____

PROJECT NO. _____

DATE _____

BY A.M.

CHK'D M.P. 10/21/03

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SUBJECT CULVERT SIZE 1 & 2

L = 50 FT

S = 1%

$Q = (22\,CFS)\left(\frac{1}{3}\right) = 7.3\,CFS$

USE 7.5 CFS / PIPE

FROM FIG 4 12 IN Ø

HW - INLET = 3.45 > Allowable head water depth

OUTLET OFF CHART

TRY 18" Ø FIGURE 8

INLET HW = 1.42'

OUTLET HW = 1.8' - (50 FT × 0.01)

= 1.3'

BELOW LIMITING HW OF 1.5' 0.75 FT + 0.5' FREEBOARD

18" Ø OK = 1.25 MIN HW

A

FIGURE 4: 12-Inch Diameter Concrete Pipe

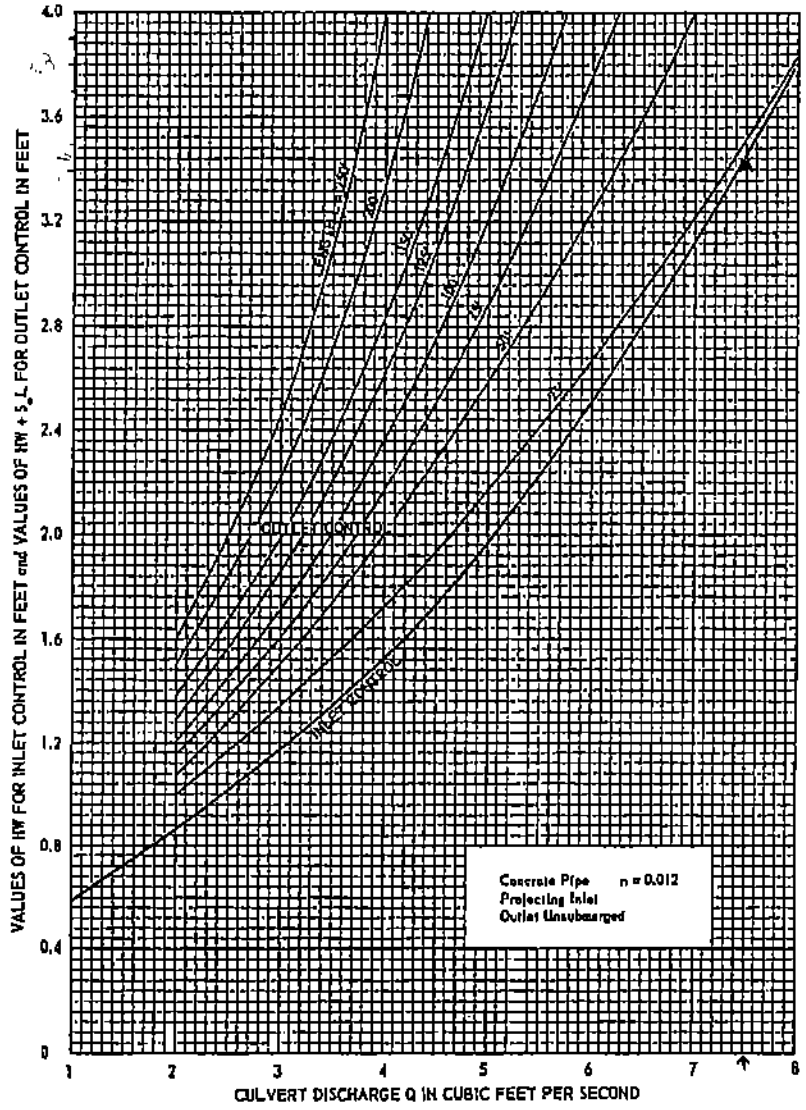
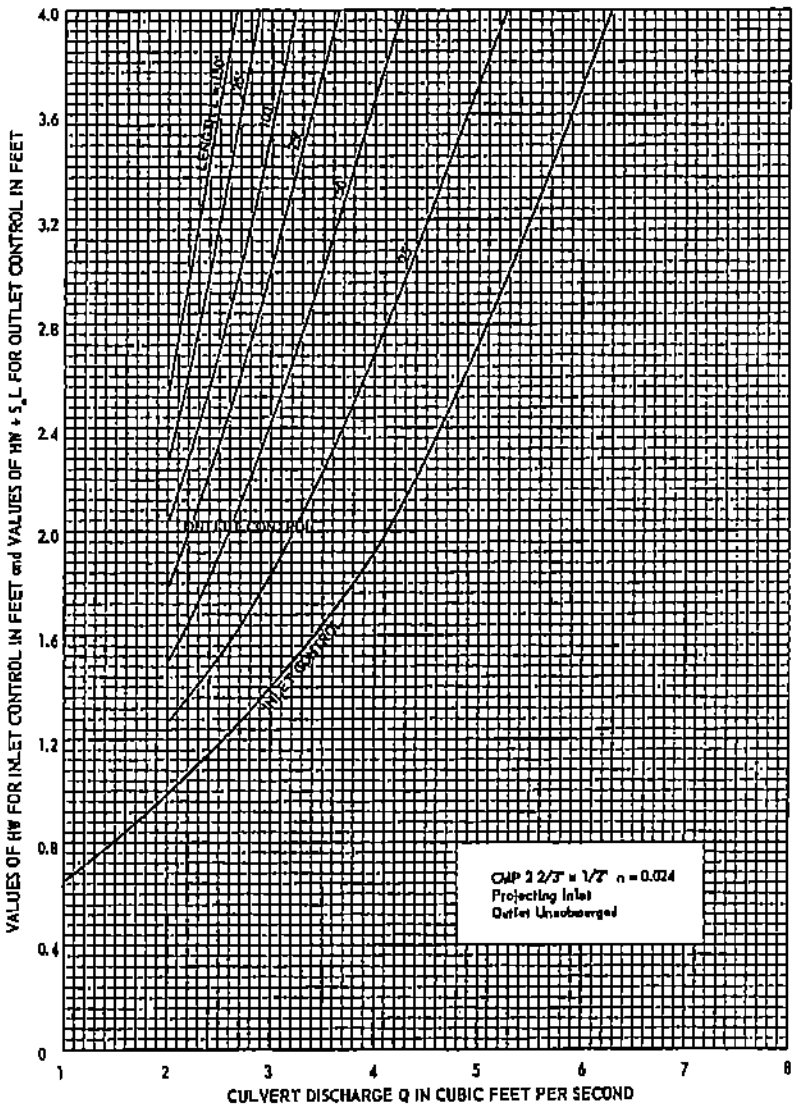


FIGURE 5: 12-Inch Diameter Corrugated Metal Pipe



Interpolate for intermediate culvert lengths

FIGURE 8: 18-Inch Diameter Concrete Pipe

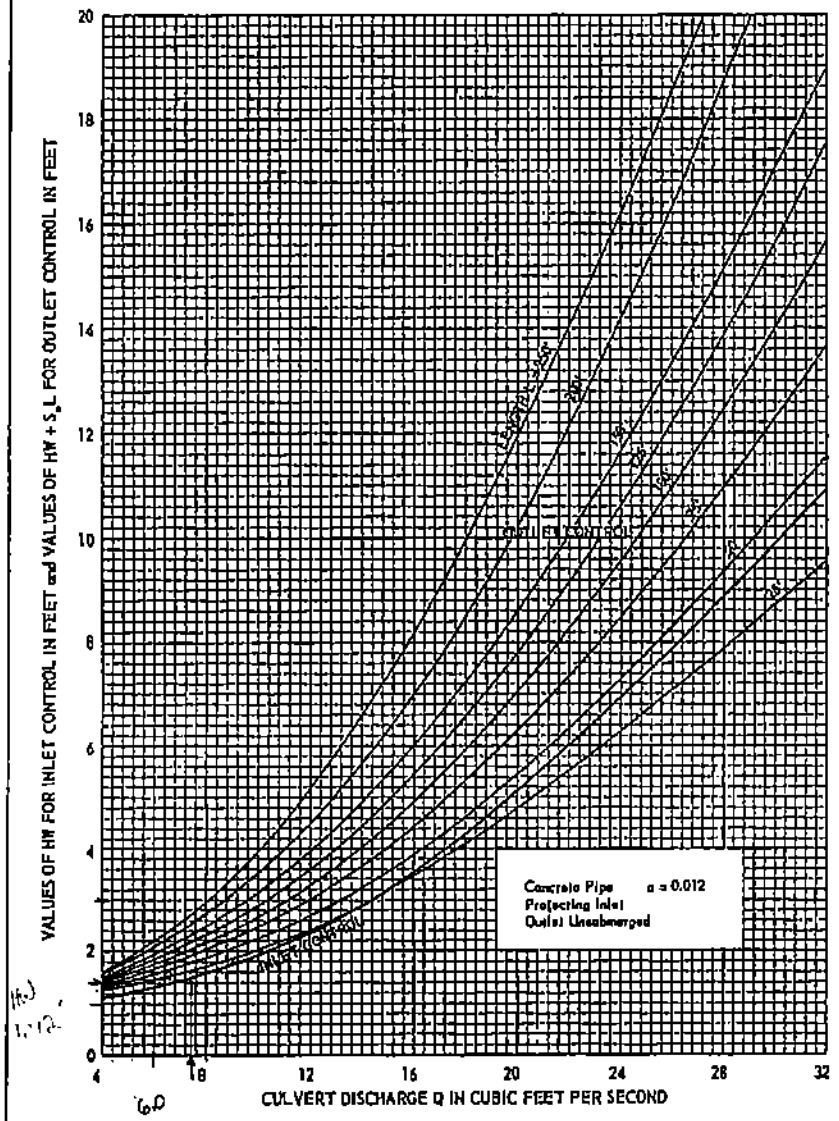
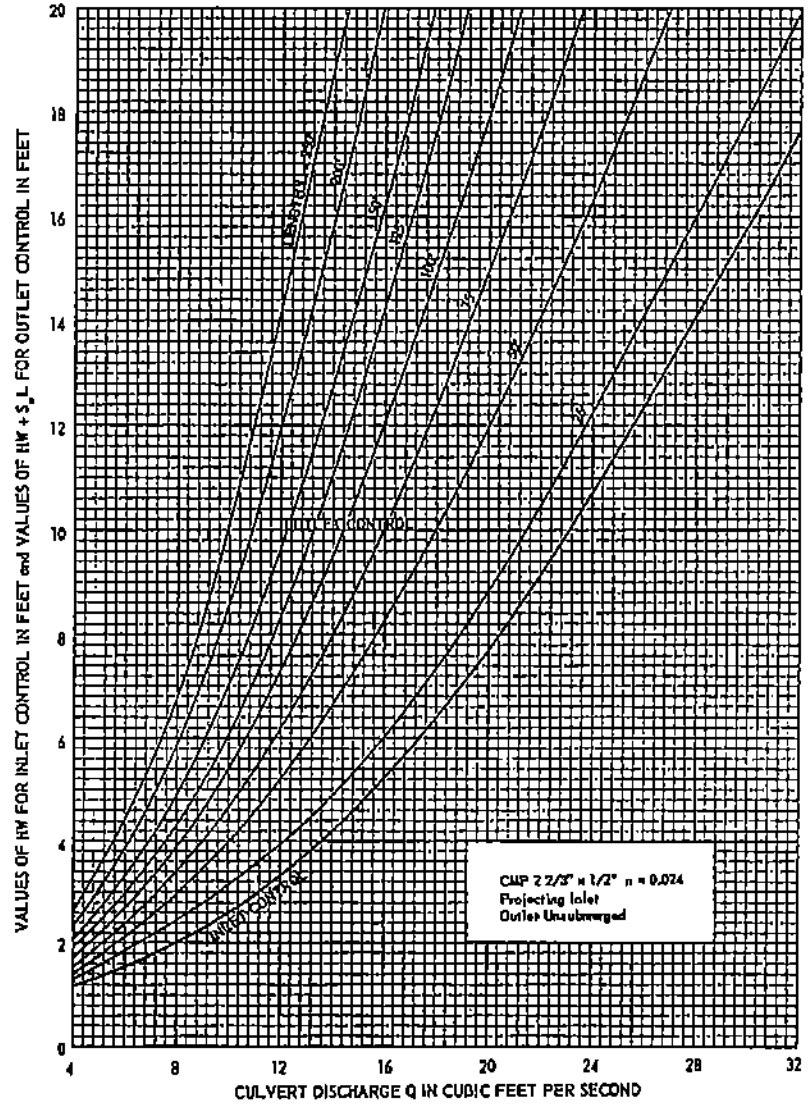


FIGURE 9: 18-Inch Diameter Corrugated Metal Pipe



Interpolate for intermediate culvert lengths

APPENDIX I-3

Trapezoidal Drainage Channel Analysis
Pownal Tannery Superfund Site
Main Landfill, Riprapped-lined Drainage Channels, Southern Side

Manning's Equation

B	4	(Bottom Width)
N	0.069	(Mannings n) **For depth of flow 0.5 ft to 2 ft; D_{50} = 6"; Table 5.1 from Urban Drainage Design Manual**
S	0.01	(Channel Slope)
z	3	(Sideslope z:1)
z	3	(Sideslope z:1)

Depth (ft.)	Area (ft^2)	Perimeter (ft.)	Hydraulic Radius	Discharge (ft.^3/sec.)	Velocity (ft./sec.)
0.5	2.750	7.162	0.384	3.136	1.140
0.6	3.480	7.795	0.446	4.389	1.261
0.7	4.270	8.427	0.507	5.859	1.372
0.75	4.688	8.743	0.536	6.679	1.425 ←
0.8	5.120	9.060	0.565	7.556	1.476
0.85	5.568	9.376	0.594	8.492	1.525
0.9	6.030	9.692	0.622	9.488	1.574
0.95	6.508	10.008	0.650	10.545	1.620
1	7.000	10.325	0.678	11.664	1.666
1.05	7.508	10.641	0.706	12.847	1.711
1.1	8.030	10.957	0.733	14.094	1.755
1.15	8.568	11.273	0.760	15.406	1.798
1.2	9.120	11.589	0.787	16.785	1.840
1.25	9.688	11.906	0.814	18.232	1.882
1.3	10.270	12.222	0.840	19.747	1.923
1.35	10.868	12.538	0.867	21.333	1.963
1.4 ←	11.480	12.854	0.893	22.989	2.003 ←
1.45	12.108	13.171	0.919	24.718	2.042
1.5	12.750	13.487	0.945	26.520	2.080
1.55	13.408	13.803	0.971	28.396	2.118
1.6	14.080	14.119	0.997	30.348	2.155
1.65	14.768	14.436	1.023	32.377	2.192
1.7	15.470	14.752	1.049	34.483	2.229
1.75	16.188	15.068	1.074	36.667	2.265
1.8	16.920	15.384	1.100	38.932	2.301
1.85	17.668	15.700	1.125	41.277	2.336
1.9	18.430	16.017	1.151	43.704	2.371
1.95	19.208	16.333	1.176	46.214	2.406
2	20.000	16.649	1.201	48.807	2.440

(CAP IN PLACE) (AREA 3 POTW 25-YR) (AREA 4 POTW 25-YR)

FLOW = 4.0 CFS + 0.7 CFS + 1.5

= 6.2 CFS

Trapezoidal Drainage Channel Analysis
Pownal Tannery Superfund Site
Landfill, Drainage Channel Northern Side

Manning's Equation

B	2	(Bottom Width)
N	0.41	(Mannings n) **Dense Grass**
S	0.01	(Channel Slope)
z	3	(Sideslope z:1)
z	3	(Sideslope z:1)

Depth (ft.)	Area (ft^2)	Perimeter (ft.)	Hydraulic Radius	Discharge (ft.^3/sec.)	Velocity (ft./sec.)
0.5	1.750	5.162	0.339	0.309	0.177
0.6	2.280	5.795	0.393	0.445	0.195
0.7	2.870	6.427	0.447	0.609	0.212
0.75	3.188	6.743	0.473	0.703	0.220
0.8	3.520	7.060	0.499	0.804	0.228
0.85	3.868	7.376	0.524	0.914	0.236
0.9	4.230	7.692	0.550	1.032	0.244
0.95	4.608	8.008	0.575	1.158	0.251
1	5.000	8.325	0.601	1.293	0.259
1.05	5.408	8.641	0.626	1.438	0.266
1.1	5.830	8.957	0.651	1.591	0.273
1.15	6.268	9.273	0.676	1.754	0.280
1.2	6.720	9.589	0.701	1.927	0.287
1.25	7.188	9.906	0.726	2.109	0.293
1.3	7.670	10.222	0.750	2.301	0.300
1.35	8.168	10.538	0.775	2.504	0.307
1.4	8.680	10.854	0.800	2.717	0.313
1.45	9.208	11.171	0.824	2.941	0.319
1.5	9.750	11.487	0.849	3.176	0.326
1.55	10.308	11.803	0.873	3.422	0.332
1.6	10.880	12.119	0.898	3.679	0.338
1.65	11.468	12.436	0.922	3.948	0.344
1.7	12.070	12.752	0.947	4.229	0.350
1.75	12.688	13.068	0.971	4.521	0.356
1.8	13.320	13.384	0.995	4.825	0.362
1.85	13.968	13.700	1.019	5.142	0.368
1.9	14.630	14.017	1.044	5.471	0.374
1.95	15.308	14.333	1.068	5.813	0.380
2	16.000	14.649	1.092	6.167	0.385

CAP IN PLACE Q = 1.64 CFS

Trapezoidal Drainage Channel Analysis
Pownal Tannery Superfund Site
Landfill, Drainage Channel Northern Side

Manning's Equation

B	2	(Bottom Width)
N	0.15	(Mannings n) **Short Grass**
S	0.01	(Channel Slope)
z	3	(Sideslope z:1)
z	3	(Sideslope z:1)

Depth (ft.)	Area (ft^2)	Perimeter (ft.)	Hydraulic Radius	Discharge (ft.^3/sec.)	Velocity (ft./sec.)
0.5	1.750	5.162	0.339	0.845	0.483
0.6	2.280	5.795	0.393	1.216	0.533
0.7	2.870	6.427	0.447	1.665	0.580 ←
0.75	3.188	6.743	0.473	1.921	0.603
0.8	3.520	7.060	0.499	2.198	0.624
0.85	3.868	7.376	0.524	2.498	0.646
0.9	4.230	7.692	0.550	2.820	0.667
0.95	4.608	8.008	0.575	3.165	0.687
1	5.000	8.325	0.601	3.535	0.707
1.05	5.408	8.641	0.626	3.929	0.727
1.1	5.830	8.957	0.651	4.349	0.746
1.15	6.268	9.273	0.676	4.794	0.765
1.2	6.720	9.589	0.701	5.266	0.784
1.25	7.188	9.906	0.726	5.764	0.802
1.3	7.670	10.222	0.750	6.291	0.820
1.35	8.168	10.538	0.775	6.845	0.838
1.4	8.680	10.854	0.800	7.428	0.856
1.45	9.208	11.171	0.824	8.040	0.873
1.5	9.750	11.487	0.849	8.682	0.890
1.55	10.308	11.803	0.873	9.354	0.908
1.6	10.880	12.119	0.898	10.057	0.924
1.65	11.468	12.436	0.922	10.792	0.941
1.7	12.070	12.752	0.947	11.558	0.958
1.75	12.688	13.068	0.971	12.357	0.974
1.8	13.320	13.384	0.995	13.189	0.990
1.85	13.968	13.700	1.019	14.054	1.006
1.9	14.630	14.017	1.044	14.954	1.022
1.95	15.308	14.333	1.068	15.888	1.038
2	16.000	14.649	1.092	16.856	1.054

CAP IN PLACE Q = 1.64 CFS

APPENDIX I-4

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SUBJECT POONAL RIPRAP DESIGN

PROBLEM: DETERMINE RIPRAP SIZE FOR THE WESTERN SLOPE OF THE LANDFILL ASSUMING A RIGHT OVERBANK CHANNEL VELOCITY OF 8.5 FT/SEC. AND A SIDE SLOPE OF 3H TO 1V.

SOLUTION: USING THE BASIC EQUATION FOR REPRESENTATIVE STONE SIZE IN STRAIGHT OR CURVED CHANNELS FROM U.S. ARMY CORPS OF ENGINEERS, ENGINEER'S MANUAL EM 1110-2-1601, HYDRAULIC DESIGN OF FLOOD CONTROL CHANNELS p. 3-5

$$D_{30} = S_f C_s C_v C_T d \left[\left(\frac{\gamma_w}{\gamma_s - \gamma_w} \right)^{1/2} \frac{V}{\sqrt{K_1 g d}} \right]^{2.5}$$

WHERE:

D_{30} = RIPRAP SIZE OF WHICH 30% IS FINER BY WEIGHT, LENGTH

S_f = SAFETY FACTOR; $S_{f_{min}} = 1.1$

C_s = STABILITY COEFFICIENT FOR INCIPIENT FAILURE.
$D_{85}/D_{15} = 1.7$ TO 5.2
= 0.30 FOR ANGULAR ROCK

C_v = VERTICAL VELOCITY DISTRIBUTION COEFFICIENT
= 1.0 FOR STRAIGHT CHANNELS, INSIDE OF BENDS
= 1.283 - 0.2 LOG (R/W), OUTSIDE OF BENDS [1 FOR R/W > 26]

C_T = THICKNESS COEFFICIENT
= 1.0 FOR THICKNESS = 1 D_{100} (MAX) OR 1.5 D_{50} (MAX) WHICHEVER IS GREATER.

d = LOCAL DEPTH OF FLOW, LENGTH; ASSUME 15 FT.

γ_w = UNIT WEIGHT OF WATER 62.4 LB/FT³

V = LOCAL DEPTH-AVERAGED VELOCITY; V_{SS} FOR SIDESLOPE RIPRAP

K_1 = SIDE SLOPE CORRECTION FACTOR

$$= \sqrt{1 - \frac{\sin^2\theta}{\sin^2\phi}} = \sqrt{1 - \frac{\sin^2 33^\circ}{\sin^2 40^\circ}} = .53$$

θ = ANGLE OF S. OF SLOPE WITH HORIZONTAL

ϕ = ANGLE OF REPOSE OF RIPRAP MATERIAL (NORMALLY 40 DEG.)

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SUBJECT POWDAL RIPRAP DESIGN

g = GRAV. CONSTANT 32.2 FT/SEC^2

γ_s = UNIT WEIGHT OF STONE; USE 165 lb/FT^3

$$D_{30} = (1.1)(0.30)(1.0)(1.0)(15\,FT)\left[\frac{62.4\ lb/FT^3}{165\ lb/FT^3 - 62.4\ lb/FT^3}\right]^{1/2}\left[\frac{8.5\ FT/SEC}{\sqrt{(.53)(32.2\ FT/SEC^2)\,15\,FT}}\right]^{2.5}$$

$D_{30} = 0.55$

USING TABLE 3-1 FROM EM 1110-2-1601 SPECIFIC WEIGHT = 165 PCF

$D_{100} = 15''$
$D_{30} = 0.61'$
$D_{90} = 0.88'$

RIPRAP THICKNESS $= 1.5 \times D_{100}$
$= 1.5 \times 15''$
$= 22.5''$
$= 1.90'$

$\sim 2'$

A

M.P. 5/27/03

Table 3-1
Gradations for Riprap Placement in the Dry, Low-Turbulence Zones

	D_{100}(max)	Limits of Stone Weight, lb[1], for Percent Lighter by Weight						D_{30}(min)	D_{50}(min)	
		100		50		15				
	In.	Max	Min	Max[2]	Min	Max[2]	Min	ft	ft	
	Specific Weight = 155 pcf									
*	9	34	14	10	7	5	2	0.37	0.53	*
	12	81	32	24	16	12	5	0.48	0.70	
	15	159	63	47	32	23	10	0.61	0.88	
	18	274	110	81	55	41	17	0.73	1.06	
	21	435	174	129	87	64	27	0.85	1.23	
	24	649	260	192	130	96	41	0.97	1.40	
	27	924	370	274	185	137	58	1.10	1.59	
	30	1,268	507	376	254	188	79	1.22	1.77	
	33	1,688	675	500	338	250	105	1.34	1.94	
	36	2,191	877	649	438	325	137	1.46	2.11	
	42	3,480	1,392	1,031	696	516	217	1.70	2.47	
	48	5,194	2,078	1,539	1,039	769	325	1.95	2.82	
	54	7,396	2,958	2,191	1,479	1,096	462	2.19	3.17	
	Specific Weight = 165 pcf									
*	9	36	15	11	7	5	2	0.37	0.53	*
	12	86	35	26	17	13	5	0.48	0.70	
	15	169	67	50	34	25	11	0.61	0.88	
	18	292	117	86	58	43	18	0.73	1.06	
	21	463	185	137	93	69	29	0.85	1.23	
	24	691	276	205	138	102	43	0.97	1.40	
	27	984	394	292	197	146	62	1.10	1.59	
	30	1,350	540	400	270	200	84	1.22	1.77	
	33	1,797	719	532	359	266	112	1.34	1.96	
	36	2,391	933	691	467	346	146	1.46	2.11	
	42	3,704	1,482	1,098	741	549	232	1.70	2.47	
	48	5,529	2,212	1,638	1,106	819	346	1.95	2.82	
	54	7,873	3,149	2,335	1,575	1,168	492	2.19	3.17	
	Specific Weight = 175 pcf									
*	9	39	15	11	8	6	2	0.37	0.53	*
	12	92	37	27	18	14	5	0.48	0.70	
	15	179	72	53	36	27	11	0.61	0.88	
	18	309	124	92	62	46	19	0.73	1.06	
	21	491	196	146	98	73	31	0.85	1.23	
	24	733	293	217	147	109	46	0.97	1.40	
	27	1,044	417	309	209	155	65	1.10	1.59	
	30	1,432	573	424	286	212	89	1.22	1.77	
	33	1,906	762	565	381	282	119	1.34	1.94	
	36	2,474	990	733	495	367	155	1.46	2.11	
	42	3,929	1,571	1,164	786	582	246	1.70	2.47	
	48	5,864	2,346	1,738	1,173	869	367	1.95	2.82	
	54	8,350	3,340	2,474	1,670	1,237	522	2.19	3.17	

1.5 x D_{100} for T

Notes:
1. Stone weight limit data from ETL 1110-2-120 (HQUSACE, 1971 (14 May), "Additional Guidance for Riprap Channel Protection, Ch 1," US Government Printing Office, Washington, DC). Relationship between diameter and weight is based on the shape of a sphere.
2. The maximum limits at the W_{50} and W_{15} sizes can be increased as in the Lower Mississippi Valley Division Standardized Gradations shown in Appendix F.

SHEET NO. 1 OF 3
PROJECT NO. 08136-0510-0N98
DATE 5-2-03
BY A.N.
CHK'D A.P. 5/27/03

TRC
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SUBJECT TOE & END PROTECTION
ROWNAL - RIPRAP DESIGN

PROBLEM: DETERMINE WESTERN SLOPE END PROTECTION AND TOE PROTECTION DETAILS FOR THE WESTERN SLOPE OF THE LANDFILL.

SOLUTION: EM 1110-2-1601
US ACE HYDRAULIC DESIGN OF FLOOD CONTROL CHANNELS.

END PROTECTION:

SEE PLATE B-41 ATTACHED

METHOD A - RIPRAP REVETMENTS ≤ 12 IN. THICK, EXTENDED TO AREAS WHERE VELOCITIES WILL NOT ERODE CHANNEL BANKS.

METHOD B - RIPRAP REVETMENTS > 12 IN THICK, EXTENDED TO AREAS WHERE VELOCITIES WILL NOT ERODE CHANNEL BANKS.

⇒ METHOD C - RIPRAP REVETMENTS THAT DO NOT TERMINATE IN NONERODING CHANNEL VELOCITIES. THE WESTERN SLOPE OF THE LANDFILL TERMINATES IN THE RIGHT OVERBANK CHANNEL THAT HAS A VELOCITY OF 8.5FT/SEC.

TOE PROTECTION

METHOD A - TOE EXC. CAN BE MADE IN DRY, DUE TO HIGH WATER TABLE AT SITE - NOT APPROPRIATE.

SEE PLATE B-43

METHOD B - FOR CHANNEL BOTTOM THAT IS NONERODIBLE; NOT APPLICABLE.

⇒ METHOD C - APPROPRIATE WHEN LITTLE TOE SCOUR IS EXPECTED. BUILDUP OF ACCESS ROAD ON CHANNEL SIDE WILL MINIMIZE TOE SCOUR.

METHOD D - USES TOE SCOUR AS A SUB. FOR MECHNICAL EXC. (LAUNCHING STONE); NOT APPROPRIATE FOR REASON NOTED ABOVE IN METHOD C.

A

M.P. 5/20/03

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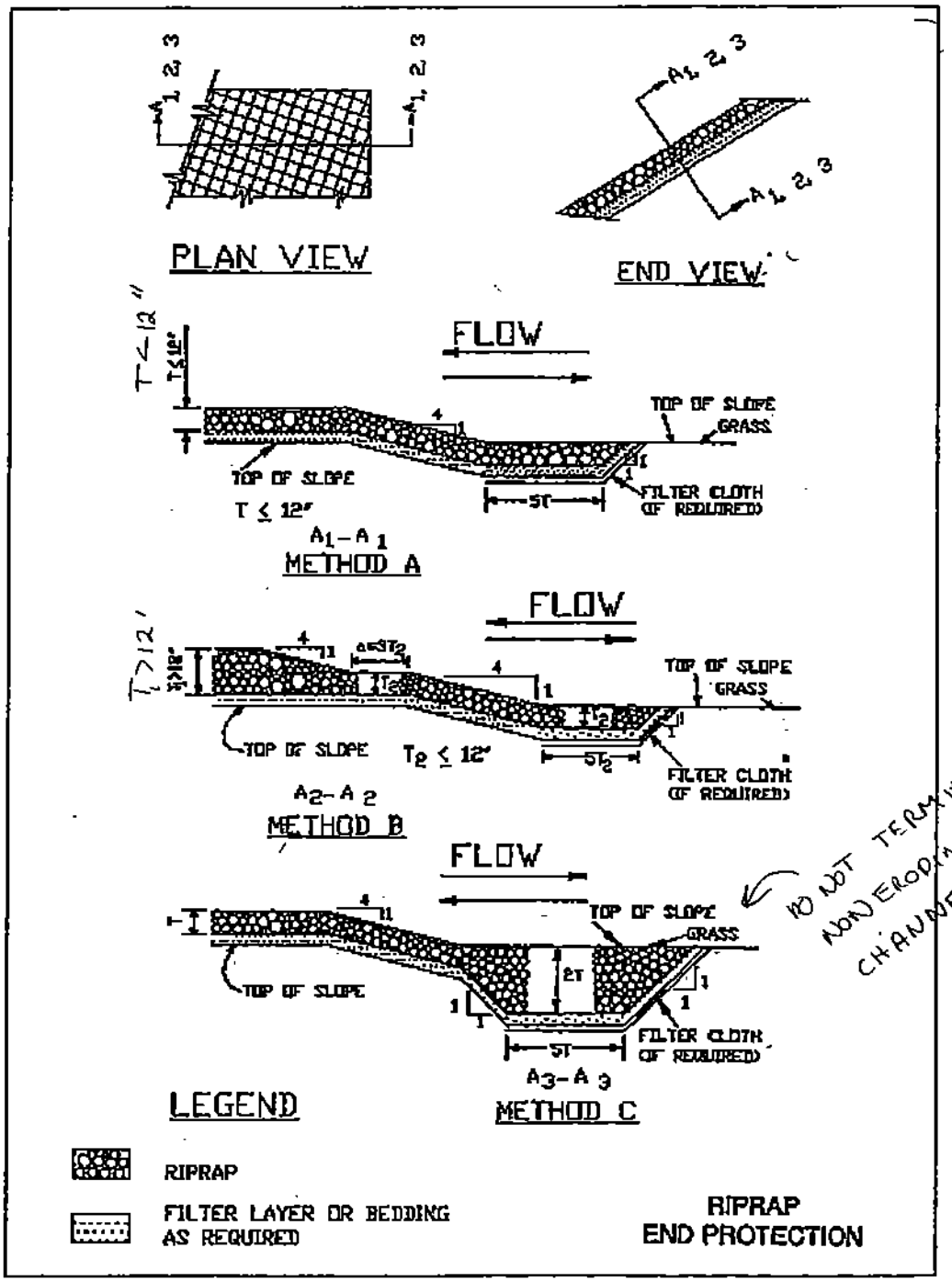

DO NOT TERMINATE IN NON-ERODING NATURAL CHANNEL VELOCITIES

Plate B-41

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M.P. 5/27/03

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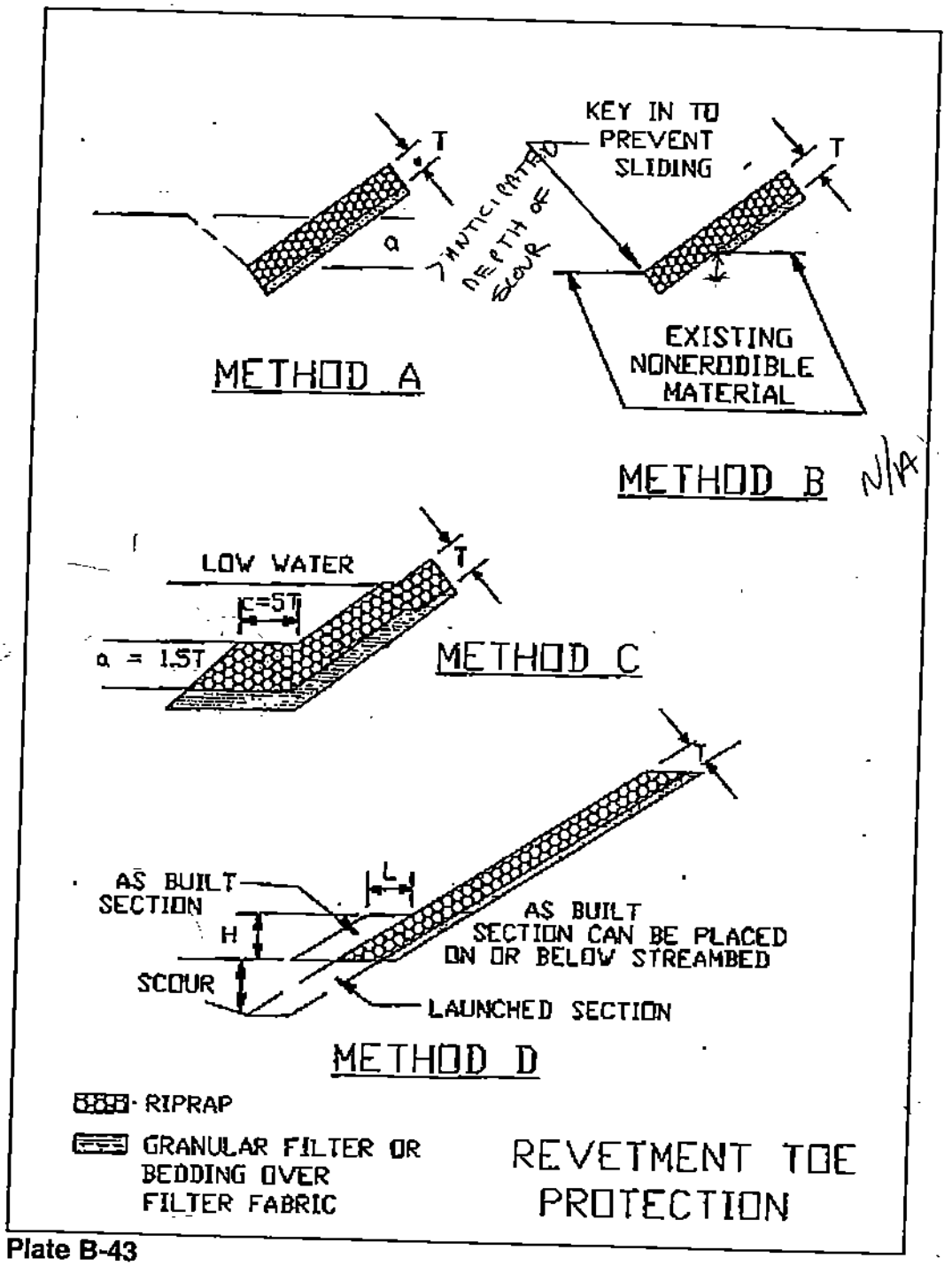

Plate B-43

*

SHEET NO. 1 OF 2

PROJECT NO. 02136-0510-01M8

DATE 5-8-03

BY A.H.

CHK'D M.P. 5/27/03

TRC
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SUBJECT RIPRAP DESIGN FOR POWNAL - BERM OPENING

PROBLEM: DETERMINE RIPRAP SIZE FOR THE BERM OPENING THAT WILL ALLOW THE RIGHT OVERBANK FLOW TO REENTER THE HOOSIC RIVER CHANNEL. THE OPENING IS LOCATED AT THE FAR NORTHERN TIP OF LAGOON 4 AT THE PORTION OF THE EXISTING BERM THAT RUNS PERPENDICULAR TO THE HOOSIC RIVER. ASSUME A RIGHT OVERBANK VELOCITY OF 8.5 FT/SEC.

SOLUTION: USE BASIC REPRESENTATIVE STONE SIZE EQUATION FOUND IN THE USACE EM 1110-2-1601

A

SHEET NO. 2 OF 2

PROJECT NO. 52136-0510-01N98

DATE 5-8-03

BY AH.

CHK'D M.P. 5/27/03

TRC
Customer-Focused Solutions

SUBJECT RIPRAP DESIGN FOR BERM OPENING

$$D_{30} = S_F\, C_S\, C_V\, C_T\, d \left[\left(\frac{\gamma_w}{\gamma_s - \gamma_w} \right)^{1/2} \frac{V}{\sqrt{k_1 g d}} \right]^{2.5}$$

$S_F = 1.1$
$C_S = 0.30$
$C_V = 1.0$
$C_T = 1.0$
$d = 15'$
$\gamma_w = 62.4\ lb/ft^3$
$V = 8.5\ ft/sec$
$k_1 = 1$
$g = 32.2\ ft/sec^2$
$\gamma_s = 165\ lb/ft^3$

$$D_{30} = (1.1)(0.30)(1.0)(1.0)(15') \left[\left(\frac{62.4\ lb/ft^3}{165\ lb/ft^3 - 62.4\ lb/ft^3} \right)^{1/2} \left(\frac{8.5\ ft/sec}{\sqrt{(32.2\ ft/sec^2)(15')}} \right) \right]^{2.5}$$

$D_{30} = 0.247'$

USE $\Rightarrow$ $D_{100} = 9"$
$D_{30} = 0.37'$
$D_{90} = 0.53'$

A

Table 3-1
Gradations for Riprap Placement in the Dry, Low-Turbulence Zones

D_{100}(max) in.	Limits of Stone Weight, lb[1], for Percent Lighter by Weight: 100 Max	100 Min	50 Max[2]	50 Min	15 Max[2]	15 Min	D_{30}(min) ft	D_{50}(min) ft
Specific Weight = 155 pcf								
* 9	34	14	10	7	5	2	0.37	0.53 *
12	81	32	24	16	12	5	0.48	0.70
15	159	63	47	32	23	10	0.61	0.88
18	274	110	81	55	41	17	0.73	1.06
21	435	174	129	87	64	27	0.85	1.23
24	649	260	192	130	96	41	0.97	1.40
27	924	370	274	185	137	58	1.10	1.59
30	1,268	507	376	254	188	79	1.22	1.77
33	1,688	675	500	338	250	105	1.34	1.94
36	2,191	877	649	438	325	137	1.46	2.11
42	3,480	1,392	1,031	696	516	217	1.70	2.47
48	5,194	2,078	1,539	1,039	769	325	1.95	2.82
54	7,396	2,958	2,191	1,479	1,096	462	2.19	3.17
Specific Weight = 165 pcf								
* 9	36	15	11	7	5	2	0.37	0.53 *
12	86	35	26	17	13	5	0.48	0.70
15	169	67	50	34	25	11	0.61	0.88
18	292	117	86	58	43	18	0.73	1.06
21	463	185	137	93	69	29	0.85	1.23
24	691	276	205	138	102	43	0.97	1.40
27	984	394	292	197	146	62	1.10	1.59
30	1,350	540	400	270	200	84	1.22	1.77
33	1,797	719	532	359	266	112	1.34	1.96
36	2,331	933	691	467	346	146	1.46	2.11
42	3,704	1,482	1,098	741	549	232	1.70	2.47
48	5,529	2,212	1,638	1,106	819	346	1.95	2.82
54	7,873	3,149	2,335	1,575	1,168	492	2.19	3.17
Specific Weight = 175 pcf								
* 9	39	15	11	8	6	2	0.37	0.53 *
12	92	37	27	18	14	5	0.48	0.70
15	179	72	53	36	27	11	0.61	0.88
18	309	124	92	62	46	19	0.73	1.06
21	491	196	146	98	73	31	0.85	1.23
24	733	293	217	147	109	46	0.97	1.40
27	1,044	417	309	209	155	65	1.10	1.59
30	1,432	573	424	286	212	89	1.22	1.77
33	1,906	762	565	381	282	119	1.34	1.94
36	2,474	990	733	495	367	155	1.46	2.11
42	3,929	1,571	1,164	786	582	246	1.70	2.47
48	5,864	2,346	1,738	1,173	869	367	1.95	2.82
54	8,350	3,340	2,474	1,670	1,237	522	2.19	3.17

Notes:
1. Stone weight limit data from ETL 1110-2-120 (HQUSACE, 1971 (14 May), "Additional Guidance for Riprap Channel Protection, Ch 1," US Government Printing Office, Washington, DC). Relationship between diameter and weight is based on the shape of a sphere.
2. The maximum limits at the W_{50} and W_{15} sizes can be increased as in the Lower Mississippi Valley Division Standardized Gradations shown in Appendix F.

e. Layer thickness. All stones should be contained within the riprap layer thickness to provide maximum resistance against erosive forces. Oversize stones, even in isolated spots, may result in riprap failure by precluding mutual support and interlock between individual stones, causing large voids that expose filter and bedding materials, and creating excessive local turbulence that removes smaller size stone. Small amounts of oversize stone should be removed individually and replaced with proper size stones. The following criteria apply to the riprap layer thickness:

(1) It should not be less than the spherical diameter of the upper limit W_{100} stone or less than 1.5 times the spherical diameter of the upper limit W_{50} stone, whichever results in the greater thickness.

(2) The thickness determined by (1) above should be increased by 50 percent when the riprap is placed underwater to provide for uncertainties associated with this type of placement. At one location in the US Army Engineer Division, Missouri River, divers and sonic sounders were used to reduce the underwater thickness to 1.25 times the dry placement thickness.

Section II
Channel Characteristics

3-3. Side Slope Inclination

The stability of riprap slope protection is affected by the steepness of channel side slopes. Side slopes should ordinarily not be steeper than 1V on 1.5H, except in special cases where it may be economical to use larger hand-placed stone keyed well into the bank. Embankment stability analysis should properly address soils characteristics, groundwater and river conditions, and probable failure mechanisms. The size of stone required to resist the erosive forces of channel flow increases when the side slope angle approaches the angle of repose of a riprap slope protection. Rapid water-level recession and piping-initiated failures are other factors capable of affecting channel side slope inclination and needing consideration in design.

3-4. Channel Roughness, Shape, Alignment, and Gradient

As boundary shear forces and velocities depend on channel roughness, shape, alignment, and invert gradient, these factors must be considered in determining the size of stone required for riprap revetment. Comparative cost estimates should be made for several alternative channel plans to determine the most economical and practical combination of channel factors and stone size. Resistance coefficients (Manning's n) for riprap placed in the dry should be estimated using the following form of Strickler's equation:

$$n = K\left[D_{90}(\text{min})\right]^{1/6} \qquad (3\text{-}2)$$

where

K = 0.036, average of all flume data

= 0.034 for velocity and stone size calculation

= 0.038 for capacity and freeboard calculation

D_{90}(min) = size of which 90 percent of sample is finer, from minimum or lower limit curve of gradation specification, ft

The K values represent the upper and lower bounds of laboratory data determined for bottom riprap. Resistance data from a laboratory channel which had an irregular surface similar to riprap placed underwater show a Manning's n about 15 percent greater than for riprap placed in the dry. Equation 3-2 provides resistance losses due to the surface roughness of the riprap and does not include form losses such as those caused by bends. Equation 3-2 should be limited to slopes less than 2 percent. *

Section III
Design Guidance for Stone Size

3-5. General

Riprap protection for open channels is subjected to hydrodynamic drag and lift forces that tend to erode the revetment and reduce its stability. Undermining by scour beyond the limits of protection is also a common cause of failure. The drag and lift forces are created by flow velocities adjacent to the stone. Forces resisting motion are the submerged weight of the stone and any downward and lateral force components caused by contact with other stones in the revetment. Stone availability and experience play a large part in determining size of riprap. This is particularly true on small projects where hydraulic parameters are ill-defined and the total amount of riprap required is small.

3-6. Design Conditions

Stone size computations should be conducted for flow conditions that produce the maximum velocities at the riprapped boundary. In many cases, velocities continue to increase beyond bank-full discharge; but sometimes backwater effects or loss of flow into the overbanks results in velocities that are less than those at bank-full. Riprap at channel bends is designed conservatively for the point having the maximum force or velocity. For braided channels, bank-full discharges may not be the most severe condition. At lesser flows, flow is often divided into multiple channels. Flow in these channels often impinges * abruptly on banks or levees at sharp angles.

3-7. Stone Size

This method for determining stone size uses depth-averaged local velocity. The method is based on the idea that a designer will be able to estimate local velocity * better than local boundary shear. Local velocity and local flow depth are used in this procedure to quantify the imposed forces. Riprap size and unit weight quantify the resisting force of the riprap. This method is based on a large body of laboratory data and has been compared to available prototype data (Maynord 1988). It defines the stability of a wide range of gradations if placed to a thick- * ness of $1D_{100}$(max). Guidance is also provided for thickness greater than $1D_{100}$(max). This method is applicable * to side slopes of 1V on 1.5H or flatter.

a. Velocity estimation. The characteristic velocity for side slopes V_{SS} is the depth-averaged local velocity over the slope at a point 20 percent of the slope length from * the toe of slope. Plate 33 presents the ratio V_{SS}/V_{AVG}, where V_{AVG} is the average channel velocity at the upstream end of the bend, as a function of the channel geometry, which is described by R/W, where R is the center-line radius of bend and W is the water-surface width. V_{AVG}, R, and W should be based on flow in the main channel only and should not include overbank areas. The trapezoidal curve for V_{SS}/V_{AVG} shown in Plate 33 is based on the STREMR numerical model described in Bernard (1993). The primary factors affecting velocity distribution in riprap-lined, trapezoidal channel bendways are R/W, bend angle, and aspect ratio (bottom width/depth). Data in Maynord (1992) show a trapezoidal channel having the same bottom width but side slopes ranging from 1V:1.5H to 1V:3H to have the same maximum V_{SS}/V_{AVG} at the downstream end of the bend. Plate 33 should be used for side slopes from 1V:3H to 1V:1.5H. For straight channels sufficiently far (>5W) from upstream bends, large values of R/W should be used, resulting in constant values of V_{SS}/V_{AVG}. Very few channels are straight enough to justify using $V_{SS}/V_{AVG} < 1$. A minimum ratio of $V_{SS}/V_{AVG} = 1$ is recommended for side slopes in straight channels. Rock stability should be checked for both side slopes and the channel bottom. In bendways, the outer bank side slope will generally require the largest rock size. In straight reaches, the channel bottom will often require the largest stone size. Velocities in the center of a straight channel having equal bottom and side slope roughness range from 10 to 20 percent greater than V_{AVG}. Plate 34 describes V_{SS} and Plate 35 shows the location in a trapezoidal channel bend of the maximum V_{SS}. Velocity downstream of bends decays at approximately the following rate: No decay in first channel width downstream of bend exit; decay of $V_{SS}/V_{AVG} = 0.1$ per channel width until $V_{SS}/V_{AVG} = 1.0$. Plate 36 shows the variation in velocity over the side slope in a channel. The straight channel curve in Plate 36 was found applicable to both 1V:2H and 1V:3H side slopes. The bend curve for R/W = 2.6 was taken from a channel having strong secondary currents and represents a severe concentration of high velocity upon the channel side slope. These two curves represent the extremes in velocity distribution to be expected along the outer bank of a channel bend having a riprap side slope from toe of bank to top of bank. Knowing V_{SS} from Plate 33, the side slope velocity distribution can be determined at the location of V_{SS}. An alternate means of velocity estimation based on field observation is discussed in Appendix G. The alpha method (Appendix C), or velocities resulting from subsections of a water-surface profile computation, should be used only in straight reaches. When the alpha method is used, velocity from the subsection adjacent to the bank subsection should be used as V_{SS} in design of bank riprap.

b. Stone size relations. The basic equation for the representative stone size in straight or curved channels is

$$D_{30} = S_f C_s C_v C_T d \left[\left(\frac{\gamma_w}{\gamma_s - \gamma_w} \right)^{1/2} \frac{V}{\sqrt{K_1 g d}} \right]^{2.5} \qquad (3\text{-}3)$$

where

D_{30} = riprap size of which 30 percent is finer by weight, length

S_f = safety factor (see *c* below)

* C_s = stability coefficient for incipient failure, D_{85}/D_{15} = 1.7 to 5.2

= 0.30 for angular rock

* = 0.375 for rounded rock

C_v = vertical velocity distribution coefficient

= 1.0 for straight channels, inside of bends

= 1.283 - 0.2 log (R/W), outside of bends (1 for (R/W) > 26)

= 1.25, downstream of concrete channels

= 1.25, ends of dikes

C_T = thickness coefficient (see d(1) below)

* = 1.0 for thickness = $1D_{100}$(max) or 1.5 D_{50}(max), whichever is greater

* d = local depth of flow, length (same location as V)

γ_w = unit weight of water, weight/volume

* V = local depth-averaged velocity, V_{SS} for side slope riprap, length/time

K_1 = side slope correction factor (see *d*(1) below)

g = gravitational constant, length/time^2

* Some designers prefer to use the traditional D_{50} in riprap design. The approximate relationship between D_{50} and D_{30} is $D_{50} = D_{30}\ (D_{85}/D_{15})^{1/3}$. Equation 3-3 can be used with either SI (metric) or non-SI units and should be limited to slopes less than 2 percent.

c. Safety factor. Equation 3-3 gives a rock size that should be increased to resist hydrodynamic and a variety of nonhydrodynamic-imposed forces and/or uncontrollable physical conditions. The size increase can best be accomplished by including the safety factor, which will be a * value greater than unity. The minimum safety factor is * $S_f = 1.1$. The minimum safety factor may have to be increased in consideration for the following conditions:

(1) Imposed impact forces resulting from logs, uprooted trees, loose vessels, ice, and other types of large floating debris. Impact will produce more damage to alighter weight riprap section than to a heavier section. For moderate debris impact, it is unlikely that an added * safety factor should be used when the blanket thickness exceeds 15 in.

(2) The basic stone sizing parameters of velocity, * unit weight of rock, and depth need to be determined as accurately as possible. A safety factor should be included to compensate for small inaccuracies in these parameters. If conservative estimates of these parameters are used in the analysis, the added safety factor should not be used. The safety factor should be based on the anticipated error in the values used. The following discussion shows the importance of obtaining nearly correct values rather than relying on a safety factor to correct inaccurate or assumed stone sizing parameters. The average velocity over the toe of the riprap is an estimate at best and is the parameter to which the rock size is the most sensitive. A check of the sensitivity will show that a 10 percent change in velocity will result in a nearly 100 percent change in the weight limits of the riprap gradation (based on a sphere) and about a 30 percent change in the riprap * thickness. The riprap size is also quite sensitive to the unit weight of the rock to be used: a 10 percent change in the * unit weight will result in a 70 percent change in the weight limits of the riprap gradation (based on a sphere) and about a 20 percent change in the riprap thickness. The natural variability of unit weight of stone from a stone source adds to the uncertainty (EM 1110-2-2302). * The rock size is not nearly as sensitive to the depth parameter.

(3) Vandalism and/or theft of the stones is a serious problem in urban areas where small riprap has been placed. A W_{50}(min) of 80 lb should help prevent theft and vandalism. Sometimes grouted stone is used around vandalism-prone areas.

(4) The completed revetment will contain some * pockets of undersized rocks, no matter how much effort is devoted to obtaining a well-mixed gradation throughout the revetment. This placement problem can be assumed to occur on any riprap job to some degree but probably more frequently on jobs that require stockpiling or additional handling. A larger safety factor should be considered with stockpiling or additional hauling and where placement will be difficult if quality control cannot be expected to address these problems.

(5) The safety factor should be increased where severe freeze-thaw is anticipated.

The safety factor based on each of these considerations should be considered separately and then the largest of these values should be used in Equation 3-3.

d. Applications.

(1) The outer bank of straight channels downstream of bends should be designed using velocities computed for the bend. In projects where the cost of riprap is high, a channel model to indicate locations of high velocity might be justified. Equation 3-3 has been developed into Plate 37, which is applicable to thicknesses equal to $1D_{100}$(max), γ_s of 165 pcf, and the S_f of 1.1. Plate 38 is used to correct for values of other than γ_s of 165 pcf (when D_{30} is determined from Plate 37). The K_1 side slope factor is normally defined by the relationship of Carter, Carlson, and Lane (1953)

$$K_1 = \sqrt{1 - \frac{\sin^2 \theta}{\sin^2 \phi}} \qquad (3\text{-}4)$$

where

θ = angle of side slope with horizontal

ϕ = angle of repose of riprap material (normally 40 deg)

Results given in Maynord (1988) show Equation 3-4 to be conservative and that the repose angle is not a constant 40 deg but varies with several factors. The recommended relationship for K_1 as a function of θ is given in Plate 39 along with Equation 3-4 using ϕ = 40 deg. Using the recommended curve for side slope effects, the least volume of rock per unit length of bank line occurs on a 1V:1.5H to 1V:2H side slope. Also shown on Plate 39 is the correction for side slope when D_{30} is determined from Plate 37. Correction for the vertical velocity distribution in bends is shown in Plate 40. Testing has been conducted to determine the effects of blanket thickness greater than $1D_{100}$(max) on the stability of riprap. Results are shown in Plate 40. The thickness coefficient C_T accounts for the increase in stability that occurs when riprap is placed thicker than the minimum thickness of $1D_{100}$(max) or 1.5 D_{50}(max), whichever is greater.

(2) The basic procedure to determine riprap size using the graphical solution of this method is as follows:

(a) Determine average channel velocity (HEC-2 or other uniform flow computational methods, or measurement).

(b) Find V_{ss} using Plate 33.

(c) Find D_{30} using Plate 37.

(d) Correct for other unit weights, side slopes, vertical velocity distribution, or thicknesses using Plates 38 through 40.

(e) Find gradation having D_{30}(min) ≥ computed D_{30}. Alternately Equation 3-3 is used with Plates 39 and 40 to replace steps (c) and (d).

(3) This procedure can be used in both natural channels with bank protection only and prismatic channels having riprap on bed and banks. Most bank protection sections can be designed by direct solution. In these cases, the extent of the bank compared to the total perimeter of the channel means that the average channel velocity is not significantly affected by the riprap. The first example in Appendix H demonstrates this type of bank protection.

(4) In some cases, a large part of the channel perimeter is covered with riprap; the average channel velocity, depth, and riprap size are dependent upon one another; and the solution becomes iterative. A trial riprap gradation is first assumed and resistance coefficients are computed using Equation 3-2. Then the five steps described in (2) above are conducted. If the gradation found in paragraph (e) above is equal to the assumed trial gradation, the solution is complete. If not, a new trial gradation is assumed and the procedure is repeated. The second example in Appendix H demonstrates this type of channel riprap.

(5) In braided streams and some meandering streams, flow is often directed into the bank line at sharp angles (angled flow impingement). For braided streams having impinged flow, the above stone sizing procedures require modification in two areas: the method of velocity estimation and the velocity distribution coefficient C_v. All other factors and coefficients presented are applicable.

(a) The major challenge in riprap design for braided streams is estimating the imposed force at the impingement point. Although unproven, the most severe bank

* attack in braided streams is thought to occur when the water surface is at or slightly above the tops of the midchannel bars. At this stage, flow is confined to the multiple channels that often flow into or "impinge" against bank lines or levees. At lesser flows, the depths and velocities in the multiple channels are decreased. At higher flows, the channel area increases drastically and streamlines are in a more downstream direction rather than into bank lines or levees.

(b) The discharge that produces a stage near the tops of the midchannel bars is Q_{tmcb} . Q_{tmcb} is probably highly correlated with the channel-forming discharge concept. In the case of the Snake River near Jackson, Wyoming, Q_{tmcb} is 15,000-18,000 cfs, which has an average recurrence interval of about 2-5 years. Using cross-section data to determine the channel area below the tops of the midchannel bars and Q_{tmcb} allows determination of the average channel velocity at the top of the midchannel bars, V_{tmcb} .

(c) Field measurements at impingement sites were taken in 1991 on the Snake River near Jackson, Wyoming, and reported in Maynord (1993). The maximum observed ratio $V_{SS}/V_{tmcb} = 1.6$, which is almost identical to the ratio shown in Plate 33 for sharp bendways having $R/W = 2$ in natural channels, and this ratio is recommended for determining V_{SS} for impinged flow. The second area of the design procedure requiring modification for impinged flow is the velocity distribution coefficient C_V , which varies with R/W in bendways as shown in Plate 40. Impinged flow areas are poorly aligned bends having low R/W , and $C_V = 1.25$ is recommended for design.

(6) Transitions in size or shape may also require riprap protection. The procedures in this paragraph are applicable to gradual transitions where flow remains tranquil. In areas where flow changes from tranquil to rapid and then back to tranquil, riprap sizing methods applicable to hydraulic structures (HDC 712-1) should be used. In converging transitions, the procedures based on Equation 3-3 can be used unaltered. In expanding transitions, flow can concentrate on one side of the expansion and design velocities should be increased. For installations immediately downstream of concrete channels, a vertical velocity distribution coefficient of 1.25 should be used due to the difference in velocity profile over the two surfaces.

* *e. Steep slope riprap design.*

In cases where unit discharge is low, riprap can be used on steep slopes ranging from 2 to 20 percent. A typical application is a rock-lined chute. The stone size equation is

$$D_{30} = \frac{1.95\ S^{0.555}\ q^{2/3}}{g^{1/3}} \qquad (3\text{-}5)$$

where

S = slope of bed

q = unit discharge

Equation 3-5 is applicable to thickness = 1.5 D_{100}, angular rock, unit weight of 167 pcf, D_{85}/D_{15} from 1.7 to 2.7, slopes from 2 to 20 percent, and uniform flow on a downslope with no tailwater. The following steps should be used in application of Equation 3-5:

(1) Estimate $q = Q/b$ where b = bottom width of chute.

(2) Multiply q by flow concentration factor of 1.25. Use greater factor if approach flow is skewed.

(3) Compute D_{30} using Equation 3-5.

(4) Use uniform gradation having $D_{85}/D_{15} \leq 2$ such as Table 3-1.

* (5) Restrict application to straight channels with side slope of 1V:2.5H or flatter.

(6) Use filter fabric beneath rock.

The guidance for steep slope riprap generally results in large riprap sizes. Grouted riprap is often used instead of loose riprap in steep slope applications. *

3-8. Revetment Top and End Protection

Revetment top and end protection requirements, as with all channel protective measures, are to assure the project benefits, to perform satisfactorily throughout the project economic life, and not to exceed reasonable maintenance

costs. Reference is made to ER 1110-2-1405, with emphasis on paragraph 6c.

a. Revetment top. When the full height of a levee is to be protected, the revetment will cover the freeboard, i.e., extend to the top of the levee. This provides protection against waves, floating debris, and water-surface irregularities. Similar provisions apply to incised channel banks. A horizontal collar, at the top of the bank, is provided to protect against escaping and returning flows as necessary. The end protection methods illustrated in Plate 41 can be adapted for horizontal collars. Plate 36 provides general guidance for velocity variation over channel side slopes that can assist in evaluating the economics of reducing or omitting revetment for upper bank areas. Revetment size changes should not be made unless a sufficient quantity is involved to be cost effective. Many successful revetments have been constructed where the top of the revetment was terminated below the design flow line. See USACE (1981) for examples.

b. Revetment end protection. The upstream and downstream ends of riprap revetment should be protected against erosion by increasing the revetment thickness T or extending the revetment to areas of noneroding velocities * and relatively stable banks. A smooth transition should be provided from where the end protection begins to the design riprap section. The keyed-in section should satisfy filter requirements. The following guidance * applies to the alternative methods of end protection illustrated in Plate 41.

(1) Method A. For riprap revetments 12 in. thick or less, the normal riprap layer should be extended to areas where velocities will not erode the natural channel banks.

(2) Method B. For riprap revetments exceeding 12 in. in thickness, one or more reductions in riprap thickness * and stone size may be required (Plate 41) until velocities decrease to a noneroding natural channel velocity.

(3) Method C. For all riprap revetments that do not terminate in noneroding natural channel velocities, the ends of the revetment should be enlarged, as shown in * Plate 41. The decision to terminate the revetment in erosive velocities should be made with caution since severe erosion can cause the revetment to fail by progressive flanking.

c. Length. Riprap revetment is frequently carried too far upstream and not far enough downstream of a channel bend. In a trapezoidal channel, the maximum velocities along the outer bank are often located in the straight reach immediately downstream of the bend for relatively large distances downstream. In a natural channel, the limit of protection on the downstream end should depend on where the flow crosses to the opposite bank, and should consider future bar building on the opposite bank, resulting in channel constriction and increased velocities. Guidance is generally lacking in this area, but review of aerial photographs of the subject location can provide some insight on where the crossover flow occurs. Model tests in a sand bed and bank flume (USACE 1981) were conducted to determine the limits of protection required to prevent scour that would lead to destruction of the revetment. These tests were conducted in a 110-deg bend having a constant discharge. The downstream end of the revetment had to be 1.5 channel widths downstream of the end of the bend. Geomorphic studies to determine revetment ends should be considered.

Section IV
Revetment Toe Scour Estimation and Protection

3-9. General

Toe scour is probably the most frequent cause of failure of riprap revetments. This is true not only for riprap, but also for a wide variety of protection techniques. Toe * scour is the result of several factors, including these three:

a. Meandering channels, change in cross section that occurs after a bank is protected. In meandering channels the thalweg often moves toward the outer bank after the bank is protected. The amount of change in cross section that occurs after protection is added is related to the erodibility of the natural channel bed and original bank material. Channels with highly erodible bed and banks can experience significant scour along the toe of the new revetment.

b. Meandering channels, scour at high flows. Bed profile measurements have shown that the bed observed at low flows is not the same bed that exists at high flows. At high flows the bed scours in channel bends and builds up in the crossings between bends. On the recession side of the flood, the process is reversed. Sediment is eroded from the crossings and deposited in the bends, thus obscuring the maximum scour that had occurred.

c. Braided channels. Scour in braided channels can reach a maximum at intermediate discharges where flow in the channel braids attacks banks at sharp angles.

Note that local scour is the mechanism being addressed herein. When general bed degradation or headcutting is expected, it must be added to the local scour. When scour mechanisms are not considered in the design of protection works, undermining and failure may result. * Plate 42 may be used for depth of scour estimates. The design curve in Plate 42 represents an upper limit for scour in channels having irregular alignments. For bendways having a relatively smooth alignment, a 10 percent reduction from the design curve is recommended. Neill (1973) provides additional information on scour depth estimation.

3-10. Revetment Toe Protection Methods

Toe protection may be provided by two methods:

a. Extend to maximum scour depth. Place the lower extremity below the expected scour depth or found it on nonerodible material. These are the preferred methods, but they can be difficult and expensive when underwater excavation is required.

b. Place launchable stone. Place sufficient launchable stone to stabilize erosion. Launchable stone is defined as stone that is placed along expected erosion areas at an elevation above the zone of attack. As the attack and resulting erosion occur below the stone, the stone is undermined and rolls/slides down the slope, stopping the erosion. This method has been widely used on sand bed streams. Successful applications include:

(1) Windrow revetments: riprap placed at top of bank.

(2) Trench-fill revetments: riprap placed at low water level.

(3) Weighted riprap toes: riprap placed at intersection of channel bottom and side slope.

Trench-fill revetments on the Mississippi River have * successfully launched to protect for a vertical scour depth of up to 50 ft. On gravel bed streams, the use of launchable stone is not as widely accepted as in sand bed streams. Problems with using launchable stone in some gravel bed rivers may be the result of underestimating stone size, scour depth, or launchable stone volume because the concept of launchable stone has been successful on several gravel bed rivers.

3-11. Revetment Toe Protection Design

The following guidance applies to several alternative methods of toe protection illustrated in Plate 43.

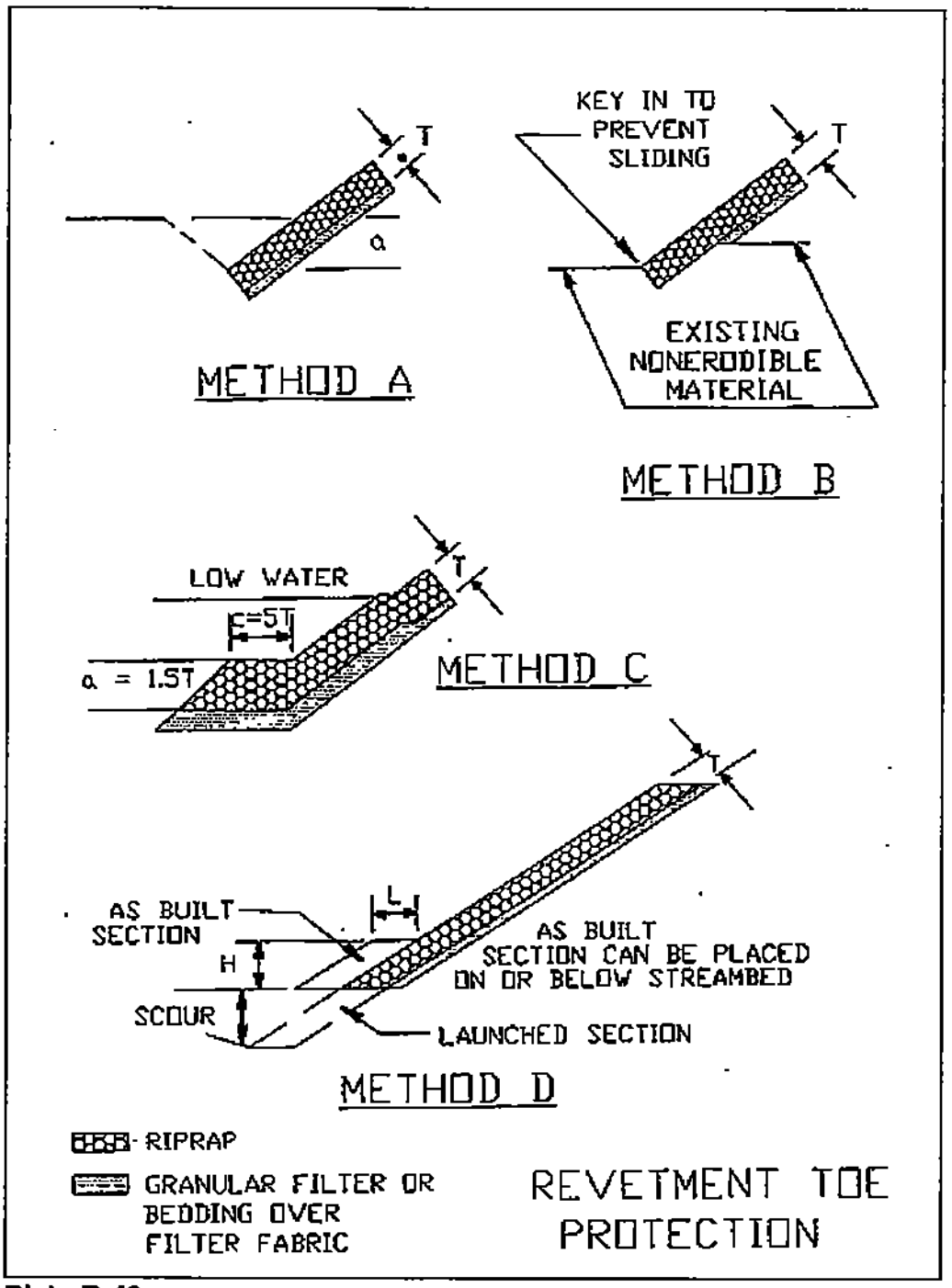
a. Method A. When toe excavation can be made in the dry, the riprap layer may be extended below the existing groundline a distance exceeding the anticipated depth of scour. If excavation quantities are prohibitive, the * concept of Method D can be adapted to reduce excavation.

b. Method B. When the bottom of the channel is nonerodible material, the normal riprap should be keyed in at streambed level.

c. Method C. When the riprap is to be placed underwater and little toe scour is expected (such as in straight reaches that are not downstream of bends, unless stream is braided), the toe may be placed on the existing bottom with height a and width c equal to 1.5T and 5T , respectively. This compensates for uncertainties of underwater placement.

d. Method D. An extremely useful technique where water levels prohibit excavation for a toe section is to place a launchable section at the toe of the bank. Even if excavation is practicable, this method may be preferred for cost savings if the cost of extra stone required to produce a launched thickness equal to or greater than * T plus the increase shown in Table 3-2 is exceeded by the cost of excavation required to carry the design thickness T down the slope. This concept simply uses toe scour as a substitute for mechanical excavation. This method also has the advantage of providing a "built-in" scour gage, allowing easy monitoring of high-flow scour and the need for additional stone reinforcement by visual inspection of the remaining toe stone after the high flow subsides or by surveyed cross sections if the toe stone is underwater. It is readily adaptable to emergency protection, where high flow and the requirement for quick action make excava- * tion impractical. Shape of the stone section before launching is not critical, but thickness of the section is important because thickness controls the rate at which rock is released in the launching process. For gradual scour in regular bendways, the height of the stone section before launching should be from 2.5 to 4.0 times the bank protection thickness (T). For rapid scour in impinged flow environments or in gravel bed streams, the stone section height before launching should be 2.5 to 3.0 T. In

*


T
a
METHOD A
KEY IN TO PREVENT SLIDING
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EXISTING NONERODIBLE MATERIAL
METHOD B
LOW WATER
T
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METHOD C
T
L
AS BUILT SECTION
H
SCOUR
AS BUILT SECTION CAN BE PLACED ON OR BELOW STREAMBED
LAUNCHED SECTION
METHOD D
RIPRAP
GRANULAR FILTER OR BEDDING OVER FILTER FABRIC
REVETMENT TOE PROTECTION

Plate B-43

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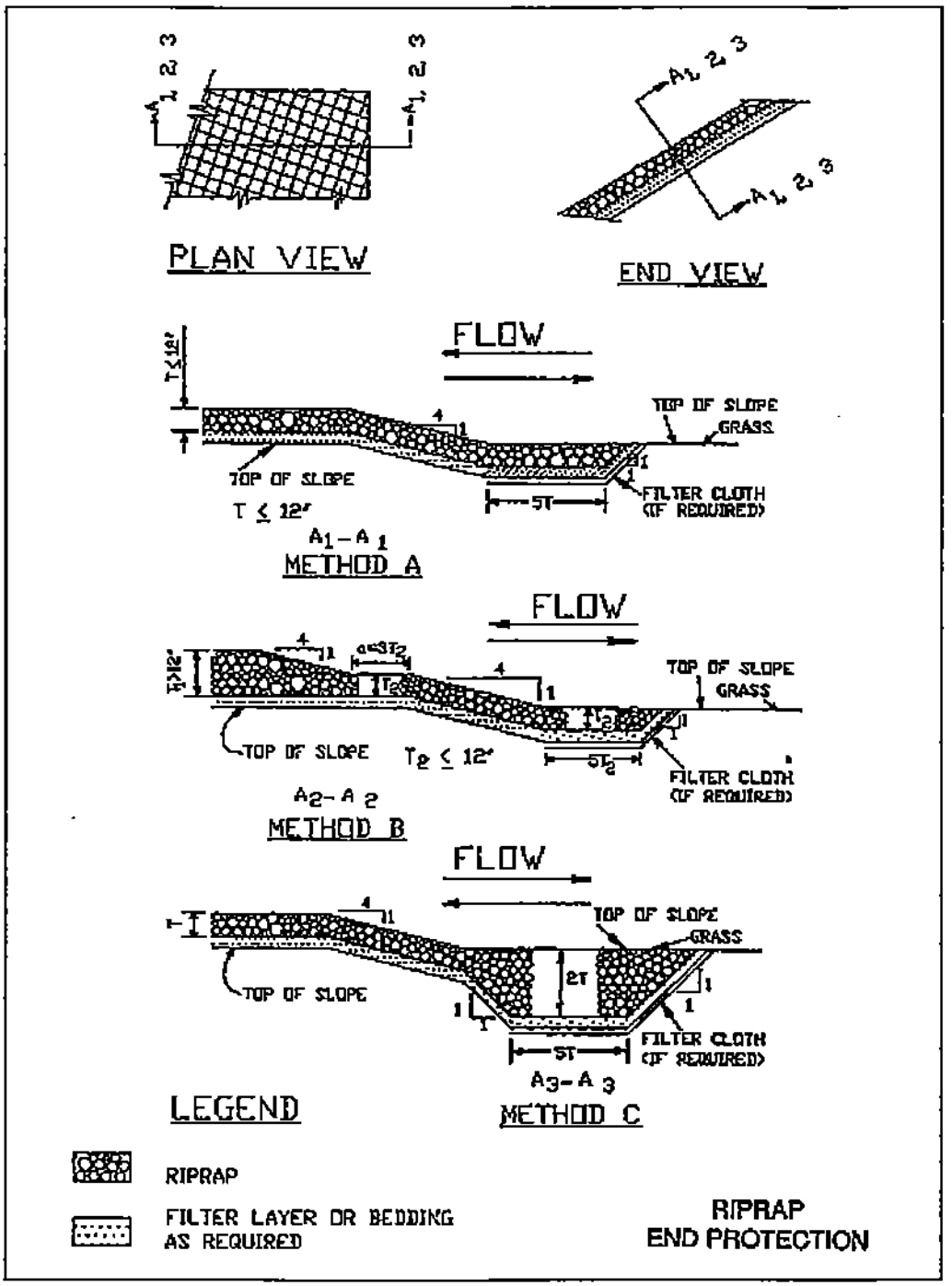
PLAN VIEW
END VIEW
FLOW
TOP OF SLOPE
GRASS
TOP OF SLOPE
T ≤ 12'
FILTER CLOTH
(IF REQUIRED)
A1 - A1
METHOD A
FLOW
TOP OF SLOPE
GRASS
TOP OF SLOPE
T2 ≤ 12'
FILTER CLOTH
(IF REQUIRED)
A2 - A2
METHOD B
FLOW
TOP OF SLOPE
GRASS
TOP OF SLOPE
2T
FILTER CLOTH
(IF REQUIRED)
A3 - A3
METHOD C
LEGEND
RIPRAP
FILTER LAYER OR BEDDING
AS REQUIRED
RIPRAP
END PROTECTION

Plate B-41

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APPENDIX J

ACOE HYDRAULIC DESIGN OF FLOOD CONTROL CHANNELS EM 110-2-1601

DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
Washington, DC 20314-1000

EM 1110-2-1601
Change 1

CECW-EH-D

Engineer Manual
No. 1110-2-1601

30 June 1994

Engineering and Design
HYDRAULIC DESIGN OF FLOOD CONTROL CHANNELS

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Chapter 3
Riprap Protection

Section I
Introduction

3-1. General

* The guidance presented herein applies to riprap design for open channels not immediately downstream of stilling basins or other highly turbulent areas (for stilling basin riprap, use HDC 712-1, Plates 29 and 30). The ability of * riprap slope protection to resist the erosive forces of channel flow depends on the interrelation of the following factors: stone shape, size, weight, and durability; riprap gradation and layer thickness; and channel alignment, cross-section, gradient, and velocity distribution. The bed material and local scour characteristics determine the design of toe protection which is essential for riprap revetment stability. The bank material and groundwater conditions affect the need for filters between the riprap and underlying material. Construction quality control of both stone production and riprap placement is essential for successful bank protection. Riprap protection for flood control channels and appurtenant structures should be designed so that any flood that could reasonably be expected to occur during the service life of the channel or structure would not cause damage exceeding nominal maintenance or replacement (see ER 1110-2-1150). While the procedures presented herein yield definite stone sizes, results should be used for guidance purposes and revised as deemed necessary to provide a practical protection design for the specific project conditions.

3-2. Riprap Characteristics

The following provides guidance on stone shape, size/weight relationship, unit weight, gradation, and layer thickness. Reference EM 1110-2-2302 for additional guidance on riprap material characteristics and construction.

a. Stone shape. Riprap should be blocky in shape rather than elongated, as more nearly cubical stones "nest" together best and are more resistant to movement. The stone should have sharp, angular, clean edges at the intersections of relatively flat faces. Stream rounded stone is less resistant to movement, although the drag force on a rounded stone is less than on angular, cubical stones. As rounded stone interlock is less than that of equal-sized angular stones, the rounded stone mass is more likely to be eroded by channel flow. If used, the rounded stone should be placed on flatter side slopes than angular stone and should be about 25 percent larger in diameter. The following shape limitations should be specified for riprap obtained from quarry operations:

(1) The stone shall be predominantly angular in shape.

(2) Not more than 30 percent of the stones distributed throughout the gradation should have a ratio of a/c greater than 2.5.

(3) Not more than 15 percent of the stones distributed throughout the gradation should have a ratio of a/c greater than 3.0.

(4) No stone should have a ratio of a/c greater than 3.5.

To determine stone dimensions a and c, consider that the stone has a long axis, an intermediate axis, and a short axis, each being perpendicular to the other. Dimension a is the maximum length of the stone, which defines the long axis of the stone. The intermediate axis is defined by the maximum width of the stone. The remaining axis is the short axis. Dimension c is the maximum dimension parallel to the short axis. These limitations apply only to the stone within the required riprap gradation and not to quarry spalls and waste that may be allowed.

b. Relation between stone size and weight. The ability of riprap revetment to resist erosion is related to the size and weight of stones. Design guidance is often expressed in terms of the stone size $D_{\%}$, where % denotes the percentage of the total weight of the graded material (total weight including quarry wastes and spalls) that contains stones of less weight. The relation between size and weight of stone is described herein using a spherical shape by the equation

$$D_{\%} = \left(\frac{6W_{\%}}{\pi \gamma_s} \right)^{1/3} \qquad (3\text{-}1)$$

where

$D_{\%}$ = equivalent-volume spherical stone diameter, ft

$W_{\%}$ = weight of individual stone having diameter of $D_{\%}$

γ_s = saturated surface dry specific or unit weight of stone, pcf

Plate 31 presents relations between spherical diameter and weight for several values of specific or unit weight. Design procedures for determining the stone size required to resist the erosive forces of channel flow are presented in paragraph 3-5 below.

c. Unit weight. Unit weight of stone γ_s generally varies from 150 to 175 pcf. Riprap sizing relations are relatively sensitive to unit weight of stone, and γ_s should be determined as accurately as possible. In many cases, the unit weight of stone is not known because the quarry is selected from a list of approved riprap sources after the construction contract is awarded. Riprap coming from the various quarries will not be of the same unit weight. Under these circumstances, a unit weight of stone close to the minimum of the available riprap sources can be used in design. Contract options covering specific weight ranges of 5 or 10 pcf should be offered when sufficient savings warrant.

d. Gradation.

(1) The gradation of stones in riprap revetment affects the riprap's resistance to erosion. Stone should be reasonably well graded throughout the in-place layer thickness. Specifications should provide for two limiting gradation curves, and any stone gradation as determined from quarry process, stockpile, and in-place field test samples that lies within these limits should be acceptable. Riprap sizes and weights are frequently used such as D_{30}(min), D_{100}(max), W_{50}(min), etc. The D or W refers to size or weight, respectively. The number is the percent finer by weight as discussed in b above. The (max) or (min) refers to the upper or lower limit gradation curves, respectively. Engineer Form 4794-R is a standard form for plotting riprap gradation curves (Plate 32). The gradation limits should not be so restrictive that production costs would be excessive. The choice of limits also depends on the underlying bank soils and filter requirements if a graded stone filter is used. Filters may be required under riprap revetments. Guidance for filter requirements is given in EM 1110-2-1901. Filter design is the responsibility of the Geotechnical Branch in each District.

(2) Standardized gradations having a relatively narrow range in sizes (D_{85}/D_{15} of 1.4-2.2) are shown in Table 3-1. Other gradations can be used and often have a wider range of allowable sizes than those given in Table 3-1. One example is the Lower Mississippi Valley Division (LMVD) Standardized Gradations presented in Appendix F. The LMVD gradations are similar to the gradations listed in Table 3-1 except the LMVD W_{50}(max) and W_{15}(max) weights are larger, which can make the LMVD gradations easier to produce. Most graded ripraps have ratios of D_{85}/D_{15} less than 3. Uniform riprap ($D_{85}/D_{15} < 1.4$) has been used at sites in the US Army Engineer Division, Missouri River, for reasons of economy and quality control of sizes and placement.

(3) Rather than a relatively expensive graded riprap, a greater thickness of a quarry-run stone may be considered. Some designers consider the quarry-run stone to have another advantage: its gravel- and sand-size components serve as a filter. The gravel and sand sizes should be less by volume than the voids among the larger stone. This concept has resulted in considerable cost savings on large projects such as the Arkansas and Red River Navigation Projects. Not all quarry-run stone can be used as riprap; stone that is gap graded or has a large range in maximum to minimum size is probably unsuitable. Quarry-run stone for riprap should be limited to $D_{85}/D_{15} \leq 7$.

(4) Determining optimum gradations is also an economics problem that includes the following factors:

(a) Rock quality (durability under service conditions)

(b) Cost per ton at the quarry (including capability of quarry to produce a particular size)

(c) Number of tons required

(d) Miles transported

(e) Cost of transportation per ton-mile

(f) Cost per ton for placement

(g) Need for and cost of filter

(h) Quality control during construction (it is easier to ensure even coverage with a narrow gradation than with a wide gradation)

(i) Number of different gradations required. Sometimes cost savings can be realized by using fewer gradations.

See EM 1110-2-2302 for further discussion of these factors.

APPENDIX K

EROSION AND SEDIMENT CONTROL PLAN FOR CONSTRUCTION OF POWNAL TANNERY REMEDY

EPA Contract No. 68-W6-0042
EPA Work Assignment No. 147-RDRD-01N9

EPA Project Officer: Diana King
EPA Remedial Project Manager: Leslie McVickar

EROSION AND SEDIMENT CONTROL PLAN FOR CONSTRUCTION OF POWNAL TANNERY REMEDY – PHASE II

Pownal Tannery Superfund Site
Pownal, Vermont

November 2003

Prepared By:

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Wakefield, MA 01880

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Boott Mills South, Foot of John Street
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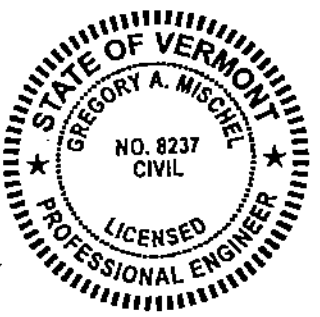

Gregory A. Mischel, P.E.
Senior Project Engineer

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APPENDIX

A Design Calculations

1.0 INTRODUCTION

This Erosion and Sediment Control Plan (Plan) describes the soil erosion and sediment control measures to be implemented during Phase II of the United States Environmental Protection Agency's Remedial Action (RA) of the Pownal Tannery Superfind Site (Site) in North Pownal, Vermont (Project). The 28-acre Site was a former hide tanning and finishing facility owned by the Pownal Tanning Company, Inc. The Site originally consisted of three contamination sources: the former tannery building complex, a capped sludge landfill, and a lagoon system. The lagoon complex is partially covered with soil over which disturbed wetlands vegetation occurs. The lagoons contain elevated concentrations of lead, arsenic, pentachlorophenol, and dioxin, among other contaminants.

The RA includes excavation and consolidation of contaminated sludge materials within the lagoon area, and capping with a landfill cover system. The RA will be conducted in two construction phases.

Phase I consists of Site preparation work, including: installing sedimentation and erosion controls; clearing and grubbing the landfill footprint areas and areas of sludge; excavation; construction of a sludge processing area; establishing staging areas and installing security fencing; and backfilling Lagoon 2 with clean-fill.

Phase II work includes the following activities:

- Excavation of sludge from the lagoons (over 40,000 cubic yards);
- Removal and treatment of potentially contaminated water;
- Sludge conditioning with a stabilizing agent (e.g., Quicklime or Portland Cement);
- Sludge placement and compaction in the consolidation landfill; and
- Capping of the landfill (e.g., sand gas vent layer, low density polyethylene geomembrane, geocomposite drainage layer, vegetative support layer, topsoil, and riprap).

During all construction activities, a sediment and erosion control plan will be implemented in accordance with the State of Vermont Agency of Natural Resources, Department of Environmental Conservation, General Permit 3-9001 (2002) for Stormwater Runoff from Construction Sites. The overall strategy for sediment and erosion control includes minimizing areas of disturbed soils and the duration of exposure, control of storm water run-on/runoff, and on-Site sediment control measures. Minimizing the area and duration of exposure of disturbed soils will be accomplished through careful consideration of construction activities sequencing.

This Erosion and Sediment Control Plan covers the following:

- Prevention of soil erosion due to construction activities;
- Prevention of sedimentation of waterways, open drainage ways, and storm and sanitary sewers due to construction activities; and
- Prevention of storm water run-on onto work areas.

A separate Erosion and Sediment Control Plan was developed to address Phase I activities.

This plan and the associated drawings will be revised as needed to account for actual topographic or construction conditions that are encountered.

1.1 Site Characteristics

The area to be addressed by the planned remedial activities consists of a system of five lagoons. Current topography of the lagoon area includes a series of soil berms surrounding Lagoons 1, 4, and 5. Each of these lagoons has a generally flat, low-lying surface within their respective surrounding soil berms. Surface topography of Lagoon 3 is higher than the elevation of the Lagoons 1, 4, and 5. Lagoon 2 has been subject to a removal action, which left the area as an isolated surface depression.

1.2 Site Drainage

Storm water drainage patterns under current conditions are controlled by the elevated soil berms surrounding the individual lagoons and the lagoon area as a whole. Soil berms surrounding Lagoons 1, 4 and 5 contain any potential surface water runoff within the footprint of each respective lagoon. This runoff ponds and percolates through the underlying native soils and/or sludge material, recharging shallow ground water.

Due to the topographic depression at Lagoon 2, no precipitation falling within this footprint is able to produce runoff. Also, any potential storm water runoff from areas immediately adjacent to Lagoon 2 flows into this depression. All accumulated water within the footprint of Lagoon 2 then percolates to the subsurface.

The ground surface elevation of Lagoon 3 is higher than that at the other lagoons. Storm water runoff from Lagoon 3 flows mainly westward towards Lagoon 4. However, some portions of Lagoon 3 contribute storm water flow to Lagoons 1 and 2. Any potential storm water runoff from Lagoon 4 is contained by the continuous soil berm, which separates the Hoosic River and the lagoon area.

In addition to storm water runoff generated from within the footprint of the lagoons, portions of the lagoon area are periodically inundated with extreme flood flows of the Hoosic River. Under these extreme flood flow conditions, the surface of the lagoon area is subjected to significant erosive forces, potentially mobilizing contaminated materials down stream. As these floodwaters

subside, the berms and the lagoon area will remain flooded for some period of time as the retained water percolates downward. The potential for the lagoon area to be subjected to the erosive forces and flooding associated with extreme events of the Hoosic River will be considered during design of the proposed landfill.

1.3 Sequence and Timetable of Construction Activities

It is currently estimated that Phase I construction activities will occur over a three-month period, and will begin in the Fall of 2003. Phase II construction activities will occur over nine- month period and will begin in the Fall of 2003.

Fall 2003	Regrade a portion of the landfill footprint and construct the portion of the perimeter access road in Lagoon 4 sediment traps, temporary dike/swale at toe of proposed landfill in Lagoon 4, culvert under access road to convey stormwater to sediment trap No. 2
Winter	Shut down approximately December 2003 to March 2004.
April 2004	Remobilize to excavate/stabilize sludge, consolidate in landfill, construct cap.
September 2004	Demobilize

The general sequence for Phase I construction activities follows: (Some activities may occur concurrently. Activities are listed generally in the order in which they will occur.)

- Set-up of temporary field office trailer and associated facilities;
- Installation of stabilized construction entrance;
- Installation of temporary erosion and sedimentation control measures (e.g., silt-fencing and hay bales);
- Erection of Site perimeter fencing;
- Clearing and grubbing of Lagoons 1, 2, 3, 4 (southeast portion only), and 5;
- Collection and demolition of solid debris currently located on Site and consolidation within the proposed footprint of the sludge landfill;
- Backfilling of Lagoon 2 to construct the Main Staging Area for use during the Phase II of the project;
- Stabilization of areas disturbed by construction by mulch or temporary seed/mulch depending on the slope of the disturbed area (ongoing, as construction permits); and

- On-going inspections and maintenance of erosion and sediment controls until final Site stabilization.

The construction sequence for Phase II construction activities is summarized below:

- Maintanance of sedimentation and erosion control measures installed during Phase I, including silt fence, hay bales and stabilized construction entrance;
- Minor re-grading in footprint of landfill;
- Construct portion of perimeter access road around landfill in Lagoon 4 to provide construction access and also provide barrier to storm water flow;
- Install culvert and two (2) sediment traps;
- Construct perimeter dike and swale around western perimeter of landfill (between road and landfill);
- Excavate contaminated sludge;
- Stabilize excavated sludge;
- Place and compact sludge in landfill;
- Construct landfill cap;
- Construct permanent sediment and erosion and control measurers, including:
  - Riprap along western side of landfill to protect side-slopes of landfill during 100-year flood event.
  - Six inches of top soil and seed and mulch over remainder of landfill cap;
  - Buffer zone planning plan; and
  - A riprap stabilized flood water outlet at the north end of the Lagoon Area.

Temporary sedimentation and erosion controls will be left in place until the completion of the Phase II construction work. Every effort will be made to complete construction and to stabilize disturbed soils prior to October 15th. If this is not possible, then a Winterization Plan will be prepared, submitted for review, and implemented

2.0 EROSION AND SEDIMENTATION CONTROL PERFORMANCE STANDARDS

The performance requirements for Erosion and Sedimentation Control for the RA are described in the Specifications and include the following:

- Comply with requirements of U.S. Environmental Protection Agency for erosion and sedimentation control.
- Submit periodic inspection reports.
- ***Timing:*** Put preventive measures in place prior to disturbance or as soon as possible after disturbance of surface cover and before precipitation occurs.
- ***Erosion On Site:*** Minimize wind, water, and vehicular erosion of soil on project Site due to construction activities for this project.
  - Control movement of sediment and soil from temporary stockpiles of soil.
  - Prevent development of ruts due to equipment and vehicular traffic.
  - If erosion occurs due to non-compliance with these requirements, restore eroded areas at contractor's expense.
- ***Erosion Off Site:*** Prevent erosion of soil and deposition of sediment on other properties caused by water leaving the project Site due to construction activities for this project.
  - Prevent windblown soil from leaving the project Site.
  - Prevent tracking of mud onto public roads outside Site.
  - If erosion occurs due to non-compliance with these requirements, restore eroded areas.
- ***Sedimentation of Waterways:*** Prevent sedimentation of waterways on or adjacent to the project Site, including rivers, streams, lakes, ponds, open drainage ways, storm sewers, and sanitary sewers.
  - If sedimentation occurs, install or correct preventive measures immediately; remove deposited sediments; comply with requirements of authorities having jurisdiction.
  - If sediment basins are used as temporary preventive measures pump dry and remove deposited sediment after each storm when sediment depth reaches ½ the design depth of the trap.
- ***Open Water:*** Prevent the creation of new standing water that could become stagnant.
- ***Maintenance:*** Maintain temporary preventive measures until permanent measures have been established.

- ***Regulatory Requirements:*** Sediment and Erosion Control measures will be designed and implemented in accordance with the following, as applicable to this project:

  - EPA 832-R-92-005 – Storm Water Management for Construction Activities; U.S. Environmental Protection Agency; 1992.

  - FHWA (BMP) – Best Management Practices for Erosion and Sediment Control; Federal Highway Administration; 1995.

  - Vermont Handbook for Soil Erosion and Sediment Control on Construction Sites, Special Publication No. 3, Vermont Geological Survey, rev. 1987.

  - General Permit 3-9001 (2002) for Stormwater Runoff from Construction Sites, State of Vermont Agency of Natural Resources Department of Environmental Conservation

3.0 EROSION AND SEDIMENT CONTROL MEASURES

This section presents temporary erosion and sediment control techniques that will be used during Phase I and Phase II construction activities. All control features are to be installed, constructed, and maintained as described in this plan and in accordance with the Project Specifications and Project Drawings. The Phase II Project Drawings dated August 2003 are herein incorporated by reference.

The sedimentation and erosion control measures installed during Phase I will be maintained throughout Phase II construction activities.

Stabilized Construction Entrance: To prevent the deposition of materials onto traversed public thoroughfare(s) all points of construction access and egress will be protected by installing and maintaining stabilized construction entrances as indicated on Drawing C-3.

The stabilized construction road will be maintained as shown on Drawing C-3.

Linear Sediment Barriers: Silt fence and hay bales will be used to control soil and sediments from migrating outside the construction areas and protect the wetland and surface water resources. The silt fence and hay bales will be installed at the beginning of Phase I of the project, before any soil disturbance on the Site including grubbing of vegetation. The barriers will be maintained through completion of Phase II construction activities.

- Along downhill perimeter edge of disturbed areas, including soil stockpiles as shown on the Drawings and as necessary to fulfill the objectives of this plan.

- Along the top of the slope or top bank of drainage channels and swales that traverse disturbed areas.

- Along the toe of cut slopes and fill slopes.

Earth Berm: A single, continuous elevated soil berm separates the Hoosic River from the western boundary of the lagoon area. During periods of flood flows within the Hoosic River, the water surface rises up the western face of this soil berm. This earth berm will be maintained to the extent possible during the Project to prevent onsite impacts due to river flows. This berm will also serve as a sediment and erosion control barrier. Breaching of this berm will only occur to construct the flood water outlet at the north end of the Lagoon Area only after the riprap layer has been place on the landfill cap.

Soil Stockpiles: Soil stockpiles will be protected from wind and precipitation by covering with polyethylene film, secured by placing soil on the outer edges.

Temporary Stabilization: All disturbed areas will be temporarily stabilized until completion of the Phase II work. Disturbed areas will be stabilized using the following:

- Mulching: For areas with slopes less than 4:1. (Dry straw and or hay).
- Temporary Seeding and mulching: For areas with slopes steeper than 4:1.

Perimeter Dike/Swale: A temporary dike/swale will be used around the perimeter of the landfill to collect and convey stormwater to the sediment traps during placement of stabilized sludge. The perimeter dike/swale will be reconstructed as needed to account for changes in landfill topography. No more than 5 acres of drainage area shall be directed to any one sediment trap at any time.

Sediment Traps and Culverts: Two temporary sediment traps will be constructed during Phase II. The sediment traps, which are small temporary basins, will serve to intercept sediment-laden runoff and retain the sediment. Sediment traps can be filled quite rapidly, and therefore must be inspected, maintained, and cleaned out frequently. One culvert will also be installed to collect and channel storm water drainage discharge during construction activities. Location and details of the sediment traps and culvert are shown on Drawing C-5 and C-13.

These control measures will remain in place throughout the construction effort. Routine inspections will be undertaken to ensure that their integrity is maintained. The stabilized construction entrance, silt fencing, hay bales, and sediment traps will be removed once Phase II construction is complete and final stabilization established.

4.0 MAINTENANCE

Erosion and sediment control structures will be inspected weekly or after each storm event for evidence of damage or excessive sedimentation. The following maintenance procedures are to be performed as noted.

During construction meetings, the effectiveness of the installed measures will be evaluated and, if necessary, additional measures will be implemented as needed.

- Continuously monitor public roadways near the Site for deposition of material. Street sweepings will be conducted as necessary to remove deposited soil.

- Preventive measures will be inspected weekly, within 24 hours after the end of any storm that produces 0.5 inches or more rainfall at the project Site, and daily during prolonged rainfall.

- Deficiencies will be repaired immediately.

- ***Silt Fences:***

  - Promptly replace fabric that deteriorates unless need for fence has passed.

  - Remove silt deposits that exceed one-third of the height of the fence.

  - Repair fences that are undercut by runoff or otherwise damaged, whether by runoff or other causes.

- ***Sediment Traps:***

  - Promptly remove accumulated sediment when the depth of sediment reaches ½ the design depth of the trap.

  - Place removed sediment within consolidation landfill.

  - Maintain earthern berm and spillway and repair as needed.

- ***Straw Bale Rows:***

  - Promptly replace bales that fall apart or otherwise deteriorate unless need has passed.

  - Remove silt deposits that exceed one-half of the height of the bales.

  - Repair bale rows that are undercut by runoff or otherwise damaged, whether by runoff or other causes.

- Temporary sediment control structures shall be cleaned as necessary and soil will be relocated to the onsite landfill.

- Sediment shall not be removed from the Site.

- Litter, construction debris, and chemicals shall be prevented from exposure to storm water and from becoming a pollutant source.

- Fertilizer applications, if required, shall be applied strictly in accordance with the Specifications and manufacturer's instructions.

- Vehicle tire cleaning devices shall be maintained to ensure their proper operation.

The contractor will maintain a separate log of erosion and sedimentation control installations, inspections, and maintenance activities. The log will include a record of rainfall events, result of inspections, conducted maintenance, problem areas and repairs, measures taken to prevent future problems, and all other pertinent information. The log shall be kept on Site and shall be available upon request.

5.0 PERMANENT EROSION AND SEDIMENT CONTROL MEASURES

The following permanent erosion control measures will be implemented: riprap side slopes, outlet protection structures, and permanent vegetative cover. Drawing C-10, Drainage and Permanent Erosion Control Plan, shows the location of these structures, and Drawing C-13 shows the details of the structures. Drawing C-11 presents the buffer zone planting plan. Appendix A presents supporting design calculations.

- ***Riprap.*** Due to the potential for erosion from river flow under extreme flood conditions; the steeper side slopes of the landfill will be armored with riprap material to at least the elevation of a 100-year flood event. The size of the riprap and the thickness of the riprap layer will resist the expected flow velocity from the 100-year flood and will include a conservative factor of safety.

- ***Outlet Protection Structures.*** At the discharge location of each culvert or drainage swale a stabilized outlet structure will be required to adsorb the energy of the storm water flow and dissipate runoff evenly over the ground surface. Riprap will be used to prevent scour at the outlet and to minimize the potential for erosion by reducing the velocity of flows.

- ***Permanent Vegetative Cover.*** The flat slopes at the top of the landfill will be stabilized with permanent vegetative cover. The surface shall be properly prepared as a seedbed and treated with fertilizer as appropriate. The mixture of seed will be fast growing and suitable to the Site and regional conditions. Seeded surfaces will be compacted and mulched, and then watered and maintained until an adequate and permanent vegetative cover is established.

- ***Buffer Zone Planting Plan.*** The riparian buffer zone and the buffer zone of the Class Two wetland located along the southern end of the site, adjacent to the Hoosic River, will be planted with native wetland trees and shrubs as shown on Drawing C-11.

- ***Maintenance.*** Conveyance structures shall be maintained so as to operate in the design condition. When necessary, velocity-attenuating devices, such as riprap or other means, shall be used to accomplish the desired result. Foreign debris shall not be allowed to accumulate in swales, drainage ditches, and detention ponds.

  Storm water infiltration basins and inlet protection controls are to be maintained in working order. Settled sediment and foreign debris shall be removed and properly disposed of as necessary.

APPENDIX A

DESIGN CALCULATIONS

SHEET NO. 1 OF 3
PROJECT NO. 0236 - POWNAL
DATE 6/23/03
BY AH
CHK'D M.P. 10/2/03

TRC
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SUBJECT DOUBLE CULVERT
SW. CORNER SED. TRAP 2

CULVERT ELEVATION: 500.5 FT (INLET ELEVATION TO SED TRAP)

DRAINAGE AREA: 5 ACRES (WORST CASE)

VOLUME REQUIRED: 1800 CF/ACRE

1800 CF/ACRE × 5 ACRES = 9,000 CF

ELEV. H2O TABLE = 496 FT

EXCAVATION DEPTH = 3 FT BOTTOM ELEVATION = 497 FT

$\frac{9,000 \text{ CF}}{3 \text{ FT}} = 3,000 \text{ SF}$

MAINTAIN 30 FT WIDTH

LENGTH = 100 FT

LENGTH OF OUTLET = 6 × DRAINAGE ARE

= 30 FT

A

SHEET NO. 2 OF 3

PROJECT NO. 02136 - BONDAL

DATE

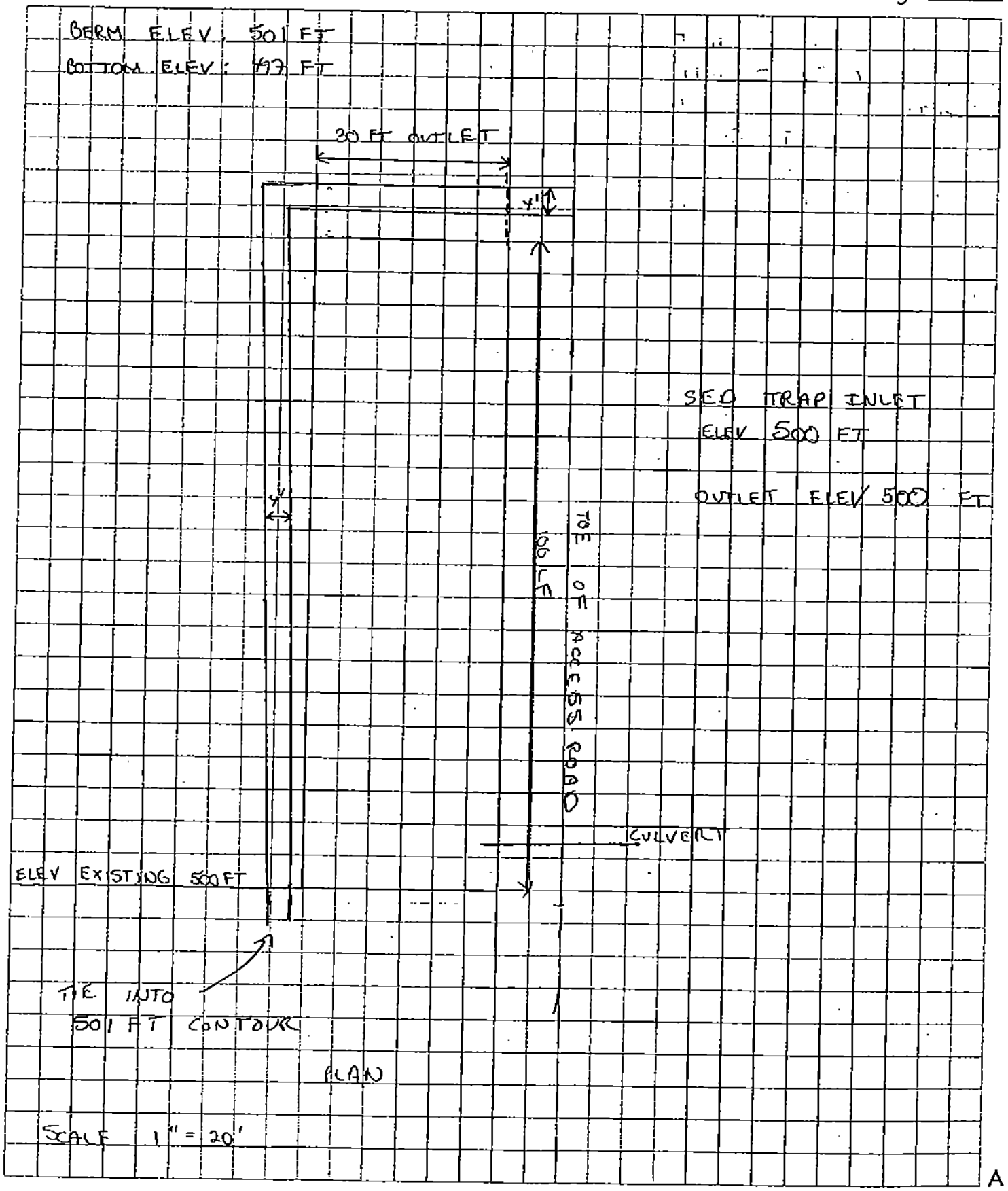
BY A.H.

CHK'D M.P. 10/21/03

TRC
Customer-Focused Solutions

SUBJECT SW CORNER SED TRAP

PLAN VIEW



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SHEET NO. 3 OF 3

PROJECT NO. 02136 - POWNAL

DATE

BY A.H

CHK'D M.P. 10/21/03

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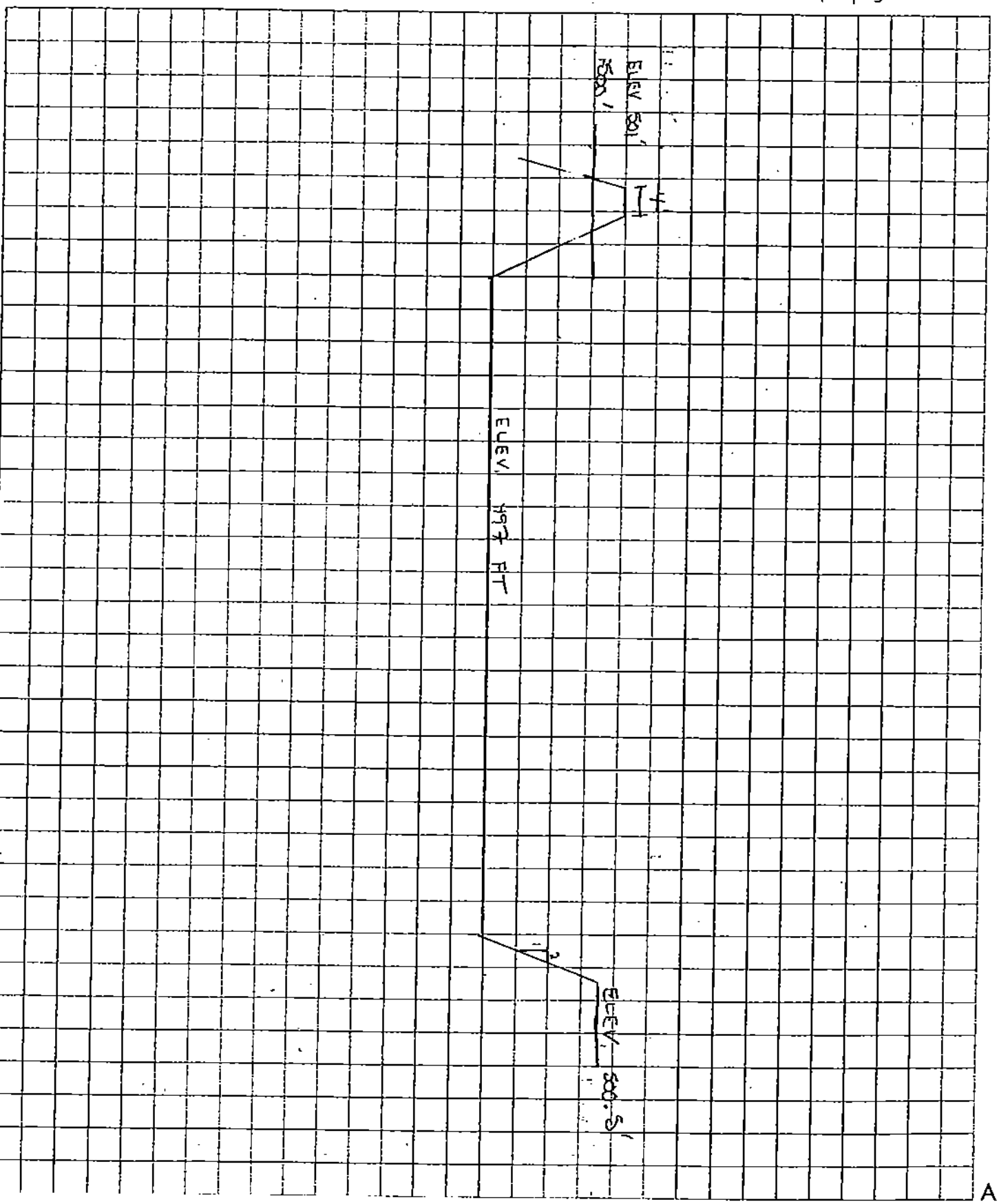
Customer-Focused Solutions

SUBJECT CROSS SECTION SW CORNER SED. TRAP



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SHEET NO. 1 OF

PROJECT NO. 02136 - POWNAL

DATE 6/23/03

BY AH

CHK'D M.P. 10/21/03

TRC
Customer-Focused Solutions

SUBJECT SINGLE CULVERT SED TRAP

→ CULVERT INLET 497.8 FT
50 LF @ .5% SLOPE

CULVERT ELEV = 497.55 FT

DRAINAGE AREA = 1 ACRE

VOLUME REQUIRED = 1,800 CF

DEPTH = 417.3 FT + 496 FT H2O ELEV.

= 1.3 FT

AREA = 1,385 SF

= 37' x 37' → HAVE ABOUT 37' x 50' AVAILABLE IN EXISTING DEPRESSION.

25 YR 24 HR EVENT = 4.8" EXTEND AREA IF FILLED IN DURING CONSTRUCTION OF ACCESS RD.

OUTLET ELEV = 497.0 FT

OPTION 1 OUTLET:

RISER PIPE WITH OUTLET THRU. BERM
DIRECT DISCHARGE TO HOOSIC RIVER.
PROBLEM - POSS. BLE ESCAPE ROUTE FOR CONSTRUCTION.

⇒ OPTION 2. EXCAVATE OUT A WIDER AREA TO CREATE AN ONSITE STORMWATER STORAGE AREA.

REASON → STORMWATER MANAGEMENT FEATURE MORE THAN SED TRAP

A

SHEET NO. _____ OF _____

PROJECT NO. _____

DATE _____

BY _____

CHK'D M.P. 10/21/03

TRC
Customer-Focused Solutions

SUBJECT RAIN VOLUME

25 YR STORM EVENT, 24 HR DURATION

4.8" = 0.40 FT

VOLUME = 0.4 FT × 43,560 SF

= 17,424 CF / 43,560 SF

= 0.4 ACRE-FT

A

SHEET NO. _____ OF _____

PROJECT NO. _____

DATE _____

BY A.H.

CHK'D A.P. 10/21/03

TRC
Customer-Focused Solutions

SUBJECT NORTHERN TOE SED. TRAP 1

INLET ELEV. = 498 FT.

DRAINAGE AREA = 5 ACRES

VOLUME REQUIRED: 1800 CF/ACRE

= 9,000 CF

ASSUME G.W. ELEV. = 496'

9,000 CF / 2' = 4500

9,000 CF / 1.5' = 6,000

AREA = 67' x 67'

A

Trapezoidal Drainage Channel Analysis
Pownal Tannery Superfund Site
Main Landfill, Riprapped-lined Drainage Channels, Southern Side

Manning's Equation

B	4	(Bottom Width)
N	0.069	(Mannings n) **For depth of flow 0.5 ft to 2 ft; D_{50} = 6"; Table 5.1 from Urban Drainage Design Manual**
S	0.01	(Channel Slope)
z	3	(Sideslope z:1)
z	3	(Sideslope z:1)

Depth (ft.)	Area (ft^2)	Perimeter (ft.)	Hydraulic Radius	Discharge (ft.^3/sec.)	Velocity (ft./sec.)
0.5	2.750	7.162	0.384	3.136	1.140
0.6	3.480	7.795	0.446	4.389	1.261
0.7	4.270	8.427	0.507	5.859	1.372
0.75	4.688	8.743	0.536	6.679	1.425 ←
0.8	5.120	9.060	0.565	7.556	1.476
0.85	5.568	9.376	0.594	8.492	1.525
0.9	6.030	9.692	0.622	9.488	1.574
0.95	6.508	10.008	0.650	10.545	1.620
1	7.000	10.325	0.678	11.664	1.666
1.05	7.508	10.641	0.706	12.847	1.711
1.1	8.030	10.957	0.733	14.094	1.755
1.15	8.568	11.273	0.760	15.406	1.798
1.2	9.120	11.589	0.787	16.785	1.840
1.25	9.688	11.906	0.814	18.232	1.882
1.3	10.270	12.222	0.840	19.747	1.923
1.35	10.868	12.538	0.867	21.333	1.963
1.4 ←	11.480	12.854	0.893	22.989	2.003 ←
1.45	12.108	13.171	0.919	24.718	2.042
1.5	12.750	13.487	0.945	26.520	2.080
1.55	13.408	13.803	0.971	28.396	2.118
1.6	14.080	14.119	0.997	30.348	2.155
1.65	14.768	14.436	1.023	32.377	2.192
1.7	15.470	14.752	1.049	34.483	2.229
1.75	16.188	15.068	1.074	36.667	2.265
1.8	16.920	15.384	1.100	38.932	2.301
1.85	17.668	15.700	1.125	41.277	2.336
1.9	18.430	16.017	1.151	43.704	2.371
1.95	19.208	16.333	1.176	46.214	2.406
2	20.000	16.649	1.201	48.807	2.440

(CAP IN PLACE) (AREA 3 POTW 25-YR) (AREA 4 POTW 25-YR)

FLOW = 4.0 CFS + 0.7 CFS + 1.5

= 6.2 CFS

Trapezoidal Drainage Channel Analysis
Pownal Tannery Superfund Site
Landfill, Drainage Channel Northern Side

Manning's Equation

B	2	(Bottom Width)
N	0.41	(Mannings n) **Dense Grass**
S	0.01	(Channel Slope)
z	3	(Sideslope z:1)
z	3	(Sideslope z:1)

Depth (ft.)	Area (ft^2)	Perimeter (ft.)	Hydraulic Radius	Discharge (ft.^3/sec.)	Velocity (ft./sec.)
0.5	1.750	5.162	0.339	0.309	0.177
0.6	2.280	5.795	0.393	0.445	0.195
0.7	2.870	6.427	0.447	0.609	0.212
0.75	3.188	6.743	0.473	0.703	0.220
0.8	3.520	7.060	0.499	0.804	0.228
0.85	3.868	7.376	0.524	0.914	0.236
0.9	4.230	7.692	0.550	1.032	0.244
0.95	4.608	8.008	0.575	1.158	0.251
1	5.000	8.325	0.601	1.293	0.259
1.05	5.408	8.641	0.626	1.438	0.266
1.1	5.830	8.957	0.651	1.591	0.273 ←
1.15	6.268	9.273	0.676	1.754	0.280
1.2	6.720	9.589	0.701	1.927	0.287
1.25	7.188	9.906	0.726	2.109	0.293
1.3	7.670	10.222	0.750	2.301	0.300
1.35	8.168	10.538	0.775	2.504	0.307
1.4	8.680	10.854	0.800	2.717	0.313
1.45	9.208	11.171	0.824	2.941	0.319
1.5	9.750	11.487	0.849	3.176	0.326
1.55	10.308	11.803	0.873	3.422	0.332
1.6	10.880	12.119	0.898	3.679	0.338
1.65	11.468	12.436	0.922	3.948	0.344
1.7	12.070	12.752	0.947	4.229	0.350
1.75	12.688	13.068	0.971	4.521	0.356
1.8	13.320	13.384	0.995	4.825	0.362
1.85	13.968	13.700	1.019	5.142	0.368
1.9	14.630	14.017	1.044	5.471	0.374
1.95	15.308	14.333	1.068	5.813	0.380
2	16.000	14.649	1.092	6.167	0.385

CAP IN PLACE Q = 1.64 CFS

Trapezoidal Drainage Channel Analysis
Pownal Tannery Superfund Site
Landfill, Drainage Channel Northern Side

Manning's Equation

B	2	(Bottom Width)
N	0.15	(Mannings n) **Short Grass**
S	0.01	(Channel Slope)
z	3	(Sideslope z:1)
z	3	(Sideslope z:1)

Depth (ft.)	Area (ft^2)	Perimeter (ft.)	Hydraulic Radius	Discharge (ft.^3/sec.)	Velocity (ft./sec.)	
0.5	1.750	5.162	0.339	0.845	0.483	
0.6	2.280	5.795	0.393	1.216	0.533	
0.7	2.870	6.427	0.447	1.665	0.580	←
0.75	3.188	6.743	0.473	1.921	0.603	
0.8	3.520	7.060	0.499	2.198	0.624	
0.85	3.868	7.376	0.524	2.498	0.646	
0.9	4.230	7.692	0.550	2.820	0.667	
0.95	4.608	8.008	0.575	3.165	0.687	
1	5.000	8.325	0.601	3.535	0.707	
1.05	5.408	8.641	0.626	3.929	0.727	
1.1	5.830	8.957	0.651	4.349	0.746	
1.15	6.268	9.273	0.676	4.794	0.765	
1.2	6.720	9.589	0.701	5.266	0.784	
1.25	7.188	9.906	0.726	5.764	0.802	
1.3	7.670	10.222	0.750	6.291	0.820	
1.35	8.168	10.538	0.775	6.845	0.838	
1.4	8.680	10.854	0.800	7.428	0.856	
1.45	9.208	11.171	0.824	8.040	0.873	
1.5	9.750	11.487	0.849	8.682	0.890	
1.55	10.308	11.803	0.873	9.354	0.908	
1.6	10.880	12.119	0.898	10.057	0.924	
1.65	11.468	12.436	0.922	10.792	0.941	
1.7	12.070	12.752	0.947	11.558	0.958	
1.75	12.688	13.068	0.971	12.357	0.974	
1.8	13.320	13.384	0.995	13.189	0.990	
1.85	13.968	13.700	1.019	14.054	1.006	
1.9	14.630	14.017	1.044	14.954	1.022	
1.95	15.308	14.333	1.068	15.888	1.038	
2	16.000	14.649	1.092	16.856	1.054	

CAP IN PLACE Q = 1.64 CFS

SHEET NO. 1 OF 3

PROJECT NO. 02136-0510-0198

DATE 4-30-03

BY A.H.

CHK'D A.P. 5/27/03

TRC
Customer-Focused Solutions

SUBJECT POWNAL RIPRAP DESIGN

PROBLEM: DETERMINE RIPRAP SIZE FOR THE WESTERN SLOPE OF THE LANDFILL ASSUMING A RIGHT OVERBANK CHANNEL VELOCITY OF 8.5 FT/SEC. AND A SIDE SLOPE OF 3H TO 1V.

SOLUTION: USING THE BASIC EQUATION FOR REPRESENTATIVE STONE SIZE IN STRAIGHT OR CURVED CHANNELS FROM U.S. ARMY CORPS OF ENGINEERS, ENGINEER'S MANUAL EM 1110-2-1601, HYDRAULIC DESIGN OF FLOOD CONTROL CHANNELS p. 3-5

$$D_{30} = S_f C_s C_v C_T d \left[\frac{\left(\frac{\gamma_w}{\gamma_s - \gamma_w}\right)^{1/2} V}{\sqrt{K_1 g d}} \right]^{2.5}$$

WHERE:

D_{30} = RIPRAP SIZE OF WHICH 30% IS FINER BY WEIGHT, LENGTH

S_f = SAFETY FACTOR; $S_{f\,min} = 1.1$

C_s = STABILITY COEFFICIENT FOR INCIPIENT FAILURE.
$D_{85}/D_{15} = 1.7$ TO 5.2
= 0.30 FOR ANGULAR ROCK

C_v = VERTICAL VELOCITY DISTRIBUTION COEFFICIENT
= 1.0 FOR STRAIGHT CHANNELS, INSIDE OF BENDS
= $1.283 - 0.2 \log (R/W)$, OUTSIDE OF BENDS [1 FOR $R/W > 26$]

C_T = THICKNESS COEFFICIENT
= 1.0 FOR THICKNESS = $1 D_{90}$ (MAX) OR $1.5 D_{50}$ (MAX) WHICHEVER IS GREATER.

d = LOCAL DEPTH OF FLOW, LENGTH; ASSUME 15 FT.

γ_w = UNIT WEIGHT OF WATER 62.4 LB/FT³

V = LOCAL DEPTH-AVERAGED VELOCITY; V_{ss} FOR SIDE SLOPE RIPRAP.

K_1 = SIDE SLOPE CORRECTION FACTOR

$$= \sqrt{1 - \frac{\sin^2\theta}{\sin^2\phi}} = \sqrt{1 - \frac{\sin^2 33^\circ}{\sin^2 40^\circ}} = .53$$

θ = ANGLE OF SIDE SLOPE WITH HORIZONTAL

ϕ = ANGLE OF REPOSE OF RIPRAP MATERIAL (NORMALLY 40 DEG.)

A

SHEET NO. 2 OF 3

PROJECT NO. 02136-0510-000098

DATE 4-30-03

BY A.H.

CHK'D M.P 5/27/03

TRC
Customer-Focused Solutions

SUBJECT RIPRAP DESIGN

g = GRAV. CONSTANT 32.2 FT/SEC^2

γ_s = UNIT WEIGHT OF STONE; USE 165 lb/FT^3

$$D_{30} = (1.1)(0.30)(1.0)(1.0)(15\ FT)\left[\left(\frac{62.4\ lb/FT^3}{165\ lb/FT^3 - 62.4\ lb/FT^3}\right)^{\frac{1}{2}}\left(\frac{8.5\ FT/SEC}{\sqrt{(.53)(32.2\ FT/SEC^2)15\ FT}}\right)\right]^{2.5}$$

$D_{30} = 0.55$

USING TABLE 3-1 FROM EM 1110-2-1601 SPECIFIC WEIGHT = 165 PCF

$D_{100} \doteq 15"$

$D_{30} = 0.61'$

$D_{10} = 0.88'$

RIPRAP THICKNESS $= 1.5 \times D_{100}$

$= 1.5 \times 15"$

$= 22.5"$

$= 1.90'$

$\sim 2'$

A

M.P. 5/27/03

Table 3-1
Gradations for Riprap Placement in the Dry, Low-Turbulence Zones

D_{100}(max) in.	Limits of Stone Weight, lb[1], for Percent Lighter by Weight: 100 Max	100 Min	50 Max[2]	50 Min	15 Max[2]	15 Min	D_{50}(min) ft	D_{85}(min) ft
Specific Weight = 155 pcf								
9	34	14	10	7	5	2	0.37	0.53
12	81	32	24	16	12	5	0.48	0.70
15	159	63	47	32	23	10	0.61	0.88
18	274	110	81	55	41	17	0.73	1.06
21	435	174	129	87	64	27	0.85	1.23
24	649	260	192	130	96	41	0.97	1.40
27	924	370	274	185	137	58	1.10	1.59
30	1,268	507	376	254	188	79	1.22	1.77
33	1,688	675	500	338	250	105	1.34	1.94
36	2,191	877	649	438	325	137	1.46	2.11
42	3,480	1,392	1,031	696	516	217	1.70	2.47
48	5,194	2,078	1,539	1,039	769	325	1.95	2.82
54	7,396	2,958	2,191	1,479	1,096	462	2.19	3.17
Specific Weight = 165 pcf								
9	36	15	11	7	5	2	0.37	0.53
12	86	35	26	17	13	5	0.48	0.70
15	169	67	50	34	25	11	0.61	0.88
18	292	117	86	58	43	18	0.73	1.06
21	463	185	137	93	69	29	0.85	1.23
24	691	276	205	138	102	43	0.97	1.40
27	984	394	292	197	146	62	1.10	1.59
30	1,350	540	400	270	200	84	1.22	1.77
33	1,797	719	532	359	266	112	1.34	1.96
36	2,331	933	691	467	346	146	1.46	2.11
42	3,704	1,482	1,098	741	549	232	1.70	2.47
48	5,529	2,212	1,638	1,106	819	346	1.95	2.82
54	7,873	3,149	2,335	1,575	1,168	492	2.19	3.17
Specific Weight = 175 pcf								
9	39	15	11	8	6	2	0.37	0.53
12	92	37	27	18	14	5	0.48	0.70
15	179	72	53	36	27	11	0.61	0.88
18	309	124	92	62	46	19	0.73	1.06
21	491	196	146	98	73	31	0.85	1.23
24	733	293	217	147	109	46	0.97	1.40
27	1,044	417	309	209	155	65	1.10	1.59
30	1,432	573	424	286	212	89	1.22	1.77
33	1,906	762	565	381	282	119	1.34	1.94
36	2,474	990	733	495	367	155	1.46	2.11
42	3,929	1,571	1,164	786	582	246	1.70	2.47
48	5,864	2,346	1,738	1,173	869	367	1.95	2.82
54	8,350	3,340	2,474	1,670	1,237	522	2.19	3.17

Notes:
1. Stone weight limit data from ETL 1110-2-120 (HQUSACE, 1971 (14 May), "Additional Guidance for Riprap Channel Protection, Ch 1," US Government Printing Office, Washington, DC). Relationship between diameter and weight is based on the shape of a sphere.
2. The maximum limits at the W_{50} and W_{15} sizes can be increased as in the Lower Mississippi Valley Division Standardized Gradations shown in Appendix F.

SHEET NO. 1 OF 3

PROJECT NO. 02136-0510-0IN9B

DATE 5-2-03

BY A. H.

CHK'D A.P. 5/27/03

TRC
Customer-Focused Solutions

SUBJECT TOE & END PROTECTION
BOUNDARY - RIPRAP DESIGN

PROBLEM: DETERMINE WESTERN SLOPE END PROTECTION AND TOE PROTECTION DETAILS FOR THE WESTERN SLOPE OF THE LANDFILL.

SOLUTION: EM 1110-2-1601
US ACE HYDRAULIC DESIGN OF FLOOD CONTROL CHANNELS.

END PROTECTION:

METHOD A - RIPRAP REVETMENTS ≤ 12 IN. THICK; EXTENDED TO AREAS WHERE VELOCITIES WILL NOT ERODE CHANNEL BANKS.

METHOD B - RIPRAP REVETMENTS > 12 IN THICK; EXTENDED TO AREAS WHERE VELOCITIES WILL NOT ERODE CHANNEL BANKS

⇒ METHOD C - RIPRAP REVETMENTS THAT DO NOT TERMINATE IN NONERODING CHANNEL VELOCITIES. THE WESTERN SLOPE OF THE LANDFILL TERMINATES IN THE RIGHT OVERBANK CHANNEL THAT HAS A VELOCITY OF 8.5FT/SEC.

SEE PLATE B-41 ATTACHED

TOE PROTECTION

METHOD A - TOE EXC. CAN BE MADE IN DRY. DUE TO HIGH WATER TABLE AT SITE - NOT APPROPRIATE.

SEE PLATE B-43

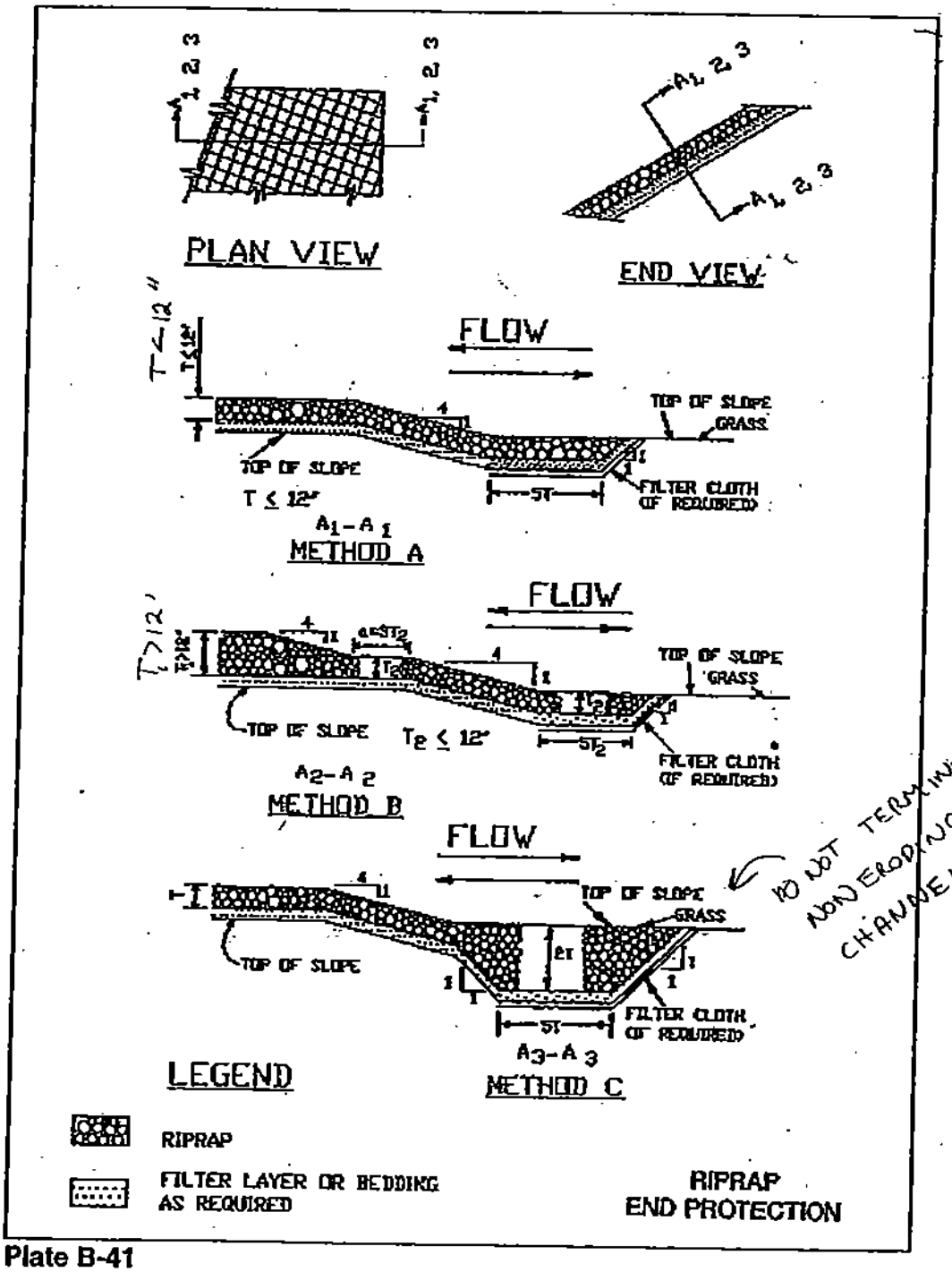
METHOD B - FOR CHANNEL BOTTOM THAT IS NONERODIBLE; NOT APPLICABLE.

⇒ METHOD C - APPROPRIATE WHEN LITTLE TOE SCOUR IS EXPECTED. BUILDUP OF ACCESS ROAD ON CHANNEL SIDE WILL MINIMIZE TOE SCOUR.

METHOD D - USES TOE SCOUR AS A SUB. FOR MECHANICAL EXC. (LAUNCHING STONE); NOT APPROPRIATE FOR REASON NOTED ABOVE IN METHOD C.

A

n.P. 5/20/03



DO NOT TERMINATE IN NONERODING NATURAL CHANNEL VELOCITIES

Plate B-41

M.P. 5/27/03

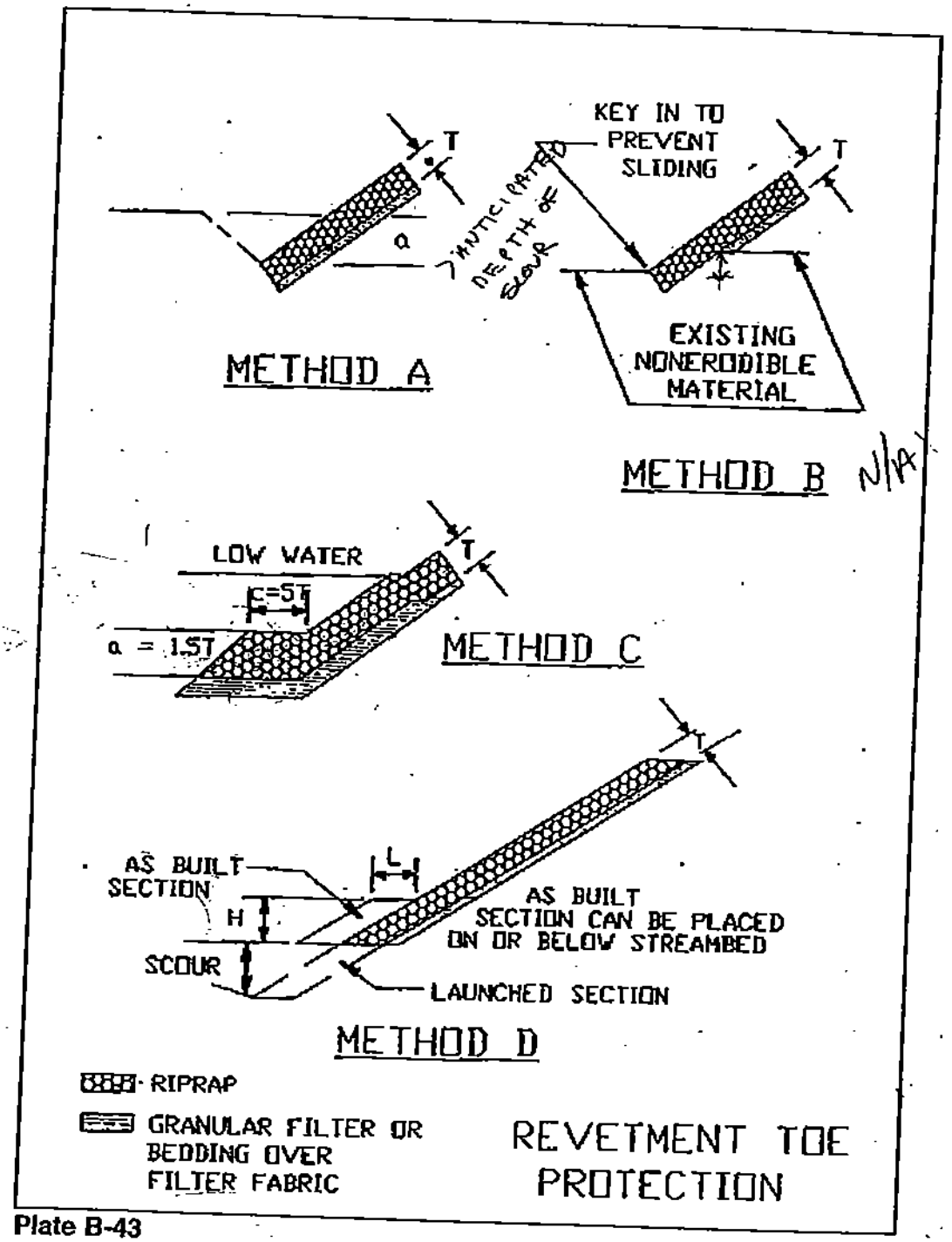


Plate B-43

SHEET NO. 1 OF 2

PROJECT NO. 02136-0510-01MB

DATE 5-8-03

BY A.H.

CHK'D M.P. 5/27/03

TRC
Customer-Focused Solutions

SUBJECT POWNAL - BERM OPENING — RIPRAP DESIGN FOR

PROBLEM: DETERMINE RIPRAP SIZE FOR THE BERM OPENING THAT WILL ALLOW THE RIGHT OVER BANK FLOW TO REENTER THE HOOSIC RIVER CHANNEL. THE OPENING IS LOCATED AT THE FAR NORTHERN TIP OF LAGOON 4 AT THE PORTION OF THE EXISTING BERM THAT RUNS PERPENDICULAR TO THE HOOSIC RIVER. ASSUME A RIGHT OVERBANK VELOCITY OF 8.5 FT/SEC.

SOLUTION: USE BASIC REPRESENTATIVE STONE SIZE EQUATION FOUND IN THE USACE EM 1110-2-1601

A

SHEET NO. 2 OF 2

PROJECT NO. 52136-0510-01W98

DATE 5-8-03

BY A.H.

CHK'D M.P. 5/27/03

TRC
Customer-Focused Solutions

SUBJECT RIPRAP DESIGN FOR BERM OPENING

$$D_{30} = S_F\, C_S\, C_V\, C_T\, d \left[\left(\frac{\gamma_w}{\gamma_s - \gamma_w} \right)^{1/2} \frac{V}{\sqrt{k_1 g d}} \right]^{2.5}$$

$S_F = 1.1$
$C_S = 0.30$
$C_V = 1.0$
$C_T = 1.0$
$d = 15'$
$\gamma_w = 62.4 \ lb/ft^3$
$V = 8.5 \ ft/sec$
$k_1 = 1$
$g = 32.2 \ ft/sec^2$
$\gamma_s = 165 \ lb/ft^3$

$$D_{30} = (1.1)(0.30)(1.0)(1.0)(15') \left[\left(\frac{62.4 \ lb/ft^3}{165 \ lb/ft^3 - 62.4 \ lb/ft^3} \right)^{1/2} \left(\frac{8.5 \ ft/sec}{\sqrt{(32.2 \ ft/sec^2)(15')}} \right) \right]^{2.5}$$

$D_{30} = 0.247'$

USE $\Rightarrow$ $D_{100} = 7''$
$D_{30} = 0.37'$
$D_{90} = 0.53'$

A

SHEET NO. 1 OF 2

PROJECT NO. 02136-0510-0N93

DATE

BY A.N.

CHK'D GAM

TRC
Customer-Focused Solutions

SUBJECT Rock outlet protection

Culvert 1

1-18" ø Pipe
Flow = 11 cfs
From Fig 5B.12
D_o = 1.5' use 2'
d_{50} = 5"
L_c = 10'
W = D_o + L_c
2' + 10' = 12'

Culvert 2

2-18" Pipes
Flow = 11 cfs / pipe
From Fig. 5B.12
D_o = 1.5 use 2'
d_{50} = 5"
L_c = 10'
W = (2' + 2') + 10' = 14'

Culvert 3

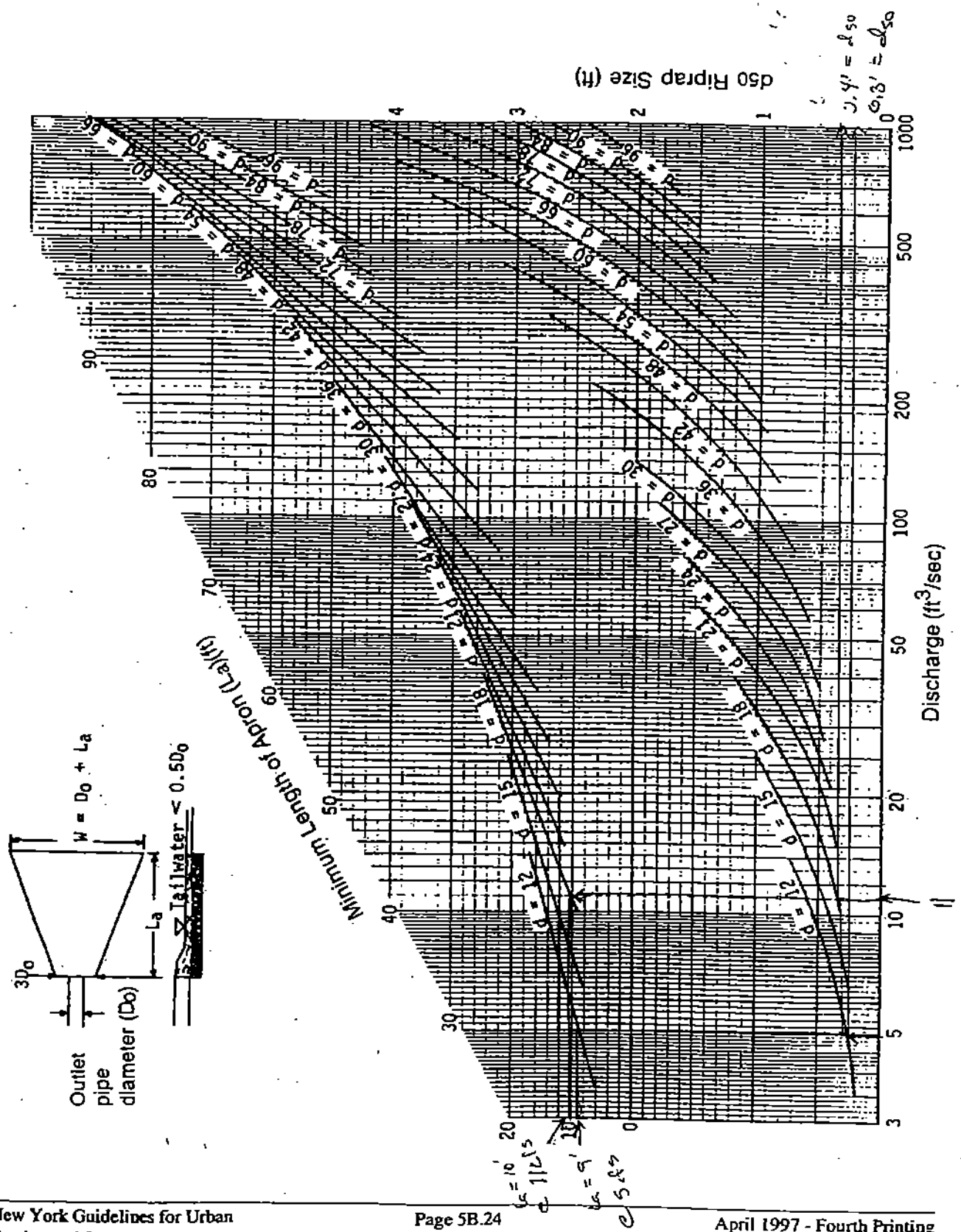
12" ø Pipe
Flow = 5 cfs
Fig 5B.12
D_o = 1'
d_{50} = 3"
L_c = 9'
W = 10'

→ Flow rates represent worst case condition calculated using rational method

L = Apron Length
W = Apron Width
D_o = Pipe Diameter

A

Figure 5B.12
Outlet Protection Design - Minimum Tailwater Condition
(Design of Outlet Protection from a Round Pipe Flowing Full, Minimum Tailwater Condition: $T_w < 0.5D_o$)

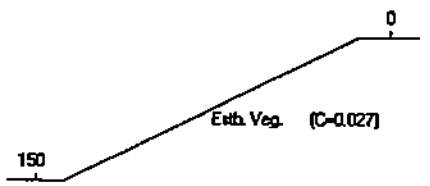


North American Green - ECMDS Version 4.2 | 11/3/2006 6:55 PM | COMPUTED BY: AH

PROJECT NAME: Pownal | PROJECT NO.: 02136 | SLOPE DESCRIPTION: Top of Landfill

County	United States
State/Region	Vermont
City	Bennington
Annual R Factor	100
Total Slope Length (ft)	150
Protection Type	Permanent
Protection Period (months)	
Beginning Month	
Adjusted R Value	100
Slope Gradient (H:1)	50
Soil Type	Silt Loam
K Factor	0.33
Soil Loss Tolerance (in)	0.03

Slope Gradient = 50:1



Not to Scale

Prepared By : AH

Checked By : M.D

Reach	Cum. Dist. Begin (ft)	Cum. Dist. End (ft)	Material	Vegetation Type Growth Habit	Density	ASL bare (in)	ASL mat (in)			SLT (in)	SF	Remarks
1	0	150	Estb. Veg.	Sod Former	50-75%	0.053	0.001			0.03	20.792	STABLE
2												
3												
	0	150		Composite		0.053	0.001					

Vegetation Density=Percentage of soil coverage provided by vegetation (Fraction of soil loss of unprotected)
C=Cover material performance factor

ASLbare=Average Soil Loss potential of unprotected soil (uniform inches) w/material (uniform inches)
ASLmat=Average Soil Loss potential

MSLbare=Maximum Soil Loss potential on unprotected soil (uniform inches) w/material (uniform inches)
MSLmat=Maximum Soil Loss potential

SLT=Soil Loss Tolerance for slope segment (uniform inches)
SF=Safety Factor

Composite=Average soil loss from total slope length (uniform inches)

$$ASL_{mat} = \frac{0.001 \text{ uni in/acre}}{0.00595} = .17 \text{ tons/acre/yr}$$

< 2 tons/acre/yr

****

NORTH AMERICAN GREEN EROSION CONTROL MATERIALS DESIGN SOFTWARE VERSION 4.2
NORTH AMERICAN GREEN SLOPE PROTECTION - ENGLISH/S.I.
USER SPECIFIED - PERMANENT BACK-UP COMPUTATIONS
****

PROJECT NAME: Pownal PROJECT NO.: 02136
COMPUTED BY: AH DATE: 11/3/2003
SLOPE DESCRIPTION: Top of Landfill

***** INPUT PARAMETERS *****

Slope Gradient: 50:1
Slope Degrees = tan^(-1) (1/50) = 01.15 degrees
Slope Length: 150 feet (45.7 meters)
Soil Type: Silt Loam
K Factor: K= 0.33 t*ac*h/100*ac*ft*tonf*in (K= 0.04 t*ha*h/ha*MJ*mm)
Annual R Factor: 100 100ft*t*in/ac*hr*yr (1702 MJ*mm/ha*h*y)
for United States, Vermont, Bennington
PRECIPDIST = 100

REACH NO.	CUMULATIVE DISTANCE TO END OF REACH	MATERIAL	TYPE	Density	C FACTOR
1	150 feet/45.7 meters	Estb. Veg.	Sod Former		0.027

SLT = 0.03 inches (0.08 centimeters)
ADJR = 100 * 100.0 / 100 =100.0 100ft*tonf*in/ac*hr*yr (1702. MJ*mm/ha*h*yr)
Soil Loss Factor (SLF) = 1.13 inches (2.87 cm)

***** CALCULATIONS *****

REACH NUMBER: ***1***
CUMHORZL1 =150 * cos(1.1) = 150.0 feet (45.7 meters)
LS 1 Factor = 0.27
Cumulative LS 1 Factor = 0.27
ASLBARE 1 = .00595 * 100 * 0.33 * 0.27 =0.053 in (0.136 cm)
MSLBARE 1 = .00595 * 100 * 0.33 * 1.13 *0.27 =0.060 in (0.153 cm)
ASLMAT 1 = 0.027 * 0.053 =0.001 in (0.004 cm)
MSLMAT 1 = 0.027 * 0.060 =0.002 in (0.004 cm)
SF 1 = 0.030 / 0.001 =20.792

COMPASLBARE 1 =0.053 * [(150 - 0) / 150] = 0.053 in (0.136 cm)

TOTCOMPASLBARE = 0.053 in (0.136 cm)

COMPASLMAT 1 =0.001 * [(150 - 0) / 150] = 0.001 in (0.004 cm)
TOTCOMPASLMAT = 0.001 in (0.004 cm)

For additional computation details, see the North American Green Users Manual
and the Natural Resource Conservation Service RUSLE Documentation.
"

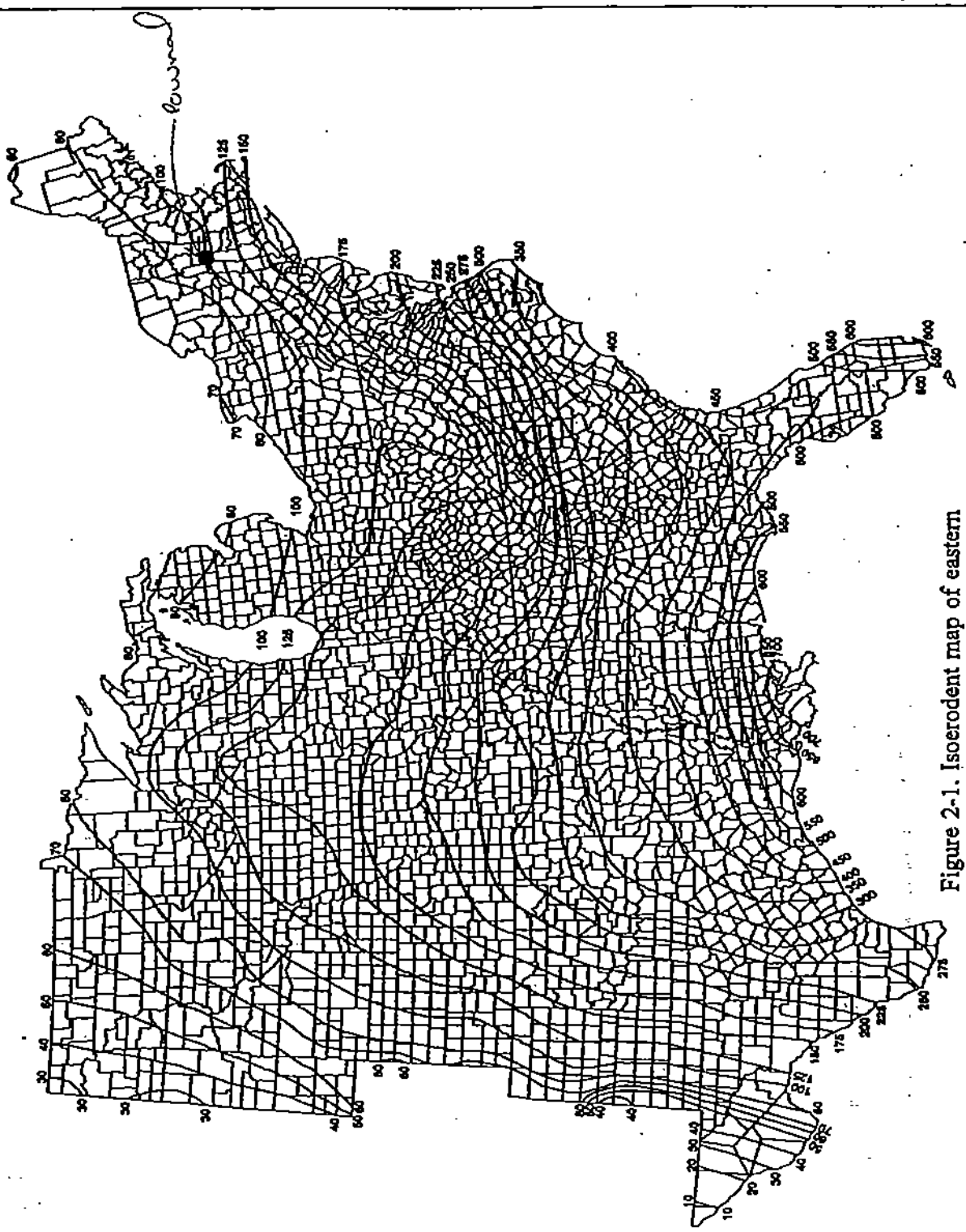
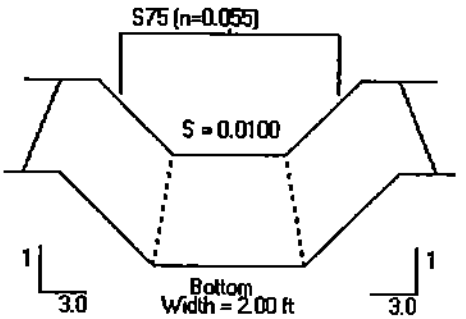


Figure 2-1. Isoerodent map of eastern United States. Units are hundreds ft·tonf·in(ac·h·yr)$^{-1}$.

North American Green - ECMDS Version 4.2		11/4/200	04:11 PM	COMPUTED BY: GAM
PROJECT NAME: Pownal Tannery Site		PROJECT NO.: 02136-0510		
FROM STATION/REACH: North	TO STATION/REACH:	DRAINAGE AREA:		DESIGN FREQUENCY: 25 year

HYDRAULIC RESULTS

Discharge (cfs)	Peak Flow Period (hrs)	Velocity (fps)	Area (sq.ft)	Hydraulic Radius(ft)	Normal Depth (ft)
1.6	2.0	1.20	1.37	0.29	0.42



BEND RESULTS

Bend Radius (ft)	Length Protection (ft)	Super Elevation Depth (ft)
90.0	2.6	0.4

Not to Scale

LINER RESULTS

Reach	Matting Type / Staple Pattern	Stability Analysis	Vegetation Characteristics: Phase	Class	Type	Density	Permissible Shear Stress (psf)	Calculated Shear Stress (psf)	Safety Factor	Remarks
Straight	S75	Unvegetated					1.55	0.26	5.91	STABLE
	Staple D									
Bend	S75	Unvegetated					1.55	0.26	5.91	STABLE
	Staple D									

****

ORTH AMERICAN GREEN EROSION CONTROL MATERIALS DESIGN SOFTWARE VERSION 4.2
ORTH AMERICAN GREEN CHANNEL PROTECTION - ENGLISH/S.I.
SER SPECIFIED CHANNEL LINING BACK-UP COMPUTATIONS
****

ROJECT NAME: Pownal Tannery Site PROJECT NO.: 02136-0510
OMPUTED BY: GAM DATE: 11/4/2003
ROM STATION/REACH: North Channel TO STATION/REACH:
RAINAGE AREA: DESIGN FREQUENCY: 25 year

****

INPUT PARAMETERS

****

annel Discharge : 1.6 cfs (.05 m^3/s)
ak Flow Period : 2 hours
annel Slope : 0.01 ft/ft (0.01 m/m)
annel Bottom Width : 2.0 ft (.61 m)
ft Side Slope : 3:1
ght Side Slope : 3:1

nd Curve Radius : 90.0 ft (27.43 m)

annel Lining : S75 Staple D
mi. Shear(Tp) :1.55 psf (74.2 Pa)
Phase = 0

****

CALCULATIONS

****

ial Depth Estimate = 0.16 * (1.6 /(0.010^0.5))^0.375 = 0.45 ft (.14 m)
al Channel Depth (after 9 iterations) = .42 ft (0.13 m)
w Area = (2.0 * 0.4)+(0.5 *0.42^2 * (3.0+3.0)) = 1.4 sq.ft (0.1 m^2)
t Per. =2.0 +(0.4*(((3.0^2)+1)^.5 +((3.0^2)+1)^.5)) = 4.7 ft (1.4 m)
draulic Radius = (1.4 / 4.7) = 0.3 ft (0.1 m)
annel Velocity =(1.486/0.055)*(0.3^0.667)*(0.010^.5) = 1.2 fps (0.4 m/s)

annel Effective Manning's Roughness = 0.055
Width = 2.0 + (0.4 * 3.0) + (0.4 * 3.0) = 4.5 ft (1.4 m)
lta Depth = (1.2^2 * 4.5) / (32.2 * 90.0) = .00 ft (0.00 m)
per Elevation Depth = 0.4 + 0.00 = 0.42 ft (0.13 m)
= 2.366*(e^(-.08347*90.0/2.0)) = .06
culated Shear (Td) = 62.4 * 0.42 * 0.010 = 0.26 psf (12.6 Pa)

ıfety Factor = (Tp/Td) = (1.55 /0.26) = 5.91
ılculated Bend Shear (Tdb) = (Kb*Td) = .06 * 0.26 = 0.26 psf (12.6 Pa)

fety Factor = (Tp/Tdb) = (1.55 / 0.26) = 5.91

APPENDIX L

TECHINICAL SPECIFICATIONS

EPA Contract No. 68-W6-0042
EPA Work Assignment No. 147-RDRD-01N9

EPA Project Officer: Diana King
EPA Remedial Project Manager: Leslie McVicker

Technical Specifications
Phase II Lagoon Area Remediation

Pownal Tannery Superfund Site
Pownal, Vermont

November 4, 2003

Prepared By:

Metcalf & Eddy, Inc.
30 Harvard Mill Square
Wakefield, MA 01880

TRC Environmental Corporation
Boott Mills South
Foot of John Street
Lowell, MA 01852

EPA Contract No. 68-W6-0042
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Boott Mills South
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Gregory A. Mischel, P.E.
Senior Project Engineer

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SECTION 01100

SUMMARY

PART 1 GENERAL

1.01 PROJECT

A. Project Name: Pownal Tannery Superfund Site Lagoon Area Remediation.

B. U.S. Environmental Protection Agency (USEPA) Identification No. VT069910354

C. Project Location: Between Route 346 and Hoosic River in the village of North Pownal, Vermont (Latitude: +42.797167; Longitude: -073.265750)

1.02 DEFINITIONS

A. "Engineer" - Response Action Contract (RAC) Subcontractor. RAC is the contract between EPA and Metcalf & Eddy.

B. "Subcontractor"- Remedial Action (RA) Subcontractor to Metcalf & Eddy and their subcontractors.

C. "the Drawings" - refers to set of project drawings entitled, "Lagoon Area Remediation, Pownal Tannery Superfund Site, Pownal, Vermont" prepared by Metcalf & Eddy and TRC Environmental Corporation.

D. "the Work" - the work described in these Specifications and the Drawings.

E. "the site" - Pownal Tannery Superfund Site

F. "Contract Documents" - collectively refers to subagreement and associated documents as defined in the Standard General Conditions including these specifications and the Drawings.

1.03 OVERALL PROJECT DESCRIPTION

A. The site consists of a 28-acre set of parcels located between Route 346 and the Hoosic River in the Village of North Pownal, Vermont which is in the south-western corner of the state. The site is a former hide tanning and finishing facility formerly owned by the Pownal Tanning Company, Inc. The site has been inactive since 1988. The site originally consisted of three contamination sources: the former tannery building complex, a capped sludge landfill, and a lagoon system. The lagoon complex area is the subject of the work described herein. The lagoon area is partially covered with soil, over which disturbed wetlands vegetation occurs. The lagoons contain elevated concentrations of lead, arsenic, pentachlorophenol, and dioxin, among other contaminants. The selected overall remedy includes: clearing and grubbing the lagoon area, excavation of contaminated sludge materials from two lagoons, construction dewatering, material stabilization for geotechnical purposes and consolidation over existing lagoons, and capping of the consolidated sludge with a landfill cover system.

B. The RA will be separated into two construction phases.

1. Phase I, which will have been completed prior to the Phase II work described herein, consists of site preparation work including: (1) installing sedimentation and erosion controls, (2) clearing and grubbing the future landfill footprint and adjacent areas and areas of sludge excavation, (3) establishing staging areas and installing security fencing, (4) monitoring well abandonment, and (5) backfilling Lagoon 2 with clean fill.

2. Phase II work will consist of: (1) installation and maintenance of sediment and erosion control measures, (2) excavation of sludge or stabilized sludge from the lagoons (over 40,000 cubic yards), (3) collection and treatment of potentially contaminated water, (4) sludge conditioning (stabilization) with a stabilizing agent (e.g. Quicklime and/or Portland

Cement), (5) placement and compaction in the consolidation landfill, (6) capping of the landfill (sand gas vent layer, low density polyethylene geomembrane, geocomposite drainage layer, vegetative support layer, topsoil and riprap), (7) installation of permanent sedimentation and erosion control measures and storm water management structures, and (8) site restoration.

1.04 GENERAL DESCRIPTION OF THE WORK UNDER THIS CONTRACT

A. Phase II of the Pownal Tannery Superfund Site Lagoon Area Remediation consists primarily of sludge excavation, stabilization, backfill and landfill consolidation and capping as defined in the Contract Documents. It is currently estimated that Phase II construction activities will occur over an approximate 10-month period, which includes a winter shutdown period. A summary of the Phase II Work is as follows:

1. Mobilization and Demobilization
   a. The Subcontractor will mobilize necessary labor, equipment, and materials to the site required to perform the Work, including storage trailers and temporary utilities necessary to complete the Work. Submit the required information and plans at beginning and at completion of the Work. At the end of the Work, demobilize labor, equipment, and materials from the site.
2. Site Control and Management
   a. The Subcontractor will furnish, install, and maintain erosion and dust control measures. Maintain the Existing Site Access Road to perform work. Conduct a pre-work survey to identify locations of the Work and a post-work survey to identify locations of completed construction.
3. Health and Safety
   a. The Subcontractor will prepare and implement a detailed site-specific Health and Safety Plan in accordance with Section 01120 – Health and Safety. The Subcontractor will take all necessary safeguards to prevent personal injury and property damage. The Subcontractor will provide protection for all persons including but not limited to his employees and employees of other Subcontractors or subcontractors; members of the public; and employees, agents, and representatives of the EPA, Engineer, and regulatory agencies that may be on or about the Work. The Subcontractor will provide protection for all public and private property including, but not limited to structures, pipes, and utilities. The Subcontractor will provide maintain all necessary safety equipment and security measures such as fences, barriers, signs, and fire prevention and fire-fighting equipment.
   b. The Subcontractor will designate a responsible member of his organization at the site whose duty shall be the prevention of accidents. The responsible person will have the authority to take immediate action to correct unsafe or hazardous conditions and to enforce safety precautions and programs.
   c. The potential for worker exposure will be addressed by implementing monitoring techniques suitable to ensure exposure limits set by the Occupational Safety and Health Agency (OSHA) are not exceeded. The requirements for appropriate personal protection equipment (PPE) and location, frequency and parameters to be monitored during all aspects of the air monitoring program, will be evaluated by a Certified Industrial Hygienist (CIH) and incorporated into the construction procedures and methods required for remedy implementation. In addition to worker exposure issues, hydrogen sulfide gas also has the potential to pose an explosion hazard. The plan shall address monitoring and mitigation measures to remedy any potential unacceptable emissions. Such measures may include continuous monitoring of the potential for explosive conditions in the work area, ventilation of excavations and use of non-sparking equipment.

4. Air Monitoring
   a. The Subcontractor will prepare and implement a Perimeter Air Monitoring and Emission Control Plan in accordance with Section 01130 – Perimeter Air Monitoring and Emission Control Plan. The Plan will address potential generation and mitigation of hydrogen sulfide gas, dust, and nuisance odors during remedial activities.

5. Excavation of Sludge (or stabilized sludge - see No. 8 below) from Lagoons 1 and 5
   a. The Contractor will prepare an Excavation Plan in accordance with Section 02315 – Excavation. This plan will address the means and methods of removing sludge and overlying cover material from Lagoons 1 and 5. In general, the excavation and backfill of Lagoons 1 and 5 will be phased to:
      1) limit the generation of gasses and vapors, including hydrogen sulfide and nuisance odors, that will likely be encountered while excavating sludge;
      2) minimize the accumulation of water within the excavation; and
      3) prevent contamination of clean backfill with potentially contaminated excavation water.
   b. Sludge in Lagoons 1 and 5 will be excavated and transported to the consolidation landfill. The sludge will require stabilization in order to compact in the Landfill. After conducting stabilization in situ, the stabilized material will be excavated and transported directly to the landfill. Observations of the sludge maintaining its in-situ form under saturated conditions during previous test pits excavations in Lagoons 1 and 5 suggest that the sludge can be excavated using standard excavation equipment. Unconfined compression tests on sludge samples, however, show very low undrained shear strengths indicating the sludge would not likely support the weight of heavy equipment.
   c. Cover soils have been placed over the sludge in Lagoon 1. These cover soils consist of a clay layer that is up to four feet thick and granular berm soils around the perimeter. Several feet of granular soil has also been observed over sludge around the perimeter of Lagoon 5. The clay cover material will be removed with the sludge and transported directly to the landfill for consolidation under the cap. Uncontaminated granular soil that is currently located over the sludge layer around the perimeter of Lagoons 1 and 5 will be removed, set aside, and reused as backfill in Lagoons 1 and 5 and/or to construct temporary berms within the excavation to contain loose sludge materials to the working face of the excavation and prevent the co-mingling of contaminated sludge and water with clean sidewall soils or backfill. Samples of the granular material will be collected and analyzed for contaminants of concern prior to re-use as clean backfill.
   d. Sludge will be excavated down to the underlying gravel layer. The area of exposed sludge during excavation shall be limited to minimize odors and dewatering. Excavated areas will be inspected to document sludge removal and backfilled as soon as possible to limit groundwater seepage into the excavation.
   e. Excavation side wall soil samples will be collected and analyzed by the Subcontractor for site-related contaminants. Engineer may order additional excavation based on the results of the chemical analyses.

6. Excavation Support
   a. The Subcontractor will design and construct a sheetpile wall between Lagoon 1 and the railroad right of way to minimize potential impacts to railroad infrastructure. The Contractor will prepare and implement a Temporary Support Plan and a Construction Contingency Plan in accordance with Section 02260 - Excavation Support and Protection to address means, methods, safety, and corrective action procedures related to the use of sheetpile wall.

7. Construction Water Management
   a. The Subcontractor will prepare and implement a Construction Water Management

Plan in accordance with Section 02240 – Construction Water Management. The Plan will address pumping, treatment, and discharge of existing surface water and ground water expected to seep into excavations during sludge removal activities.

b. Prior to excavation, surface water from Lagoons 1 and 5 will be pumped to a temporary, on-site treatment system. Treated water will then be discharged to the Hoosic River. Requirements for discharge, analytical testing, and testing frequency are outlined in Section 02240 - Construction Water Management.

8. Sludge Stabilization
   a. The Subcontractor shall select the means and methods to stabilize the Lagoon sludge. Both in-situ and ex-situ methods are acceptable.
   b. Due to the presence of hydrogen sulfide the Subcontractor shall stabilize the sludge using in situ methods.
   c. The Subcontractor will prepare and implement a Stabilization Plan in accordance with Section 02343 – Sludge Stabilization. The Plan will address means and methods for stabilizing the sludge and other materials to be placed in the landfill.
   d. Geotechnical testing of the sludge from Lagoons 1 and 5 indicates that the material exhibits a high water content and low shear strength. Therefore, stabilization will be necessary to strengthen the sludge for consolidation and compaction under the cap.
   e. Test data suggest that portland cement (dry form) or a combination of portland cement and Quicklime can improve the unconfined compressive strength of Lagoon 1 sludge samples under laboratory conditions. Results obtained by the Subcontractor may vary depending on actual field conditions and the means, methods, and materials selected by the Subcontractor to administer the Subcontractor-selected reagents

9. Sludge Placement
   a. Conditioned sludge will be transported, placed, and compacted in the consolidation landfill. No chemical testing of excavated sludge will be conducted since all sludge will be moved to the landfill and capped.

10. Backfilling of Lagoons 1 and 5
    a. Lagoons 1 and 5 will be backfilled after the sludge is excavated. Backfilling may be conducted in the wet using a granular material that can be dumped into place and compacted. Coordination of excavation and backfill placement will be described in the Excavation Plan. Water displaced by the backfill may become a nuisance and impede sludge excavation or backfilling operations. Removal and treatment of this excess water may be necessary.
    b. Backfilling of Lagoons 1 and 5 may be performed in the dry by removing all accumulated water from the excavation prior to placing fill material. All water must be treated prior to discharge.

11. Construction of a Landfill Cover System
    a. The consolidation landfill cover system is designed to eliminate direct exposure to the sludge material. The top slope of the landfill cap is comprised of the following components, described from bottom to top:
       1) Six inch layer of granular foundation/gas vent sand layer;
       2) 40-mil linear low density polyethylene (LLDPE) geomembrane barrier layer;
       3) Geocomposite drainage layer;
       4) Minimum 24 inches of vegetative support soil layer,
       5) Six inch layer of topsoil.
    b. The side slope of the landfill will have maximum slopes of 33.3 percent. The configuration of the side slope cap that will be potentially exposed to river flows, will include the following layers:
       1) Six inch layer of granular gas vent sand layer;
       2) Textured 40-mil LLDPE geomembrane barrier layer;

3) 12-inch thick layer of crushed stone;
4) 24-inch thick layer of riprap - designed to resist the anticipated maximum flow velocity of the 100-year flood flow.

c. Passive gas vents.

12. Site Restoration
    a. Construct permanent storm water and sedimentation and erosion controls.
    b. Install several ground water monitoring wells for post-remediation monitoring of the landfill.
    c. Grade, loam, and seed all of the areas disturbed during construction including the landfill cover and Lagoons 1 and 5.
    d. Install fencing on portions of the landfill cap and toe of the landfill as indicated in the Contract Documents.
    e. Construct perimeter access road.

1.05 SITE CONDITIONS

A. Work under Phase I will have been completed prior to mobilizing to the project site for Phase II. The following site improvements will be completed under Phase I:

1. Installation of erosion and sedimentation controls including silt fence/straw bale barriers and a stabilized construction entrance. The Phase II Subcontractor will be required to install additional controls as needed and maintain new and existing controls.
2. Areas of the project site will be cleared and grubbed. Additional clearing and grubbing will be required to accommodate the Work under Phase II.
3. Installation of a temporary site security fence and gate.
4. Backfilling of Lagoon 2 and preparation of staging areas for Phase II Work.
5. Consolidation of on-site debris in the Stump and Demolition Disposal Area within the footprint of the proposed landfill to be constructed under Phase II.

B. The Subcontractor is responsible for becoming familiar with site conditions to address all issues relative to completing the Work. The contaminated materials located at the site are concentrated in the sludge located in the lagoon areas. The following discusses the levels and locations of contaminated materials. The locations of the lagoons are shown in the Drawings. This summary is provided for information only. Refer to the Remedial Investigation for details. A paper copy of the Remedial Investigation is available for review at the following site information repositories:

1. Solomon Wright Public Library, Pownal Vermont, 05261
2. USEPA New England Records Center, One Congress Street, Boston, MA 02114 (617) 918-1440

C. Lagoon 1

Lagoon 1 contains the thickest accumulation of sludge. The sludge contains elevated concentrations of site contaminants and is generally buried beneath a thin layer of cover material. Lagoon 1 has the highest contaminant concentrations on the site. The upper surface of this sludge deposit was often coated with thin (<1 inch) layers of dry white powder, which may be lime that was added to the sludge to minimize odor generation.

Several volatile organic compounds (VOCs) were observed in Lagoon 1, with the highest concentrations detected in the sludge. Total VOC concentrations in the sludge were generally observed to range from 50-200 parts per million (ppm).

Several semivolatile organic compounds (SVOCs) were detected in Lagoon 1, with the highest

concentrations present in the sludge buried below 1-2 feet of cover material. The total SVOC concentrations in the upper layer of cover material were less than 1 ppm but the total SVOC concentration in the buried sludge reached over 600 ppm and several samples contain total SVOCs over 100 ppm.

Elevated metals concentrations were detected in the buried sludge including chromium at concentrations ranging from 10,000-70,000 ppm and lead from 1,000 to 2,000 ppm. The typical concentrations observed in the surface soils for chromium and lead are less than 2,000 ppm and 200 ppm respectively.

Only one polychlorinated biphenyl (PCB) compound was detected at a concentration of 18 parts per billion (ppb) in a surface soil sample (SBL1-01) from Lagoon 1, but four Aroclors were detected in subsurface soils at concentrations up to 400 ppb.

Elevated concentrations of dioxin were detected towards the center of Lagoon 1. The maximum detected Toxicity Equivalency Quotient (TEQ) concentration of 4560 nanograms per kilogram (ng/kg) was found in a sample collected from 5.5 feet below the lagoon surface. Concentrations decrease towards the edges of the lagoon to below 100 ng/kg.

D. Lagoon 2

Sludge in Lagoon 2 was removed during previous remedial action taken at the site. No remediation is planned for Lagoon 2. The town of North Pownal is planning to construct a waste water treatment plant at the present location of Lagoon 2.

E. Lagoon 3

Lagoon 3 is the smallest of the lagoons. The Lagoon is presently covered with clay and gravel fill and is largely unvegetated.

Eight VOCs (carbon disulfide, 2-butanone, toluene, ethylbenzene, xylenes, isopropylbenzene, 1,2 dichlorobenzene, and 1,4 dichlorobenzene) were detected in Lagoon 3, all at low concentrations (below 75 ppb).

Four SVOCs (phenol, 4-methylphenol, naphthalene, 2-methylnaphthalene) were detected at three locations within the sludge, all at concentrations below 10 ppm.

Metals are present in the greatest concentration within the sludge layer. Cadmium was not detected in surface soils, nor in the underlying gravel layer, but is present in the sludge at concentrations up to 42 ppm. Chromium and lead are present at concentrations up to two orders of magnitude greater (chromium up to 18,000 ppm, lead up to 565 ppm) than in surface soils or the underlying soil.

F. Lagoon 4

Lagoon 4 is the largest lagoon.

The maximum total VOC concentration is less than 200 ppb.

Eleven SVOCs are present in Lagoon 4.

The highest metals concentrations in Lagoon 4 are present in surface soil. Lead, chromium, and cadmium are present at higher concentrations (one to two orders of magnitude greater) in the surface soils than in the subsurface soils.

G. Lagoon 5

Lagoon 5 is mostly underwater throughout the entire year.

Three VOCs are present at concentrations above the detection limit: carbon disulfide (up to 1,400 ppb), methyl acetate (one detection at 60 ppb), and 1,2-dichlorobenzene (one detection

at 11 ppb).

Two SVOCs were detected in Lagoon 5: pentachlorophenol (6,300 ppb at one location) and bis(2-ethylhexyl)phthalate (less than 800 ppb).

Several metals are present in Lagoon 5, including arsenic (up to 2.1 ppb), chromium (up to 16,100 ppb), lead (up to 624 ppb) and mercury (up to 4.1 ppb).

Elevated concentrations of dioxin were detected toward the center of Lagoon 5. Dioxin TEQ concentrations up to 2,300 ng/kg were detected in shallow sludge samples collected towards the center of Lagoon 5. Concentrations decrease towards the edges of the lagoon.

1.06 SUBMITTALS

A. Requirements for submittal of data, drawings, and plans are specified in Section 01300 - Administrative Requirements.

1.07 MEETINGS

A. Requirements for project meetings including attendance and agenda are specified in Section 01300 - Administrative Requirements.

1.08 PROTECTION OF ENVIRONMENTAL RESOURCES

A. General - Provide and maintain, during the life of the contract, environmental protection. Plan for and provide protective measures to control pollution that develops during normal construction practice. Plan for and provide environmental protective measures required to correct conditions that develop during the construction of permanent or temporary environmental features associated with the project. Comply with Federal, State, and local regulations pertaining to the environment, including, but not limited to water, air, and noise pollution. Initial requirements and minimum performance standards are outlined in these specifications and associated Drawings.

B. Limit of Work (LOW) - Prior to any construction, the Subcontractor will visibly mark the boundary of all areas where work is to be performed under this contract.

C. Reduction of Exposure of Unprotected Erodible Soils - Backfilling brought to final grade will be finished as indicated and specified. Side slopes and back slopes shall be protected as soon as practicable upon completion of rough grading. All work shall be planned and conducted to minimize the duration of exposure of unprotected soils. Any disturbed areas which are not planned to be graded or otherwise worked on for more than one week shall be temporarily stabilized with appropriate temporary erosion and sedimentation controls, unless otherwise approved by the Engineer

D. Protection of Water Resources - The Subcontractor shall keep construction activities under surveillance, management, and control to minimize pollution of surface and ground waters.

E. Protection of Air Resources - The Subcontractor shall keep construction activities under surveillance, management, and control to minimize pollution of air resources. All activities, equipment, processes, and work performed by the Subcontractor in accomplishing the specified construction shall be in strict accordance with Federal and State emission and performance laws and standards.

1.09 WORK SEQUENCE

A. The Subcontractor shall initiate generation and submittal of required plans, product data, and other documentation required to perform the Work immediately upon start of Contract (i.e. Subcontract) Times as indicated in the Notice to Proceed.

B. The Subcontractor shall make all necessary submittals and other arrangements in a manner which facilitates the project completion within the required project schedule time frame. This shall include allowance for associated review times by other parties.

C. The Subcontractor must provide certification that each source of imported fill material meets the requirements of Section 106 of the National Historic Preservation Act prior to delivering imported fill to the site.

D. The Subcontractor shall perform the work in such a manner as to prevent the off-site migration of contaminated sediments and prevent the contamination of clean areas of the site and imported fill material.

E. The Subcontractor may work concurrently on several areas of the site to expedite the project.

F. Coordinate construction schedule and operations with Engineer.

G. Coordinate site activities in a manner to maintain site security.

H. Work shall be sequenced to stabilize and excavate sludge and contaminated materials at the eastern end of Lagoon 1 first.

I. Subcontractor shall remove all temporary facilities, equipment and materials from the Main Staging Area (Lagoon 2) by September 30 to a allow for construction of a waste water treatment plant by others.

J. Work shall be sequenced to allow backfilling of excavations in parallel with stabilization and excavation activities.

K. Excavation work to modify the soil berm at the northern end of Lagoon 4 shall not commence until the side slopes of the landfill have been covered by at least the gas vent layer sand and geomembrane layers.

L. The stabilized sludge shall not be placed in the landfill until the temporary access road and associated storm water management and erosion control measures have been installed.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION - NOT USED

END OF SECTION

SECTION 01120

HEALTH AND SAFETY

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Protection of personnel working on the site and persons in the vicinity of the site from exposure to on-site contaminants generated or released as a result of the Subcontractor's work on site.

B. Subcontractor's requirements for preparing, submitting, and implementing a site-specific health and safety plan (HASP) to protect personnel working on the site and persons in the vicinity of the site from exposure to on-site contaminants generated or released as a result of the Subcontractor's work on site.

1.02 RELATED SECTIONS

A. Section 01100 - Summary of Work

B. Section 01130 - Perimeter Air Monitoring and Dust Control Plan

C. Section 01300 - Administrative Requirements

D. Section 01500 - Temporary Facilities and Controls

E. Section 02260 - Excavation Support and Protection

F. Section 02315 - Excavation

G. Section 02343 - Sludge Stabilization

1.03 REFERENCES

A. Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities: NIOSH, 85-115.

B. Vermont's Occupational Safety and Health Administration (VOSHA).

C. Code of Federal Regulations (CFR) Title 29: Labor: U.S. Occupational Safety and Health Administration (OSHA), including, but not limited to the following:

1. 29 CFR 1904 - Recording and Reporting Occupational Injuries and Illnesses
2. 29 CFR 1910 - Occupational Safety and Health Standards
3. 29 CFR 1926 - Safety and Health Regulations for Construction.

D. CFR Title 49: Transportation, including, but not limited to the following:

1. 49 CFR 172 - Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements

E. USEPA Standard Operating Safety Guides: November 1984.

F. ACGIH Threshold Limit Values and Biological Exposure Indices, 2003.

G. American National Standards Institute (ANSI) Z358.1 (1990) Emergency Eyewash and Shower Equipment

1.04 PERFORMANCE REQUIREMENTS

A. OSHA Standards 29 CFR 1910, Section 120 (b) and 29 CFR 1926, Section 65 (b) require employers to develop and implement a written Health and Safety Program for employees involved in hazardous waste operations. The site-specific program requirements of the OSHA

Standards shall be integrated into one site-specific document, the HASP. The HASP shall interface with the employer's overall Health and Safety Program. Any portions of the overall Health and Safety Program that are referenced in the HASP shall be included as appendices to the HASP.

B. Comply with applicable laws and regulations of any public body having jurisdiction for safety of persons or property. Requirements delineated in this section are in addition to or an amplification of procedures and requirements of the referenced regulations and documents.

C. Initiate, maintain, and supervise safety precautions and programs in connection with the Work. Take necessary precautions for safety of employees and other persons and organization that may be affected by the Work. Implement and enforce health and safety requirements and take necessary precautions and provide protection for the following:

1. Personnel working on or visiting site, irrespective of employer, including subcontractors hired by the Subcontractor.
2. Work and materials or equipment to be incorporated in work areas on site or off site.
3. Public potentially exposed to job related operations or potential release of toxic or hazardous materials.

D. Prior to construction initiation and at regular intervals during conduct of the Work, the Contractor shall conduct a safety meeting to discuss training on hazard recognition, response to emergencies, explanation of site activities, obtainment of safety supplies, identification of safety personnel, decontamination procedures, level of personal protection equipment (PPE) required, air monitoring activities, and any other topic relevant to the safety of workers at the site.

1.05 SUBMITTALS

A. See Section 01300 - Administrative Requirements, for submittal procedures.

B. Site-specific HASP; to be prepared by the Subcontractor.

1. Prior to submittal, the HASP shall be signed and dated by the Health and Safety Manager, Site Health and Safety Officer, and the Site Superintendent. The HASP shall be submitted for review at least 30 days prior to a Preconstruction Safety Conference. Deficiencies in the HASP will be discussed at the preconstruction safety conference, and the HASP shall be revised to correct the deficiencies and resubmitted for acceptance. On-site work shall not begin until the plan has been accepted by the Engineer. A copy of the written HASP shall be maintained on site. As work proceeds, the HASP shall be adapted to new situations and new conditions. Changes and modifications to the accepted HASP shall be made with the knowledge and concurrence of the Health and Safety Manager, the Site Health and Safety Officer, the Site Superintendent, and the Engineer. Should any unforeseen hazard become evident during the performance of the work, the Site Health and Safety Officer shall bring such hazard immediately to the attention of the Health and Safety Manager, the Site Superintendent, and the Engineer, both verbally and in writing, for resolution as soon as possible. In the interim, necessary action shall be taken to re-establish and maintain safe working conditions in order to safeguard on site personnel, visitors, the public, and the environment. Disregard for the provisions of this specification or the accepted HASP shall be cause for stopping of work until the matter has been rectified.
2. The HASP shall be made available in accordance with 29 CFR 1910, Section .120 (b)(1)(v) and 29 CFR 1926, Section .65 (b)(1)(v).
3. No on-site work will commence until the Subcontractor has submitted and the Engineer has accepted the HASP.

4. Submittal of Subcontractor's HASP shall neither impose on Engineer responsibility for adequacy of HASP nor relieve Subcontractor from full responsibility thereof.

C. Submit personnel exposure monitoring/sampling results, ambient air monitoring/sampling results, and site control logs to Engineer.

D. Submit accident/incident reports and other reporting documentation required by law to the Engineer within 24 hours of accident.

1.06 SITE INFORMATION

A. A summary of site contamination is presented in Section 01100 - Summary of Work.

B. The Pownal Tannery Superfund Site is listed on the EPA National Priority List. The responsibility of development, implementation, and enforcement of the HASP lies with the Subcontractor and their health and safety personnel.

C. A paper copy of the Remedial Investigation is available for review at the following site information repositories:

1. Solomon Wright Public Library, Pownal Vermont, 05261

2. EPA New England Records Center, One Congress Street, Boston, MA 02114 (617) 918-1440

D. Hydrogen Sulfide

1. Among other contaminants at the site, personnel assigned to this site should be aware that significant airborne concentrations of hydrogen sulfide have been identified during recent sampling events conducted in Lagoon 1 and Lagoon 3. These concentrations require increased diligence to health and safety procedures.

2. The apparent source of the hydrogen sulfide is the buried tannery sludge which contains significant amounts of organic material (e.g., hides, hair, leather) and appears to be generating hydrogen sulfide, methane (which is odorless) and other malodorous gaseous compounds as a result of anaerobic decay. Some malodorous compounds in landfill gas can overpower hydrogen sulfide, which is typically present in landfill gas. The presence of methane is known to enhance the perception of other malodorants, which may make it difficult to smell hydrogen sulfide odors at this site, in addition to the potential impact of olfactory fatigue.

3. Equipment to monitor for hydrogen sulfide shall be provided by the Subcontractor. Measurements shall be made utilizing equipment capable of detecting hydrogen sulfide concentrations at levels sufficiently low enough to be protective of human health.

E. Asbestos

1. As part of previous response actions conducted in the lagoon area, approximately 800 linear feet of 18-inch diameter and 800 linear feet of 6-inch diameter transite pipe were excavated and removed from beneath the Lagoon access road. The pipes were formerly used to convey primary treated wastewater and sludge from the former Screen House to the Lagoons. Sections of this transite pipe are present in lagoon areas and require removal.

F. Additional site information may be obtained at the internet web site: www.epa.gov/region01/superfund/sites/pownal/.

PART 2 PRODUCTS

2.01 GENERAL

A. Site-specific HASP

1. The HASP shall be prepared covering on-site work to be performed by the Subcontractor and all subSubcontractors. The Site Health and Safety Officer shall be responsible for the development, implementation and oversight of the HASP. -The HASP shall establish, in detail, the protocols necessary for the anticipation, recognition, evaluation, and control of hazards associated with each task performed. The HASP shall address site-specific health and safety requirements and procedures based upon site-specific conditions. The level of detail provided in the HASP shall be tailored to the type of work, complexity of operations to be performed, and hazards anticipated. Details about some activities may not be available when the initial HASP is prepared and submitted. Therefore, the HASP shall address, in as much detail as possible, anticipated tasks, their related hazards and anticipated control measures.

2. The Subcontractor is responsible for adequacy of HASP preparation, implementation, and enforcement. The HASP shall be reviewed and approved by a Certified Industrial Hygienist (CIH).

3. At a minimum, the HASP shall address the following:
   a. Site description and history.
   b. Subcontractor organization chart and responsibilities.
   c. Project activities and work plan.
   d. Hazard analysis.
   e. Safety responsibilities.
   f. Methods to monitor entry and exit from the work site.
   g. A Site Control Program including work zones with drawings identifying work zone boundaries.
   h. Personnel training program and evidence.
   i. Medical monitoring program and evidence.
   j. Air monitoring.
   k. Personal protection, clothing and equipment.
   l. Personnel and equipment decontamination procedures.
   m. Decontamination facilities.
   n. Emergency Response Plan, equipment, and emergency reporting procedures.
   o. Certification of completed training and acquired experience meeting the requirements of 29 CFR 1910.120 for all employees designated to engage in on-site activities subject to 29 CFR 1910.
   p. Resumes of the Subcontractor's Project Manager, Field Supervisor, Health and Safety Officer (HSO).
   q. Standard Operating Procedures.
   r. Method to inform Subcontractors and Subcontractors
   s. Confined space entry.
   t. Spill Containment Program.

B. At least one copy of each item listed in this section shall be present at the site at all times.

PART 3 EXECUTION

3.01 ORGANIZATIONAL RESPONSIBILITIES

A. A Key Personnel and Organizational Chart indicating lines of authority, responsibility, and communication shall be presented in the HASP. The Subcontractor must provide an organization chart and resumes of the Subcontractor's key personnel involved in all phases of

the Pownal Tannery Superfund Site construction activities. This chart must include, but not limited to, Senior Level Management, Project Manager, Health and Safety Manager, Health and Safety Officer, Field Supervisor, and Foreman Personnel. Resumes are required for the Project Manager, Health and Safety Manager, Field Supervisor, and Health & Safety Officer.

B. Health and Safety Manager. The services of an Industrial Hygienist currently certified by the American Board of Industrial Hygiene or a safety professional certified by the Board of Certified Safety Professionals shall be utilized. The name, qualifications (education summary and documentation, [ABIH] [BCSP] certificate), and work experience summary shall be included in the HASP.

1. The Health and Safety Manager shall have the following additional qualifications:
   a. A minimum of 3 years experience in developing and implementing health and safety programs at hazardous waste sites.
   b. Documented experience in supervising professional and technician level personnel.
   c. Documented experience in developing worker exposure assessment programs and air monitoring programs and techniques.
   d. Documented experience in the development of personal protective equipment programs, including programs for working in and around potentially toxic, flammable and combustible atmospheres and confined spaces.
   e. Working knowledge of state and Federal occupational health and safety regulations.

2. The Health and Safety Manager shall possess a sound working knowledge of Vermont and Federal occupational safety and health regulations and shall have formal educational training in occupational safety and health. Documentation shall be provided that the HSO has completed the 40-hour OSHA Training Course, the 8-hour OSHA Supervisor Training course and meets the field experience requirements.
   a. Be responsible for the development, implementation, oversight, and enforcement of the HASP.
   b. Sign and date the HASP prior to submittal.
   c. Be available for emergencies.
   d. Provide on-site consultation as needed to ensure the HASP is fully implemented.
   e. Coordinate any modifications to the HASP with the Site Superintendent, the HSO, and the Engineer.
   f. Provide continued support for upgrading/downgrading of the level of personal protection.
   g. Be responsible for evaluating air monitoring data and recommending changes to engineering controls, work practices, and PPE.
   h. Review accident reports and results of daily inspections, as appropriate.

C. Site Health and Safety Officer (HSO). The Subcontractor must identify and assign an HSO for the project. That individual must be responsible to the Subcontractor and have the authority and knowledge necessary to implement the site HASP and verify compliance with applicable safety and health requirements.

1. The HSO shall have the following responsibilities and authority to perform the following functions:
   a. Be present during site operations.
   b. Have the authority to enforce the HASP and stop operations if personnel safety and health may be jeopardized.
   c. Evaluate health monitoring data and make necessary field decisions regarding safety and health.
   d. Initiate evacuation of the site if necessary.
   e. The HSO will be the person responsible for causing an appropriate response to be undertaken during an emergency incident.
   f. Consult with and coordinate any modifications to the HASP with the Health and Safety

Manager, the Site Superintendent, and the Engineer.

g. Serve as a member of the Subcontractor's quality control staff on matters relating to safety and health.
h. Conduct accident investigations and prepare accident reports.
i. In coordination with site management and the Health and Safety Manager, recommend corrective actions for identified deficiencies and oversee the corrective actions.

2. The HSO shall meet the following minimum qualifications:
   a. HSO shall possess a sound working knowledge of Vermont and Federal occupational safety and health regulations and shall have formal educational training in occupational safety and health. Documentation shall be provided that the HSO has completed the 40-hour OSHA Training Course, the 8-hour OSHA Supervisor Training Course and meets the field experience requirements.
   b. Have documented experience that the HSO has worked on two (2) projects similar in nature to this one.

3.02 RISK ANALYSIS

A. The HASP shall include a health and safety hazard/risk analysis for each site task and operation to be performed. The hazard/risk analysis shall provide information necessary for determining health and safety procedures, equipment, and training to protect on-site personnel, the environment, and the public. Available site information shall be reviewed when preparing the "Hazard/Risk Analysis" section of the HASP. The following elements, at a minimum, shall be addressed.

1. Site Tasks and Operations (Workplan): The HASP shall include a comprehensive section that addresses the tasks and objectives of the site operations and the logistics and resources required to complete tasks and obtain objectives.

2. Hazards: The following potential hazards may be encountered during site work. These are not complete lists; therefore, they shall be expanded and/or revised as necessary during preparation of the HASP.
   a. Safety Hazards: Include a list of hazards expected to be encountered during site activities. Evaluate safety hazards including, but are not limited to, open excavations, slips, trips, and falls, electricity, equipment and machinery.
   b. Chemical Hazards: The Hazard/Risk Analysis section of the HASP shall describe the chemical, physical, and toxicological properties of contaminants, sources and pathways of employee exposures, anticipated on-site and off-site exposure level potentials, and regulatory (including Federal, state, and local) or recommended protective exposure standards. The HASP shall also address employee exposure to hazardous substances brought on-site, and shall comply with the requirements of 29 CFR 1910, Section .1200 and 29 CFR 1926, Section .59, Hazard Communication.

3. Action Levels: The action levels and required actions (engineering controls, changes in PPE, etc.) shall be presented in the HASP in both text and tabular form. Action levels shall be established for the situations listed below, at a minimum.
   a. Implementation of engineering controls and work practices.
   b. Upgrade or downgrade in level of personal protective equipment.
   c. Work stoppage and/or emergency evacuation of on-site personnel.
   d. Prevention and/or minimization of public exposures to hazards created by site activities.
   e. For reference, predicted air hazards and action levels are included as Attachment A. These Action Levels are based on average contaminant levels in the lagoon subsurface soils and can be used as a guide.

3.03 MEANS TO CONTROL EMPLOYEE EXPOSURE

A. Engineering and Work Practice Controls. The Subcontractor shall specify and implement engineering and work practice controls to minimize exposure of personnel working on the site to contaminants generated or released as a result of work on the site.

B. Employee Air Monitoring Program. The Subcontractor shall establish and implement an employee air monitoring program in accordance with 29 CFR 1910.120(h) to identify areas of elevated airborne contaminant concentrations and to determine the level of the concentrations relative to background. The Subcontractor shall provide the personnel, instruments, and materials necessary to perform such air monitoring and identify the individual responsible for administering the program. The program shall be included in the HASP. The Employee Air Monitoring Program shall be separate from, and in addition to, the Perimeter Air Monitoring and Emissions Plan specified in Specification 01130 - Perimeter Air Monitoring and Emissions Plan.

3.04 TRAINING

A. Site Specific Training

1. At a minimum, personnel shall receive training in accordance with the Subcontractor's written safety and health training program and 29 CFR 1910 Section .120, 29 CFR 1926 Section .65, and 29 CFR 1926 Section .21. The HASP shall include a section describing training requirements.

2. General Hazardous Waste Operations Training: Personnel entering the exclusion or contamination reduction zones shall, at a minimum, have successfully completed 40 hours of hazardous waste instruction off the site; 3 days actual field experience under the direct supervision of a trained, experienced supervisor; and 8 hours refresher training annually. On-site supervisors shall have completed the above training and 8 hours of additional, specialized training covering such topics as, but not limited to: the employer's safety and health program, personal protective equipment program, spill containment program, and health hazard monitoring procedures and techniques. Copies of current training certification statements shall be submitted prior to initial entry onto the work site.

3. Prior to construction, the Subcontractor shall provide site specific training that will provide, at a minimum, an awareness of planned operations, the site-specific HASP, the form and warning properties of potential hazards, work zones, locations of emergency/safety equipment, local emergency response procedures, site characteristics, levels of protection, communications, decontamination procedures, emergency facilities and signals, and evacuation procedures and supplement this with daily safety briefings as activities/operations change.

4. The Subcontractor shall provide a plan for safety and emergency response orientation and training for all employees. The plan shall include identification of, and credentials of, the person who shall give the training and topics to be covered.

B. Personnel Protective Equipment and Levels of Protection

1. When engineering and work practice controls are not feasible, any reasonable combination of engineering controls, work practices, and PPE shall be used to reduce and maintain exposures at or below exposure limits. The Subcontractor shall provide and use, under each item of work requiring such protection, PPE.

2. The Subcontractor shall select PPE and shall assemble the PPE into levels of protection (LOP) or ensembles appropriate for the site.

3. The Subcontractor shall include in the HASP a list of components for each protective ensemble, the LOP selected for each task, the rationale for each task specific selection, and any contaminant action levels to be followed in LOP decision making.

4. The Subcontractor shall show evidence of a PPE program meeting the requirements of 29 CFR 1910 Subpart I and 1910.120(g).

3.05 MEDICAL SURVEILLANCE

A. Medical Surveillance Program. The Subcontractor shall show evidence of a medical surveillance program (MSP), for employees engaged in on-site operations, consistent with 29 CFR 1910.120(f).

B. Personnel Certification. The Subcontractor shall provide written approval by a certified physician of the medical fitness for work of all employees designated to engage in on-site operations at a minimum of five (5) regular working days prior to the employee's start of those operations.

C. Employee Heat and Cold Stress Prevention

1. As dictated by seasonal conditions, the Subcontractor shall implement an employee heat and cold stress prevention program during site operations and shall incorporate the program into the site HASP.

2. The program shall include employee awareness of: the signs and symptoms of heat and cold stress, preventive measures, and environmental and employee parameters to be monitored.

3.06 PERSONAL PROTECTIVE EQUIPMENT

A. In accordance with 29 CFR 1910 Section .120 (g)(5) and 29 CFR 1926 Section .65 (g)(5), a written Personal Protective Equipment (PPE) program which addresses the elements listed in that regulation, and which complies with respiratory protection program requirements of 29 CFR 1910 Section .134, is to be included in the employer's Health and Safety Program. The HASP shall detail the minimum PPE ensembles (including respirators) and specific materials from which the PPE components are constructed for each site-specific task and operation to be performed, based upon the hazard/risk analysis. Components of levels of protection (B, C, D and modifications) must be relevant to site-specific conditions, including heat and cold stress potential and safety hazards. Only respirators approved by NIOSH shall be used. On-site personnel shall be provided with appropriate personal protective equipment. Protective equipment and clothing shall be kept clean and well maintained. The PPE section of the HASP shall include site-specific procedures to determine PPE program effectiveness and for on-site fit-testing of respirators, cleaning, maintenance, inspection, and storage of PPE.

B. Levels of Protection: The Health and Safety Manager shall establish appropriate levels of protection for each work activity based on review of historical site information, existing data, an evaluation of the potential for exposure (inhalation, dermal, ingestion, and injection) during each task, past air monitoring results, and a continuing safety and health monitoring program. The Health and Safety Manager shall also establish action levels for upgrade or downgrade in levels of PPE from the following specified minimum levels of protection. Protocols and the communication network for changing the level of protection shall be described in the HASP. The PPE reassessment protocol shall address air monitoring results, potential for exposure, changes in site conditions, work phases, job tasks, weather, temperature extremes, individual medical considerations, etc.

3.07 SITE STANDARD OPERATING PROCEDURES

A. The Subcontractor shall be responsible for developing and implementing necessary standard operating procedures (SOPs) for all site operations.

3.08 SITE CONTROL

A. The Subcontractor shall implement a Site Control program in accordance with 1910.120(d)(2).

B. Routine Requirements. For ongoing operations, the HSO and/or his designee will be required to meet with the Engineer or designee, when present, prior to the start of the day's activities to prepare all the necessary paperwork and outline the day's activities. The HSO shall also meet with the Engineer or designee at the completion of the day's activities to discuss the work performed.

C. Work Zones

1. The Subcontractor shall be responsible for conducting operations at the site in such a controlled fashion as to minimize the possibility of employee and community contact and exposure to contaminants present on the site and to prevent the removal of contaminants generated on the site by personnel or equipment leaving the site.

2. The Subcontractor shall incorporate into the HASP plans for routine and emergency communications appropriate for the site and Work in the HASP.

3. The Subcontractor shall keep a daily visitor log in accordance with Section 01500 - Temporary Facilities and Controls, copies to be provided to the Engineer upon request.

4. The Subcontractor shall provide the Engineer a list of all Subcontractor and subcontractor personnel who are authorized to enter the site prior to the start of operations, updating the list as necessary. No unauthorized persons shall be permitted to enter the site.

5. The Subcontractor shall provide appropriate PPE and decontamination facilities for use by the Subcontractor, subcontractors, EPA, VTDEC, and authorized site visitors. The Subcontractor shall be responsible for final disposition of disposables used by the aforementioned personnel.

D. Other

1. The Subcontractor shall be responsible for conducting operations in accordance with Federal, State and local regulations and requirements for storage of the Subcontractor's hazardous materials (i.e. gasoline, lube oils, etc.) on site.

3.09 DECONTAMINATION

A. The Subcontractor shall develop and implement personnel and equipment decontamination procedures appropriate for site specific locations and activities and include those procedures in the HASP. The procedures shall include, but not necessarily be limited to, the necessary equipment and personnel and the steps to achieve Subcontractor's specified level of decontamination, provisions for any personnel protection, and a diagram outlining the steps or stations in the procedures. The procedures must include containment and removal of any decontamination solutions and spent disposable protective apparel.

B. Personnel entering the Exclusion or Contamination Reduction Zones or otherwise exposed or subject to exposure to hazardous chemical vapors, liquids, or contaminated solids shall adhere to the following personal hygiene and decontamination provisions. Decontamination shall be performed in the CRZ prior to entering the Support Zone. Chapter 10.0 of NIOSH Pub No. 85-115 shall be consulted when preparing decontamination procedures. A detailed discussion of personal hygiene and decontamination facilities and procedures to be followed by site workers shall be submitted as part of the HASP. Employees shall be trained in the procedures and the procedures shall be enforced throughout site operations. Persons disregarding these provisions of the HASP shall be barred from the site.

C. Personnel Decontamination Facilities

1. A personnel decontamination facility shall be provided, at the support zone side of the CRZ. This facility shall be used by both Subcontractor personnel and Engineer. The decontamination facility shall provide for separation of street clothing and site clothing and

shall be equipped with heating, lighting, ventilation, a change room and lockers, hot and cold water, shower facilities with hot and cold water, towels, soap in sufficient quantities for all anticipated personnel, and waste water storage facilities for controlling the disposal of used water. Laundry facilities or provisions of laundry service. If an off-site laundry service is used, they shall be notified, in writing, of the possibility and nature of contaminants expected on clothing.

D. Minimum decontamination procedures are listed below. Available site information shall be reviewed and these procedures shall be expanded and/or revised for submittal as part of the HASP.

1. Vehicles and equipment used in the EZ shall be decontaminated in the CRZ prior to leaving the site. The procedures for decontamination of vehicles and equipment shall be addressed in the Hasp.

2. An equipment decontamination station shall be provided within the CRZ for decontaminating vehicles and equipment leaving the EZ. The decontamination station shall be designed by the Subcontractor and be a portable system constructed to capture decontamination water, including overspray, and shall allow for collection and removal of the decontamination water. Equipment within the EZ or CRZ shall be decontaminated before maintenance is performed.

E. Procedures for equipment decontamination shall be developed and utilized to prevent the spread of contamination into the SZ and off-site areas. These procedures shall address disposal of contaminated products and spent materials used on the site, including containers, fluids, oils, etc. Any item taken into the EZ shall be assumed to be contaminated and shall be inspected and decontaminated before the item leaves the area. Vehicles, equipment, and materials shall be cleaned and decontaminated prior to leaving the site. Construction material shall be handled in such a way as to minimize the potential for contaminants being spread and/or carried off-site. Prior to exiting the site, vehicles and equipment shall be monitored to ensure the adequacy of decontamination. Monitoring methods shall be defined in the HASP.

F. Decontamination shall be conducted to minimize employee contact with hazardous substances or with equipment that has contacted hazardous substances as well as minimize off-site transport of contamination.

3.10 CONTINGENCY PLANNING

A. Emergency Response Plan. Prior to the start of site operations, the Subcontractor shall develop and implement an emergency response plan (ERP) to handle potential on-site emergencies. The ERP shall be incorporated into the site HASP as a separate section of that document and shall be periodically reviewed and, as necessary, amended to keep it current with new or changing site conditions or information.

1. The ERP shall be the result of preplanning of site operations to prevent emergencies and shall, as appropriate, include the requirements of 29 CFR 1910.120(1).
   a. Key person at the site authorized and responsible for implementing the plan.
   b. Personnel roles and lines of authority, and training.
   c. Emergency recognition and prevention.
   d. Emergency alerting and response procedures.
   e. Site communications for emergencies.
   f. Site diagrams showing general layout, work zones, and prevailing weather conditions.
   g. Safe distances and places of refuge.
   h. Evacuation routes and procedures.
   i. Frequency of drills.
   j. A list of emergency telephone contacts including the name, location, telephone number and route to the nearest emergency medical treatment and first aid facility that

will provide emergency medical services if needed.

k. PPE and equipment kept at the site for emergencies.
l. Procedures for water emergencies.
m. Site security and site control measures.
n. Emergency decontamination procedures not covered elsewhere in the HASP.
o. Procuring emergency medical treatment and first aid.
p. Procedures for reporting incidents to local, state, and federal agencies.
q. Measures to review, critique and follow up on site responses.
r. Coordination with local emergency response officials including, but not limited to, hazardous materials response teams, police department, fire department, hospitals, ambulance services, poison control centers.
s. First aid and medical information including location of first aid equipment and supplies; names of personnel trained in first aid; clearly marked map with the route to the nearest medical facility; all necessary emergency phone numbers; fire rescue, local hazardous material teams; and National Emergency Response Team.

B. Special Training

1. The Subcontractor shall ensure that at least one person holding up-to-date certifications (American Red Cross or equivalent) in basic first aid (8-hour minimum) and CPR is present at the site during all site operations.

C. Accident and Exposure Reports

1. The Subcontractor shall notify the Engineer of all related injuries, illnesses, or site accidents as soon as possible after the occurence has been addressed and follow up in writing within 24 hours. This notification shall include, but not be limited to, the date, time and identity of individual(s) involved in the accident, witnesses to the accident, the nature of the accident, the actions taken to treat the victim(s), and the steps taken to prevent recurrence.

2. The Subcontractor shall notify the Engineer of all person(s) exposed at levels exceeding OSHA standards at the time of occurrence or determination and follow up in writing within 24 hours. This notification shall include, but not be limited to, the date, time, and identity of individual(s) involved in the exposure, witnesses to the exposure, the nature of the exposure episode, what the individual(s) were exposed to, the personal protective equipment worn during the exposure, and the steps taken to prevent recurrence.

3. The Subcontractor shall notify the Engineer of all environmental air measurements exceeding the criteria specified in Section 01130 - Perimeter Air Monitoring and Dust Control Plan. This notification shall include, but not be limited to, the date, time, and identity of individual(s) involved in the exposure, witnesses to the exposure, the nature of the exposure episode, what the individual(s) were exposed to, the personal protective equipment worn during the exposure, and the steps taken to prevent recurrence.

4. The Subcontractor shall immediately notify the Engineer whenever a local, state, or federal regulatory inspection is being conducted on site.

3.11 FIRE PREVENTION AND PROTECTION

A. The Subcontractor shall develop procedures for handling and responding to small and large fires, including requests for emergency assistance and notifying the Engineer of the incident. The Subcontractor shall insure that fire traffic lanes are available (not blocked) and all fire exits are properly marked.

3.12 INSPECTIONS

A. The HSO shall perform and document daily inspections of the jobsite and the work in progress

to ensure compliance with the Safety and Health Program, the HASP and other occupational health and safety requirements of the contract, and to determine the effectiveness of the HASP. Procedures for correcting deficiencies (including actions, timetable and responsibilities) shall be described in the HASP. Follow-up inspections to ensure correction of deficiencies shall be conducted and documented. Safety inspection logs shall be used to document the inspections, noting safety and health deficiencies, deficiencies in the effectiveness of the HASP, and corrective actions taken. The HSO's Safety Inspection Logs shall be attached to and submitted with the Quality Control reports. Each entry shall include the following: date, work area checked, employees present in work area, PPE and work equipment being used in each area, special safety and health issues and notes, and signature of preparer. In the event of an accident, the Engineer shall be notified immediately. An Accident Report shall be completed within 24 hours of any reportable accident and submitted to the Engineer.

END OF SECTION

SECTION 01130

PERIMETER AIR MONITORING AND EMISSIONS CONTROL PLAN

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Preparation, submission, and implementation of an acceptable Perimeter Air Monitoring and Emissions Control Plan.

1.02 RELATED SECTIONS

A. Section 01120 - Health and Safety

B. Section 01300 - Administrative Requirements

1.03 REFERENCES

A. State of Vermont Agency of Natural Resources, Air Pollution Control Regulations, November 29, 2001.

1. Section 5-231: Prohibition of Particulate Matter
2. Section 5-241: Prohibition of Nuisance and Odor

B. Vermont's Occupational Safety and Health Administration (VOSHA).

C. Code of Federal Regulations (CFR) Title 29: Labor: U.S. Occupational Safety and Health Administration (OSHA), including, but not limited to the following:

1. 29 CFR 1910.1000 - Air Contaminants

D. CFR Title 40: Protection of Environment, including but not limited to the following:

1. 40 CFR 50 - National Ambient Air Quality Standards

E. ACGIH Threshold Limit Values 2003

F. Massachusetts Threshold Effects Exposure Limits (TELs) and Allowable Ambient Limits for Ambient Air, December 1995. (Note: The Massachusetts Threshold Effects Levels were used as ambient off-site trigger levels because they are based on EPA reference concentrations for inhalation exposure and are 24-hour standards. Vermont Hazardous Air Toxic limits are based on annual averages and may not be protective for short-term projects.)

1.04 SUBMITTALS

A. See Section 01300 - Administrative Requirements, for submittal procedures.

B. Perimeter Air Monitoring and Dust Control Plan, within 21 days of the Notice to Proceed.

C. Weekly Data Reports

PART 2 PRODUCTS

2.01 PERIMETER AIR MONITORING AND EMISSIONS CONTROL PLAN

A. General

1. The purpose of the Perimeter Air Monitoring and Emissions Control Plan is to maintain concentrations of site-related constituents off site at or below regulatory levels. The air monitoring required by the Perimeter Air Monitoring and Dust Control Plan is separate from the personnel air monitoring specified in the Section 01120 - Health and Safety.
2. The Perimeter Air Monitoring and Emissions Control Plan shall describe in detail the

Subcontractor's plan of operation, means and methods of construction, proposed locations, air monitoring instruments, record keeping procedures, and response procedures.

3. The Perimeter Air Monitoring and Dust Control Plan shall describe in detail the Subcontractor's plan for implementing air emission control measures to maintain air emissions below the action levels specified herein.

B. Number and Location of Stations

1. At a minimum, four perimeter air-monitoring stations shall be established by the Subcontractor to collect data to document the amount, if any, of the following parameters leaving the site:
   a. Particulate not otherwise classified (PNOC);
   b. Volatile Organic Compounds (VOCs); and
   c. Hydrogen Sulfide (H2S).

2. For security, access, and air flow reasons; the perimeter air monitoring stations shall be approximately 15 feet from the site fencing. Each of the perimeter air monitoring stations shall be located so that it is not shielded or otherwise obstructed from collecting samples representative of the air leaving the site. If location of work and equipment prohibit this, alternate monitoring station location shall be approved by the Engineer.

3. The perimeter air monitoring stations shall be established with at least one location upwind and three locations downwind of the active work area, based on daily predictions made by the National Weather Service and data from the on-site meteorological equipment. Air monitoring locations shall focus on the potential off-site exposure to near-by residences. Three areas require priority placement of downwind monitoring devices.

4. The downwind sample locations shall be between the active work area and these off-site areas when the wind direction is moving toward these off-site areas. Regardless of wind direction, a minimum of four air-monitoring stations shall be maintained during activities in the active work area, as described below.

C. Duration of Perimeter Air Monitoring

1. Air monitoring shall be continuous during activities in the active work area. Air monitoring shall begin at least 30 minutes before work begins in the active work area and continue for at least 60 minutes after work ceases. These times are intended to allow for background levels to be established before generation of potential air contaminants and for materials generated during active work to reach the sampling locations.

D. Equipment

1. Air monitoring at each station shall be conducted with direct reading instruments for particulates, VOCs, and H2S.
   a. Air monitoring particulate detecting instruments shall be Data RAM Real-Time Aerosol Monitor Model No. MIE DATARAM with omni directional probe, or equal. The respirable cyclone precollector shall be removed prior to use. Measurements shall be collected with data logging at one-minute intervals for 30 minutes, to allow calculation and recording of a 30-minute time weighted average.
   b. Air monitoring for VOCs shall be conducted with an analyzer employing flame or photometric ionization detection with a minimum detection level of 0.10 ppm for isobutylene. Acceptable equipment includes Mini RAE PID or equal. SUMMA canisters must be available to collect the back-up analysis as needed. All samplers are to collect samples at breathing height free from obstructions. Sampling shall be conducted at least four times per day at each location for a minimum of 15-minutes each. Record the low and high reading.
   c. Air monitoring for H2S shall be conducted with an Arizona Instrument Jerome 631-X

hydrogen sulfide analyzer and data logger, or equivalent. Sampling shall be conducted at least four time per day at each station for a minimum of 15-minutes each. Measurements shall be collected with data logging at one-minute intervals for 15 minutes to allow calculation of a 15-minute time weighted average. Record low, high and averages.

2. One wind direction monitoring and recording device shall be maintained on the work area. The device shall include a wind direction indicator (wind sock or weathervane) that is visible from all positions of the work area and sited such that it is not influenced by obstructions.

3. If the Subcontractor does not provide an AC power source to air monitoring stations and the wind direction station, the Subcontractor shall maintain a sufficient supply of charged spare batteries or charged spare units, such that perimeter stations are always in service.

4. Provide Shop Drawings for air monitoring equipment.

E. Records

1. The record of the monitoring shall be available for inspection by the Engineer and authorized agencies. Data logging instruments can be used as long as the data is retrievable on site.

2. Records of calibration, according to the instrument manufacturer's instructions, shall be maintained by the Subcontractor and shall be available for inspection by the Engineer and authorized agencies. The zero baseline shall be checked daily and at set intervals.

2.02 ACTION LEVELS

A. If the downwind PNOC level (30-minute time weighted average) reaches 52 micrograms of total dust per cubic meter of air (52 ug/m3) greater than the upwind PNOC level, dust controls activities at the active site shall be initiated to reduce the level at the perimeter to below 52 ug/m3 within 15 minutes.

B. If the downwind VOC level (30-minute time weighted average) exceeds 5 ppm of total VOC, activities at the active site shall be stopped, the source of the VOC identified and actions initiated to reduce the VOC level at the perimeter to below 5 ppm within 15 minutes.

C. Sustained measurements at a downwind location above 5 ppm of total VOC will require back-up analysis using EPA Method TO-15, which uses SUMMA canisters. Canisters will be analyzed for the listed VOC constituents of concern and compared to the 24 hour TELs.

D. Current guidelines established by the American Industrial Hygiene Association under the Emergency Response Planning Guide uses 0.1 ppm as the maximum concentration below which it is believed that nearly all individuals can be exposed for up to one hour without experiencing adverse health effects. If downwind H2S levels exceed 0.1 ppm at the perimeter near or adjacent with a resident off-site receptor, activities at the site shall be stopped, the source of H2S identified and action initiated to reduce the H2S level at the perimeter to below 0.1 ppm.

PART 3 EXECUTION

3.01 GENERAL

A. The Subcontractor shall implement the Perimeter Air Monitoring and Emissions Control Plan.

B. The Subcontractor shall make every effort to minimize the generation of dust and odors during boath work and non-work hours. Appropriate methods to minimize the generation of dust include, but are not limited to:

1. Use of low permeability tarpaulin or suitable means to cover exposed areas and materials.

2. Limiting the amount of exposed areas.

3. Water spray. If water spray is used, run-off must be collected and managed as construction water.

4. The use of chloride or petroleum containing compounds for dust control is prohibited.

C. The Subcontractor shall submit a report to the Engineer summarizing data collected during the implementation of this specification on a weekly basis. The report shall include a description of sampling procedures, a discussion of calibration procedures, a summary of meteorological data, and a summary of contaminant levels. The report shall also include a summary of measures taken by the Subcontractor to address exceedances of the Action Levels specified, on an incident-by-incident basis.

D. The Subcontractor shall update the Perimeter Air Monitoring and Dust Control Plan as necessary to incorporate changes in site conditions, equipment and potentially hazardous materials identified during site activities. The Subcontractor's Perimeter Air Monitoring and Dust Control Plan shall include alternate monitoring locations and relocation procedures to accommodate site construction activities.

END OF SECTION

SECTION 01160

SPILL PREVENTION, CONTROL, AND COUNTERMEASURES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Development, implementation, and maintenance of a comprehensive Spill Prevention, Control, and Countermeasures (SPCC) Plan.

1.02 RELATED SECTIONS

A. Section 01120 - Health and Safety

B. Section 01300 - Administrative Requirements

1.03 REFERENCES

A. Vermont Hazardous Waste Management Regulations, Subchapter 1, Section 7-105, Emergency and Corrective Actions

B. Code of Federal Regulations (CFR) Title 40: Protection of Environment, including but not limited to the following:

1. 40 CFR 110 - Discharge of Oil
2. 40 CFR 112 - Oil Pollution Prevention
3. 40 CFR 280 - Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (UST)

1.04 PERFORMANCE REQUIREMENTS

A. Evaluate and implement all procedures as identified herein and within appropriate regulations and laws.

B. Comply with all Federal, State, and local oil and hazardous waste regulations.

C. Provide methods, means, and facilities required to prevent contamination of soil, water, atmosphere, uncontaminated structures, equipment, or material by the discharge of wastes from spills due to Subcontractor's operations.

D. Provide equipment and personnel to perform emergency measures required to contain any spills and to remove spilled materials and soils or liquids that become contaminated due to spillage. Collected spill material shall be properly disposed of at the Subcontractor's expense.

E. Provide equipment and personnel to perform decontamination measures that may be required.

F. Report and document releases and spills of materials as required by appropriate State and Federal laws and regulations.

1.05 SUBMITTALS

A. See Section 01300 - Administrative Requirements, for submittal procedures.

B. Develop a comprehensive SPCC Plan. The Plan at a minimum shall contain the following:

1. Procedures for containing dry and liquid spills.
2. Absorbent material available on site.
3. Procedures for storage of spilled materials.
4. Decontamination procedures.

5. Spill incident report format.
6. Notification requirements and phone numbers.
7. Spill incident reports.

C. Submit SPCC Plan within 21 days from Notice to Proceed.

D. Incident Report: Submit within 24 hours of release.

PART 2 PRODUCTS

2.01 MATERIALS

A. The Subcontractor will maintain a supply of spill control and countermeasure materials at equipment maintenance and storage areas and on refueling equipment.

B. The Subcontractor will maintain a supply of personnel protective equipment for use during a spill situation. At a minimum this equipment will include safety goggles, disposable chemical-resistant suits (e.g., Tyvek), disposable nitrile or neoprene gloves, rubber overboots, and a first aid kit which includes water-less soap.

C. The Subcontractor will maintain a supply of spill control materials for use in a spill situation. An emergency response kit will include, at a minimum, a fire extinguisher, oil absorbent material (e.g., Speedi-Dry), oil booms, oil absorbent mats, 10-mil polyethylene sheeting, shovels, nitrile or neoprene gloves, and one 55-gallon (or equivalent capacity) DOT-approved container(s).

D. The quantity of on-site spill control materials shall be appropriate to manage the maximum possible spill event.

PART 3 EXECUTION

3.01 GENERAL

A. The Subcontractor shall be responsible for all liabilities related to spills, discharges, leaks, or emissions from equipment, tanks, vessels, drums, or any other devices owned, operated, or controlled by the Subcontractor, his subcontractors, vendors, personnel, agents, or assigns.

B. In the case of a spill or discharge, the Subcontractor shall immediately follow procedures outlined in the SPCC Plan.

C. Decontamination procedures may be required after cleanup to eliminate residuals of the substance spilled or reduce it to an acceptable level. Acceptable level shall be in accordance with all applicable local, State, and Federal laws and regulations and shall be approved by the Engineer. Complete cleanup may require removal of contaminated soils. All contaminated materials that cannot be decontaminated must be properly containerized, labeled, and properly disposed of within 90 days. Testing and disposal costs related to the cleanup of a spill caused by the Subcontractor's activities shall be the responsibility of the Subcontractor.

3.02 SPILL REPORTING AND NOTIFICATION

A. Notify the Engineer immediately, or as soon as practicable, in the event of a spill or discharge.

B. Report spill or discharge to regulatory agencies, as necessary to comply with Federal, State and local regulations.

C. All discharges and/or releases of a hazardous waste exceeding two (2) gallons shall be reported immediately by the persons exercising control over such waste by calling, in order, the following entities:

1. Pownal Fire Department Chief
2. Waste Management Division of DEC at (802) 241-3888, Monday through Friday, 7:45am to

4:30 pm or the Department of Public Safety, Emergency Management Division at (800) 641-5005, 24 hours per day.

3. National Response Center at (800) 424-8802, if spill Impacts or threatens surface water.

3.03 CONTROL ACTION

A. Take immediate measures to control and contain the spill within the site boundaries. This will include the following actions:

1. Contain and eliminate the discharge, if possible.
2. Remove or retrieve any discharge liquids or solids, if possible.
3. Keep unnecessary people away from the spilled material.
4. Do not allow anyone to touch the spilled material.
5. Stay upwind; keep out of low areas.
6. Keep combustibles away from the spilled material.
7. Take samples for analysis to assess if cleanup is adequate.
8. Other action, as needed.

3.04 DOCUMENTATION

A. The Subcontractor shall prepare a written report that includes, at a minimum, details of the spill or discharge, the cause and resolution of the incident, outside agencies involved, and date the incident occurred. The report shall be submitted to the Engineer within 24 hours of the incident, and earlier if necessary to comply with local, state, or federal regulations. The Subcontractor shall document the location of all spills on the site Drawings and submit the drawings to the Engineer at project completion.

B. If sampling is conducted to assess cleanup requirements, the Subcontractor shall submit sample results to the Engineer within 24 hours of receiving the results.

END OF SECTION

SECTION 01300

ADMINISTRATIVE REQUIREMENTS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Requirements of Project Meetings:

1. Preconstruction meeting.
2. Site mobilization meeting.
3. Progress meetings.
4. Prefinal Construction Conference.
5. Completion Inspection.

B. Construction progress schedule.

C. Progress photographs.

D. Submittal Requirements:

1. Submittals for review, information, and project closeout.
2. Number of copies of submittals.
3. Submittal procedures.

E. Closeout Procedures.

1.02 RELATED SECTIONS

A. Section 01120 - Health and Safety

B. Section 01130 - Perimeter Air Monitoring and Emissions Control Plan

C. Section 01160 - Spill Prevention, Control, and Counter Measures

D. Section 01400 - Quality Requirements

E. Section 01500 - Temporary Facilities and Controls

F. Section 01575 - Temporary Erosion and Sedimentation Control

G. Section 01700 - Execution Requirements

H. Section 02240 - Construction Water Management

I. Section 02260 - Excavation Support and Protection

J. Section 02315 - Excavation

K. Section 02316 - Fill and Backfill

L. Section 02343 - Sludge Stabilization

M. Section 02370 - Erosion and Sedimentation Control

N. Section 02520 - Monitoring Wells

O. Section 02620 - Geocomposite Drainage Layer

P. Section 02623 - Geomembrane

Q. Section 02625 - Geotextiles

R. Section 02627 - Gas Vent Piping

S. Section 02821 - Fences and Gates

T. Section 02921 - Topsoil and Seeding

1.03 PROJECT COORDINATION

A. Coordinate with the Engineer in allocation of mobilization areas of site; for field offices and sheds, for site access, traffic, and parking facilities.

B. During construction, coordinate use of site and facilities through the Engineer.

C. Comply with procedures of this section for intra-project communications; submittals, reports and records, schedules, coordination drawings, and recommendations; and resolution of ambiguities and conflicts.

D. Make the following types of submittals to Engineer, when required:

1. Project Plans.
2. Requests for interpretation.
3. Requests for substitution.
4. Shop drawings, product data, and samples.
5. Test and inspection reports.
6. Manufacturer's instructions and field reports.
7. Applications for payment and change order requests.
8. Progress schedules.
9. Coordination drawings.
10. Closeout submittals.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 MEETINGS

A. Preconstruction Meeting

1. Prior to beginning any work on the contract, the Subcontractor will attend a preconstruction meeting at the Engineer's office.
2. Engineer will schedule after Notice of Award.
3. Attendance:
   a. Engineer, required.
   b. Subcontractor, required.
4. Agenda:
   a. Execution of Subcontractor Agreement.
   b. Submission of executed bonds and insurance certificates.
   c. Distribution of Contract Documents.
   d. Designation of personnel representing the parties to Contract.
   e. Procedures for processing of field decisions, submittals, substitutions, applications for payments, proposal request, Change Orders, and Contract closeout procedures.

f. Scheduling.

5. Subcontractor shall record minutes and distribute copies within two days after meeting to participants, with two copies to Engineer, participants, and those affected by decisions made.

B. Site Mobilization Meeting

1. Engineer will schedule a meeting at the site prior to Subcontractor occupancy.

2. Attendance:
   a. EPA and VTDEC, optional.
   b. Engineer, required.
   c. Subcontractor, required.

3. Agenda:
   a. Safety (Preconstruction Safety Conference).
   b. Use of premises by Subcontractor.
   c. Construction facilities and controls.
   d. Temporary utilities.
   e. Survey and site layout.
   f. Security and housekeeping procedures.
   g. Schedules.
   h. Application for payment procedures.
   i. Procedures for testing.
   j. Procedures for maintaining record documents.

4. Subcontractor shall record minutes and distribute copies within two days after meeting to participants, with two copies to Engineer, EPA, VTDEC, participants, and those affected by decisions made.

C. Progress Meetings

1. Schedule and administer meetings throughout progress of the Work at maximum bi-weekly intervals.

2. Make arrangements for meetings, prepare agenda with copies for participants, preside at meetings.

3. Attendance:
   a. EPA and VTDEC, optional.
   b. Engineer, required.
   c. Subcontractor, required.
   d. Others, as appropriate to agenda topics for each meeting.

4. Agenda:
   a. Review minutes of previous meetings.
   b. Review of Work progress.
   c. Field observations, problems, and decisions.
   d. Identification of problems which impede planned progress.
   e. Review of submittals schedule and status of submittals.
   f. Maintenance of progress schedule.
   g. Corrective measures to regain projected schedules.
   h. Planned progress during succeeding work period.
   i. Maintenance of quality and work standards.
   j. Effect of proposed changes on progress schedule and coordination.
   k. Budget update.
   l. Other business relating to Work.

5. The Subcontractor shall record minutes and distribute copies within two days after meeting to participants, with two copies to Engineer, EPA, VTDEC, participants, and those affected by decisions made.

D. Prefinal Construction Conference

1. Prior to Substantial Completion of Work, schedule and conduct a Prefinal Construction Conference.

2. The purpose of the Prefinal Construction Conference is to discuss procedures and requirements for project completion and closeout. Topics include, but are not limited to the following:
   a. Operation and Maintenance.
   b. Construction cleanup responsibilities.
   c. Demobilization activities.
   d. Security requirements for project transfer.
   e. Completion Inspection Schedule
   f. EPA/state joint inspection schedule.

3. Attendance:
   a. EPA and VTDEC, optional.
   b. Engineer, required.
   c. Subcontractor, required.
   d. Others, as appropriate to agenda topics for each meeting.

4. The Subcontractor shall record minutes and distribute copies within two days after meeting to participants, with two copies to Engineer, EPA, VTDEC, participants, and those affected by decisions made.

E. Completion Inspection

1. Upon Substantial Completion of Work, the Subcontractor shall schedule and conduct a Completion Inspection.

2. The Completion inspection shall consist of a Prefinal and a Final Inspection

3. Prefinal Inspection - At the Substantial Completion of Work, the Engineer and the Subcontractor shall conduct a prefinal inspection of the Work and develop a 'punch list' of items, if any, which do not conform to the approved plans and specifications. Such a list shall be included by the Subcontractor in the CQA documentation and shall include the estimated date by which the deficiencies will be corrected.

4. Final Inspection - the Engineer and the Subcontractor shall conduct the final inspection to confirm that all deficiencies identified in the prefinal inspection have been corrected.

5. Attendance:
   a. EPA and VTDEC, optional.
   b. Engineer, required.
   c. Subcontractor, required.

3.02 CONSTRUCTION PROGRESS SCHEDULE

A. Within 21 days after date established in Notice to Proceed, submit preliminary schedule.

B. Prepare in accordance with Contract Documents.

C. If preliminary schedule requires revision after review, submit revised schedule within 10 days.

3.03 PROGRESS PHOTOGRAPHS

A. Provide photographs of site and construction throughout progress of Work produced by an

experienced photographer, acceptable to Engineer.

B. Take digital photographs each month from a minimum of 10 locations. The location and orientation of view shall be the same each month and will be determined at the site mobilization meeting.

C. Prints: Full color; two prints of each view.

1. Glossy; smooth texture; white tint; single weight; contrast grade 4, extra hard.

2. Size: 5 x 7 inch; mounted for binder and tabs.

3. Identify each print on back. Identify name of Project, contract number, phase, orientation of view, date and time of view.

D. Deliver prints and electronic files on compact disk within three days after exposure with transmittal letter specified in this Section.

3.04 SUBMITTALS

A. Submittal Register

1. At least one week prior to the Pre-Construction Conference, the Subcontractor shall submit a completed Submittal Register (Form 01300-1), in the form attached to this section of the Specifications, complete with dates for agreement at the Pre-Construction Conference.

2. The Subcontractor shall complete the Submittal Register as necessary to ensure submittals are approved in good time to meet approved construction schedules.

3. A minimum of one page conforming to the form attached to this Section shall be assigned to each specification section on which shall be listed each item of equipment and material of each type for which fabricator's drawings and/or related descriptive data, test reports, samples, plans or other type of submittals are required by these Specifications.

4. The Subcontractor shall maintain the Register and submit updated copies of it to the Engineer when requested. All submittals to be approved by the Engineer shall be shown on the register. All submittals shall be made to the Engineer.

5. All submittals shall be listed in chronological order.

6. Submittal number, subject of the submittal, specification reference, submittal date and review status shall be entered into the Submittal Register for each update.

B. for Review

1. The following are to be submitted for review as required throughout the Contract Documents:
   a. Project Plans
   b. Product data.
   c. Qualifications Submittals
   d. Source test reports.

2. Submit to Engineer for review for the limited purpose of checking for conformance with information given and the design concept expressed in the contract documents.

3. The Engineer's approval of submittals shall not be construed as a complete check, but will indicate only that the general method of construction, materials, and other information are satisfactory. Approval will not relieve the Subcontractor of the responsibility for any error which may exist, as the Subcontractor, under the CQC requirements of this contract is responsible for dimensions, the design of adequate connections and details, and the satisfactory construction of the Work. After the submittals have been approved by the

Engineer, no resubmittal for the purpose of substituting materials or equipment will be considered unless accompanied by an explanation why a substitution in necessary.

4. After Subcontractor's internal review, provide copies and distribute in accordance with SUBMITTAL PROCEDURES article below and for record documents purposes as described herein.

C. Submittals for Information

1. When the following are specified in individual sections, submit them for information:
   a. Inspection reports.
   b. Quality control sample test reports.
   c. Analytical test reports.
   d. Other types indicated.

2. Submit for Engineer's knowledge as contract administrator for EPA. No action will be taken.

3. Submittals for information only will not be returned. Approval of the Engineer is not required on information only submittals. The Engineer reserves the right to require the Subcontractor to resubmit any item found not to comply with the Contract Documents. This does not relieve the Subcontractor from the obligation to furnish material conforming to the Contract Documents; will not prevent the Engineer from requiring removal and replacement of nonconforming material incorporated in the Work; and does not relieve the Subcontractor of the requirement to furnish samples for check testing by the Engineer in those instances were the specifications so prescribe.

D. Submittals for Project Closeout

1. Project Record Documents: Submit documents to Engineer with claim for final Application for Payment.
   a. Maintain on site one set of the following record documents; record actual revisions to the Work:
      1) Drawings.
      2) Specifications.
      3) Logs.
      4) Addenda.
      5) Change Orders and other modifications to the Contract
      6) Reviewed shop drawings, product data, and samples.
   b. Ensure entries are complete and accurate, enabling future reference by Engineer.
   c. Store record documents separate from documents used for construction.
   d. Record information concurrent with construction progress.
   e. Record Drawings: Legibly mark each item to record actual construction including:
      1) Field changes of dimension and detail.
      2) Details not on original Drawings.
   f. As-Built Site Preparation Plan: The As-Built Site Preparation Plan shall be stamped by a surveyor licensed with the State of Vermont.

2. When the following are specified in individual sections, submit them at project closeout:
   a. Project record documents.
   b. Other types as indicated.

E. Number of Copies of Submittals

1. Submittals for Review:
   a. Small Size Sheets, Not Larger Than 8-1/2 x 11 inches: Submit the number of copies which the Subcontractor requires, plus four copies which will be retained by the Engineer.

2. Submittals for Information: Submit five copies plus one copy to be mailed to site and engineer.

3. Submittals for Project Closeout: Make one reproduction of submittal originally reviewed.

4. In addition to the above requirements, all submittals shall be transmitted in electronic format (Adobe Acrobat .pdf files).

5. Requirements for Subcontractor drawings:
   a. Paper copies shall be D-size.
   b. Scale shall be equivalent to scale used in the Drawings.
   c. Submit electronic version in AutoCad Release 14 (or greater), or format fully compatible with AutoCad Release 14.
   d. Submit second electronic version in Portable Document Format (x.pdf).

F. Submittal Procedures

1. Transmit each submittal with EPA Form No. 51-043-32B(2) or equivalent. Form No. 51-043-32B(2) may be obtained from Remedial Design/remedial Action Handbook, EPA Document No. EPA 540/R-95/059, June 1995; Appendix B: Transmittal Forms.

2. Sequentially number the transmittal forms. Resubmit revised submittals with original number and a sequential alphabetic suffix.

3. Identify Project, Subcontractor, Subcontractor or supplier; pertinent drawing and detail number, and specification section number, as appropriate on each copy.

4. Apply Subcontractor's stamp, signed or initialed certifying that review, approval, verification of Products required, field dimensions, adjacent construction Work, and coordination of information is in accordance with the requirements of the Work and Contract Documents.

5. Schedule submittals to expedite the Work, and coordinate submission of related items.

6. For each submittal for review, allow 10 business days excluding delivery time to and from the Subcontractor.

7. Identify variations from Contract Documents and product or system limitations which may be detrimental to successful performance of the completed Work.

8. Provide space for Subcontractor and Engineer review stamps.

9. When revised for resubmission, identify all changes made since previous submission.

10. Distribute copies of reviewed submittals as appropriate. Instruct parties to promptly report any inability to comply with requirements.

11. Submittals not requested will not be recognized or processed.

12. Shop drawings shall not be larger than 28" x 40". Copies of drawings submitted shall be blue or black line on white background. Copies of drawings shall be accompanied by a letter of transmittal.

13. At the beginning of each letter of transmittal and each letter of inquiry, provide a reference heading indicating the following:
   a. Project Name
   b. Contract No.
   c. Transmittal No.
   d. Number of Sheets

14. A number shall be assigned to each submittal by the Subcontractor starting with No. 1 and thence numbered consecutively. Resubmittals shall be identified by the same number

followed by the suffix "A" for the first resubmittal, the suffix "B" for the second resubmittal, etc.

15. Submittals shall contain the following data:
    a. Date of submission: project title and number; contract identification; names of Subcontractor, manufacturer/ supplier;
    b. Identification of product, with specification section number;
    c. Field dimensions, clearly identified as such;
    d. Relation to adjacent or critical features of work or materials;
    e. Applicable standards, such as ASTM or Federal Specification numbers;
    f. Identification of deviations from Contract Documents;
    g. Identification of revisions on resubmittals.

G. Submittal Review

1. After the Engineer completes his review, submittals will be marked with one of the following notations:
    a. Reviewed - No Exceptions Taken;
    b. Reviewed - Correct as Noted;
    c. Revise and Resubmit;
    d. Rejected.

2. If a submittal is acceptable, it will be marked "Reviewed - No Exceptions Taken" or "Reviewed - Correct as Noted". One copy of the submittal will be returned to the Subcontractor.

3. Upon return of a submittal marked "Reviewed - No Exceptions Taken" or "Reviewed - Correct as Noted", the Subcontractor may order, ship or fabricate the materials included on the submittal, provided it is in accordance with the corrections indicated.

4. If a submittal marked "Revise and Resubmit", it has extensive corrections or corrections affecting other drawings or work, the Engineer may require that the Subcontractor make the corrections, indicated thereon and resubmit for record purposes.

5. If a submittal is unacceptable, one copy will be returned to the Subcontractor marked "Rejected".

6. Upon return of a submittal marked "Revise and Resubmit", the Subcontractor shall make the corrections indicated and repeat the initial approval procedure. The "Rejected" notation is used to indicate material or equipment that is not acceptable. Upon return of a submittal so marked, the Subcontractor shall repeat the initial approval procedure utilizing acceptable material or equipment.

7. Shop Drawings or other submittals not bearing the Engineer's notation of "Reviewed - No Exceptions Taken" or "Reviewed - Correct as Noted" shall not be issued to lower tier Subcontractors nor utilized for construction purposes. No work shall be performed or equipment installed without a "Reviewed - No Exceptions Taken" or "Reviewed - Correct as Noted" drawing or submittal.

8. Shop Drawings shall be submitted well in advance of the need for the material or equipment for construction and with ample allowance for time required to make delivery of material or equipment after data covering such is approved. The Subcontractor shall assume the risk for all materials or equipment which are fabricated or delivered prior to the approval of Shop Drawings. No materials or equipment shall be incorporated into the work nor will such be included in periodic progress payments until approval thereof has been obtained in the specified manner.

9. It is the Subcontractor's responsibility to review submittals made by his suppliers and

subcontractors before transmitting them to the Engineer to assure proper coordination of the work, to determine that each submittal is in accordance with his desires and to assure that there is sufficient information about materials and equipment for the Engineer to determine compliance with the Drawings and Specifications. Incomplete or inadequate submittals will be returned for revision without review.

H. Review Periods

1. A total of ten (10) business days from the time the Engineer receives the submittal shall be allowed for review and process by the Engineer, including each occasion that Shop Drawings are revised and resubmitted and for time required to return the approved Shop Drawings to the Subcontractor. Where the Subcontractor submits design changes that are significant, a total of fifteen (15) business days shall be allowed for review and process by the Engineer. Subcontractors shall respond in writing to Engineer's notations within ten (10) business days.

3.05 CLOSEOUT PROCEDURES

A. Make submittals that are required by governing or other authorities.

B. Notify Engineer when work is considered ready for Completion Inspection.

C. Submit written certification that Contract Documents have been reviewed, work has been inspected, and that work is complete in accordance with Contract Documents and ready for Engineer's review.

D. Correct items of work identified by Engineer during Completion Inspection.

E. Complete items of work determined by Engineer's final inspection.

F. Notify Engineer when work is considered finally complete.

END OF SECTION

FORM 01300-1
POWNAL SUPERFUND SITE REMEDIATION
SUBMITTAL REGISTER

REPORT DATE									CONTRACT #: PROJECT TITLE:				CONTRACTOR #: TRADE #:				
			Submittal														
			Shop Dwg.	Samp	Cat Cuts				Rec'd	Ret'd	Action	Rec'd	Ret'd	Action	Rec'd	Ret'd	

Approved: _____
Construction Manager

Date: _____

SECTION 01400

QUALITY REQUIREMENTS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Subcontractor Quality Control requirements.

B. Requirements for Testing and inspection services.

C. Participation in Subcontractor Quality Assurance (CQA) Plan.

1.02 RELATED SECTIONS

A. Section 01300 - Administrative Requirements

B. Section 02316 - Fill and Backfill

C. Section 02343 - Sludge Stabilization

D. Section 02620 - Geocomposite Drainage Layer

E. Section 02623 - Geomembrane

F. Section 02625 - Geotextiles

G. Section 02627 - Gas Vent Piping

1.03 DEFINITIONS

A. Quality Control - Quality Control (QC) is defined as actions or measures taken to document that the materials and methods used in construction by the Subcontractor and lower tier subcontractors are in compliance with the Contract Documents. This includes all source testing of materials, manufacturer's quality control (MQC) testing and in-place quality testing.

B. Quality Assurance - Quality Assurance (QA) is defined as actions taken by the Engineer to document that the Subcontractor and his subcontractors are performing the work according to the specified requirements and standards contained in the Contract Documents. This effort will include the analysis and evaluation of the data generated by the QC material testing activities and geosynthetic conformance testing.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM)

1. D 3740 Standard Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction; 2001.

2. E 329 Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction; 2000b.

3. E 543 Standard Practice for Agencies Performing Nondestructive Testing; 2002.

4. E 548 Standard Guide for General Criteria used for Evaluating Laboratory Competence; 1994.

B. Construction Quality Assurance (CQA) Plan, attached.

1.05 SUBMITTALS

A. See Section 01300 - Administrative Requirements, for submittal procedures.

B. Geotechnical and Geosynthetic Testing Laboratory Qualifications:

1. Prior to start of Work, submit for review laboratory name, address, and telephone number, name(s) of full time specialist(s) and responsible officer, and qualifications required herein.

C. Test Reports: After each test/inspection, submit report to Engineer within 48 hours of Subcontractor's receipt.

1. Include:
   a. Date issued.
   b. Project title and number.
   c. Name of inspector.
   d. Date and time of sampling or inspection.
   e. Identification of product and specifications section.
   f. Location in the Project.
   g. Type of test/inspection.
   h. Date of test/inspection.
   i. Results of test/inspection.
   j. Conformance with Contract Documents.
   k. When requested by Engineer, provide interpretation of results.

2. Test reports are submitted for Engineer's knowledge, for information for the limited purpose of assessing conformance with information given and the design concept expressed in the contract documents.

D. Certificates: When specified in individual specification sections, submit certification by the manufacturer and Subcontractor to Engineer, in quantities specified for Product Data.

1. Indicate material or product conforms to or exceeds specified requirements. Submit supporting reference data, affidavits, and certifications as appropriate.

1.06 Subcontractor QUALITY CONTROL (CQC) ORGANIZATION

A. The Subcontractor shall provide a CQC staff.

B. The CQC staff shall include a CQC Manager who shall be required to be on site throughout the construction period. The CQC Manager shall have demonstrated experience with earthwork projects.

1.07 TESTING AND INSPECTION AGENCIES

A. Employment of lower-tier subcontractors in no way relieves Subcontractor of obligation to perform the Work in accordance with requirements of Contract Documents.

B. The Subcontractor's CQC Geotechnical and Geosynthetic Laboratory shall be an independent laboratory not owned by the Subcontractor, or owned by a subsidiary of the Subcontractor, or owned by their subcontractors. The Geotechnical Laboratory shall have an internal QC plan to confirm that laboratory procedures conform to applicable standards. The laboratory shall follow the internal QC procedures.

C. The CQC Geotechnical Laboratory shall have a minimum of five years of experience in testing soils properties required for the project. Soil testing technicians shall have a minimum of two years of soil testing experience and be certified by the National Institute of Certified Engineering Technicians. All laboratory test results shall be certified by a Laboratory Manager with a minimum of five years of soils testing experience.

D. The CQC Geosynthetic laboratory shall have a minimum of five years experience in testing geosynthetics. The CQC Geosynthetic Laboratory Manager shall have a minimum of five years of geosynthetics testing experience. Technicians shall have a minimum of two years of experience. The Laboratory Manger shall certify all laboratory test results.

1.08 CONTROL OF INSTALLATION

A. The Subcontractor shall participate in the Construction Quality Assurance Program as described in the attached Construction Quality Assurance (CQA) Plan.

B. Monitor quality control over suppliers, manufacturers, Products, services, site conditions, and workmanship, to produce Work of specified quality.

C. Comply with manufacturers' instructions, including each step in sequence.

D. Should manufacturers' instructions conflict with Contract Documents, request clarification from Engineer before proceeding.

E. Comply with specified standards as minimum quality for the Work except where more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.

F. Perform Work by persons qualified to produce required and specified quality.

G. Verify that field measurements are as indicated on shop drawings or as instructed by the manufacturer.

H. Secure Products in place with positive anchorage devices designed and sized to withstand stresses, vibration, physical distortion, or disfigurement.

1.09 TOLERANCES

A. Monitor fabrication and installation tolerance control of Products to produce acceptable Work. Do not permit tolerances to accumulate.

B. Comply with manufacturers' tolerances. Should manufacturers' tolerances conflict with Contract Documents, request clarification from Engineer before proceeding.

C. Adjust Products to appropriate dimensions; position before securing Products in place.

1.10 REFERENCES AND STANDARDS

A. For Products or workmanship specified by association, trade, or other consensus standards, comply with requirements of the standard, except when more rigid requirements are specified or are required by applicable codes.

B. Conform to reference standard by date of issue current on date of Contract Documents except where a specific date is established by code.

C. Obtain copies of standards where required by product specification sections.

D. Neither the contractual relationships, duties, or responsibilities of the parties in Contract nor those of the Engineer shall be altered from the Contract Documents by mention or inference otherwise in any reference document.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 CONTROL

A. The controls shall be adequate to cover all construction operations, including both on-site and off-site operations, and will be keyed to the proposed construction sequence. The controls shall include at least three phases of inspection for all definitive features of work as follows:

1. Preparatory Inspection. This shall be performed prior to beginning any work on any definable feature of work. It shall include a review of contract requirements; a check to

assure that all materials and/or equipment have been tested, submitted and approved; a check to assure that provisions have been made to provide required control testing; examination of the work area to ascertain that all preliminary work has been completed; and a physical examination of materials, equipment and sample work to assure that they conform to approved drawings or submittal data and that all materials and/or equipment are on hand. The Engineer shall be notified at least 24 hours in advance of the preparatory inspection and such inspection shall be made a matter of record in the Subcontractor's Quality Control documentation as required below. Subsequent to the preparatory inspection and prior to commencement of work, the Subcontractor shall instruct each applicable worker as to the acceptable level of workmanship required in his plan in order to meet contract specifications.

2. Initial Inspection. This shall be performed as soon as a representative portion of the particular feature of work has been accomplished and shall include examination of the quality of workmanship and a review of control testing for compliance with contract requirements, use of defective or damaged materials, omissions, and dimensional requirements. The Engineer shall be notified at least 72 hours in advance of the initial inspection and such inspection

3. Follow-up Inspections. These shall be performed to assure continuing compliance with contract requirements, including control testing, until completion and acceptance of the particular feature of work. Such inspections shall be made a matter of record in the CQC documentation as required below. Final follow up inspections shall be conducted and test deficiencies corrected prior to the addition of new features of work.

3.02 TESTS

A. Test Procedure. The Subcontractor shall perform and pay for tests specified or required to verify that control measures are adequate to provide a product which conforms to contract requirements. The Subcontractor shall perform the following activities and record and provide the following data:

1. Verify that testing procedures comply with contract requirements.

2. Verify that facilities and testing equipment are available and comply with testing standards.

3. Check test instrument calibration data against certified standards with personnel who are qualified.

4. Verify that recording forms, including all of the test documentation requirements, have been prepared.

B. Testing

1. Transportation of Samples for Testing: Costs incidental to the transportation of samples or materials will be borne by the Subcontractor.

2. The results of all tests performed by Subcontractor shall be presented to the Engineer regardless of whether the test passed or failed.

3. The Engineer checking the Subcontractor's tests does not relieve the Subcontractor of the responsibility of the procedures or the results.

3.03 DOCUMENTATION

A. The Subcontractor shall maintain current records of quality control operations, activities, and tests performed including the work of suppliers and subcontractors. These records shall be on an acceptable form and indicate a description of trades working on the project, the numbers of personnel working, the weather conditions encountered, any delays encountered, and acknowledgement of deficiencies noted along with the corrective actions taken on current and

previous deficiencies. In addition, these records shall include factual evidence that required activities or tests have been performed, including but not limited to the following:

1. Type and number of control activities and tests involved.
2. Results of quality control activities or tests.
3. Nature of defects, causes for rejection, etc.
4. Proposed corrective action.
5. Corrective actions taken.

3.04 NOTIFICATION OF NONCOMPLIANCE

A. The Engineer may notify the Subcontractor of any noncompliance with the foregoing requirements. The Subcontractor shall, after receipt of such notice, immediately take corrective action. Such notice, when delivered to the Subcontractor or his representative at the site of the Work, shall be deemed sufficient for the purpose of notification. If the Subcontractor fails or refuses to comply promptly, the Engineer may issue an order stopping all or part of the Work until satisfactory corrective action has been taken. No part of the time lost due to any such stop orders shall be made the subject of claim for extension of time or for excess costs or damages by the Subcontractor.

3.05 DEFECT ASSESSMENT

A. Replace Work or portions of the Work not conforming to specified requirements.

B. If, in the opinion of Engineer, it is not practical to remove and replace the Work, Engineer will direct an appropriate remedy or adjust payment.

END OF SECTION

SECTION 01410

SAMPLING PROCEDURES AND LABORATORY SERVICES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Sampling and analysis requirements related to the following:

1. Testing of Construction Water treatment system influent and effluent.
2. Confirmatory soil sampling during excavation of lagoon sludge.
3. Testing of excavated on-site soil for potential reuse.

B. This section references a Field Sampling Plan (FSP) and Quality Assurance Project Plan (QAPP) that detail all required field activities and laboratory activities related to the acquisition and reporting of chemical data.

1.02 RELATED SECTIONS

A. Section 01300 - Administrative Requirements

B. Section 02240 - Construction Water Management

C. Section 02315 - Excavation

D. Section 02316 - Fill and Backfill

1.03 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

A. U.S. Environmental Protection Agency (EPA)

1. SW-846, Test Methods for Evaluating Solid Waste Physical/Chemical Methods, 3rd edition, November 1986, including revisions through December 1996, and any subsequent revisions.
2. EPA/625 3-89 016 Interim Procedures for Estimating Risks Associated with Exposure to Mixtures of Chlorinated Dibenzo-p-dioxin and dibenzofurans (CDDs and CDFs).
3. 40 CFR 136, Guidelines for Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act.
4. EPA/240/B-01/003, EPA Requirements for Quality Assurance Project Plans, EPA QA/R-5, March 2001.
5. EPA Method 680, EPA Method 680: Determination of Pesticides and PCBs in Water and Soil/Sediment by Gas Chromatography/Mass Spectrometry, Physical and Chemical Methods Branch, Environmental Monitoring and Support Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, OH, November 1985.
6. EPA/821-R-02-013, USEPA Short Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Water to Freshwater Organisms, Fourth Edition, October 2002, Methods 1000.0 and 1002.0.
7. Region I, EPA-NE Data Validation Functional Guidelines for Evaluating Environmental Analyses, December 1996.
8. USEPA Contract Laboratory Program National Functional Guidelines for Chlorinated Dioxin/Furan Data Review, August 2002.

B. Field Sampling Plan for Remedial Action (FSP), Metcalf & Eddy, Inc. November 2003.

C. Quality Assurance Project Plan, Pownal Tannery Superfund Site (QAPP), TRC Environmental Corporation, November 2003.

1.04 SUBMITTALS

A. See Section 01300 - Administrative Requirements, for submittal procedures.

B. FSP/QAPP Addenda

1. The Subcontractor shall adhere to requirements outlined in the FSP and QAPP included as part of the Contract Documents.

2. Prior to the start of Work, the Subcontractor shall provide a Laboratory Quality Management Manual (LQMM) for each laboratory to be used. The LQMM shall provide the chemical quality control procedures necessary for those chemical analyses to be performed by each contracted laboratory. This submittal may be in the form of a laboratory off-the-shelf Quality Management Manual, provided that all relevant quality assurance/quality control procedures are present. The LQMM must include specific standard operating procedures for each of the preparative and analytical methods to be performed by the selected laboratories. The plan(s) shall be submitted by the Subcontractor upon selection of laboratories and included as a separate volume to the attached FSP/QAPP.

3. Prior to start of Work, the Subcontractor shall provide documentation of project organization and quality management responsibilities as required in the FSP/QAPP.

C. Test Reports

1. Analytical results shall be submitted to the Engineer within 21 days of sample collection. Data submittals shall include the results of all analyses, including duplicate sample analyses. Results should also include any unusual observations such as the presence of interferences, etc. Details on the report contents and laboratory turnaround times are provided in Part 3 of this specification and in the FSP/QAPP.

2. The analytical results shall be submitted to the Engineer in the form of a Microsoft Excel spreadsheet and in Adobe (pdf) format on a 3-1/2 inch diskette or via electronic mail, and also in hard copy form. Field QC sample results (trip blanks, field duplicates, equipment blanks, MS/MSDs) shall be included and clearly identified. After the data evaluation has been performed by the Subcontractor, the results shall be submitted to the Engineer with the appropriate qualifiers in the same formats.

3. Submission of raw data and calculations by the laboratories is required in the format of a digital deliverable, such as a compact disc (CD) for archiving purposes The CD shall contain full CLP-like deliverables including all raw data.

D. Field Notes

1. Copies of field logbook entries, any sample collection forms, and detailed sample location information for all sample collection shall be submitted with the test reports required above. Results of any field measurements performed must be included in these notes and/or summarized in spreadsheet format, as described above.

E. As-Built Plan Sample Locations

1. The Subcontractor shall submit record drawings showing the surveyed locations of sample collection.

F. Data Validation Reports

1. The Subcontractor shall submit the Tier II validation reports to the Engineer within 21 days of the laboratory data package. The content requirements for the report are discussed in part 3 of this specification and in the FSP/QAPP.

1.05 SUBCONTRACTOR REQUIREMENTS

A. Laboratory Services

1. The Subcontractor shall provide and coordinate the services of an environmental chemical laboratory to perform analyses. Laboratory capabilities must be provided for the duration of the work.
   a. FSP/QAPP Requirements
      1) The Subcontractor must adhere to the requirements detailed in the attached FSP/QAPP for the project. The purpose of the FSP/QAPP is to ensure that the Subcontractor adequately addresses all chemical quality management requirements associated with this project. The Subcontractor shall ensure that all technical data generated are accurate, precise, and representative. The types and quality of the sampling procedures and analytical testing shall be based on the requirements set forth in these specifications and the FSP/QAPP. Each contracted laboratory shall submit a Laboratory Quality Management Manual (LQMM) for review and approval by the Engineer.
      2) Quality data meeting the requirements of the QAPP shall be generated by the Subcontractor from the following sampling and analysis programs:
         (a) Testing of Construction Water treatment system effluent.
         (b) Confirmatory soil sampling during excavation of lagoon sludge.
         (c) Testing of excavated soil cover for potential reuse.
   b. Quality Control/Assurance Policy
      1) The Subcontractor shall adhere to the requirements detailed in the attached FSP/QAPP. The FSP/QAPP includes consideration of the technical specification requirements and contains provisions to assure identification and compliance with requirements of EPA and Vermont Department of Environmental Conservation (DEC) regulations.
   c. Responsibilities
      1) The Subcontractor is ultimately responsible for the quality of the data generated by their subcontracted laboratories, and will be responsible for resampling or other resultant damages should that data quality not prove sufficient for the project data quality objectives
      2) The Subcontractor's Quality Management Program shall provide assurance that activities affecting chemical quality are documented and accomplished in accordance with written instructions, drawings and procedures. Provisions shall be established for communicating to all responsible individuals in the Subcontractor's organization that Quality Assurance policies, plans, and procedures are mandatory requirements which shall be implemented.
      3) Activities affecting quality shall be accomplished under controlled conditions. Controlled conditions include the use of appropriate procedures and equipment; suitable environmental conditions for accomplishing the activity, such as adequate cleanliness; documentation that specified decontamination procedures were followed; adequate off-site laboratory facilities; and assurance that all prerequisites for the given activity have been satisfied. The Subcontractor is expected to provide equipment and facilities capable of measuring samples of the discharge water to ensure acceptable measurements of select water quality criteria have been achieved. At a minimum, this should include a pH meter with appropriate accessories and a turbidity meter.
      4) The Subcontractor shall provide standard operating procedures (SOPs) which will be used for the pH and turbidity analyses of discharge water.

d. Quality Management Organization
   1) The Subcontractor shall execute the FSP/QAPP which will clearly define the organizational structure within which the FSP/QAPP is to be implemented and executed. The Subcontractor shall detail the names, qualifications, authorities and responsibilities of all QA/QC personnel as well as the relationship and/or interrelationship with the overall project organization. The authority and responsibility of persons performing quality management activities shall be stated in writing. The Quality Management organization shall document the functional lines of authority within the Quality organization. This information will subsequently be inserted in the Project Task Organization section of the QAPP.

e. Coordination with the Engineer
   1) The Subcontractor shall coordinate with the Engineer concerning the anticipated sampling schedule in order to coordinate submission and analysis of double-blind PE samples supplied by the Engineer, to submit results of analysis to the Engineer for evaluation, and to incorporate the PE sample results into data evaluation and potentially, laboratory corrective actions. The Subcontractor must make themsleves available to a field audit by the Engineer.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 PROJECT ORGANIZATION

A. The Subcontractor shall provide details relative to the project organization and quality management responsibilities for the Subcontractor and any Subcontractors to be involved in the completion of the proposed work. This information will subsequently be included in the FSP/QAPP and shall clearly define the project management assignments by name and their responsibilities to ensure compliance with QA/QC protocols.

B. Overall Project Organization

   1. Overall project organization shall include schematic diagrams indicating key QA/QC individuals by name for the prime Subcontractor and any Subcontractor and showing all Subcontractor-Subcontractor interactions and responsibilities.

C. List of Key Individuals

   1. A listing of key individuals and descriptions of qualifications and experience relative to toxic or hazardous materials/wastes sampling and analyses shall be provided.

D. Sampling Program Organization

   1. The Subcontractor shall clearly specify the sampling program organization to be utilized during all field sampling efforts. The Subcontractor shall clearly identify whether individual Subcontractors will be responsible for specific sampling programs. The Subcontractor shall identify all Subcontractors responsible for chain-of-custody transfer between sample collection and receipt by the laboratories.

E. Subcontractor Quality Control Supervisor

   1. The Subcontractor's Quality Control Supervisor shall be responsible for overall management of the Chemical Quality Assurance/Quality Control (QA/QC) System and have the authority to act in all QA/QC matters for the Subcontractor. The Quality Control (QC) Supervisor for this contract shall have the ultimate responsibility to ensure compliance with the approved FSP/QAPP as well as be in charge of the Subcontractor's Quality Control Program for the overall project specifications. The name of this person and/or authorized assistants shall be provided by the Subcontractor along with a summary of their prior experience which shall demonstrate their ability to perform correctly the duties

required to the satisfaction of the Engineer. All of the Subcontractor's submittals for approval shall be reviewed and modified or corrected as needed by him or his authorized assistants and approved prior to forwarding of such submittals to the Engineer.

2. The Subcontractor's Quality Control Supervisor may designate some of his responsibilities to another qualified person who shall be approved in advance by the Engineer in the following situations:
   a. When the Subcontractor's Quality Control Supervisor does not personally have the requisite skills
   b. When the Subcontractor's Quality Control Supervisor is unable to be physically present when tasks involving chemical sampling and analysis activities are being conducted on site.
   c. When deemed necessary by the Engineer.

F. Laboratory Certification

1. The Subcontractor shall show evidence of the prequalification auditing of the certified laboratories. The prequalification shall include a description of the facilities, analytical instrumentation, and personnel responsible for the performance of all laboratory analyses, including supervisors, chemists and technicians. These persons shall be identified together with a corresponding description of experience and qualifications.

3.02 LABORATORY APPROVAL REQUIREMENTS

A. General

1. The Subcontractor shall provide and coordinate the services of an analytical laboratory to perform analyses certified by the EPA's National Environmental Laboratory Accreditation Conference (NELAC) within the required turnaround time. The laboratory shall be certified by NELAC for the EPA analytical methodologies required under this program. The FSP/QAPP details the matrices and methods which need to be documented as NELAC accredited. The laboratory is subject to inspection (auditing) and prior approval by the Engineer. In addition, individual laboratories will be required to submit the necessary documentation demonstrating the NELAC certification for the EPA analytical methodologies required under this program.

2. Laboratories shall possess NELAC certification for each environmental matrix and each specific analytical method to be employed. The Subcontractor must show documentation of prequalification and auditing of all selected laboratories having NELAC certification for all of the analytes and matrices specific to the project. The documentation must show that the laboratories were chosen not only for the low price but for their qualifications. The laboratories' QA plan, resumes, Standard Operating Procedures (SOPs) and Statement of Qualifications which includes lists of laboratory instrumentation, facility description, and experience/references should be available for review by the Engineer. If the laboratory was audited by the Subcontractor, a record of the results of that audit must be available to the Engineer. All of the above information must show relevance to the project.

B. Inspection and Approval

1. The Subcontractor's laboratory and organization must be approved by the Engineer prior to receiving site samples for analysis. The laboratories must be available to a potential audit by the Engineer. Performance evaluation samples may be required for this project, where applicable. Satisfactory completion of the entire laboratory certification process and approval of the individual Laboratory LQMM in accordance with this section must be made before sampling and analysis of any samples may be performed.

C. Laboratory Personnel

1. General
   a. The Subcontractor's laboratory or subcontracted laboratory shall be experienced in the type of testing to be performed. A representative of the laboratory shall coordinate sampling and testing to control the quality of the work. The laboratory personnel will be evaluated and approved with reference to their education and related professional experience in the performance of specified analytical and QA/QC activities. At a minimum, the laboratory personnel shall consist of the following:

2. Organic Laboratory Supervisor
   a. An Organic Laboratory Supervisor shall have a minimum of a bachelor's degree in chemistry or any physical science and at least three years of laboratory experience, including at least one year of supervisory experience.

3. GC/MS Operator
   a. A GC/MS Operator shall have a minimum of a bachelor's degree in chemistry or any physical science and one year of experience in operating and maintaining GC/MS systems. This applies to operators of low resolution and high resolution GC/MS systems.

4. GC/ECD Operator
   a. A GC/ECD Operator shall have a minimum of a bachelor's degree in chemistry or any physical science and one year of experience in operating and maintaining GC/ECD systems.

5. Mass Spectral Interpretations Specialist
   a. A Mass Spectral Interpretations Specialist shall have a minimum of a bachelor's degree in chemistry or any physical science, a training course(s) in mass spectral interpretation and a minimum of two years experience.

6. Organic Sample Preparation Specialist
   a. An organic sample preparation specialist shall have a minimum of a high school diploma and a college level course in general chemistry or equivalent, and a minimum of six months experience in an analytical laboratory.

7. Back-Up Technician
   a. The laboratory shall have a minimum of one (1) chemist available at any one time of operation as a back-up technical person with a minimum of a bachelor's degree in chemistry or any physical science and a minimum of one year experience in each of the following areas: GC/MS operation and maintenance for volatile and semivolatile analyses; mass spectral interpretation; sample extraction and preparation; GC/ECD operation and maintenance for pesticide/PCB analyses; and HRGC/HRMS operation and maintenance for dioxin/furan analyses.

8. Inorganics Laboratory Supervisor
   a. An Inorganics Laboratory Supervisor shall have a minimum of a bachelor's degree in chemistry or any scientific/engineering discipline and a minimum of three years of laboratory experience, including at least one year in a supervisory position.

9. ICP and/or ICP/MS Spectroscopist
   a. An ICP and/or ICP/MS Spectroscopist shall have a minimum of a bachelor's degree in chemistry or any scientific/engineering discipline, a specialized training in ICP and/or ICP/MS Spectroscopy and a minimum of two years of applied experience with ICP and/or ICP/MS analysis of environmental samples.

10. ICP Operator
    a. An ICP Operator shall have a minimum of a bachelor's degree in chemistry or any scientific/engineering discipline, a minimum of one year of experience in operating and

maintaining ICP instrumentation, in conjunction with the educational requirements; or, in lieu of educational requirements, three additional years of operating and maintaining ICP instrumentation.

11. Atomic Absorption (AA) Operator
    a. An Atomic Absorption (AA) Operator shall have a minimum of a bachelor's degree in chemistry or any scientific/engineering discipline, a minimum of one year of experience in operating and maintaining AA instrumentation for whichever of the following AA techniques will be utilized during this program: (a) flame, (b) graphite furnace, and (c) cold vapor, in conjunction with the educational requirements; or, in lieu of educational requirements, three additional years of operating and maintaining AA instrumentation, including flame, graphite furnace, and cold vapor techniques.

12. Inorganic Sample Preparation Specialist
    a. An Inorganic Sample Preparation Specialist shall have a minimum of a high school diploma and a college level course in general chemistry or equivalent, and a minimum of six months of experience in an analytical laboratory.

13. Spectrophotometric and/or Titration Specialist
    a. A Spectrophotometric and/or Titration Specialist (based on which procedure is used for cyanide analysis) shall have a minimum of a high school diploma and a college level course in general chemistry or equivalent, and a minimum of six months of experience in an analytical laboratory.

14. Training
    a. The laboratory must provide documentation of all training. This will include the time of training, curriculum of material taught, the qualification of the trainers, and a testing procedure or method of documenting the learning process.

D. Laboratory Facilities

1. Certain basic facilities are necessary for the safe, accurate and timely analysis of the required samples. At a minimum, the laboratory facilities shall include the following:

2. Sample Receipt Area
    a. A sample receipt area providing adequate, contamination-free, well-ventilated work space with chemical resistant bench tops for receipt and safe handling of samples.

3. Storage Area
    a. A Storage Area with sufficient refrigerator space to maintain unused sample volume for 60 days after data submission and sample extracts for 365 days after data submission. NOTE: Volatile samples, extractable organic samples, sample extracts, and standards must each be stored separately.

4. Sample Preparation Area
    a. A Sample Preparation Area shall have adequate, contamination-free, well-ventilated work space provided with: benches with chemical resistant tops, fume hoods, laboratory ovens, dessicators, a vacuum source (Note: Standards must be prepared in a separated hood or isolated area), source of distilled or demineralized organic-free water and analytical balance(s) located away from drafts and rapid changes in temperature.

E. Laboratory Instrumentation

1. At a minimum, the laboratory shall have the following instruments in operation at the time of the post-award laboratory evaluation. The instruments must be committed for the full duration of the contract. The instruments must be capable of achieving the required reporting limits specified in the FSP/QAPP.

2. Volatile Analysis
   a. For volatile analysis, a GC/MS system with a purge and trap device shall be provided.

3. Semivolatile Analysis
   a. For semivolatile analysis, a GC/MS system with an autosampler/injector shall be provided. The GC/MS system must be capable of operating in both the full scan and selective ion monitoring (SIM) mode for select analytes.

4. PCB Homologue Analyses
   a. For PCB homologue analyses, a GC/MS system with an autosampler/injector shall be provided. The GC/MS system must be capable of operating in the SIM mode.

5. Dioxin and Furan Analyses
   a. For dioxin and furan analysis, a high resolution GC/ high resolution MS system with an autosampler/ injector shall be provided.

6. Backup for Organic Instrumentation
   a. As a backup for organic instrumentation, the laboratory shall provide, at a minimum, one (1) GC/MS system and one (1) purge and trap device. In addition, the laboratory shall have an in-house stock of instrument parts and circuit boards or maintain manufacturer instrument service contracts for each instrument to ensure continuous operation to meet contract-specified holding times and turnaround times.

7. Metals Analysis (excluding mercury)
   a. For the analysis of metals, an Inductively Coupled Plasma-Atomic Emission Spectrometer (ICP-AES) and/or an ICP/MS shall be provided. The choice of instruments used will be dependent upon the laboratory and the required reporting limits for metals. The instrument chosen must meet the required reporting limits for metals presented in the FSP/QAPP. If required reporting limits cannot be met by ICP and an ICP/MS is unavailable to the laboratory, an atomic absorption spectrophotometer may be used, as specified in this section.
   b. If an ICP/MS is unavailable to the laboratory, an Atomic Absorption Metals Analysis spectrophotometer with a graphite furnace shall be provided.

8. Mercury Analysis
   a. For mercury analysis, a mercury cold vapor AA analyzer or AA instrument modified for cold vapor analysis shall be provided.

9. Cyanide Analysis
   a. For cyanide analysis, a spectrophotometer suitable for measurements between 570 and 580 nanometers shall be provided.

10. Backup for Inorganic Instrumentation
    a. As a backup for inorganic instrumentation, the Subcontractor laboratory shall provide the following: one graphite furnace equipped atomic absorption spectrometer and one mercury cold vapor atomic absorption system. In addition, the Subcontractor laboratory shall have an in-house stock of circuit boards and instrument parts or maintain manufacturer instrument service contracts for each piece of equipment to ensure continuous operation to meet contract specified turnaround times.

F. Laboratory Management Capability

1. The Subcontractor laboratory must have an organization with well-defined responsibilities for each individual in the management system to ensure sufficient resources for this contract and to maintain a successful operation. To establish this capability, the Subcontractor laboratory shall designate personnel to carry out the following responsibilities for the contract. Functions include, but are not limited to, the following:

2. Project Manager
   a. Project Manager shall be responsible for overall aspects of the contract (from sample receipt through data delivery) and shall be the primary contact.

3. Sample Custodian
   a. Sample Custodian shall be responsible for receiving the samples (logging, handling and storage).

4. Quality Assurance Officer
   a. Quality Assurance Officer shall be responsible for overseeing the quality assurance aspects of the data, ensuring corrective action procedures are implemented when necessary and shall report directly to upper management.

5. Data Reporting and Delivery Officer
   a. Data Reporting and Delivery Officer shall be responsible for all aspects of data deliverables organization, packaging, copying, and delivery.

3.03 SAMPLING PROCEDURES

A. Sampling Plan Overview

1. The Field Sampling Plan (FSP) includes a sampling plan for each matrix to be sampled. Each plan clearly addresses procedures to obtain representative data. The FSP contains descriptions of sampling equipment and sample sizes. The FSP/QAPP contains descriptions of sample containers, sample preservation, sample shipment and handling and sampling program organization.

2. Sampling and sample custody procedures shall be consistent with EPA guidelines unless otherwise specified.

3. Specific sampling and analytical procedures are identified in the FSP/QAPP including related extraction procedures and analytical methodologies for appropriate chemical analyses. Detailed procedures are provided in the FSP/QAPP for analytical methodologies requiring special modifications.

4. The Engineer shall have the right to direct modifications to the sampling methodology or SOPs to ensure representative sampling.

B. Sampling and Analysis Requirements

Sampling and analysis requirements for each matrix are summarized in the FSP/QAPP and further described in Section 02240 - Construction Water Management and Section 02315 - Excavation.

1. Construction Water Treatment System
   a. Sampling rationale and frequency requirements associated with the Construction Water Treatment System are detailed in Section 02240 - Construction Water Management. Associated target compounds, required reporting limits, chemical analyses and required quality control analyses are detailed in the FSP/QAPP.

2. Excavated Soil During Excavation
   a. Sampling rationale and frequency requirements associated with the sludge excavation program are detailed in Section 02315 - Excavation. Associated target compounds, required reporting limits, chemical analyses and required quality control analyses are detailed in the FSP/QAPP.

3. Excavated Soil for Potential Reuse
   a. Sampling rationale and frequency requirements associated with the soil cover excavation program are detailed in Section 02315 - Excavation. Associated target compounds, required reporting limits, chemical analyses and required quality control

analyses are detailed in the FSP/QAPP.

C. Decontamination Procedures

1. The Subcontractor shall follow the decontamination procedure provided in the FSP/QAPP for the decontamination of sampling equipment. Sampling methods and equipment shall be chosen to minimize decontamination requirements and the possibility of cross contamination. Any sampling equipment used must be decontaminated before use and between sampling locations.

D. Sample Handling

1. Sample Containers and Preservation
   a. Containers for all samples and coolers shall be supplied by the laboratory. All sample containers utilized by the Subcontractor shall be provided from an EPA-approved supplier utilizing pre-cleaned containers.
   b. The Subcontractor shall employ the sample preservation methods detailed in the FSP/QAPP following sample collection. The FSP/QAPP includes all chemical preservatives to be used, required physical conditions of storage and shipment, and required holding times.

2. Chain of Custody
   a. Each sample container shall be clearly identified with the name of the project, the field sample number, date and time of sampling and the name of the sampling personnel. Field information shall be written in indelible ink and the label shall be affixed in such a manner to ensure that is does not become separated from its respective container.
   b. The Subcontractor shall follow the sample custody procedures detailed in the FSP/QAPP which will assure that any sample which is analyzed will yield results representative of the sample's condition at the time of sampling. The procedures provided are in conformance with the appropriate EPA guidelines.
   c. The Subcontractor shall follow the chain-of-custody procedures detailed in the FSP/QAPP and shall adequately record, for evidence, at a minimum, the following information:
      1) Sample type, sample number, date and time of collection and signatures of the collector.
      2) Signatures of persons involved in sample chain of custody.
      3) Inclusive dates of possession of all individuals involved in sample possession.
      4) Additional remarks the sample handler may have to transcribe onto the chain of custody form.
      5) Analytical parameters required (name and method number).
      6) Name of the project.
      7) Name and telephone number of the point of contact to call for any questions on the sample shipment.
   d. The Subcontractor shall refer to the FSP/QAPP for the methods by which written chain-of-custody information shall be stored for future use.

3. Sample Packaging and Shipping
   a. The Subcontractor shall follow the sample packaging and shipping procedures detailed in the FSP/QAPP.
   b. The Subcontractor shall be responsible for compliance with all appropriate EPA and DOT regulations regarding sample shipment.

E. Documentation

1. The Subcontractor shall refer to the FSP/QAPP for the sample documentation program. The Subcontractor shall provide the Engineer access to the field logbook at all times and shall turn it over to the Engineer in good condition at the conclusion of the project.

3.04 QUALITY CONTROL (QC) SAMPLES

A. General

1. The Subcontractor shall be responsible for collecting field QC samples. The QC samples to be collected shall be identified in the FSP/QAPP. The QC samples are a check on the potential error associated with sampling procedures and sample matrix as well as the Subcontractor's laboratory's overall quality.

B. Subcontractor Quality Control

1. To assure analytical accuracy and consistency, the system of laboratory internal quality control checks specified in the FSP/QAPP shall be followed.

3.05 ANALYTICAL METHODS

A. The proposed contracted laboratory(ies) must be identified in the FSP/QAPP and must be approved by the Engineer. The laboratory must be, at a minimum, capable of performing the analyses cited in the FSP/QAPP.

B. The FSP/QAPP provides a summary of the required analytical methods. The quantitation limits for each of the sample parameters must be comparable to published quantitation limits in SW-846 and referenced methods. In addition, the quantitation limits must be sensitive enough to monitor compliance with the discharge criteria and soil cleanup levels specified in the FSP/QAPP. Furnace atomic absorption methods or ICP/mass spectrometry shall be used for those metals for which sensitivity greater than that attainable by ICP is needed to approach soil cleanup levels and discharge criteria. Selective ion monitoring (SIM) shall be used for those semivolatile organic compounds for which sensitivity is greater than that attainable by full scan GC/MS procedures. The FSP/QAPP summarizes the semivolatile organic compounds which may require SIM analysis.

1. Dioxin/Furan Analyses of Soil Samples: In addition to the analytical requirements specified in the FSP/QAPP for dioxin/furan analyses, the contracted laboratory must report the toxicity equivalent quotient (TEQ) for each sample. The TEQ must be calculated using toxicity equivalent factors (TEFs) from "Interim Procedures for Estimating Risks Associated with Exposure to Mixtures of Chlorinated Dibenzo-p-Dioxins and Dibenzofurans (CDDs and CDFs)" 1989 Update, Part II, page 13. The TEFs are also included in the FSP/QAPP.

2. PCB Homologue Analyses of Discharge of Water Samples: In addition to the analytical requirements specified in the FSP/QAPP for PCB homologue analyses, the contracted laboratory must report the results for total PCBs in each sample. This must be calculated by summing the results for detected homologues in each sample. If no PCB homologues are detected, the total PCB results must be equivalent to the lowest quantitation limit of the homologue groups.

3. The contracted laboratory must be capable of freeze-drying soil samples which contain > 70% moisture. Freeze-drying procedures are detailed in the FSP/QAPP.

C. Analytical Instrumentation

1. The apparatus and instrumentation to be used for all analyses shall be identified as part of the Laboratory(ies) LQMM:
   a. Specific field and laboratory instrumentation including manufacturer and model number.
   b. Operating parameters.
   c. Laboratory chemicals necessary to perform the analyses.
   d. Standards including those for calibration.

D. Corrective Action

1. The Subcontractor shall refer to the FSP/QAPP for the protocol describing the corrective

actions to be taken by the Subcontractor should any analytical data fall outside of acceptable control limits during review.

E. Data Analysis and Reporting

1. The Subcontractor shall refer to the FSP/QAPP for the specific system to be used in handling the raw data from the time of analysis to the time of reporting to the time of archival storage.

2. At a minimum, the Subcontractor shall conform to EPA SW-846 and shall have procedures in place to address the following items for each analytical method and major measurement parameter.
   a. The laboratory data management system including:
      1) The date collected from the Chain of Custody and field manuals
      2) Field manual notes
      3) The raw data collection system
      4) The final calculated results
      5) The data storage system in its entirety including provisions for security and prevention of data loss
      6) Data quality assurance documentation including copies of the method-specified forms presented in SW-846
      7) Identification system for all data collected
      8) Identification of individuals involved in data management and reporting
      9) Identification of schedule for reporting QC analytical data to the Engineer and EPA
   b. The data analysis system including units and equations required to convert instrument response into chemical concentrations.
   c. Plans for testing questionable or incorrect data or inaccurate programming sequences.

3. The Subcontractor shall determine the required laboratory turnaround times for each matrix, noting the following:
   a. Lagoon excavations cannot be backfilled until sample results are received and demonstrate the achievement of soil cleanup levels, unless otherwise directed by the Engineer.
   b. Effluent water from the dewatering pump-and-treat system cannot be discharged to the river until sample results are received and demonstrate the achievement of the discharge criteria.
   c. Excavated cover soil shall not be reused for backfill until documented that it meets criteria for reuse.

4. Hard copy data deliverable requirements are outlined in the FSP/QAPP. Electronic data deliverable requirements are outlined in Section 1.04 (c) and in the FSP/QAPP

F. Data Evaluation

The Subcontractor shall utilize the quality control data provided by the Subcontractor's laboratories to evaluate the validity of the analytical data in terms of accuracy, precision, and environmental significance. The Subcontractor shall conduct a Tier II - type data evaluation consistent with *Region I, EPA-NE Data Validation Functional Guidelines for Evaluating Environmental Analyses*, December 1996. The data evaluation shall include, at a minimum, a review of chain-of-custody documents sample log-in documents, blank QC sample data, MS/MSD data, laboratory duplicate data (inorganics and dioxins/furans only), field duplicate data, surrogate recovery data, internal standard performance, laboratory control sample recovery data and holding time data. Additional QC information as summarized on forms by the laboratory shall also be included in this evaluation. The Region I validation guidelines must be modified to reflect the method-specific QC criteria and FSP/QAPP requirements. The results of the evaluation must be summarized in a data validation report consistent with the Region I data

validation guidelines cited above. The data evaluation shall be completed within 21 days of receipt of the data package by the Subcontractor.

END OF SECTION

SECTION 01500

TEMPORARY FACILITIES AND CONTROLS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Temporary utilities.

B. Temporary sanitary facilities.

C. Security requirements.

D. Vehicular access and parking.

E. Waste removal facilities and services.

F. Portable truck scale for measurement of material quantities by weight.

1.02 RELATED SECTIONS

A. Section 01575 - Temporary Erosion and Sedimentation Controls

B. Section 01732 - Waste Management

C. Section 02821 - Chain Link Fences and Gates

1.03 REFERENCES

A. 29 CFR 1926.200, Occupational Health and Safety Administration, Accident Prevention - Signs and Tags

1.04 SUBMITTALS

A. Manufacturer's specification and calibration procedures for portable truck scale.

B. Weight slips from portable truck scale shall be submitted daily to the Engineer.

1.05 TEMPORARY FACILITIES AND UTILITIES

A. The Engineer will provide an on-site field office trailer with electrical and lighting connections for use by the Subcontractor.

B. Maintain and keep clean provided field office trailer. The Contractor shall be responsible for any damage or deterioration of Contractor office trailer, other than normal wear, during his occupancy of the trailer.

C. The Contractor shall coordinate with the electric company and pay for electrical power and lighting required by the Contractor for construction purposes.

D. The Subcontractor shall provide an adequate supply of drinking water from approved sources of acceptable quality, satisfactorily cooled, for his/her employees and Subcontractors

E. The Subcontractor shall provide and pay for additional services (i.e. water, heating/cooling, ventilation) beyond those provided by the Engineer.

F. The Subcontractor shall provide and pay for all other temporary facilities and/or utilities required by the Subcontractor to conduct the Work.

1.06 TELEPHONE SERVICE

A. The Contractor shall provide and pay for telephone service to Contractor's field office trailer.

B. Telephone lines shall be connected and functional before the start of the Work.

1.07 TEMPORARY SANITARY FACILITIES

A. Provide and maintain required sanitary facilities and enclosures. Number of facilities shall be sufficient for Contractor's personnel and subcontractors. Provide at time of project mobilization.

B. Maintain daily in clean and sanitary condition.

C. Upon completion of the work, remove the conveniences from the premises, leaving the premises clean and free from nuisance.

1.08 SECURITY

A. The Contractor shall be responsible for site security.

B. Control of all persons and vehicles entering and leaving the project site shall be provided by the Subcontractor. The Subcontractor shall exclude from the site personnel not properly identified. The Subcontractor shall comply, at a minimum, with the following requirements:

1. Visitors: Visitors shall not be left unescorted. Visitors shall not be permitted to enter active hazardous work areas without the expressed permission of the Engineer.

2. Visitor Log: Maintain a log of visitors which shall include name, affiliation, purpose of visit, and arrival and departure times.

C. During construction, it may necessary for the Subcontractor to remove portions of the existing fencing system. Coordinate removal of existing fencing and erection of new fencing in a manner to maintain site security.

D. Replace warning signs where necessary.

1.09 WARNING SIGNS

A. Provide caution tape and warning signs at 100-foot intervals on the boundary of the site along the bank of the Hoosic River.

B. Warning signs shall be replaced as necessary throughout period of construction at Contractors expense.

C. Signs shall have red as the the predominating color of the upper panel, black outline on the borders, and a white lower panel for additional sign wording.

D. The warning signs shall include the following graphics:

WARNING

NO TRESSPASSING

PER ORDER OF THE U.S. ENVIRONMENTAL PROTECTION AGENCY

SITE CONTAINS WASTE MATERIALS THAT MAY BE HAZARDOUS

1.10 VEHICULAR ACCESS AND PARKING

A. Provide and maintain access to fire hydrants, free of obstructions.

B. In accordance with Section 01575 - Temporary Erosion and Sedimentation Controls, provide means of removing mud from vehicle wheels before entering streets.

1.11 WASTE REMOVAL

A. Provide waste removal facilities and services as required to maintain the site in clean and orderly condition.

B. Provide containers with lids. Remove trash from site periodically.

C. See Section 01732 - Waste Management, for additional requirements.

1.12 PORTABLE TRUCK SCALE

A. The Contractor shall provide, operate, and maintain a portable truck scale for the measurement of material quantities for payment by weight.

B. The scale shall be sized to weigh the largest piece of equipment the Contractor intends to use in one measurement.

C. The scale shall have a minimum dual tandem axle rating of 80,000 lb and a concentrated load capacity of 80,000 lb.

D. The Contractor shall calibrate the scale per the manufacturer's recommendations prior to weighing any materials and at intervals recommended by the manufacturer.

E. The scale shall include controls, instrumentation, and a printer to record and print the date, time gross weight, net weight and tarre weight.

1.13 METEOROLOGICAL STATION

A. Subcontractor shall provide a meteorological monitoring station for the duration of the project.

B. Meteorological station shall be capable of measuring wind speed and direction, temperature, barometric pressure, relative humidity and rain depth.

C. Subcontractor shall take measurements daily and record monitoring data in a log book. Monitoring records shall be made available to Engineer upon request.

1.14 REMOVAL OF FACILITIES AND CONTROLS

A. Remove equipment and materials prior to completion.

B. Clean and repair damage caused by installation or use of temporary facilities and controls.

C. Restore existing facilities used during construction to original condition.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION - NOT USED

END OF SECTION

SECTION 01575

TEMPORARY EROSION AND SEDIMENTATION CONTROL

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Prevention of soil erosion due to construction activities.

B. Prevention of sedimentation of waterways, open drainage ways, and storm and sanitary sewers due to construction activities.

C. Restoration of areas and controls eroded due to insufficient preventive measures.

D. Prevention of storm water run on onto work areas.

E. Compensation of EPA and/or Engineer for fines levied by authorities having jurisdiction due to non-compliance by Subcontractor.

1.02 RELATED SECTIONS

A. Section 01300 - Administrative Requirements

B. Section 02315 - Excavation

C. Section 02316 - Fill and Backfill

D. Section 02343 - Sludge Stabilization

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM)

1. D 4355 - Standard Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus); 1999.

2. D 4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity; 1999a.

3. D 4533 - Standard Test Method for Trapezoid Tearing Strength of Geotextiles; 1991 (Reapproved 1996).

4. D 4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles; 1991 (Reapproved 1996).

5. D 4751 - Standard Test Method for Determining Apparent Opening Size of a Geotextile; 1999a.

6. D 4873 - Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples; 2001.

B. EPA 832-R-92-005 - Storm Water Management for Construction Activities; U.S. Environmental Protection Agency; 1992. (Note: The EPA Construction General Permit for Large Construction expired on February 17, 2003. A new permit is expected to be issued in May 2003.

C. FHWA (BMP) - Best Management Practices for Erosion and Sediment Control; Federal Highway Administration; 1995.

D. Vermont Handbook for Soil Erosion and Sediment Control on Construction Sites, Special Publication No. 3, Vermont Geological Survey, rev. 1987.

E. General Permit 3-9001 (2002) For Stormwater Runoff from Construction Sites, State of Vermont Agency of Natural Resources Department of Environmental Conservation

F. Erosion and Sediment Control Plan for Construction of Pownal Tannery Remedy - Phase II, Metcalf & Eddy, Inc./TRC Environmental Corporation, November 2003.

1.04 PERFORMANCE REQUIREMENTS

A. Comply with requirements of U.S. Environmental Protection Agency and State of Vermont for erosion and sedimentation control.

B. Submit periodic inspection reports for information.

C. Timing: Install preventive measures in place prior to any soil disturbance.

D. Erosion On Site: Minimize wind, water, and vehicular erosion of soil on project site due to Subcontractor Work.

1. Control movement of sediment and soil from temporary stockpiles of soil.

2. Prevent development of ruts due to equipment and vehicular traffic.

3. If erosion and/or off-site sediment deposition of site materials occurs due to non-compliance with these requirements, restore areas of erosion and/or deposition at Subcontractor's expense.

E. Erosion Off Site: Prevent erosion of soil and deposition of sediment on other properties caused by water leaving the project site due to construction activities for this project.

1. Prevent windblown soil from leaving the project site.

2. Prevent tracking of mud onto public roads outside site.

3. If erosion occurs due to non-compliance with these requirements, the Subcontractor shall restore eroded areas at his own cost.

F. Sedimentation of Waterways: Prevent sedimentation of waterways on or adjacent to the project site, including rivers, streams, lakes, ponds, open drainage ways, storm sewers, and sanitary sewers.

1. If sedimentation occurs due to non-compliance with project requirements or those of authorities having jurisdiction, install or correct preventive measures immediately at Subcontractor's expense; remove deposited sediments; comply with requirements of authorities having jurisdiction.

2. If sediment basins are used as temporary preventive measures, pump dry and remove deposited sediment, when necessary.

G. Open Water: Prevent standing water that could become stagnant.

H. Maintenance: Maintain temporary preventive measures throughout the conduct of the Work.

I. Take necessary measures to protect the Work during periods when Subcontractor will not be present at the work site, including weekends, holidays, or work stoppages or slowdowns due to weather, strikes, seasons, or any other cause. Additional precautionary measures may include temporary scarifying of sideslopes, covering surfaces potentially subject to erosion with heavy burlap or erosion control material, additional silt fence placement, and spreading of mulch or temporary or permanent erosion control matting. Such precautionary measures must be undertaken immediately by the Subcontractor at the request of the Engineer at Subcontractor's expense.

1.05 SUBMITTALS

A. See Section 01300 - Administrative Requirements, for submittal procedures.

B. Inspection Reports: Submit for information weekly report of each inspection on form approved

by the Engineer; identify results of inspection, each preventive measure, indicate condition, specify maintenance or repair required and accomplished and record of rainfall events.

C. Erosion and Sedimentation Control Log: Maintain on site. Submit at project closeout.

D. Manufacturer's specification for seed mixes used: Submit prior to installation.

PART 2 PRODUCTS

2.01 MATERIALS

A. Mulch: Use one of the following:

1. Straw or hay.

B. Straw Bales

1. Straw bales shall consist of straw from acceptable grasses and legumes, free from weeds, reeds, twigs, chaff, debris, other objectionable material or excessive amounts of seeds and grain. It should be free from rot or mold, and the moisture content shall not exceed 15 percent of weight at the time of weighing. The straw shall be securely baled with wire of adequate size to allow for rusting while in use and to permit rehandling when the bale is in a saturated condition. Individual bales shall be of a longitudinal shape not exceeding 100 pounds when baled.

2. Straw bales shall be wire or nylon bound straw bales. Wire or nylon shall be placed horizontally to prevent deterioration of the bindings. Straw bales shall have 2 rebars, steel pickets or 2"x 2" wooden stakes placed a minimum of 1-1/2" into the ground. First stake shall be angled toward previously placed straw bale. Gaps shall be filled with loose straw or hay.

C. Silt Fence Fabric: Polypropylene geotextile resistant to common soil chemicals, mildew, and insects; non-biodegradable; in longest lengths possible; fabric including seams with the following minimum average roll lengths:

1. Average Opening Size: 30 U.S. Std. Sieve, maximum, when tested in accordance with ASTM D 4751.

2. Permittivity: 0.05 sec^-1, minimum, when tested in accordance with ASTM D 4491.

3. Ultraviolet Resistance: Retaining at least 70 percent of tensile strength, when tested in accordance with ASTM D 4355 after 500 hours exposure.

4. Tensile Strength: 100 lb-f, minimum, in cross-machine direction; 124 lb-f, minimum, in machine direction; when tested in accordance with ASTM D 4632.

5. Elongation: 15 to 30 percent, when tested in accordance with ASTM D 4632.

6. Tear Strength: 55 lb-f, minimum, when tested in accordance with ASTM D 4533.

7. Color: Manufacturer's standard.

D. Silt Fence Posts: One of the following, minimum 3 feet long:

1. Steel U- or T-section, with minimum mass of 1.33 lb per linear foot.

2. Softwood, 4 by 4 inches in cross section.

3. Hardwood, 2 by 2 inches in cross section.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine site and identify existing features that contribute to erosion resistance; maintain such existing features to greatest extent practicable.

3.02 PREPARATION

A. Schedule work so that soil surfaces disturbed by the Subcontractor's Work are left exposed for the minimum amount of time.

3.03 INSTALLATION

A. Silt Fence and straw bales:

1. Install perimeter silt fence and straw bales immediately at the beginning of the Work, before any soil disturbance.
2. Install perimeter silt fence and straw bales together as indicated in the Drawings.
3. Install straw bales immediately adjacent to silt fence on uphill side.

B. Soil Stockpiles: Protect using one of the following measures:

1. Cover with polyethylene film, secured by placing soil on outer edges.

C. Mulching Over Large Areas:

1. Dry Straw and Hay: Apply 2-1/2 tons per acre.

D. Mulching Over Small and Medium Areas:

1. Dry Straw and Hay: Apply 3 inches depth.

E. Temporary Sediment Traps:

1. Install temporary sediment traps in accordance with Vermont Handbook for Soil Erosion and Sediment Control on Construction Sites.

3.04 MAINTENANCE

A. Maintain stabilized construction entrance.

B. Continuously monitor public roadways near the site for deposition of material. Clean up deposition areas and conduct street sweeping as necessary.

C. Inspect preventive measures weekly, within 24 hours after the end of any storm that produces 0.5 inches or more rainfall at the project site, and daily during prolonged rainfall.

D. Repair deficiencies immediately.

E. Silt Fences:

1. Promptly replace fabric that deteriorates unless need for fence has passed.
2. Remove silt deposits that exceed one-third of the height of the fence.
3. Repair fences that are undercut by runoff or otherwise damaged, whether by runoff or other causes.

F. Straw Bale Rows:

1. Promptly replace bales that fall apart or otherwise deteriorate unless need has passed.

2. Remove silt deposits that exceed one-half of the height of the bales.

3. Repair bale rows that are undercut by runoff or otherwise damaged, whether by runoff or other causes.

G. Temporary Seeding: Begin maintenance immediately after planting.

1. Maintain grass seed to ensure germination.

2. If necessary, maintain by watering, fertilizing, weeding, mowing, trimming, and other operations such as rolling, regrading and replanting as required to establish graded surface free of eroded or bare areas.

H. Clean out temporary sediment trap structures when sediment has accumulated to one-half the design depth and relocate soil on site.

I. Place sediment in on site landfill; do not remove from site.

J. Review effectiveness of installed measures during construction meetings. If necessary, additional measures shall be implemented subject to requirements of regulatory agencies (EPA, VTDEC).

3.05 RECORDS

A. Maintain a separate log of erosion and sedimentation control installations, inspections and maintenance activities. Log will include a record of rainfall events, result of inspections, conducted maintenance, problem areas and repairs, measures taken to prevent future problems, and all other pertinent information. The log shall be kept on site and shall be available upon request.

B. Logs shall be submitted to Engineer following completion of construction activities.

END OF SECTION

SECTION 01700

EXECUTION REQUIREMENTS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Surveying for laying out the work.

B. Survey to ensure proper grades, lines, and levels are established as set forth in the Contract Documents.

1.02 RELATED SECTIONS

A. Section 01300 - Administrative Requirements

B. Section 02315 - Excavation

C. Section 02316 - Fill and Backfill

D. Section 02520 - Monitoring Wells

1.03 SUBMITTALS

A. See Section 01300 - Administrative Requirements, for submittal procedures.

B. Survey work: Submit name, address, and telephone number of Surveyor before starting survey work.

1. On request, submit documentation verifying accuracy of survey work.
2. Submit a copy of site drawing signed by the licensed Land Surveyor, that the elevations and locations of the work are in conformance with Contract Documents.
3. Submit surveys and survey logs for the project record.

C. Prior to final acceptance of the work specified herein, the Subcontractor shall submit a letter or drawings to the Engineer verifying conformance to the requirements identified in this specification.

D. Submit to Engineer, all field notes from surveying, layout activities when completed, verified and checked.

1.04 QUALITY ASSURANCE

A. The Subcontractor shall be responsible for protecting and maintaining all horizontal and vertical control points during construction.

B. All survey work shall be conducted by a licensed land surveyor, licensed in the state of Vermont.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 GENERAL REQUIREMENTS

A. Prior to the initiation of work, the Subcontractor shall submit descriptions of survey equipment, procedures used to establish temporary or permanent benchmarks or measurements, field notes, calculations, reductions, closures, and documentation for any found benchmarks or monuments to Engineer.

B. Data must be reduced and plotted by the Subcontractor in a form acceptable to the Engineer. Legible notes, drawings, and reproducible documentation shall be submitted to the Engineer for

approval. As a minimum, the Subcontractor shall supply the following survey data to the Engineer:

1. Topographic plot of prepared landfill subgrade.
2. Topographic plot of surface of compacted stabilized waste.
3. Topographic plot of bottom of excavation.
4. A final survey plat showing the topography of the engineered cover and the surrounding project site (including all access roads, ditches and swales, and all new and/or altered structures and utilities.

C. All survey drawings shall show elevations relative to NGVD 1929. In addition to the above noted submittals, all plats shall also be submitted in electronic format.

D. The Subcontractor shall not proceed with placement of an overlying layer or with subsequent work phases until the Surveyor has completed the survey measurements.

E. All surveying shall be recorded in the coordinate system used in the design drawings.

F. The as-built surveying shall be supervised and certified by a licensed Professional Land Surveyor in the State of Vermont.

G. The Subcontractor shall check and verify constructed thickness and elevations with those shown on the plans and prepare record drawings of the construction.

H. The Subcontractor is responsible for controlling lift thickness and engineered cover component thickness such that the engineered cover conforms to the specified dimensions as shown on the Drawings. The Subcontractor shall be responsible for establishing, recording, protecting, and maintaining all permanent and temporary horizontal and vertical control.

3.02 SURVEY MEASUREMENTS

A. Prior to commencement of construction work, the Subcontractor shall establish survey control inside the work area.

B. Survey control points shall be established such that any point within the job site can accurately be re-established and elevations are obtained to the required tolerances at any time during the course of construction. The Subcontractor shall tie all baselines, horizontal and vertical control benchmarks into stated coordinate system.

C. Precision of survey measurements shall be +/- 0.1 feet horizontal and +/- 0.01 feet vertical.

3.03 TOLERANCES

A. The Subcontractor shall survey, at a maximum of 50-foot center to center spacing and all grade breaks, all placed materials within the tolerances specified below:

Description	Vertical	Horizontal
Backfill	+/- 0.2 feet	+/- 0.5 feet
Limit of Stabilized Waste	+/- 0.1	+/- 0.1 feet
Limit of Geomembrane	+/- 0.1 feet	+/- 0.1 feet
Limit of Geocomposite	+/- 0.1 feet	+/- 0.1 feet
Gas Vents	NA	+/- 0.1 feet

3.04 ACCEPTANCE

A. Surveying work not in accordance with the requirements of this specification shall be resurveyed

by the Subcontractor. Acceptance criteria for corrected actions shall be in accordance with the original requirements of this specification.

B. In the event of a survey discrepancy, the area in question shall be resurveyed by the Subcontractor.

3.05 REPORTING REQUIREMENTS

A. Survey data for all boring and confirmatory soil sample locations shall be submitted in tabulated format, in hard copy and on diskette in an AutoCAD file, and on a site base map, with surveyed locations clearly delineated and correctly labeled consistent with identifiers specified in the project QAPP.

B. All drawing files (site base map) shall be submitted as a .DWG produced using AutoCAD Release 14 (or greater), with a scale of 1:1, and with lettering sizes and line widths suitable for reading on a 1" = 60' plan.

C. The site base map shall use AutoCAD's XREF function to display information on separate layers. At a minimum, separate layers shall include soil boring locations, groundwater monitoring locations, key boundary points (fence posts, etc.), and building corners.

D. The subcontractor shall submit all field books, original topographic notes, and computations at no additional cost, if requested by Engineer.

END OF SECTION

SECTION 01732

WASTE MANAGEMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Management of waste generated by the Subcontractor including, but not limited to, hazardous waste, personal protection equipment (PPE), recyclable material, and daily trash.

1.02 RELATED SECTIONS

A. Section 01300 - Administrative Requirements

B. Section 01500 - Temporary Facilities and Controls

1.03 REFERENCES

A. State of Vermont Agency of Natural Resources Department of Environmental Conservation (VTDEC) Regulations

1. Solid Waste Management Rules, Rule Number 02P-002, Effective Date: June 24, 2002.
2. Hazardous Waste Management Regulations, March 2001.

B. Vermont Regulations for Asbestos Control, 18 V.S.A. Chapter 26.

C. Code of Federal Regulations (CFR) Title 40: Protection of Environment, including but not limited to the following:

1. 40 CFR Part 261 - Identification and Listing of Hazardous Waste
2. 40 CFR Part 262 - Standards Applicable to Generators of Hazardous Waste
3. 40 CFR Part 263 - Standards Applicable to Transporters of Hazardous Waste
4. 40 CFR Part 264 - Standards for Asset Managements and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
5. 40 CFR Part 265 - Interim Status Standards for Asset Managements and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
6. 40 CFR Part 266 - Standards for the Management of Specific Hazardous Waste and Specific Types of Hazardous Waste Management Facilities

D. CFR Title 49: Transportation, including but not limited to the following:

1. 49 CFR Part 172 - Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements
2. 49 CFR Part 173 - Shippers – General Requirements for Shipments and Packaging
3. 49 CFR Part 178 - Specifications for Packaging
4. 49 CFR Part 179 - Specifications for Tank Cars

1.04 WASTE MANAGEMENT REQUIREMENTS

A. Generate the least amount of trash and waste possible.

B. Employ processes that ensure the generation of as little waste as possible due to error, poor planning, breakage, mishandling, contamination, or other factors.

C. Minimize trash/waste disposal in landfills; reuse, salvage, or recycle as much waste as

economically feasible.

D. Required Recycling, Salvage, and Reuse: The following may not be disposed of in landfills or by incineration:

1. Aluminum and plastic beverage containers.
2. Corrugated cardboard.
3. Wood pallets.
4. Clean dimensional wood: May be used as blocking or furring.
5. Metals of sufficient quality, including fence posts and other items made of steel, iron, galvanized steel, stainless steel, aluminum, copper, zinc, lead, brass, and bronze.

E. Methods of imported trash/waste disposal that are not acceptable are:

1. Burning on the project site.
2. Burying on the project site.
3. Dumping or burying on other property, public or private, other than licensed facility(ies).
4. Other illegal dumping or burying.

F. Regulatory Requirements: Subcontractor is responsible for knowing and complying with regulatory requirements, including but not limited to Federal, State and local requirements, pertaining to legal disposal of all construction and demolition and hazardous waste materials.

1.05 SUBMITTALS

A. See Section 01300 - Administrative Requirements, for submittal procedures.

B. Waste Disposal Report: Submit for Information at Completion of Work. The Waste Disposal Report shall include, at a minimum, details of waste quantities, means of disposal or reuse, costs, and the following information, as applicable:

1. Recycled and Salvaged Materials: Include the following information for each:
   a. Identification of material.
   b. Amount, in tons or cubic yards, date removed from the project site, and receiving party.
   c. Transportation cost, amount paid or received for the material, and the net total cost or savings of salvage or recycling each material.
   d. Include manifests, weight tickets, receipts, and invoices as evidence of quantity and cost.
2. Waste characterization data for waste requiring characterization.
3. Bills of lading and/or manifests.
4. Certificates of final treatment/disposal signed by the responsible facility official.

C. Disposal Facility: Information required throughout this specification.

D. Transporters: No less than one week prior to transportation, provide name and address of all hazardous material transporters to be used to complete project including state transporter identification number and expiration date and proof of permit, license, or authorization to transport hazardous material in all affected states.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 WASTE MANAGEMENT PROCEDURES

A. See Section 01300 - Administrative Requirements.

B. See Section 01500 - Temporary Facilities and Controls.

3.02 WASTE MANAGEMENT

A. General

1. Facilities: Provide specific facilities for separation and storage of materials for recycling, salvage, reuse, return, and trash disposal, for use by the Subcontractor.
   a. Provide containers as required.
   b. Keep recycling and trash/waste bin areas neat and clean and clearly marked in order to avoid contamination of materials.
   c. PPE: Properly dispose of used PPE at an off site disposal facility.
   d. Recycling: Separate, store, protect, and handle at the site identified recyclable waste products in order to prevent contamination of materials and to maximize recyclability of identified materials. Arrange for timely pickups from the site or deliveries to recycling facility in order to prevent contamination of recyclable materials. Decontaminate materials to be recycled off site.
   e. Reuse of Materials On Site: Set aside, sort, and protect separated products in preparation for reuse.
   f. Salvage: Set aside, sort, and protect products to be salvaged for reuse off-site.

B. Hazardous Wastes: Separate, store, and dispose of hazardous wastes according to applicable regulations.

1. The Subcontractor shall prepare hazardous waste manifest(s) identifying the EPA Region 1 as the generator. Engineer shall sign the manifests as an agent for the EPA prior to transport and disposal of hazardous wastes. The Subcontractor shall track and distribute all copies of the manifest to the appropriate agencies and the Engineer. The Subcontractor shall provide a copy of the manifest for review by the Engineer prior to scheduling waste pick-up.

2. The Subcontractor shall provide for the safe transportation of all hazardous waste materials for proper final disposal at a licensed facility.

3. Disposal Facility Requirements:
   a. The Subcontractor shall furnish to the Engineer, no less than three weeks prior to disposal, the names, locations, EPA/RCRA ID numbers, facility contacts, and documentation that the facilities will accept the waste, for at least two eligible disposal facilities. The Subcontractor shall designate one disposal facility as the primary facility and the other as the alternate facility should project conditions require the use of a back-up facility. Any additional costs if an alternate facility is used shall not be incurred by the Engineer.
   b. The final disposal facilities shall be approved by EPA prior to removal of any hazardous wastes, including tanks and drums, as in 3.03. Coordination of this approval shall be conducted by Engineer.
   c. Subcontractor-selected disposal facilities shall be established, fully operational, and in full compliance with all applicable federal, state and local regulations. The Subcontractor shall document that the disposal locations proposed have all certifications and permits as required by local, state, and federal regulatory agencies to receive and dispose of hazardous materials or wastes, including tank, drums and tank and drum contents.

d. The Subcontractor shall obtain approvals or letters of intent and facility information for the disposal facilities and/or salvage facilities selected to receive wastes. The Subcontractor shall furnish such documents to the Engineer no less than one week prior to disposal. The facilities information shall include the following:
   1) The disposal facilities shall specify the volume of material that can be accepted from this project on a total basis.
   2) The disposal facilities shall provide written confirmation that they are permitted to accept and will accept the hazardous waste of the general quality and quantity described by these specifications.
   3) The disposal facilities shall provide a listing of all permits, licenses, letters of approval, and other authorizations to operate that they hold, pertaining to the receipt and management of the waste specified in these specifications.

4. Transportation Requirements
   a. Before offering hazardous waste for transportation off-site, the Subcontractor shall package that waste in compliance with applicable regulations of the Department of Transportation (DOT), 49 CFR Parts 173, 178, and 179.
   b. Before offering hazardous waste for transportation off-site, the Subcontractor shall label each package in compliance with the applicable regulations of the DOT, 49 CFR Part 172, as may be amended from time to time.
   c. Before transporting hazardous waste off-site, the Subcontractor shall placard, or offer the initial transporter the appropriate placards, in compliance with regulations of the DOT, 49 CFR Part 172, as may be amended from time to time.
   d. The Subcontractor shall transport material off-site for final disposal to the disposal facility approved by the EPA and Engineer.
   e. The Subcontractor shall transport material from the Site to the disposal facilities in accordance with all DOT, EPA, state, local, and other applicable regulations.
   f. The Subcontractor and/or transporter(s) shall be licensed in all states affected by transport.
   g. The Subcontractor shall be responsible for ensuring that all containers are labeled and sealed properly and that spillage does not occur during transport.
   h. The Subcontractor shall maintain complete control of the transport of waste and in case of a spill, shall be responsible for all clean-up.
   i. The portion of the vehicle (either tractor, trailer or both) which is used for the transport of hazardous waste shall bear all markings, including placards, required by any federal or state statute or regulation.
   j. The Subcontractor shall have in place:
      1) Current registration with DOT via the Hazardous Materials Certificate of Registration;
      2) Insurance coverage based on type of waste/vehicle;
      3) DOT safety rating;
      4) Results of state inspections of terminals which usually address level of maintenance and the general condition of the company's equipment;
      5) Verification that Subcontractor keeps transportation manifests on file for three years from the date of transport, including emergency telephone numbers;
      6) Name and address of all hazardous waste transporters; and
      7) EPA identification number and expiration date.

5. Vehicle for off-site transport of hazardous waste must be DOT approved and must display the proper DOT placard. Such vehicles must also conform with appropriate state(s), local, federal hazardous materials requirements and/or other relevant transportation requirements.

C. Asbestos Waste

1. As part of previous response actions conducted in the lagoon area, approximately 800

linear feet of 18-inch diameter and 800 linear feet of 6-inch diameter transite pipe were excavated and removed from beneath the Lagoon access road. The pipes were formerly used to convey primary treated wastewater and sludge from the former Screen House to the Lagoons. Sections of this transite pipe are present in lagoon areas and require removal.

2. Removal of transite pipe shall be in accordance with the Vermont Regulations for Asbestos Control, 18 V.S.E. Chapter 26.

3. Disposal of transite pipe shall be in accordance with the Vermont Solid Waste Management Rules, Subchapter 8 – Special Wastes.

END OF SECTION

SECTION 02240

CONSTRUCTION WATER MANAGEMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Development of a Construction Water Management Plan describing the handling, storage, treatment, disposal, and discharge of Construction Water and associated sludge generated during the Work.

B. Requirements for furnishing and installing the construction water treatment system.

C. Procedure for conducting pilot-scale evaluation of on-site water treatment system.

1.02 RELATED SECTIONS

A. Section 01300 - Administrative Requirements

B. Section 01410 - Sampling Procedures and Laboratory Requirements

C. Section 01575 - Temporary Erosion and Sedimentation Control

D. Section 02315 - Excavation

E. Section 02316 - Fill and Backfill

F. Section 02343 - Sludge Stabilization

1.03 REFERENCES

A. Vermont Water Quality Standards, State of Vermont Water Resources Board, July 2000.

B. Groundwater Protection Rule and Strategy, Rule Number 99-P35, State of Vermont Agency of Natural Resources, Department of Environmental Conservation, January 2000.

C. Maximum Contaminant Levels (MCLs) for Drinking Water, EPA 822/R-02-038, U.S. Environmental Protection Agency, Summer 2002.

1.04 DEFINITIONS

A. Construction Water shall be defined as the following:

1. Surface water bodies in the Lagoon Area that must be removed to perform the Work.
2. Ground water or surface water entering excavations.
3. Liquids generated during decontamination activities.
4. Surface water resulting from precipitation during construction which has come into contact with potentially contaminated soils, sludge, sediments, fill, or debris.
5. Water or other liquids, in addition to that resulting from precipitation, which have come into contact with potentially contaminated soils, sludge sediments, or debris.

1.05 SUBMITTALS

A. See Section 01300 - Administrative Requirements, for submittal procedures.

B. Construction Water Management Plan. Submit no later than 21 days prior to pilot test of water treatment system.

C. The Subcontractor shall submit to the Engineer for review all analytical test reports for effluent water samples a maximum of one week after sample collection.

D. The Subcontractor shall submit to the Engineer a weekly report of treatment system operation including dates of operation, results of field testing, total flow, and average pumping rate, in gallons per minute (gpm).

PART 2 PRODUCTS

2.01 CONSTRUCTION WATER MANAGEMENT PLAN

A. The Subcontractor shall submit a plan for managing Construction Water. The plan shall include, but is not limited to:

1. Methods, means, and facilities required to manage Construction Water and residuals generated during the Work.
2. The Subcontractor's proposed method of handling, sampling, analysis, storage (if necessary), treatment, disposal, and discharge of Construction Water generated during the Work.
3. Equipment and personnel required to manage Construction Water.
4. A detailed description of the water treatment system including, but not limited to, shop drawings, technical specifications, performance criteria, and limitations.
5. Analytical results from preliminary sampling of water representative of water to be pumped from Lagoons 1 and 5. The Subcontractor is responsible for collecting samples that are representative of Construction Water expected to be generated during the Work.
6. A detailed description of a stabilized outfall area designed to meet the performance requirements of Section 01575 - Temporary Erosion and Sedimentation Control.
7. Procedure for pilot test.
8. Procedure for decontamination of equipment prior to demobilization from site.

B. The acceptable method of handling Construction Water is limited to collection and discharge to the Hoosic River after appropriate treatment.

C. The acceptable method of handling sludge and sediments generated by the Subcontractor's management of Construction Water is limited to collection and stabilization in accordance with Section 02343 - Sludge Stabilization, and placement within the limits of the landfill. Sediments and settleable solids resulting from this method must meet all requirements for placing sludge beneath the cap.

2.02 CONSTRUCTION WATER MANAGEMENT SYSTEM

A. Base Treatment System

1. The Subcontractor shall provide all labor, equipment, and materials to furnish and install the "base" treatment system at the project site, set up the system, and perform a clean water test to ensure proper mechanical operation of treatment system components. This shall include, but is not limited to loading/securing treatment system components and shipment to the project site, unloading and set-up of treatment system components on the project site, including connecting treatment system components to required utilities, and start-up which includes performing a clean water test of the treatment system using river water as the source.
2. The base treatment system shall be capable of continuous treatment of 400 gallons per minute (gpm) of sediment-laden, surface water pumped from Lagoon 1 and Lagoon 5. The base system shall include an influent settling tank, a sand filter unit, a bag filter unit, a granular activated carbon (GAC) unit, and an effluent holding tank. The base system shall include flow meters, totalizer, and all applicable transfer and backwash pumps, piping,

valves, pressure gauges, and sampling ports. Materials shall include all media including filter sand, bag filters, and GAC filter vessel. The vessels shall be equipped with pressure gauges to use in monitoring the need for backwashing and/or replacing filters. Sampling ports shall be provided, positioned to allow for sampling of influent and effluent from the filter vessels for process monitoring purposes.

3. The sand filter vessels shall be configured to allow for efficient change out of media in the field. Backwash pumps, transfer piping, and valves shall also be provided, and sized to allow for thorough and efficient backwashing of the media contained in each of the vessels. Totalizing flow meters shall be located on the total influent of the sand filter system and the effluent from the final treatment system holding tank.

4. The bag filter unit shall consist of a skid-mounted bank of steel vessels, each equipped to house a single bag filter. The bag filters shall be sized to facilitate meeting the anticipated discharge criteria. The bag filter vessels shall be configured to allow for efficient change out of the filters in the field. The bag filter system shall be configured to allow for isolation of any single vessel to allow for change out of its bag filter while the entire flow rate is diverted through the remaining vessels. Sampling ports shall be located, positioned to allow for sampling of influent and effluent from the bag filters for process monitoring purposes.

5. The discharge system shall consist of a pump to transfer treated water from an effluent holding tank, piping to convey the treated water to the Hoosic River, and outfall structure(s) designed to prevent erosion along the river bank and scouring of river bed sediment. A sampling port shall be located, positioned to allow for sampling of the effluent line for process and compliance monitoring purposes.

B. Optional Components - If base construction water treatment system does not provide adequate removal of contaminants to meet discharge criteria, additional components shall be added to the base system. The components include, but are not limited to coagulation and flocculation system to filter finely dispersed particles and pH adjustment components to raise or lower the pH, as required.

PART 3 EXECUTION

3.01 GENERAL

A. The Subcontractor shall provide all labor, materials, and equipment required for handling, storage, treatment, and disposal of Construction Water in accordance with the approved Construction Water Management Plan.

B. It shall be the responsibility of the Subcontractor to investigate and comply with all applicable Federal, State, and Local laws and regulations governing the handling, storage, and disposal of Construction Water. All Construction Water shall be disposed of in a manner which meets applicable permit requirements, laws, and regulations.

C. Any sampling and analysis necessary to protect the health and welfare of the Subcontractor's employees and/or agents and/or to characterize collected water, treated water, or residuals shall remain the sole responsibility of the Subcontractor

D. Construction water shall be handled using equipment compatible with anticipated contaminants which may be present.

E. Subcontractor may transfer existing surface water in Lagoon 1 and 4 to Lagoon 5 without treatment. The transfer of water shall not cause erosion, disturbance of sludge, or mixing with the sludge.

3.02 TREATMENT SYSTEM MOBILIZATION

A. The Subcontractor shall be responsible for the placement of the water treatment system at a

location that does not interfere with the Work.

B. The Subcontractor is responsible for providing utilities required for operation of the treatment system.

3.03 DISCHARGE TO HOOSIC RIVER

A. General

1. No Construction Water shall be discharged to the Hoosic River until pilot test establishes that the water treatment system can meet the discharge criteria listed in Table 02240-1.

2. All testing required for compliance with discharge criteria shall be the responsibility of the Subcontractor and shall be in accordance with Section 01410 - Sampling Procedures and Laboratory Requirements.

B. Influent and Effluent Testing Frequency

1. During Pilot Test - Approximately 20,000 gallons, or one fractionation (frac) tank, will be treated as part of the pilot test. One sample from the frac tank will be collected. If the discharge criteria are achieved, the water will be discharged. If not, the treatment system will be modified, and an additional 20,000 gallons of water will be treated and the effluent will be retested.

2. During Surface Water Removal - One sample will be collected per 100,000 gallons for the first 500,000 gallons. If discharge criteria are achieved, the frequency will be decreased to one sample per 500,000 gallons.

3. During Excavation Dewatering - One sample will be collected per 100,000 gallons for the first 500,000 gallons. If discharge criteria are achieved, the frequency will be decreased to one sample per 500,000 gallons.

4. At no time shall the discharged volume sample frequency be less than specified requirements.

5. All stored water shall be retreated to meet discharge criteria prior to discharge to river.

C. Discharge volume shall be monitored by means of a flow totalizer or equivalent method installed at the discharge of the treatment system.

D. Unless otherwise allowed by the Engineer, discharge flow rate to the Hoosic River shall not exceed 400 gallons per minute.

E. The Subcontractor shall construct a stabilized outfall area to prevent erosion of soil and sediment.

3.04 MINIMIZATION OF CONSTRUCTION WATER

A. The Subcontractor shall make every effort to minimize the generation of Construction Water and associated sediments and sludges. Methods to minimize generation of Construction Water include, but are not limited to:

1. Erection of temporary berms.

2. Use of low permeability tarpaulin or suitable means to cover exposed contaminated areas and materials.

3. Limiting the amount of exposed contaminated areas.

4. Grading to control run-on and run-off.

5. Engineering controls on construction activities to minimize contact of personnel and equipment with contaminated areas to minimize the amount of decontamination required

and other appropriate methods.

3.05 PILOT-SCALE TESTING OF TREATMENT SYSTEM

A. The Subcontractor shall conduct a test of the water treatment system to demonstrate that that the system meets the performance requirements of this section.

B. Prior to the Work, the Subcontractor shall conduct a pilot-scale test of the treatment system to reproduce, as close as possible, conditions that will be present during excavation activities.

C. The pilot test shall be conducted by pumping construction water at a flow rate of 400 gallons per minute from an area of exposed sludge and passing the water through the treatment system. A minimum of 20,000 gallons shall be treated as part of the pilot test.

D. The pilot test shall be repeated until the treatment system meets the discharge criteria listed in Table 02240-1. The Subcontractor shall make any adjustments or modifications to treatment system needed to reduce contaminant concentrations and meet the discharge criteria.

E. Whole Effluent Toxicity Testing

1. Subcontractor shall collect and test the treatment system effluent using USEPA Short Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Water to Freshwater Organisms, Fourth Edition, October 2002 (EPA/821-R-02-013), Method 1000.0 and Method 1002.0

2. Evaluation of Test Data:
   a. Effluent fails at all dilutions - Rerun test or modify treatment train and rerun toxicity tests until a passing result is obtained.
   b. Test results inconclusive - Rerun test until conclusive results are obtained.
   c. Test passes - Test results exhibit no observed acute or chronic toxicity to aquatic biota at one or more dilutions. The allowed discharge rate shall be revised to the rate below the rate associated with the dilution that exhibited any toxic effects. The rate shall be calculated using a river flow rate of 56 cubic feet per second.

3. No further toxicity testing will be required once an acceptable test result is obtained.

3.06 OPERATION AND MAINTENANCE

A. The Subcontractor shall provide all labor, materials, and equipment to operate and maintain the water treatment and discharge system. The Subcontractor's labor to operate and maintain the treatment and discharge system shall include a supervisor knowledgeable and experienced in water treatment system operation, maintenance, and troubleshooting.

END OF SECTION

TABLE 02240-1
DISCHARGE CRITERIA
POWNAL TANNERY SUPERFUND SITE
LAGOON AREA REMEDIATION

Compound	Discharge Criteria (ug/L)	Basis of Criteria
VOCs		
Acetone	130,000	Vermont Groundwater Enforcement Standard
Benzene	13,200	Protection of Human Health
Bromodichloromethane (Dibromodichloromethane)	1,380	Protection of Human Health
Bromoform	67,100	Protection of Human Health
Bromomethane (Methyl Bromide)	251,000	Protection of Human Health
2-Butanone (MEK)	782,000	Vermont Groundwater Enforcement Standard
Carbon tetrachloride	820	Protection of Human Health
Chlorobenzene (Monochlorobenzene)	1,320,000	Protection of Human Health
Chloroform	67,500	Protection of Human Health
1,2-Dichlorobenzene	1,070,000	Protection of Human Health
1,3-Dichlorobenzene	163,000	Protection of Human Health
1,4-Dichlorobenzene	484,000	Protection of Human Health
1,1-Dichloroethane	13,000	Vermont Groundwater Enforcement Standard
1,2-Dichloroethane	18,400	Protection of Human Health
1,1-Dichloroethene	690	Protection of Human Health
trans-1,2-Dichloroethene	18,600	Vermont Groundwater Enforcement Standard
Ethylbenzene	1,620,000	Protection of Human Health
4-Methyl-2-pentanone	104,000	Vermont Groundwater Enforcement Standard
Methyl tert-butyl ether	7,450	Vermont Groundwater Enforcement Standard
Methylene chloride	298,000	Protection of Human Health
Styrene	18,600	Vermont Groundwater Enforcement Standard
Tetrachloroethylene	1,650	Protection of Human Health
Toluene	12,600,000	Protection of Human Health
1,2,4-Trichlorobenzene	13,000	Vermont Groundwater Enforcement Standard
1,1,1-Trichloroethane	37,300	Vermont Groundwater Enforcement Standard
Trichloroethene	15,100	Protection of Human Health
Xylene	1,860,000	Vermont Groundwater Enforcement Standard
SVOCs		
Anthracene	6,910,000	Protection of Human Health
Atrazine	559	Vermont Groundwater Enforcement Standard
Benzo(a)anthracene	5.77	Protection of Human Health
Benzo(a)pyrene	5.77	Protection of Human Health
Benzo(b)fluoranthene	5.77	Protection of Human Health
Benzo(k)fluoranthene	5.77	Protection of Human Health
Bis(2-chloroethyl)ether	281.0	Protection of Human Health
Bis(2-ethylhexyl)phthalate	371	Protection of Human Health
Chrysene	5.77	Protection of Human Health
Dibenzo(a,h)anthracene	5.77	Protection of Human Health
2,4-Dichlorophenol	49,600	Protection of Human Health
Diethylphthalate	7,540,000	Protection of Human Health
Di-n-butylphthalate	754,000	Protection of Human Health
Fluoranthene	23,200	Protection of Human Health
Fluorene	880,000	Protection of Human Health
Hexachloroethane	1,860	Protection of Human Health
Indeno(1,2,3-cd)pyrene	5.77	Protection of Human Health
Isophorone	37,700	Protection of Human Health
Naphthalene	3,730	Vermont Groundwater Enforcement Standard
Nitrobenzene	119,000	Protection of Human Health
2,2-oxybis-1-Chloropropane (bis-2 Chloroisopropyl ether	10,700,000	Protection of Human Health
Pentachlorophenol	360	Protection of Aquatic Biota
Phenol	289,000,000	Protection of Human Health
Pyrene	691,000	Protection of Human Health
2,4,6-Trichlorophenol	1,210	Protection of Human Health
Metals		
Aluminum	37,300	Vermont Groundwater Enforcement Standard
Antimony	270,000	Protection of Human Health
Arsenic	279	Protection of Human Health
Barium	373,000	Vermont Groundwater Enforcement Standard
Beryllium	745	Vermont Groundwater Enforcement Standard
Cadmium	71.3	Protection of Aquatic Biota
Chromium	13,000	Protection of Aquatic Biota
Copper	743	Protection of Aquatic Biota
Iron	62,800	Protection of Aquatic Biota
Lead	200	Protection of Aquatic Biota
Manganese	158,000	Vermont Groundwater Enforcement Standard
Mercury	0.75	Protection of Aquatic Biota
Nickel	9,910	Protection of Aquatic Biota
Selenium	314	Protection of Aquatic Biota
Silver	18,600	Vermont Groundwater Enforcement Standard
Sodium	48,600,000	Vermont Groundwater Enforcement Standard
Thallium	398	Protection of Human Health
Zinc	8,680	Protection of Aquatic Biota
Cyanide	327	Protection of Aquatic Biota
PCBs		
Total PCBs	0.02	Method detection limit
Dioxin		
Dioxin (2,3,7,8-TCDD)	2.61E-08	Protection of Human Health
Water Quality Parameters		
pH	4 < pH <10	Vermont Water Quality Standard
Turbidity	50 NTU	Vermont Water Quality Standard

Note:
Discharge criteria calculated for discharge flow rate of 400 gallons per minute.

SECTION 02260

TEMPORARY EXCAVATION SUPPORT SYSTEMS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Requirements for providing temporary excavation support systems to maintain lateral support, prevent loss of ground, limit soil movements to acceptable limits, and protect from damage existing and proposed improvements including, but not limited to, pipelines, utilities, structures, roadways, and other facilities.

1.02 RELATED SECTIONS

A. Section 01300 - Administrative Requirements

B. Section 01120 - Health and Safety

C. Section 02240 - Construction Water Management

D. Section 02315 - Excavation

E. Section 02316 - Fill and Backfill

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM)

1. A36/A36M-01 Standard Specification for Carbon Structural Steel
2. A328/A328M-03 Standard Specification for Steel Sheet Piling
3. A615/A615M-01b Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement

B. OSHA Standard 29 CFR 1926, Subpart P, Excavation, Trenching, and Shoring

C. American Welding Society, AWS D1.1, Structural Welding Code - Steel

1.04 DEFINITIONS

A. Sheeting - Wherever the word "sheeting" is used in this section or on the Drawings, it shall be in reference to any type of excavation support system specified except trench box. Common types of excavation support system include, but are not limited to, singular or multiple stages comprised of cantilevered or internally braced soldier piles and lagging, steel sheetpile wall, timber sheetpile wall, trench box, or combinations thereof. Trench box temporary excavation support system is only acceptable for pipe or utility trench excavations.

1.05 SUBMITTALS

A. See Section 01300 - Administrative Requirements, for submittal procedures.

B. Temporary Excavation Support Plan

1. Submit a temporary excavation support plan stamped and signed by a Registered Professional Engineer at least 21 days prior to installation. Do not submit design calculations. The review will be only for the information of the Engineer for an overall understanding of the project relating to access, maintenance of existing facilities and proper utilization of the site. The Subcontractor shall remain responsible for the adequacy and safety of the means, methods and sequencing of construction. The plan shall include the following items as a minimum:
   a. Proposed temporary excavation support system(s), details, location, layout, depths,

extent of different types of support relative to existing features and the permanent structures to be constructed, and methods and sequence of installation and removal.

b. Certificate of Design: (attached at end of this Section).
c. Requirements of dewatering during the construction.
d. Minimum lateral distance from the edge of the excavation support system for use for vehicles, construction equipment, and stockpiled construction and excavated materials.
e. List of equipment used for installing the excavation support systems.
f. A plan to monitor lateral movements of the temporary excavation support system, movements of the ground adjacent to excavation support systems and adjacent structures to be performed by a registered land surveyor. The plan shall include, but not be limited to locations, details and monitoring schedule of geotechnical instruments such as survey markers (reference points on structures).

2. Submit a Construction Contingency Plan specifying the methods and procedures to maintain temporary excavation support system stability if the allowable movement of the adjacent ground and adjacent structures is exceeded.

3. For excavation support systems left in place, submit the following as-built information prior to backfilling and covering the excavation support systems:
   a. Survey locations of the temporary excavation support systems, including coordinates of the ends and points of change in direction.
   b. Type of the temporary excavation support system.
   c. Elevations of top and bottom of the excavation support systems left in place.

1.06 DESIGN REQUIREMENTS

A. Design of temporary excavation support systems shall meet the following minimum requirements:

1. Support systems shall be designed for earth pressures, hydrostatic pressure, equipment, temporary stockpiles, construction loads, and other surcharge loads.

2. Design a bracing system to provide sufficient reaction to maintain stability.

3. Limit movement of ground adjacent to the excavation support system to be within the allowable ground deformation as specified.

4. Design the embedment depth below bottom of excavation to minimize lateral and vertical earth movements and provide bottom stability. Toe of braced temporary excavation support systems shall not be less than 5 feet [1.5 m] below the bottom of the excavation.

5. Design temporary excavation support systems to withstand an additional 2 feet [60 cm] of excavation below proposed bottom of excavation without redesign except for the addition of lagging and/or bracing.

1.07 PERFORMANCE REQUIREMENTS

A. Construction of the temporary excavation support systems shall not disturb the existing structures or the completed proposed structures. Damage to such structures shall be repaired by the Subcontractor at the expense of the Subcontractor.

B. The Subcontractor shall bear the entire cost and responsibility of correcting any failure, damages, subsidence, upheaval or cave-ins as a result of improper installation, maintenance or design of the temporary excavation support systems. The Subcontractor shall pay for all claims, costs and damages that arise as a result of the work performed.

1.08 QUALITY ASSURANCE

A. A Competent Person in accordance with OSHA 29 CFR 1926, Subpart P shall be present at all times during excavation activities. Name and qualifications of the Competent Person shall be

included in the HASP.

B. Conform to the Subcontractor's Health and Safety Plan (see Section 01120 - Health and Safety), specifically requirements of the OSHA Standards and Interpretations: "Part 1926 Subpart P - Excavation, Trenching, and Shoring"; and all other applicable laws, regulations, rules, and codes.

C. All welding shall be performed in accordance with AWS D1.1.

1.09 DELIVERY, STORAGE, AND HANDLING

A. Store sheeting and bracing materials to prevent sagging which would produce permanent deformation. Keep concentrated loads which occur during stacking or lifting below the level which would produce permanent deformation of the material.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Structural Steel: All soldier piles, wales, rakers, struts, wedges, plates, waterstop and accessory steel shapes shall conform to ASTM A36.

B. Steel Sheet Piling: ASTM A328, continuous interlocking type.

C. Timber Lagging Left in Place: Pressure treated per appropriate AWPA standards.

D. Raker Ties: ASTM A615 Grade 60.

E. Tamping tools adapted for backfilling voids after removal of the excavation support system.

F. Where necessary, provide specific trench box sizes for each pipe and utility excavation with structural capacity of retaining soil types as described in OSHA 29 CFR Part 1926 Subpart P.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Installation of the temporary excavation support systems shall not commence until the Contaminated Material Excavation Plan (see Section 02315 - Excavation) and Construction Water Management Plan (see Section 02240 - Construction Water Management) submittals have been reviewed by the Engineer with all Engineer's comments satisfactorily addressed.

B. Install excavation support systems in accordance with the Temporary Excavation Support Plan.

C. Do not drive sheeting within 100 feet [30 m] of concrete less than seven (7) days old.

D. Carry out program of temporary excavation support in such a manner as to prevent undermining or disturbing foundations of existing structures of work ongoing or previously completed.

E. Bottom of trench box excavation support system shall be above the pipe invert prior to installing the pipe.

F. Install and read geotechnical instrumentation in accordance with the temporary excavation support plan. Notify the Engineer immediately if any geotechnical instrumentation is damaged. Repair or replace damaged geotechnical instrumentation at the sole option of the Engineer and at Subcontractor's expense.

G. Continuously monitor movements of the temporary excavation support system, ground adjacent to excavation support systems and adjacent structures. In events of the measured movements approaching or exceeding the allowable movements, take immediate steps to arrest further movement by revising procedures such as providing supplementary bracing, filling voids behind the trench box, supporting utilities or other measures (Construction Contingency Plan) as required.

H. Notify utility owners if existing utilities interfere with the temporary excavation support system. Modify the existing utility with the utility owners permission or have the utility owner make the modifications at Subcontractor's expense.

3.02 GROUND DEFORMATION ADJACENT TO EXCAVATION SUPPORT SYSTEMS

A. Criteria for "threshold" and "limiting" movements of wall elements of excavation support system have been established as follows:

1. "Threshold" Horizontal Movement:
   Dx = No greater than 1.25 inch where no buildings are present within 25 ft. of support system
   Dx = No greater than 0.5 inch where buildings are present within 25 ft. of support system.
   Where Dx = measured horizontal wall movement at any level.

2. "Limiting" Horizontal Movement:
   Dx = No greater than 2.0 inches where no buildings are present within 25 ft. of support system
   Dx = No greater than 0.75 inch where buildings are present within 25 ft. of support system.

B. The Subcontractor shall notify the Engineer and shall take immediate steps to control further movement by revising his procedures, providing supplemental bracing or other measures (working 24 hours per day or temporarily terminating work in the area of movement if necessary) as required if any of the following occur:

1. Field measurements indicate that any of the "threshold" movement criteria are reached or exceeded.

2. Field measurements or observations indicate that significant or sustained wall movements are occurring (total movement may be less than the "Limiting" movement criteria).

3. Movements of adjacent structures, utilities or other facilities are detected.

C. If "Limiting" movements are being approached or reached, the Engineer, based on his judgment and review of the movement monitoring data, may require the Subcontractor to temporarily terminate the work in the area where such movement is occurring and implement all necessary mitigation measures which are satisfactory to the Engineer, to arrest the movements, at no cost to the Engineer.

D. Horizontal or vertical movement of any point on adjacent structures shall not exceed 0.5 inches. "Threshold" vertical movement on existing ground within 25-feet of rails and top of rails is no greater than 0.25-inches. "Limiting" vertical movement on existing ground within 25-feet of rails and top of rails is no greater than 0.50-inches. The Subcontractor shall provide a registered land surveyor to establish and monitor survey points on the adjacent structures. The Subcontractor shall take all necessary measures to prevent greater settlements, at Subcontractor's cost.

E. These criteria are intended to establish a minimum basis for the Subcontractor's design and procedures and in no way relieve the Subcontractor of his sole responsibility for preventing detrimental movements and damage to adjacent structures, utilities or other work.

F. Monitoring personnel shall use a procedure for reading and recording geotechnical instrumentation data which compares the current reading to the last reading during data collection to eliminate spurious readings.

G. Plot the observed ground deformation readings versus time. Annotate the plots with construction loading and excavation events having an impact on the readings. Evaluate plots by means of secondary rate-of-change plots to provide early warning of accelerating ground

movements.

H. Survey markers shall be installed at maximum interval of one per 50 feet along the length of excavation support system wall elements.

I. Implement Construction Contingency Plan under direction of the temporary excavation support system designer and the Engineer.

3.03 REMOVAL OF EARTH RETENTION SYSTEM

A. Sheeting shall be removed unless indicated or approved in writing by Engineer.

B. Remove the temporary excavation support system without endangering the constructed or adjacent structures, utilities, or property. Immediately backfill all voids left or caused by withdrawal of temporary excavation support systems with Screened Gravel per Section 02316 - Fill and Backfill by tamping with tools specifically adapted for that purpose.

FORM 02160-F01

CERTIFICATE OF DESIGN

The undersigned hereby certifies that he/she is a Professional Engineer registered in the state of _____ and that he/she has been employed by (Name of Subcontractor) _____ to design _____ in accordance with Specifications Section _____ for the (Name of Project) _____. The undersigned further certifies that he/she has performed similar designs previously and has performed the design of the _____; that said design is in conformance with all applicable local, state, and federal codes, rules, and regulations and professional practice standards; that his/her signature and Professional Engineer (P.E.) Stamp have been affixed to all calculations and drawings used in, and resulting from, the design; and that the use of that stamp signifies the responsibility of the undersigned for that design.

The undersigned hereby agrees to make all original design drawings and calculations available to the Engineer with seven (7) days following written request.

_____	_____
P.E. Name	Subcontractor's Name
_____	_____
Signature	Signature
_____	_____
Title	Title
_____	_____
Address	Address

END OF SECTION

SECTION 02315

EXCAVATION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Excavation of contaminated materials as shown on the Drawings.

B. General excavation of on-site materials and excavation of soils to expose contaminated materials.

C. Stockpiling and collection of 8-point composite samples for laboratory analysis prior to on-site reuse.

D. On-site transportation of contaminated soil for stabilization as deemed necessary for Subcontractor's stabilization method.

E. Decontamination of equipment and vehicles and disposal of resulting liquid and solids.

1.02 RELATED SECTIONS.

A. Section 01120 - Health and Safety

B. Section 01130 - Perimeter Air Monitoring and Emissions Control Plan

C. Section 01300 - Administrative Requirements

D. Section 01410 - Sampling Procedures and Laboratory Services

E. Section 01700 - Execution Requirements

F. Section 02240 - Construction Water Management

G. Section 02260 - Excavation Support and Protection

H. Section 02316 - Fill and Backfill

I. Section 02343 - Sludge Stabilization

1.03 SUBMITTALS

A. See Section 01300 - Administrative Requirements for submittal procedures.

B. The Subcontractor shall prepare a Contaminated Material Excavation Plan for review at least 21 days prior to start of excavation. The Plan shall include the following:

1. Methods for keeping contaminated materials and non-contaminated materials separate.
2. Methods to minimize groundwater inflow during excavation and backfill.
3. The type, number, and anticipated production rate of equipment to be used.
4. The sequence of excavation to maintain access to the site.
5. The location of staging areas for contaminated and non-contaminated materials.
6. A description of how the excavation will be coordinated with stabilization and backfilling.

C. The Subcontractor shall submit to the Engineer for information all analytical test reports for on-site soil for reuse at least two business days prior to on-site reuse.

D. The Subcontractor shall submit to the Engineer for information all analytical test reports for confirmatory soil samples a maximum of one week after sample collection.

E. As-Built Excavation Plan

1. The Subcontractor shall submit to the Engineer, record drawings showing the limits of excavation and location of confirmatory soil samples.

1.04 REGULATORY REQUIREMENTS

A. The Work of this Section shall be performed in accordance with all applicable Federal, State, and local regulations, laws, codes, and ordinances governing the handling, transportation, and disposal of hazardous materials.

B. The Subcontractor shall obtain all necessary permits and state licenses in conjunction with contaminated soil and water, restricted soil hauling and disposition.

1.05 DEFINITIONS

A. Contaminants of Concern (COC) – Organic and inorganic contaminants as follows:

1. Benzo(a)anthracene
2. Benzo(a)pyrene
3. Pentachlorophenol
4. N-Nitroso-di-n-propylamine
5. Arsenic
6. Chromium
7. Mercury
8. Lead
9. Dioxin TEQ

B. Contaminated Materials – Sludge and associated contaminated soils to be excavated, stabilized and placed in the on-site landfill. On-site soil that has been excavated for possible on-site reuse with contaminant concentrations exceeding the cleanup criteria listed in Table 02315-01.

C. 8-Point Composite Sample - A composite homogeneous soil sample comprised of eight representative soil samples of equal mass to represent the intended quantity of soil.

1.06 QUALITY ASSURANCE

A. Neither the presence of Engineer nor any observation and testing by Engineer shall excuse the Subcontractor from defects discovered in his Work.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 GENERAL

A. The Subcontractor shall furnish all labor, materials, tools, and equipment necessary for excavation, tracking, handling, and temporary storage (staging) of soil and sludge, and for on site treatment of fluids and solids generated during decontamination of vehicles and personnel as part of this work.

B. The Subcontractor shall perform all soil excavation work in accordance with the Subcontractor's Health and Safety Plan. Contaminated soil excavation work shall include mass excavations and any incidental soil work.

C. The Subcontractor shall excavate soil to the limits delineated in the Drawings.

D. The Subcontractor shall provide all layout field data, including ties, to Engineer. The Subcontractor shall maintain all required field controls throughout the performance of the Work.

E. The Subcontractor shall employ methods, including benching, necessary to isolate contaminated soils from non-contaminated soils.

F. All site health and safety controls shall be fully established and in operation prior to beginning any contaminated or potentially contaminated soil excavation. Site controls shall include but not be limited to work zones properly secured, decontamination facilities, and all support equipment and supplies including personal protective equipment.

3.02 PREPARATION

A. Identify required lines, levels, contours, and datum locations.

B. Locate, identify, and protect utilities that remain and protect from damage.

3.03 GENERAL EXCAVATION

A. Excavate to accommodate new construction operations.

B. Notify Subcontractor of unexpected subsurface conditions and discontinue affected Work in area until notified to resume work.

C. Unless otherwise indicated, slope banks of excavations deeper than 4 feet to angle of repose or less until shored.

D. Do not interfere with 45 degree bearing splay of foundations.

E. Cut utility trenches wide enough to allow inspection of installed utilities.

F. Hand trim excavations. Remove loose matter.

G. Correct areas that are over-excavated and load-bearing surfaces that are disturbed; see Section 02316 - Fill and Backfill.

H. Grade top perimeter of excavation to prevent surface water from draining into excavation.

3.04 TRENCH EXCAVATION

A. Excavations for all pipelines (where required) shall be carried out in a manner which will preserve the undisturbed state of the subgrade soils or waste material. For excavations greater than 5 feet, the sides will have to have appropriate cut back slopes or shoring and bracing for the open cuts if personnel are to enter the excavation.

B. Excavation for all trenches required for the installation of pipe and drains shall be made to the depths indicated on the contract drawings and in such a manner and to such widths as will give suitable room for bedding material placement, laying the pipe, for required bracing and supporting, and for pumping and drainage facilities.

C. Remove unsuitable material from within limits of trench. Excavated refuse will be relocated to other portions of the landfill as directed by the Engineer.

D. The Subcontractor is responsible for maintaining safe excavations side slopes.

E. Slope sides of excavations to comply with OSHA, local codes and ordinances having jurisdiction.

F. Sheet, shore, and brace in accordance with Section 02260 - Excavation Support and Protection where sloping is not possible either because of space restrictions or stability of material excavated.

G. Maintain sides and slopes of excavations in a safe condition until completion of backfilling.

H. Trenching Tolerances:

1. Excavate so pipes, ducts, and conduits can be laid straight at uniform grade, without sags or humps, between elevations shown on Drawings.

2. Maximum width of excavation at top of pipe shall be as shown on Drawings. When stringers and sheathing are required, width of trench may be increased to allow for their use, provided provisions for this excess width of trench are met.

3. Where trench width for that portion of trench depth between trench bottom and outside top of pipe barrel, for any reason within Subcontractor's control, exceeds specified limits, Subcontractor shall furnish pipe with strength adequate for actual trench width, and backfilling method.

4. Minimum trench width shall be outside pipe diameter plus 12 inches unless specifically shown on Drawings.

I. Do not advance excavation of trenches more than the length of pipe anticipated to be installed during the days work, or 300 feet ahead of completed pipe installation.

3.05 MANAGEMENT OF CONSTRUCTION WATER

A. Management of Construction Water encountered during excavation (i.e. surface water and ground water entering excavations) shall be conducted in accordance with Section 02240 - Construction Water Management.

B. The Subcontractor shall decide whether to excavate "in the wet" or "in the dry."

C. The Subcontractor may perform excavation "in the wet" unless:

1. Presence of water in excavation has negative effect on Subcontractor's ability to excavate; or

2. Lagoon sludge becomes significantly suspended in excavation water; or

3. Excavation water contaminates clean backfill.

D. The Subcontractor may remove limited quantities of excavation water until all of the above conditions are eliminated.

3.06 EXCAVATION OF ON-SITE SOIL FOR REUSE

A. Granular soil has been placed over the sludge in Lagoons 1 and 5 during historical operation of the lagoon system. The Subcontractor shall remove this soil in order to access the sludge for excavation and stabilization. The Subcontractor shall excavate, load, transport, and stockpile the granular soil for possible reuse on site as fill.

B. The Subcontractor shall stockpile excavated soil identified for potential on-site reuse at approved staging areas and collect 8-point composite soil samples at a minimum frequency of one per 1,000 tons.

C. The Subcontractor shall analyze the 8-point composite soil samples for EPA Contract Laboratory Program (CLP) list of volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), metals and dioxins in accordance with the requirements of Section 01410 - Sampling Procedures and Laboratory Services.

D. If any one COC exceeds the clean up criteria presented in Table 02315-01, the soil represented by the 8-point composite sample shall be deemed "contaminated" and placed within the landfill and compacted. Sludge or soils that cannot be compacted using standard equipment shall be stabilized in accordance with the requirements of Section 02343 - Sludge Stabilization prior to placement within landfill.

E. Soil meeting the clean up criteria presented in Table 02315-01 shall be deemed

"non-contaminated" and may be reused on site as General Fill if it meets the requirements of Section 02316 - Fill and Backfill.

3.07 EXCAVATION OF CONTAMINATED MATERIAL

A. Work and decontamination procedures in areas containing contaminated material shall be performed in accordance with standard engineering and construction practices. The Subcontractor shall apply engineering and/or work practice controls as a means of protecting personnel in performance of site-specific tasks. Engineering controls shall be implemented to reduce and maintain employee exposure to at or below safe levels for those tasks demonstrating known or suspected hazards.

B. Adequate measures must be taken to minimize dust and control the emission of nuisance odors, volatile organic compounds, and hydrogen sulfide. The Subcontractor shall implement air emission controls when action levels are exceeded as defined in paragraph 2.02 ACTION LEVELS of Section 01130 - Perimeter Air Monitoring and Emissions Plan. Air emission controls shall also be implemented by the Subcontractor if air monitoring indicates an upgrade to level B PPE is required outside of the exclusion zone. Air emission controls shall be maintained until level B PPE is no longer required.

C. Subcontractor shall excavate to the limits shown on the Drawings at which time the Engineer shall inspect the excavation. Based on the Engineer's inspection, Engineer may instruct the Subcontractor to continue to excavate if visible sludge is observed and a physical limit has not been reached, or the Engineer may instruct the Subcontractor to collect a confirmatory sidewall sample for analysis.

D. The excavation may include removing additional soils found to contain residual contamination as directed by Engineer based on field screening and/or the results of confirmatory soil sample analyses. Additional excavation may be required if the results of confirmatory soil sample analyses show the presence of COCs greater than the clean up criteria presented in Table 02315-01.

E. The Subcontractor shall separate excavated contaminated soil from uncontaminated soil and stockpile uncontaminated soil for on-site reuse as fill.

3.08 CONFIRMATORY SOIL SAMPLING

A. The Subcontractor shall collect soil samples from the limits of excavation.

B. Acceptable methods of soil sample collection include collecting the sample directly from the excavation sidewall using a decontaminated stainless steel spoon or scoop, or using the decontaminated bucket of an excavator to obtain soil from which the sample is collected using a decontaminated stainless steel spoon or scoop.

C. The Engineer shall select confirmatory soil sample locations. A minimum of one confirmatory soil sample will be collected for every 100 linear feet of excavation sidewall.

D. The Engineer shall be present during sample collection by Subcontractor. Any soil samples collected by Subcontractor in the absence of Engineer shall be rejected and the Subcontractor shall collect an additional sample at Subcontractor's expense.

E. The Subcontractor shall collect and analyze each soil sample for COCs in accordance with the requirements of Section 01410 – Sampling Procedures and Laboratory Services.

F. The Subcontractor shall survey and record confirmatory sample locations in accordance with the requirements of Section 01700 - Execution Requirements.

3.09 STORAGE OF EXCAVATED MATERIAL

A. Contaminated solids shall only be stockpiled within the landfill footprint or in staging areas

approved by Engineer.

B. Excavated contaminated material may be stockpiled for stabilization in quantities not to exceed two (2) days normal production. Soil shall be stockpiled in accordance with this Section.

C. Haybales shall be place around the stockpile as per Section 01575 - Temporary Erosion and Sedimentation Control.

D. Runoff from areas containing contaminated soils shall not be permitted to migrate off-site or onto uncontaminated areas of the site.

3.10 EQUIPMENT AND VEHICLE DECONTAMINATION

A. All tools and any equipment used to handle any contaminated material shall be decontaminated using a steam cleaner prior to leaving the work area. This shall include all tools, heavy machinery, and excavation and hauling equipment used during excavation and handling of contaminated material including the tires, tracks, and under carriages of equipment.

B. The Subcontractor shall construct a decontamination pad to be used to decontaminate equipment and vehicles exiting the contamination reduction zone. The Subcontractor shall be responsible for the maintenance and operation of the decontamination station (decontamination pad and wash down equipment) throughout the duration of the work activities. The Subcontractor shall provide a collection system for the decontamination pad wash water. The Subcontractor shall collect all wash water resulting from the decontamination process. At the completion of the project, the Subcontractor shall dismantle and properly dispose of the decontamination pad and resulting contaminants within the on-site landfill.

C. The minimum design requirements of the decontamination pad are as follows:

1. Pad shall have adequate size to accommodate the width and length of the largest piece of equipment that will be used in contaminated areas.

2. The pad shall be constructed of 40-mil LLDPE geomembrane material or 20-mil scrim reinforced HDPE and non-woven geotextile cushion, and shall have a minimum 24-inch high supported containment berm around the perimeter.

3. Pad shall be sloped to a low point sump to allow for thorough collection of decontamination water.

D. All decontamination water within the decontamination pad shall be collected, pumped to, and contained in a secure aboveground storage tank prior to treatment. The Subcontractor shall have adequate storage facilities to properly contain all decontamination water. Decontamination water shall be treated in the on-site Construction Water treatment system in accordance with Section 02240 - Construction Water Management.

Table 02315-01

Soil Cleanup Criteria

Pownal Tannery Superfund Site

Pownal, Vermont

Contaminant	Soil Cleanup Criteria (mg/kg)
Benzo(a)anthracene	1.7
Benzo(a)pyrene	0.017
Pentachlorophenol	7.7
N-Nitroso-di-n-propylamine	0.27
Arsenic	1.1
Chromium	733
Mercury	23
Lead	1,000
Dioxin TEQ	0.001

**** END OF SECTION ****

SECTION 02316

FILL AND BACKFILL

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Requirements for filling, backfilling, and compacting.

B. Preparation of sludge surface to accept landfill cap materials.

C. Placement of landfill cap materials.

D. Protection of geosynthetics.

1.02 RELATED SECTIONS

A. Section 01300 - Administrative Requirements

B. Section 01400 - Quality Requirements

C. Section 01410 - Sampling Procedures and Laboratory Services

D. Section 01575 - Temporary Erosion and Sedimentation Control

E. Section 01700 - Execution Requirements

F. Section 02315 - Excavation

G. Section 02620 - Geocomposite Drainage Layer

H. Section 02623 - Geomembrane

I. Section 02625 - Geotextiles

J. Section 02921 - Topsoil and Seeding

1.03 REFERENCES

A. State of Vermont, Agency of Transportation, Standard Specifications for Construction, 2001

B. American Society for Testing and Materials (ASTM)

1. C 33 Standard Specification for Concrete Aggregates; 2002.
2. C 88 Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate; 1999.
3. C 127 Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate; 2001.
4. C 131 Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine; 2003.
5. D 422 Standard Test Method for Particle Size Analysis of Soils; 1998.
6. D 698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)); 2000a.
7. D 1556 Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method; 2000.
8. D 1587 Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes; 2000.

9. D 2216 Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass; 1998.
10. D 2434 Standard Test Method for Permeability of Granular Soils (Constant Head) ; 2000.
11. D 2487 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System); 2000.
12. D 2922 Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth); 2001.
13. D 3017 Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth); 2001.
14. D 3080 Standard Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions; 1998.
15. D 4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils; 2000.

C. U.S. Environmental Protection Agency, Technical Guidance Document EPA/600/R-93/182, Quality Assurance and Quality Control for Waste Containment Facilities, September 1993.

1.04 SUBMITTALS

A. See Section 01300 - Administrative Requirements, for submittal procedures.

B. Materials Sources

1. Submit name, address, and telephone number of all imported materials sources within 21 days of Notice to Proceed.
2. An official finding as certification from the State Historic Preservation Officer (SHPO) certifying all sources of imported material comply with Section 106 of the NHPA. Submit finding or certification prior to importing each material.

C. Material Test Reports

1. Source Testing - Submit for review results of laboratory tests on actual materials to be used within 14 days of Notice to Proceed.
2. Testing of Delivered Material - Submit results of laboratory tests prior to placing material for information to demonstrate conformance with specification requirements.

D. In-Place Testing Reports. Submit copies of compaction density reports within 24 hours of the completion of the test.

E. As-Built drawing with final grades and limit of stabilized waste. Submit prior to project closeout.

1.05 PROJECT CONDITIONS

A. Provide sufficient quantities of fill to meet project schedule and requirements. When necessary, store materials on site in advance of need.

B. When fill materials need to be stored on site, locate stockpiles in staging areas as indicated on the Drawings, or as approved by the Engineer.

1. Separate differing materials with dividers or stockpile separately to prevent intermixing.
2. Prevent contamination of clean fill materials.
3. Protect stockpiles from erosion and deterioration of materials in accordance with Section 01575 - Temporary Erosion and Sedimentation Control.

C. Verify that survey bench marks and intended elevations for the Work are as specified in Section 01700 - Execution Requirements.

1.06 TESTING

A. Laboratory Testing: Testing of soil shall be performed in accordance with the following standards:

Sieve Analysis	ASTM D422
Moisture Content	ASTM D2216
Moisture Density (Standard Proctor)	ASTM D698
Atterberg Limits	ASTM D4318
Hydraulic Conductivity	ASTM D2434

B. Field Testing: Testing of soil shall be performed in accordance with the following standards:

1.	Shelby Tube Sampling	ASTM D1587
2.	Density - Nuclear Method	ASTM D2922
3.	Density - Sand Cone	ASTM D1556
4.	Moisture Content - Nuclear Method	ASTM D3017

PART 2 PRODUCTS

2.01 FILL MATERIALS

A. General

1. All materials utilized for the Work shall be obtained from a source that has been licensed or permitted for such use by local and state authorities, as applicable.

B. **General Fill**

1. Earth suitable for general fill shall be free from frozen material, blue or plastic clay, vegetation, perishable rubble, peat, and other unsuitable materials. The moisture content shall be sufficient to provide specified compaction and stable embankment.

2. General Fill shall have a maximum particle size of two-thirds of the specified compacted lift thickness and shall be classified according to the Unified Soil Classification System as GW, GP, GM, SW, SM, SP, or combinations thereof, as determined by ASTM D 422 and ASTM D 2487.

3. Substitution: Use of clean, recycled material meeting the above requirements may be substituted for General Fill. Approval of Engineer shall be required prior to importing substitute materials to the project site.

4. May include "On-Site Soil for Reuse" as defined below in this subsection. Use all acceptable "On-Site Soil for Reuse" prior to importing General Fill from off-site sources.

C. **Gas Vent Sand**

1. Granular material, free from organic matter, clay, rubble, peat, and other unsuitable materials, and capable of achieving a minimum hydraulic conductivity of 1E-3 cm/sec for laboratory sample compacted to 92% of maximum dry density per ASTM D698.

2. Sieve analysis by weight shall be as follows:

Sieve Designation	% by Weight Passing Square Mesh Sieves
1/2 inch	75 to 100

No. 200	0 to 10

D. **Cover Soil**

1. Soil free from frozen material, clods or clumps of blue or plastic clay, vegetation, perishable rubble, peat, and other unsuitable materials.

2. Sieve analysis by weight:

Sieve Designation	% by Weight Passing Square Mesh Sieves
2 inch	100
1 inch	90 to 100
No. 4	70 to 100
No. 40	40 to 85
No. 100	20 to 60
No. 200	5 to 30

3. Well graded meeting the following criteria:
   a. Coefficient of Uniformity (d60/d10) is greater than 6; where d60 = diameter at which 60 percent of soil is finer, and d10 = diameter at which 10 percent of soil is finer.

E. **Screened Gravel**

1. Screened gravel shall be free from roots, leaves, and other organic materials, and free of ice, snow, frost, and frozen soil particles.

2. Gradation and physical property requirements shall conform to ASTM C33, Coarse Aggregate number 67, with sieve analysis, by weight, as follows:

Sieve Designation	% by Weight Passing Square Mesh Sieves
1 inch	100
3/4 inch	90 to 100
3/8 inch	20 to 55
No. 4	0 to 10
No. 8	0 to 5

3. Crushed rock of equivalent size and grading may be used instead of screened gravel.

F. **Crushed Gravel**

1. Shall conform to State of Vermont Vermont Agency of Transportation Specification Section 704.05 CRUSHED GRAVEL FOR SUBBASE, FINE-GRADED. Gradation is as follows:

Sieve Designation	% by Weight Passing Square Mesh Sieves
2 inch	100
1 1/2 inch	90 to 100
No. 4	30 to 60
No. 100	0 to 12
No. 200	0 to 6

G. **Road Gravel**

1. Shall conform to State of Vermont Vermont Agency of Transportation Specification Section 704.12 AGGREGATE FOR SURFACE COURSE AND SHOULDERS. Gradation is as follows:

Sieve Designation	% by Weight Passing Square Mesh Sieves
1 1/2 inch	100
1 inch	90 to 100

No. 4	45 to 65
No. 100	0 to 15
No. 200	0 to 12

H. **1 1/2 Inch Crushed Stone**

1. Crushed stone shall consist of clean, inert, hard durable grains of rock free from organic matter, shale, and lumps or balls of clay and conform the following gradation requirements:

Sieve Designation	% by Weight Passing Square Mesh Sieves
1 3/4 inch	100
1 1/2 inch	90 to 100
1 inch	20 to 55
3/4 inch	0 to 15
3/8 inch	0 to 5
No. 200	0 to 2

I. **Topsoil**

1. Material requirements for topsoil are specified in Section 02921 - Topsoil and Seeding.

J. **Riprap**

1. General
   a. All riprap stone shall be sound, durable rock, angular in shape, and resistant to abrasion and freeze and thaw deterioration. No boulders or rounded stones will be accepted for this work.
   b. All riprap stone shall have at least three (3) flat faces to enable the stones to be properly locked together to form a compact mass. Unacceptable rock includes mica schist, slate, micaceous or thinly-bedded sandstone, shale, coarse limestone, gypsiferous rock, poorly cemented sandstone and conglomerate or soft or closely jointed rock of any sort. The rock shall have the physical properties required by ASTM C 33 for quarry rock suitable for producing coarse aggregate for concrete, in accordance with ASTM C 88 and C 131, respectively. The requirements of the Los Angeles Abrasion Test for all rock shall be a maximum loss of 40 percent (after 500 cycles). All stone shall not weigh less than 165 pounds per cubic foot, as determined by the standard test for apparent specific gravity ASTM C 127), using representative chips about one inch in size taken from the stone as furnished. Stones shall have a loss not exceeding ten percent (10%) when subjected to five (5) cycles of the sulfate soundness test (ASTM C 88).
   c. The riprap stone to be used will be accepted only after its suitability has been established to the satisfaction of the Engineer. Samples of the proposed riprap stone shall be submitted as directed by the Engineer, as well as the name and location of proposed quarry for approval prior to shipment of any riprap stone.
   d. Approval of samples submitted, or of the quarries, shall not be construed as a waiver by the Engineer of the right to reject any riprap stone which does not comply with the requirements noted hereinafter.

2. Riprap A
   a. A well-graded mixture composed primarily of the larger stone sizes, but with a sufficient mixture of other sizes to fill the progressively smaller voids between the stones shall be used. The riprap shall be composed of a well-graded mixture such that:
      1) The d100 value (diameter of the largest stone size) is 12 inches.
      2) The d50 value (diameter at which 50 percent of the mixture is smaller) is 4 inches.

3. Riprap B
   a. A well-graded mixture composed primarily of the larger stone sizes, but with a sufficient mixture of other sizes to fill the progressively smaller voids between the stones shall be used. The riprap shall be composed of a well-graded mixture such that:
      1) The d100 value (diameter of the largest stone size) is 15 inches.
      2) The d90 value (diameter at which 90 percent of the mixture is smaller) is 10.5 inches.
      3) The d30 value (diameter at which 30 percent of the mixture is smaller) is 7 inches.

K. **On-site Soil for Reuse**

1. Granular soil has been placed over the sludge in Lagoons 1 and 5 during historical operation of the lagoon system. This granular cover soil will be removed as part of the Work to access the sludge. The Subcontractor shall use this material, and other material excavated on site, as General Fill if:
   a. It meets the fill type requirements.
   b. Contaminant concentrations are below the soil cleanup criteria listed in Section 02315 - Excavation, Table 02315-01. The Subcontractor shall conduct testing of On-site Soil for Reuse in accordance with the requirements of Section 01410 - Sampling Procedures and Laboratory Procedures at a frequency of 1 sample per 1,000 tons.

2.02 SOURCE QUALITY CONTROL

A. See Section 01400 - Quality Requirements, for general requirements for testing and analysis of fill materials.

B. Borrow Source Requirements

1. All sources of borrow soil materials shall comply with Section 106 of the NHPA.

2. The Subcontractor shall perform all necessary studies, assessment, and reporting required by the Vermont SHPO, or equivalent entity if in another state to obtain certification that cultural resources will not be impacted at each imported material borrow source location in accordance with Section 106 of the NHPA.

C. Source Testing

1. Unless otherwise specified, the Subcontractor shall collect and analyze a minimum of one sample from every source of every fill type. Samples shall be analyzed in accordance with Section 01400 - Quality Requirements to demonstrate that the fill type meets the requirements specified herein. Analytical reports demonstrating conformance with the specifications shall be submitted to the Engineer before delivery to site.

2. If tests indicate fill materials do not meet specified requirements, change material or source, and retest.

D. Alternate fill materials are not allowed unless approved by the Engineer.

E. Unsuitable material, including, but not limited to contaminated and/or hazardous material, shall not be used as fill. Unsuitable backfill shall be removed and replaced by appropriate materials at the Subcontractor's expense.

PART 3 EXECUTION

3.01 GENERAL

A. Identify required lines, levels, contours, and datum locations.

B. Place acceptable soil material in layers to required elevations as shown on the Drawings.

C. Fill, backfill, and compact to to produce minimum subsequent settling.

D. Place material in approximately horizontal layers, beginning at the lowest area to be filled.

E. Do not impair drainage.

3.02 PLACEMENT OF FILL

A. General

1. The Subcontractor shall prepare subgrade by removing vegetation, debris, unsatisfactory soil materials, obstructions, and deleterious materials from ground surface prior to placement of fills. Scarify surfaces so that fill material will bond with existing surface.
2. Fill to contours and elevations indicated using unfrozen materials.
3. Unless otherwise specified, place soil backfill and fill materials in layers not more than 12 inches in loose depth (9 inches in compacted depth) for material compacted by heavy equipment, and not more than 9 inches in loose depth (6 inches in compacted depth) for material compacted by hand-operated tampers.
4. Employ a placement method that does not disturb or damage other work.
5. Systematically fill to allow maximum time for natural settlement. Do not fill over porous, wet, frozen or spongy subgrade surfaces.
6. Maintain moisture content of fill materials within 2% of optimum and to attain required compaction density.

B. Placement of Prepared Sludge

1. The Subcontractor shall place prepared sludge material in accordance with Section 02343 - Sludge Stabilization.

C. Placement of Gas Vent Sand

1. Gas vent collection piping shall be installed by the Subcontractor prior to placement of the gas vent sand in accordance with Section 02627 - Gas Vent Piping.
2. Gas vent sand shall be placed in a single 6-inch lift in a manner that protects the gas collection piping from damage.
3. The Subcontractor shall immediately repair any damage to the gas vent piping resulting from gas vent sand placement.
4. The Subcontractor shall take necessary actions to prevent damage to the gas vent sand layer and shall repair damage at Subcontractor's cost.
5. The Subcontractor shall perform the gas vent sand placement in a manner that minimizes material waste.

D. Placement of Cover Soil and Crushed Gravel on Geomembrane/Geocomposite

1. Equipment used for placing cover materials shall not be driven directly on the geocomposite/geomembrane. The Subcontractor shall closely monitor such equipment during placement of cover soil to ensure that no damage, including tensioning or wrinkling, occurs to the geomembrane/geocomposite.
2. A minimum thickness of 12 inches of soil shall be maintained between the geomembrane/geocomposite and the equipment.
3. Do not dump soil materials directly onto the geomembrane/geocomposite.
4. Low ground pressure equipment having a contact pressure less than 5 pounds per square

inch shall be used to spread material over the geomembrane/geocomposite. Wheeled vehicles shall not operate directly over the geomembrane/geocomposite.

5. Any turning of the equipment shall be performed with extreme caution so as to prevent damage to the geomembrane/geocomposite.

6. The Subcontractor shall repair damage to geocomposite and geocomposite materials caused by operation of equipment.

7. On slopes greater than 5% place cover soil and crushed gravel from the bottom of the slope upward.

E. Placement of Screened Gravel In the Wet

1. The Subcontractor shall place Screened Gravel as fill material when backfill is to be performed in the wet in Lagoons 1 and 5.

2. Subcontractor shall remove and treat water in excavation to within 2 ± feet from the excavation bottom.

3. Screened Gravel shall be dumped and pushed into place up to a minimum elevation of 2 feet above the water surface.

4. Geotextile A shall be placed on compacted surface of screened gravel prior to further backfill with General Fill.

F. Placement of Riprap

1. Riprap shall be placed in such manner as to produce a well-graded mass of rock with the minimum practicable percentage of voids, and shall be constructed within the specified tolerances to the lines and grades shown on the Drawings.

2. Placement shall begin at the bottom of the area to be covered and continue up slope. Subsequent loads of material shall be placed against previously placed material in such a manner as to ensure a relatively homogenous mass.

3. No stone shall be dropped through the air from a height greater than 3 feet.

4. The finished riprap shall be free from objectionable pockets of small stones and clusters of larger stones.

5. The following is not permitted:
   a. Placing riprap in layers.
   b. Placing riprap by dumping into chutes or by similar methods likely to cause segregation of the various sizes.
   c. Placing riprap by dumping it at the top of the slope and pushing it down the slope.

6. No equipment shall be operated directly on the completed stone protection system.

7. The desired distribution of the various sizes of stones throughout the mass shall be obtained by selective loading of the material at the quarry or other source, by controlled placement.

3.03 COMPACTION

A. Use methods which will produce the required degree of compaction throughout the entire depth of material without having a negative impact on the integrity of any material which has already been placed. Compact to the following minimum densities per ASTM D698 (Standard Proctor):

Material	Density
General Fill	90% of max

Gas Vent Sand	92% max
Cover Soil within 12" of Geomembrane	90% of max
Cover Soil	92% of max
Crushed Gravel for Cap	90% of max
Crushed Gravel for Road	95% max
Road Gravel	95% of max

B. Compaction of the top of Screened Gravel placed "In the Wet" shall be with a minimum of 4 passes with a 10-ton vibratory roller with vibration frequency of 60 MHz. Additional layers of Screened Gravel placed in 12-inch loose lift in the dry shall be compacted with at least 4 passes of the vibratory roller.

3.04 GRADING

A. Perform required site grading and survey to establish and verify finish grades as indicated in the Drawings. Survey in accordance with Section 01700 - Execution Requirements to document the depth and aerial extent of excavations shall also be included.

B. Uniformly grade areas within the limits of grading shown on the Drawings, including adjacent transition areas. Smooth finished surfaces within specified tolerances, compact with uniform levels or slopes between points where elevations are shown, or between such points and existing grades.

C. Final slopes of compacted contaminated material in landfill shall be between 5% (20H:1V) and 33.3% (3H:1V).

D. Final slopes of landfill cap surface shall be between 1% and 2% on the top and no steeper than 33.3% (3H:1V) on the side slopes.

3.05 TOLERANCES

A. The Subcontractor shall finish surfaces free from irregular surface changes and shall be finished to required elevation +/- one-tenth (0.1) foot in five (5) feet.

B. Riprap - A tolerance of plus 4 inches or minus 2 inches from the slope lines and grades shown on the drawings will be allowed in the finished surface of the riprap, except that the extreme of such tolerance shall not be continuous over an area greater than 200 square feet.

3.06 FIELD QUALITY CONTROL

A. General

1. See Section 01400 - Quality Requirements, for general requirements for field inspection and testing.
2. The Subcontractor shall conduct all field quality control sampling and analyses described herein.
3. If tests indicate work does not meet specified requirements, the Subcontractor shall remove work, replace and retest at the Subcontractor's expense.
4. When testing frequencies are specified, the Subcontractor shall ensure that the entire quantity of tested material is represented by the test samples.

B. **General Fill**

1. Testing of Delivered Soil
   a. Samples shall be taken as the material is delivered to the project site to ensure

uniformity of the material at the source. The frequency at which samples will be collected and testing performed is as follows:

Laboratory Analysis	Minimum Frequency
Sieve Analysis	1 every 5,000 cubic yards
Moisture/Density (Standard Proctor)	1 every 5,000 cubic yards

2. In-place Testing
   a. Compaction and Moisture: A minimum of 5 field density/moisture content tests per acre shall be performed by nuclear methods.
   b. Lift Thickness: The Engineer will verify the thickness of the installed layer by measuring at a frequency of 2 measurements per acre.

C. **Gas Vent Sand**

1. Testing of Delivered Material
   a. Samples shall be taken as the material is delivered to the project site to ensure uniformity of the material at the source. The frequency at which samples will be taken and testing performed for Gas Vent Sand delivered to the site are as follows:

Laboratory Analysis	Minimum Frequency
Sieve Analysis	1 every 2,500 cubic yards
Moisture/Density (Standard Proctor)	1 every 2,500 cubic yards

2. In-place Testing
   a. Compaction: A minimum of 5 field density/moisture content tests per acre shall be performed by nuclear methods.
   b. Lift Thickness: The Engineer will verify the thickness of the installed layer by measuring at a frequency of 5 measurements per acre.

D. **Cover Soil**

1. Testing of Delivered Soil
   a. Samples shall be taken as the material is delivered to the project site to ensure uniformity of the material at the source. The frequency at which samples will be taken and testing performed for Cover Soil delivered to the site are as follows:

Laboratory Analysis	Minimum Frequency
Sieve Analysis	1 every 2,500 cubic yards
Moisture/Density (Standard Proctor)	1 every 2,500 cubic yards
Remolded Hydraulic Conductivity	1 every 2,500 cubic yards

2. In-place Testing
   a. Compaction and Moisture: A minimum of 5 field density/moisture content tests per acre shall be performed by nuclear methods.
   b. Lift Thickness: The Engineer will verify the thickness of the installed layer by measuring at a frequency of 5 measurements per acre.

E. **Gravels and Crushed Stone**

1. Testing of Delivered Soil
   a. Samples shall be taken as the material is delivered to the project site to ensure uniformity of the material at the source. The frequency at which samples will be taken and testing performed for Cover Soil delivered to the site are as follows:

Laboratory Analysis	Minimum Frequency
Sieve Analysis	1 every 5,000 cubic yards
Moisture/Density (Standard Proctor)	1 every 5,000 cubic yards

2. In-place Testing
   a. Compaction and Moisture: A minimum of 5 field density/moisture content tests per acre shall be performed by nuclear methods.

b. Lift Thickness: The Engineer will verify the thickness of the installed layer by measuring at a frequency of 5 measurements per acre.

F. **On-site Soil for Reuse**

1. Source Testing for Contaminants - To qualify for on-site filling, contaminant concentrations shall be below the criteria listed in Section 02315 - Excavation, Table 02315-01. The Subcontractor shall conduct testing of On-site Soil for Reuse in accordance with the requirements of Section 01410 - Sampling Procedures and Laboratory Procedures.

2. Field Quality Control Testing - On-site Soil for Reuse shall be tested in accordance with the requirements specified for the appropriate fill type (e.g. General Fill).

END OF SECTION

SECTION 02343

SLUDGE STABILIZATION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Requirements for the stabilization of sludge and associated contaminated soil materials including:

1. "Shake-Down" demonstration to test the Subcontractors means and methods for sludge stabilization and determine the final reagent design mix.
2. Stabilization of sludge and soils with reagents to allow handling, placement and compaction within the on site Landfill.
3. Placement and compaction of stabilized material in the landfill.
4. Confirmation testing of stabilized material samples collected at the landfill.
5. Control of air emissions generated during the application of reagents, and during the transportation, placement, and compaction of the stabilized sludge and soil materials.

1.02 RELATED SECTIONS

A. Section 01130 - Perimeter Air Monitoring and Emissions Plan

B. Section 01400 - Quality Requirements

C. Section 02240 - Construction Water Management

D. Section 02260 - Excavation Support and Protection

E. Section 02315 - Excavation

F. Section 02316 - Fill and Backfill

G. Section 02370 - Erosion and Sedimentation Control

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM)

1. C 25-99 Standard Test Methods for Chemical Analysis of Limestone, Quicklime, and Hydrated Lime
2. C 150-02a Standard Specification for Portland Cement
3. D 698-00a Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3))
4. D 1587 Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes; 2000.
5. D 1633-00 Standard Test Method for Compressive Strength of Molded Soil-Cement Cylinders
6. D 2166-00 Standard Test Method for Unconfined Compressive Strength of Cohesive Soil
7. D 2922 Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth); 2001.
8. D 3017 Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth); 2001.

1.04 DEFINITIONS

A. Stabilization - Mixing of sludge or other contaminated material with reagent(s) to enhance the engineering properties of the sludge for placement and compaction in the landfill.

1.05 SUBMITTALS

A. The Subcontractor shall submit for review a Stabilization Plan no less than 21 days prior to the start of stabilization. At a minimum, the Stabilization Plan shall contain the following:

1. Listing of supervisory personnel: Name and experience of the various persons, their role, and primary responsibilities.
2. A description of the means and methods to be used by the Subcontractor to store, convey, and deliver the stabilizing reagent(s) to the point of mixing including methods for controlling dust emissions.
3. A description of the means and methods for mixing the stabilizing reagents with the sludge.
4. Equipment setup and site use layout: Including storage areas, mixing location(s), haul roads, and work platform.
5. A description of the sequence of operations and the types and number of equipment to be used.
6. A description of the means and methods of determining the amount of reagent(s) needed and controlling rate of reagent application to achieve the required mix ratio.
7. A description of the means and methods to be used by Subcontractor to control the release of airborne contaminants including but not limited to nuisance odors, volatile organic compounds, hydrogen sulfide, and particulates.
8. A detailed explanation and flow diagram of the methodology to be employed, including estimated production rate and method of measuring quantity of material processed.

B. Product Data: Certificates of Analysis for each reagent shall be submitted to the Engineer prior to delivery of reagent to the project site.

C. The Subcontractor shall submit for review and maintain a copy on site the following stabilization test results within 48 hours of sample collection.

1. Results of "Shake Down" test of mix design or any other testing intended to establish the mix design.
2. Geotechnical laboratory test results indicating stabilization is successful.
3. Geotechnical Laboratory test results for all substitute reagents proposed for use by Subcontractor.

D. Pre and Post-placement survey data and drawings: submit to Engineer within 21 days of the survey.

1.06 QUALITY ASSURANCE

A. The Subcontractor and all subcontractors or consulting advisors shall submit evidence of experience and competence to conduct stabilization of lagoon sludge. The evidence shall include references from at least five similar successful stabilization projects constructed over the last 10 years, at least two which shall involve in situ mixing of reagents if in situ mixing is the selected method. Project descriptions shall include, at a minimum, the dimensions of the work, type of reagent(s), type of soil treated or stabilized and equipment description.

B. The Subcontractor shall use personnel who are experienced with techniques and equipment

necessary to evaluate and design a reagent ratio mix for stabilization, and to perform stabilization and testing.

C. The geotechnical testing laboratory shall meet the requirements of Section 01400 - Quality Requirements.

PART 2 PRODUCTS

2.01 REAGENTS

A. Laboratory testing using Type II Portland cement and a combination of Portland cement and quicklime has been shown to meet the strength requirements in Table 02343-1. Laboratory test reports are included in the Contract Documents for Subcontractor's information only. The test results are indicative of controlled laboratory preparation and curing conditions and may not be representative of stabilization under full-scale field conditions using Subcontractor's means and methods. The percentages of quicklime (8 percent) and Type II Portland cement (4 percent), by wet sludge weight, in the Contract Documents (Bid Form) have been established to allow comparison of bids only. The Subcontractor is responsible for evaluating and developing the mix design for stabilization as specified herein.

B. The Subcontractor shall furnish the required reagents as per the mix ratio determined by the Subcontractor during the initial shake down evaluation.

C. Approved stabilizing reagents:

1. Type II Portland cement
2. Quicklime
3. Substitute Reagents - Subcontractor may request, in writing to the Engineer, to substitute approved reagents with alternative reagent(s). The written request shall provide sufficient data to show that proposed substitute reagent meets the performance requirements for sludge stabilization as set forth in this specification.
4. Any combination of above reagents

D. The reagent materials shall meet the material requirements set forth below. Reagent material shall have documentation of meeting the material requirements. The Subcontractor shall furnish such documentation to Engineer prior to delivery to site.

E. A Certificate of Analysis supplied by the Vendor shall accompany each shipping unit of reagent. The certificate of analysis shall state that the material does not contain any hazardous constituents above regulatory limits.

F. Reagents will be shipped in properly labeled containers or tanks in accordance with all state and federal regulations.

G. Subcontractor shall store and handle reagents according the manufacturer's recommendations.

H. Subcontractor shall protect reagents from damage during shipment, storage and handling that reduces the ability of the reagents to stabilize sludge. Subcontractor will not be reimbursed for wet or damaged reagents.

2.02 PORTLAND CEMENT

A. Portland Cement purchased for use as a solidification reagent will conform with ASTM C150 for Type II Cement.

2.03 HIGH CALCIUM QUICKLIME

A. High calcium quicklime purchased for use as a stabilizing reagent shall be produced by the calcinations of high-purity limestone and composed essentially of calcium oxide (CaO) and shall

conform with ASTM C25.

B. High calcium quicklime shall have the following chemical properties:

Total calcium and calcium oxide (CaO), (%)	95.0
Available lime index as calcium oxide (CaO), (%)	92.3
Magnesium oxide (MgO), (%)	1.1
Insoluble matter including silica (SiO2), (%)	1.8
Ferric Oxide (Fe2O3), (%)	0.2
Alumina (Al2O3), (%)	0.7

C. Typical Physical Properties:

Bulk Density by ASTM C 110, (kg/m3),	Packed	1050
	Loose	910
Specific Gravity		3.4
pH (saturated solution at 25° C)		12.45

D. Gradation

Sieve Designation	% by Weight Passing Square Mesh Sieves
25 mm	100
20 mm	100
14 mm	85 to 99
10 mm	25 to 75
5 mm	0 to 15
2.5 mm	0

2.04 ADDITIVES

A. Subcontractor may request, in writing to the Engineer, to use admixtures to enhance the workability or final properties of the stabilized material. Common additives include bentonite, lime, set retarder, etc. Additives may be added to the sludge or the reagent(s). Proprietary chemicals may be approved based on the results of the "shake-down" demonstration. The Subcontractor shall not add bulking materials such as sand, gravel, or stone unless otherwise approved by the Engineer.

PART 3 EXECUTION

3.01 GENERAL REQUIREMENTS

A. Become familiar with and assume responsibility for the safety of all processes and materials.

B. Contain stabilization operations within the designated limits as indicated on the design drawings. If conditions encountered warrant modification to the designated limits, Engineer shall be notified prior to proceeding.

C. Work in inclement weather shall be performed at the risk of the Subcontractor. Replace and rework any materials that become unsuitable or unstable as the result of work during inclement weather.

D. Perform stabilization operations such that drainage is maintained at all times. Surface water

run-on to the stabilization processing area shall be prevented. Runoff from the stabilization area shall be collected and treated as per Section 02240 - Construction Water Management.

E. Deposit materials suitable for reuse in protected, maintained piles that are separate from other materials and readily available. Upon project completion, restore all material storage areas to their original condition

3.02 PROTECTION

A. Comply with the rules and regulations of OSHA Construction Safety and Health Regulations.

B. Areas where buried debris, undefined pipes or utilities or any soils of peculiar nature are encountered during excavation and trenching shall be brought to the immediate attention of Engineer.

C. Provide protection necessary to prevent damage to existing improvements indicated to remain in place. Restore damaged improvements to their original condition.

D. Locate existing underground utilities in the areas of work. If the utilities are to remain in place, provide adequate means to protect them during excavation operations.

3.03 CONSTRUCTION SURVEY

A. The Subcontractor shall perform a pre-placement survey of the landfill subgrade area and a post-placement survey of the treated contaminated material. The Subcontractor shall provide Engineer with survey data and corresponding survey drawings.

B. Survey drawings shall show elevations relative to NGVD 1929 as contours of equal elevation (two-foot intervals) and the limit of sludge placement.

3.04 INITIAL "SHAKE-DOWN" DEMONSTRATION

A. The Subcontractor shall perform a methodology and reagent design mix verification exercise, hereafter referred to as the "shake-down" demonstration.

B. The Subcontractor shall perform all evaluations, sample collection, sample preparation, and sample testing required to determine the appropriate materials and material proportions (design mix) for the required stabilization performance. Contractor shall determine the final design mix.

C. A minimum of 1,000 tons of sludge from Lagoon 1 and 1,000 tons of sludge from Lagoon 5 shall be stabilized to meet the performance standards during the "shake-down" demonstration using the Subcontractor's means and method of stabilization, and reagent design mix.

D. The "shake-down" demonstration shall occur over the first week of stabilization activities, although it is possible that this duration may be longer if unexpected or exceptionally difficult conditions are encountered. The "shake-down" demonstration will be deemed complete, when a minimum of 1,000 tons of sludge from Lagoon 1 and 1,000 tons of sludge from Lagoon 5 have been stabilized and meets Performance Standards under the minimal reagent(s) design mix ratio.

E. The Subcontractor shall identify the minimum amounts of reagents needed to stabilize the contaminated materials during the "shake-down" demonstration. Subcontractor shall use the minimum amount of reagents for stabilization and modify the reagent mix ratio as needed to address any changes in sludge characteristics as may be encountered.

F. The Subcontractor shall determine the maximum practicable density of the compacted stabilized materials. The Subcontractor shall demonstrate compaction to the maximum practicable density using means and methods selected by the Subcontractor. The maximum practicable density shall be expressed as a percent compaction as determined by ASTM D 698, which will become the minimum dry density requirement for the remainder of the stabilized material placement.

G. During the "shake-down" demonstration period, the Subcontractor shall collect stabilized material samples at a minimum frequency of four per 1,000 tons. The Subcontractor shall analyze the samples at the geotechnical laboratory for the parameters specified in Table 02343-1.

H. Means and methods for air emission controls shall be evaluated during the "shake-down" demonstration.

3.05 STABILIZATION OF SLUDGES AND CONTAMINATED SOIL

A. Subcontractor shall provide means and methods to stabilize sludge and contaminated soil as shown on Drawings. The means and methods selected by Subcontractor shall include air emission controls to prevent the release of airborne contaminants. Significant potential for the release of hydrogen sulfide and VOCs exists, particularly in Lagoon 1. The ability of the means and methods to meet the performance criteria will be evaluated during the "shake-down" demonstration.

B. The Subcontractor shall perform stabilization of contaminated material including but not limited to sludges and contaminated soils contained in the site areas designated as Lagoon 1 and Lagoon 5.

C. The method of applying the reagents to the contaminated materials shall provide sufficient mixing to meet the Performance Standards in Table 02343-1.

D. Reagent distribution shall be such that stabilized material will be free from lenses, pockets, streaks or layers of material differing substantially in texture or gradation from the surrounding material.

E. The method of applying and mixing the reagents and sludge shall minimize the release of airborne contaminants and nuisance odors.

F. The percentage of reagents, by weight, to be incorporated during the stabilization shall be at a minimum that established in the "shake-down" demonstration.

G. The Subcontractor shall have capability to efficiently stockpile the stabilized material in accessible locations in interim staging areas.

H. Treated material stockpile areas shall be maintained in a free-draining condition.

3.06 PLACEMENT AND COMPACTION OF STABILIZED MATERIAL

A. Do not place stabilized material until the required grading and surface preparation have been completed and the landfill subgrade has been inspected and surveyed. Do not place fill on frozen surface, in standing water, or when materials contain snow, ice, or frozen material.

B. The Subcontractor shall provide access and safe working area for Engineer and Quality Assurance personnel to perform required oversight.

C. The Subcontractor shall place fill material in appropriate loose lifts to attain maximum 12-inch compacted lift thickness.

D. Stabilized material shall be compacted to meet the performance standards in Table 02343-01.

E. Any oversize materials removed prior to stabilization may be incorporated directly into the landfill. Materials that are larger than the thickness of the lift shall be managed in such a manner to insure proper compaction around the oversize material. Oversize material shall not be placed within two feet of the finish contaminated material grade. Oversize materials may include cobbles, boulders, and organic materials such as small stumps (up to 4-inch diameter at the base of the tree).

F. Stumps larger than four inches in diameter shall be broken down by chopping, chipping, or

grinding. The reduced materials may be incorporated into the landfill.

G. Moisture content of stabilized material shall be uniformly distributed prior to and during compaction.

H. Layers of stabilized material shall be placed to form a continuous homogeneous material. The Subcontractor shall scarify to a depth of three inches and moisture condition the surface of the subgrade immediately prior to the first treated material placement to aid adhesion. The two inches of the previously compacted treated material shall be scarified prior to placement of the next lift to create a homogeneous bond.

I. The Subcontractor shall be responsible for protection of the treated material fill area during storm events and shall make necessary repairs to any damaged treated material. The Subcontractor shall provide a uniform slope of one percent minimum to prevent ponding of water on the surface, and shall roll smooth the surface of stabilized material before any rain events and at the end of each day.

3.07 AIR EMISSION CONTROL

A. Activities described in this section shall be conducted in accordance with requirements of Section 01130 - Perimeter Air Monitoring and Emissions Plan.

B. Subcontractor shall control air emissions during stabilization, transportation and placement of stabilized material.

C. Contractor shall provide means and methods to control the release of airborne contaminants including but not limited to nuisance odors, volatile organic compounds, hydrogen sulfide and particulates.

D. All air emissions associated with the stabilization treatment train (including particulates) shall be controlled in accordance with all applicable local, state and federal air quality regulations.

3.08 FIELD QUALITY CONTROL

A. Confirmation Testing of Stabilized Materials

1. The Subcontractor shall collect stabilized material samples at a minimum frequency of one per production day during stabilization and analyze the samples at the geotechnical laboratory for the parameters specified in Table 02343-1. Failure to meet the Acceptance Criteria summarized in Table 02343-1 will result in retreatment of all of the material represented by the sample. The Subcontractor shall perform any additional stabilization and testing at Subcontractor's cost.

2. Samples for confirmation testing shall be collected from the compacted lift in the landfill using ASTM D 1587, or equivalent. A minimum of one duplicate specimen shall be archived with each sample.

3. Samples shall be collected in the presence of Engineer.

4. The Subcontractor shall dispose of all sample specimens in the landfill prior to construction of landfill cap.

5. A minimum of four samples that meet all criteria shall be collected during the shake down test for each 1,000 tons of material processed.

B. Compaction Testing

1. Moisture/density relationships will be developed by Subcontractor as determined by ASTM D 698 at a minimum frequency of one test per 5,000 tons or change in material.

2. Three moisture/density checks shall be performed by Subcontractor for each production

day in accordance with ASTM D-3017 for moisture and ASTM D-2922 for in-place density.

END OF SECTION

Table 02343-1 Stabilization Confirmation Testing Program				
Parameter	**Analysis/ Testing Method**	**Performance Standard**	**Frequency**	**Acceptance Criteria**
Structural Criteria				
Compaction	ASTM D2922 and D3017	90% of the maximum density	3 per Production Day	Average > 90%, 20% of tests allowed to be as low as 87%
Strength	ASTM D1633 or D2166	> 10 psi	Production Day	> 10 psi at 3 days Contractor able to compact after 3 days
Free Liquids	Field Observation	No visible liquid observed	Every 250 tons	None visible

Contractor shall be responsible for completion of Structural Criteria and Related Compaction testing.

SECTION 02520

MONITORING WELLS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Installation of groundwater monitoring wells.

B. Installation of gas probes.

1.02 RELATED SECTIONS

A. Section 01300 - Administrative Requirements

1.03 REFERENCES

A. Rule Number 02033, Well Driller Licensing Rule, Environmental Protection Rules Chapter 15, State of Vermont Agency of Natural Resources, Department of Environmental Conservation, Water Supply Division; September 20, 2002.

B. American Society for Testing and Materials (ASTM)

1. C 150-02a Standard Specification for Portland Cement
2. D 1586 Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils; 1999.
3. D 1785 Specification for Polyvinylchloride (PVC) Plastic Pipe, Schedules 40, 70, and 120; 1986.
4. D 2487 Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System); 2000

1.04 SUBMITTALS

A. See Section 01300 - Administrative Requirements, for submittal procedures.

B. Documentation: The following shall be submitted within 14 days of completion of drilling activities:

1. Boring logs and well construction diagrams. Accurately record actual locations of well, depth, subsoil strata, and drilling difficulties encountered.
2. Submit signed copy of driller's log book statements.
3. Keys for monitoring well caps.

C. As-Built Plan

1. Prior to project closeout, the Subcontractor shall submit to the Engineer, record drawings showing monitoring well locations.

1.05 QUALITY ASSURANCE

A. Drilling Firm Qualifications:

1. Firm shall specialize in performing the Work of this Section with minimum three (3) years experience.
2. Firm shall be licensed with the State of Vermont pursuant to the State of Vermont Agency of Natural Resources, Department of Environmental Conservation Well Drillers Licensing Rule, Environmental Protection Rules; Chapter 15. Firm shall comply with the rule.
3. Firm shall have completed the 40-hour HAZWOPER training required under OSHA and

shall conform with OSHA requirements.

PART 2 PRODUCTS

2.01 MONITORING WELL MATERIALS

A. General: Materials and equipment shall be the standard product of manufacturers regularly engaged in the manufacture of such products.

B. Well Riser Pipe: Two-inch ID, Schedule 40, flush-jointed, threaded, PVC pipe, ASTM D 1785.

C. Well Screen: Fifteen feet of two-inch ID, 0.006-inch, Schedule 40, flush-jointed, threaded, PVC pipe, ASTM D 1785.

D. Filter Pack: Quartz sand, at least 99.5 percent silicon dioxide.

E. Cement Grout: Portland cement conforming to ASTM C 150, Type I or II, mixed with 7 gallons of water per 94-lb. bag, and 3 percent bentonite powder by weight.

F. Protective Casing: Four-inch diameter steel, 5-foot minimum length, vented, and with a locking cap.

G. Bentonite Well Seal: Compressed bentonite pellets, 1/2 or 3/8 inch diameter.

H. Padlock: Master Lock Model 510KAD with F27 key.

2.02 GAS PROBE MATERIALS

A. Probe Riser Pipe: One-inch ID, Schedule 40, flush-jointed, threaded, PVC pipe, ASTM D 1785.

B. Probe Screen: Five feet of one-inch ID, Schedule 40, flush-jointed, threaded, PVC pipe, ASTM D 1785.

C. Filter Pack: Quartz sand, at least 99.5 percent silicon dioxide.

D. Cement Grout: Portland cement conforming to ASTM C 150, Type I or II, mixed with 7 gallons of water per 94-lb. bag, and 3 percent bentonite powder by weight.

E. Protective Casing: Four-inch diameter steel, 5-foot minimum length, vented, and with a locking cap.

F. Bentonite Well Seal: Compressed bentonite pellets, 1/2 or 3/8 inch diameter.

G. Padlock: Master Lock Model 510KAD with F27 key.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that site conditions will support equipment for performing drilling operations and testing.

3.02 DRILLING

A. General

1. Drilling and associated work shall be conducted or supervised by a well drilling firm licensed in the State of Vermont. Water from a potable source or air will be the only acceptable drilling fluids. If at any time during drilling, an unexpected condition is encountered (i.e., sludge, hydrogen sulfide or other gas, subsurface structures) the Engineer shall be notified.

B. Location

1. Locations of monitoring wells are indicated on the Drawings.

2. Monitoring well locations shall be flagged prior to installation for inspection by the Engineer

C. Drill Method

1. Monitoring wells will be drilled to a depth of 20 feet below the water table using hollow stem augers or drive and wash techniques to achieve a nominal borehole diameter of 6 inches.

D. Sampling

1. Split spoon samples shall be taken in the monitoring well borings in accordance with ASTM D 1586 and retained in 8-ounce jars. Samples are to be classified by compositional texture in accordance with ASTM D 2487 and geologic type.

2. Samples will be taken at 2-foot intervals (continuous sampling) from monitoring well borings.

E. Construction of Casing and Screen

1. The well screen and casing shall be lowered into the borehole by a method which will allow for control of the rate of fall of the well screen and casing at all times to the required depth. Well screen and casing shall not be dropped or allowed to fall uncontrolled into the borehole.

F. Construction of Gravel Pack

1. After the screen and casing have been concentrically set in the hole to the required depth, the approved gravel pack shall be constructed around the screen by filling the space around the screen with the filter pack. Add sand by tremie pipe method, keeping the tremie pipe within 10 feet of the top of the placed material. In order to prevent bridging of the gravel pack within the annulus, the screened interval of the well will be surged as the gravel pack is being installed. The filter pack shall be placed to a height of 1 foot above the top of the screen.

G. Well Seal Installation

1. A 2-foot bentonite seal will be placed directly above the filter pack in the annular space between the 2-inch PVC riser and native formation to prevent leakage of grout into the filter pack.

2. Allow bentonite pellets to hydrate for a minimum of four hours before placement of the overlying grout.

H. Place grout tight to surrounding work.

1. Grout by placing feed pipe to within 3 feet of the bentonite seal. The feed pipe must direct grout horizontally, not downward. Force grout down feed pipe under pressure with grout pump and force upward into annular space between the casing and surrounding formation. Slowly remove grout feed pipe as grouting operation progresses with bottom of pipe submerged in grout. Grout continuously in such a manner to ensure entire annular filling of space in one operation. Do not drill or work in well within 72 hours after grouting of the casing.

I. Protective Casing Installation

1. Install protective casing into grout with 3 feet below ground and 2 feet above ground. A 2-foot square, 4-inch thick concrete pad, sloped away from the well, shall be constructed around the well casing. A vent hole, shall be drilled in the protective casing within 6 inches above the top of the concrete pad. The protective casing shall have a hinged cover with a hasp that can be secured with a padlock with a 5/16-inch shackle.

J. Monitoring Well Development

1. Development of wells will be conducted to remove fines and create proper hydraulic contact between the well screen and surrounding filter sand pack.

2. Monitoring wells will be developed using a submersible pump or an equivalent method. Acids or dispersing agents will not be used. Development will begin no earlier than 24 hours following well completion to allow the bentonite seal and bentonite-grout to set properly. Development may begin prior to installation of the protective surface casing.

3. Determination of monitoring well development completion will be dependent upon stabilization of field parameters, removal of water used in well installation, and water clarity. As monitoring wells are developed, field parameters (e.g., conductivity, pH, and temperature) will be monitored. Development will continue until the water is visibly clear and the water quality parameters have stabilized to within 10 percent. At least three borehole volumes of water plus the volume of water added during drilling, if any, will be removed.

4. It is recognized that occasionally shallow groundwater within fine grained materials is naturally turbid. As a result, extensive development may not result in the production of clear water. Therefore, a maximum of eight well volumes will be removed during monitoring well development. Development will be considered complete if field parameters have stabilized prior to the removal of eight well volumes. If the well recharges slowly during development, removal of additional water may continue over a 24 hour period. The well should not be pumped or bailed dry.

5. No water will be introduced to the monitoring wells during development. A record of all removed water and field parameter measurements will be maintained. The pumping and/or bailing equipment will be decontaminated both internally and externally before and after use.

6. Monitoring well development water may be discharged to the ground surface.

7. After development, monitoring wells will be allowed to stabilize a minimum of 48 hours prior to determining groundwater levels.

3.03 RECORDS

A. Boring Logs - The Subcontractor shall prepare a log of the hole that shall include, but not limited to, the following information:

1. Reference point for depth measurements.
2. Depth at which water was first encountered.
3. Depth of each change of stratum in formation.
4. Thickness of each stratum in formation.
5. Identification of material at each stratum.
6. Depth interval from which each formation sample was collected.
7. Field screening results.
8. Ground surface elevation.

B. Well Construction Diagram - The Subcontractor shall prepare a well completion report that shall include, but not limited to the following:

1. Total depth of completed well.
2. Screened interval depth.
3. Well riser depth, diameter, type, and top elevation.
4. Depths of filter pack, bentonite seal, and grout.

5. Well development records including measurements at regular intervals of specific conductance, pH, temperature, and turbidity.

6. Top of casing elevation.

3.04 DECONTAMINATION

A. The Subcontractor shall decontaminate drilling rig(s) by steam cleaning. Decontamination of drilling sampling (i.e., split spoons, stainless steel sample mixing bowls and pans, spatulas/ trowels, etc.) equipment will consist of steam cleaning, laboratory-grade non-phosphate detergent wash, potable water rinse, ASTM water rinse, methanol rinse and air drying. Used methanol decontamination fluids shall be segregated from decontamination wastewater and placed in large trays provided by the Subcontractor to encourage evaporation of residual liquid. Decontamination shall be performed to the satisfaction of the Engineer.

B. The drilling rig(s) shall be thoroughly decontaminated on Station prior to first use. Prior to the beginning of any work at an exploration location and at the discretion of the Engineer's on-site representative, the rig will be inspected and, if necessary, the drilling platform or other area(s) shall be steam cleaned.

C. All down-hole drilling equipment, including well screen and casing, augers, bits, drilling and sampling rods, and other non-sampling equipment, will be steam cleaned before each use. This method of cleaning will also be applicable to other miscellaneous equipment such as pumps, piping and fittings used to develop wells. The cleaned tools, materials and equipment will be covered with clear polyethylene plastic sheeting before transportation to individual boring locations.

D. The Subcontractor shall decontaminate all tools used for sampling, including split spoons, sample cutting knives, stainless steel bowls, etc. on site, before each use and between sampling intervals. Tools not used immediately shall be wrapped in aluminum foil.

E. Equipment decontamination, including management of decontamination residuals and fluids shall be in accordance with Equipment and Vehicle decontamination requirements set forth in Section 02315 - Excavation

3.05 SURVEY

A. The Subcontractor shall perform a land survey to establish the locations and elevations of existing and newly installed monitoring wells. Ground surface and top of PVC riser pipe elevations shall be documented. All work shall be conducted under the direct supervision of a Professional Land Surveyor currently registered by the State of Vermont.

B. The degree of accuracy required is as follows:

	Relative	Absolute
Vertical	+/- 0.01 foot	+/- 0.10 foot
Horizontal	+/- 0.10 foot	+/- 1.00 foot

END OF SECTION

SECTION 02610

PIPE CULVERTS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Pipe culvert, joints and accessories.

1.02 RELATED SECTIONS

A. Section 01300 - Administrative Requirements

B. Section 02315 - Excavation

C. Section 02316 - Fill and Backfill

1.03 REFERENCES

A. American Society of Testing and Materials (ASTM)

1. C 76 - Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe; 2000.
2. C 76M - Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe (Metric); 2000.
3. C 443 - Standard Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets; 2001.
4. C 443M - Standard Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets (Metric); 2001.

1.04 SUBMITTALS

A. See Section 01300 - Administrative Requirements, for submittal procedures.

B. Product Data: Prior to installation, provide data on pipe, fittings and accessories.

C. Accurately record actual locations of pipe runs, connections, and invert elevations. Submit data in an as-built drawing to be submitted prior to project closeout.

1.05 DELIVERY, STORAGE, AND PROTECTION

A. Care shall be exercised when unloading pipe from delivery trucks and moving pipe to its final position. If the Engineer rejects damaged pipe, new pipe shall be furnished by the Subcontractor at his expense.

PART 2 PRODUCTS

2.01 CONCRETE CULVERT PIPE

A. Concrete Pipe: Reinforced, ASTM C 76 (ASTM C 76M), Class I with Wall Type A; mesh reinforcement; bell and spigot end joints:

1. Shape: Circular with a nominal diameter of 12 inches.

B. Reinforced Concrete Pipe Joint Device: ASTM C 443 (ASTM C 443M) rubber compression gasket joint.

2.02 BEDDING AND COVER MATERIALS

A. Bedding Material: Use Road Subbase as specified in Section 02316, or other approved by the Engineer.

B. Cover Material: Use Cover Soil as specified in Section 02316, or other approved by the Engineer.

PART 3 EXECUTION

3.01 EXCAVATION

A. Where the pipe is to be laid below the existing ground line, a trench shall be excavated to the required depth and to a width sufficient to allow for joining of the pipe, and compaction of the bedding and backfill material under and around the pipe.

B. The completed trench bottom shall be firm for its full length and width. The invert grade shall be cambered by an amount to be determined by the Engineer.

C. Unsuitable foundation material encountered below the normal grade of the culvert bed shall be removed and replaced with Bedding Material, or other specified or approved material.

3.02 BEDDING

A. Existing soil shall be removed and replaced with Bedding Material having a width measurement of the inside width of the pipe plus 600 mm (24 inches) and to a minimum depth of 300 mm (12 inches) below the pipe grade, unless otherwise shown on the Drawings.

B. Unless otherwise specified, the bed shall be shaped and compacted to fit the pipe for a depth of not less than 50 percent of its total height. Recesses to receive the bell shall be formed when applicable.

3.03 PLACEMENT

A. No pipe shall be placed until the trench and the prepared foundation have been approved by the Engineer.

B. Placement shall begin at the outlet end and the lower segment of the pipe shall be in contact with the shaped bedding throughout its full length. Bell or grooved ends of rigid pipes and the outside circumferential laps of flexible pipe shall be placed facing upstream. The longitudinal laps or seams of riveted pipe shall be at the sides.

C. The handling holes in concrete pipes shall be filled with a precast plug, sealed, and covered with mastic or mortar.

3.04 JOINING PIPE

A. Concrete pipe shall be of bell and spigot or tongue and groove design, or as specified. Pipe sections shall be joined so that the ends are fully entered and the inner surfaces are reasonably flush and even.

B. Joints shall be made with portland cement mortar, portland cement grout, rubber gaskets, oakum and mortar, oakum and joint compound, a combination of these types, or any one type as specified and approved by the Engineer. Joints in concrete pipe should be thoroughly wetted before mortar or grout is applied.

C. Mortar joints shall be made with an excess of mortar to form a bead around the outside of the pipe and finished smooth on the inside. For grouted joints, molds, or runners shall be used to retain the poured grout. Rubber ring gaskets shall be installed so as to form a flexible watertight seal. Where oakum is used, the joint shall be caulked with this material and then sealed with the specified materials.

D. When portland cement mixtures are used, the completed joints shall be protected against rapid drying by suitable curing materials, and protected from freezing until adequate set and strength have been reached.

E. The first three sections, at ends of culverts that are not restrained by drop inlets or catch basins, shall be connected together at the springline on each side of the pipe to restrain movement of the sections. If an end section is used, it shall be one of the three sections to be connected together.

F. The connecting devices shall be at least 3.7 m (12 feet) in length when used with 2.3 m (7.5 foot) minimum length sections and at least 3 m (10 feet) in length when used with 1.8 m (6 foot) minimum length sections. Each device shall be securely anchored to the pipe, with minimum slack in the device and the joints. The anchoring points shall be a minimum of 450 mm (18 inches) from the end of the pipe sections and the flared end sections. Each end of the device shall be anchored with an M24 (1 inch) bolt with a nut and washer, or its equivalent, through the section wall.

G. Each device shall be a steel strap with an effective cross-sectional area of 150 mm2 (0.23 square inch) for all pipe 1200 mm (48 inches) in diameter or smaller. For pipe larger than 1200 mm (48 inches) in diameter, the required steel area for restraining devices shall be as shown on the Plans.

H. Alternate designs of restraining devices and anchoring hardware will be considered for approval as long as they provide equivalent restraining properties and durability.

I. Restraining devices may be placed on either the inside or outside of the pipe. If placed on the inside, the device shall not protrude from the wall to the degree that flow would be obstructed. Any bending of the device for proper installation shall be done by the cold bending method. Holes in the pipe and end sections, required for the anchor bolts, may be drilled in the field.

3.05 BACKFILLING

A. The installed pipe will be inspected and approved before any backfill is placed. Any pipe found to be damaged or out of alignment shall be removed and replaced or re-laid without additional compensation.

B. Cover Material shall be placed to a height of 600 mm (24 inches) over the pipe. No stones in excess of 75 mm (3 inches) in diameter shall be placed in contact with the pipe. Rock fill or boulders shall not be placed within 600 mm (24 inches) of the outside of the pipe.

C. The backfill material shall be placed and compacted in accordance with Section 02316 - Fill and Backfill. Care shall be exercised to thoroughly compact the material under the haunches of the pipe. The backfill shall be placed evenly on both sides of the pipe for its full length. In embankment sections the fill shall be compacted for a width on each side of the pipe equal to at least twice the horizontal inside diameter of the pipe or 4 m (12 feet), whichever is less. Fill at the sides of the pipe may be compacted by operating compaction equipment, longitudinally parallel with the pipe, provided care is taken to avoid displacement or injury to the pipe.

3.06 CLEANING OF CULVERTS

A. Pipe culverts that contain silt, debris, and other material within the barrel and appurtenances shall have the silt, debris, and other material removed and disposed of by methods that do not damage the pipe.

B. If however, the Engineer determines that the pipe must be replaced, replacement will be paid for under the appropriate Contract items.

3.07 PROTECTION

A. Protect pipe and bedding from damage or displacement until backfilling operation is in progress.

END OF SECTION

SECTION 02620

GEOCOMPOSITE DRAINAGE LAYER

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Materials, installation and handling procedures, and testing of geocomposite drainage layer for the landfill cap.

1.02 RELATED SECTIONS

A. Section 01300 - Administrative Requirements

B. Section 01400 - Quality Requirements

C. Section 02316 - Fill and Backfill

D. Section 02623 - Geomembrane

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM)

1. D 1505-98 Standard Test Method for Density of Plastics by the Density-Gradient Technique
2. D 1603-94 Standard Test Method for Carbon Black in Olefin Plastics
3. D 4355-02 Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus
4. D 4491-99 Standard Test Method for Water Permeability of Geotextiles by Permittivity
5. D 4716-00 Standard Test Method for Determining the (In-Plane) Flow Rate Per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head
6. D 4751-99 Standard Test Method for Determining Apparent Opening Size of a Geotextile
7. D 4833-88 (1996) Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products
8. D 5035-95 Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)
9. D 5199-99 Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes
10. D 5261-92 (1996) Standard Test Method for Measuring the Mass Per Unit Area of Geotextiles

B. Geosynthetic Research Institute (GRI)

1. GRI GC-7 Determination of Adhesion and Bond Strength of Geocomposites.

C. Relevant publications from the Environmental Protection Agency (EPA):

1. Daniel, D.E. and R.M. Koerner, (1993), Technical Guidance Document: Quality Assurance and Quality Control for Waste Containment Facilities, EPA/600/R-93/182.

1.04 DEFINITIONS

A. Construction Quality Assurance Consultant (CQA Consultant) – Party, independent from Manufacturer and Installer that is responsible for observing and documenting activities related to quality assurance during geocomposite drainage layer construction.

B. Geocomposite Manufacturer (Manufacturer)- The party responsible for manufacturing the geocomposite rolls.

C. Geosynthetic Quality Assurance Laboratory (Testing Laboratory) – Party, independent from the Manufacturer and Installer, responsible for conducting laboratory tests on samples of geosynthetics obtained at the site or during manufacturing, under the direction of the Engineer.

D. Installer – Party responsible for field handling, transporting, storing and deploying the geocomposite.

E. Lot – A quantity of resin (usually the capacity of one rail car) used to manufacture polyethylene geocomposite rolls. The finished rolls will be identified by a roll number traceable to the resin lot.

1.05 SUBMITTALS

A. See Section 01300 - Administrative Requirements, for submittal procedures.

B. Sample: Subcontractor shall submit one 8" x 10" sample of drainage geocomposite within 21 days of the Notice to Proceed.

C. Geocomposite Manufacturer Qualifications, within 21 days of Notice to Proceed.

D. Geocomposite Installer Qualifications, within 21 days of Notice to Proceed.

E. Manufacturer Quality Control Information: to be submitted to Engineer prior to delivery to the project site.

1. Copy of Manufacturer Quality Control Plan.
2. Copy of product specification sheet listing all test methods and property values as identified in this section.
3. Copies of quality control certificates issued by the raw material supplier.
4. Results of tests conducted to verify the quality of the resin used to manufacture the drainage geocomposite rolls assigned to the project.
5. Certification that no post-consumer reclaimed polymer is added to the resin during the manufacture of the drainage geocomposite.
6. Manufacturer quality control test results.

F. Interface Friction Sample: Submit to CQA Consultant one 3-foot by full roll width sample of drainage geocomposite, two 5-gallon buckets of Cover Soil, and two 5-gallon buckets of Crushed Gravel.

G. Conformance Sample: Submit to CQA Consultant one 3-foot by full roll width sample of geocomposite for every 50,000 square feet of material.

H. As-built drawing showing actual area of geocomposite.

1.06 QUALITY ASSURANCE

A. Manufacturer and Installer shall participate in and conform to all terms and requirements of the Engineer's Subcontractor Quality Assurance (CQA) Plan. Subcontractor shall be responsible for assuring this participation.

B. Qualifications

1. Manufacturer
   a. Manufacturer shall have manufactured a minimum of 10,000,000 square feet of polyethylene geocomposite material during the last year.
2. Installer

a. Installer shall have installed a minimum of 5,000,000 square feet of geocomposite in last 10 years.
b. Installer shall have worked in a similar capacity on at least three projects similar in complexity to the project described in the contract documents, and with in at least 150,000 square feet of geocomposite installation on each project.
c. The Installation Supervisor shall have worked in a similar capacity on projects similar in size and complexity to the project described in the Contract Documents.

1.07 MATERIAL LABELING, DELIVERY, STORAGE AND HANDLING

A. Labeling - Each roll of geocomposite delivered to the site shall be wrapped and labeled by the Manufacturer. The label will identify:

1. manufacturer's name
2. product identification
3. length
4. width
5. roll number

B. Delivery - Rolls of geocomposite will be prepared to ship by appropriate means to prevent damage to the material and to facilitate off-loading.

C. Storage- The on-site storage location for the geocomposite, provided by the Subcontractor to protect the geonet from abrasions, excessive dirt and moisture shall have the following characteristics:

1. level (no wooden pallets)
2. smooth
3. dry
4. protected from theft and vandalism
5. adjacent to the area being lined

D. Handling

1. The Subcontractor and Installer shall handle all geocomposite in such a manner as to ensure it is not damaged in any way.
2. The Installer shall take any necessary precautions to prevent damage to underlying layers during placement of the geocomposite.

1.08 WARRANTY

A. Material shall be warranted, on a pro-rata basis against defects for a period of five years from the date of the geocomposite installation.

B. Installation shall be warranted against defects in workmanship for a period of one year from the date of geocomposite completion.

C. See Section 01300 - Administrative Requirements, for additional warranty requirements.

PART 2 PRODUCTS

2.01 GEOCOMPOSITE PROPERTIES

A. A geocomposite shall be manufactured by using a bi-planar or tri-planar drainage net structure with a non-woven geotextile bonded to both sides.

B. The geocomposite specified shall have properties that meet or exceed the values listed in the following table:

PROPERTY	TEST METHOD	MINIMUM AVERAGE VALUE
Geocomposite		
Transmissivity*, m2/sec	ASTM D4716	6.0E-3
Ply Adhesion, lb/in average	GRI GC-7 or F9404 Modified	0.5
Geonet Core		
Transmissivity, m2/sec	ASTM D 4716	8E-3
Thickness, mil (mm)	ASTM D 5199	275 (7)
Density, g/cm3	ASTM D 1505	0.94
Tensile Strength (MD), lb/in (N/mm)	ASTM D 5035	65 (11.5)
Carbon Black Content, %	ASTM D 1603	2.0
Geotextile		
Mass per Unit Area, oz/yd2 (g/m2)	ASTM D 5261	6 (200)
Grab Tensile, lb (N)	ASTM D 4632	157 (700)
Puncture Strength, lb (N)	ASTM D 4833	56 (250)
AOS, US Sieve (mm)	ASTM D 4751	70 (0.212)
Flow Rate, gpm/ft2 (l/min/m2)	ASTM D 4491	110 (4,480)
UV Resistance, % Retained	ASTM D 4355 (after 500 hours)	70

*Gradient of 0.1, normal load of 1,000 psf

C. Resin

1. Resin shall be new first quality, compounded polyethylene resin.
2. Natural resin (without carbon black) shall meet the following additional minimum requirements:

PROPERTY	TEST METHOD	VALUE
Density, g/m3	ASTM D 1505	Greater than 0.94
Melt Flow Index (g/10 min)	ASTM D 1238	Greater than/equal to 1.0

D. Ties

1. Ties used to secure adjacent sheets of drainage geocomposite shall be strings, plastic fasteners, or polymer braid. Metallic ties will not be allowed. Ties shall be yellow or white to facilitate inspection.

E. Thread

1. Thread used to seam geotextile portion of geocomposite shall be polymeric material with chemical resistance properties equal to or exceeding those of the geotextile. The thread shall be a different color than the geotextile to facilitate inspection.

2.02 MANUFACTURING QUALITY CONTROL

A. The geocomposite shall be manufactured in accordance with the Manufacturer's Quality Control Plan submitted to and approved by the Engineer.

B. The geocomposite shall be tested according to the test methods and frequencies listed below:

PROPERTY	TEST METHOD	FREQUENCY
Resin		
Polymer Density, g/cm3	ASTM D 1505	Once per lot
Melt Flow Index, g/10 min	ASTM D 1238	Once per lot
Geocomposite Tests		
Transmissivity, m2/sec	ASTM D4716	1 per 540,000 sq. ft.
Ply Adhesion, lb/in	GRI GC-7	1 per 100,000 sq. ft.
Geonet Tests		
Tensile Strength (MD), lb/in	ASTM D 5035 or or D 4595	1 per 50,000 sq. ft.
Carbon Black Content, %	ASTM D 1603 or D 4218	1 per 50,000 sq. ft.
Geotextile		
Mass per Unit Area, oz/yd2	ASTM D 5261	1 per 90,000 sq. ft.
Grab Tensile, lbs	ASTM D 4632	1 per 90,000 sq. ft.
Puncture Strength, lbs	ASTM D 4833	1 per 90,000 sq. ft
AOS, US Sieve, mm	ASTM D 4751	1 per 540,000 sq. ft.
Water Flow Rate, gpm/ft2	ASTM D 4491	1 per 540,000 sq. ft.
UV Resistance, % Retained	ASTM D 4355 or ASTM G 154	Once per resin formula

PART 3 EXECUTION

3.01 EXAMINATION

A. Prior to implementing any of the work in a section to be lined, the Installer shall carefully inspect the installed work of all other installed sections and verify that all work is complete to the point where the installation of the current section may properly commence without adverse impact.

B. If the Installer has any concerns regarding the installed work of other sections, he shall notify the Engineer.

3.02 INSTALLATION

A. Drainage geocomposite shall be installed in accordance with manufacturer's recommendations and as shown on the Drawings and specified herein.

B. Folds or excessive wrinkling of deployed drainage geocomposite shall be removed to the extent practicable. The Subcontractor shall exercise care not to entrap stones, excessive dust, or foreign objects between the drainage geocomposite and the geomembrane.

C. The geocomposite roll should be installed in the direction of the slope and in the intended direction of flow with no horizontal seams unless otherwise specified by the Engineer.

D. If the project contains long, steep slopes, special care should be taken so that only full length rolls are used at the top of the slope.

E. In the presence of wind, all geocomposites shall be weighted down with sandbags or the equivalent. Such sandbags shall be used during placement and remain until replaced with cover material.

F. In applying fill material, no equipment can drive directly across the geocomposite. The specified fill material shall be placed and spread utilizing vehicles with a low ground pressure (less than 5 pounds per square inch). Wheeled vehicles shall not operate on the geocomposite.

G. All cover soils shall be placed on the geocomposite in a manner that prevents damage to the geocomposite in accordance with Section 02316 - Fill and Backfill. Placement of the cover soil shall proceed immediately following the placement and inspection of the geocomposite. Soils installed on the geocomposite shall be placed from the bottom to the top of the slope.

3.03 SEAMS AND OVERLAPS

A. In general, no horizontal seams shall be allowed on side slopes thus seams shall be along, not across, the slope, except as part of a patch. If horizontal seam are required, offset adjacent horizontal seams.

B. Adjacent geocomposite shall be overlapped so that the geonet overlaps by at least 4 in. (100 mm) and geotextile overlap by at least 3 in.

C. The geonet overlaps shall be tied with plastic fasteners. Tying devices shall be white or yellow for easy inspection. Metallic devices are not allowed.

D. Tying shall be every 5 ft. (1.5m) along the slope, and every 6 in. (150 mm) along end-to-end seams.

E. Once geonet is tied, the geotextile of the geocomposite shall be seamed. All geotextiles shall be continuously sewn or thermally bonded, spot sewing or bonding is not allowed. On slopes shallower than 10:1, geotextiles shall be sewn, or thermally bonded. The Installer shall pay particular attention to seams to ensure that no earth cover material could be inadvertently inserted beneath the geotextile if applicable.

F. Any sewing shall be done using polymeric thread and chemical and ultraviolet light resistance properties equal to or exceeding those of the geotextile. Sewing shall be done using machinery and stitch types specified in the project specifications or as approved in writing by the Engineer.

3.04 REPAIR

A. Prior to covering the deployed geocomposite, each roll shall be inspected for damage resulting from construction.

B. Any rips, tears or damaged areas on the deployed geocomposite shall be removed and patched. The patch shall be secured to the original geonet by tying every 6 inches with the approved tying devices. If the area to be repaired is more than 50 percent of the width of the panel, the damaged area shall be cut out and the two portions of the geonet shall be cut out and the two portions of the geonet shall be joined in accordance with he requirements herein.

3.05 FIELD QUALITY CONTROL

A. Perform field inspection and testing in accordance with Section 01400 - Quality Requirements.

B. Manufacturer and Installer shall participate in and conform to all terms and requirements of the Construction Quality Assurance (CQA) Plan. The Subcontractor shall be responsible for assuring this participation.

C. Interface Friction Testing

1. The Subcontractor shall provide interface friction test samples to the CQA Consultant.

2. Prior to construction and once materials have been selected from their appropriate sources, interface shear testing in accordance with ASTM D 5321 will be performed to determine interface friction values (degrees) and cohesion (psf) between the drainage geocomposite and:
   a. Underlying geomembrane
   b. Overlying Cover Soil
   c. Overlying Crushed Gravel
   (Note: Interface friction test between drainage geocomposite and geomembrane is discussed in Section 02623 - Geomembrane.)

3. Following delivery of the drainage geocomposite to the project site, a sample of material shall be obtained by the CQA Consultant to conduct one interface friction test per interface. Sample sizes shall be as follows:
   a. Cover Soil: two 5-gallon buckets
   b. Crushed Gravel: two 5-gallon buckets
   c. Drainage geocomposite: 3 feet by full roll width, do not include the first 3 feet of the material on the roll.

4. Test will be performed at normal stresses of 100, 300, and 600 psf with a displacement rate of at least 0.2 in/min, under inundated conditions. Soil specimen shall be compacted as specified for final installation in Section 02316 - Fill and Backfill. Peak and residual values will be reported.

5. The interface friction test results shall demonstrate a minimum friction angle of 28 degrees or adequate interface friction and cohesion to provide an acceptable factor of safety as determined by the Engineer.

6. Any materials that have been placed and do not provide an adequate factor of safety, as determined by the Engineer, shall be removed or reworked by the Subcontractor at the Subcontractor's expense.

D. Conformance Testing

1. Following delivery of the geocomposite to the project site, one sample for every 50,000 square feet of material, or one sample per lot, whichever is greater, shall be obtained by the CQA Consultant for conformance testing. Sample shall be 3 feet by full roll width, and shall not include the first 3 feet of the material on the roll.

2. The following testing shall be conducted on the conformance samples:
   a. Transmissivity, ASTM D4716, under the following test conditions:

1) steel plate, geocomposite, cover soil.
2) normal stress 1,000 psf.
3) gradient: 0.1, 0.33.
4) seating time of 100 hours

b. Ply Adhesion, GRI GC-7.

3. Test Results: All test results will be made available to the Subcontractor, and reviewed by the Engineer prior to deployment of the materials. All test results must meet or exceed values specified for the material.

4. Retesting: In the event of failing conformance tests, the Subcontractor or Manufacturer may elect to retest the failed lot(s). All costs of retesting shall be the responsibility of the Subcontractor. Retesting shall consist of one of the following two options:
   a. The Engineer shall select and sample each lot of failed rolled goods, obtaining at least one sample for every 50,000 square feet of material. Samples will be retested at two different laboratories acceptable to the Engineer. If both laboratories produce passing results, the material lot will be accepted. If either lab produces failing results, the material lot will be rejected.
   b. The Engineer shall sample each roll within the failed lot. Testing will be performed at the independent laboratory, in the presence of a Manufacture representative (if desired). Rejection or acceptance of the retested materials in the lot shall be made on a roll by roll basis.

5. Any material not meeting the requirements specified herein will be rejected by the Engineer. The rejected material shall be replaced by the Subcontractor with suitable material at his cost.

E. Inspection

1. The CQA Consultant shall inspect installation for compliance with the CQA plan including, but not limited to:
   a. Drainage geocomposite ties, prior to sewing upper geotextile.
   b. Sewed geotextile seams, prior to covering with subsequent cap layer components.

END OF SECTION

SECTION 02623

GEOMEMBRANE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Requirements for manufacturing, transport, and installation of linear low density polyethylene (LLDPE) geomembrane.

1.02 RELATED SECTIONS

A. Section 01300 - Administrative Requirements

B. Section 01400 - Quality Requirements

C. Section 02316 - Fill and Backfill

D. Section 02620 - Geocomposite Drainage Layer

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM)

1. D 1004 Test Method for Initial Tear Resistance of Plastic Film and Sheeting
2. D 1238 Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer
3. D 1505 Test Method for Density of Plastics by the Density-Gradient Technique
4. D 1603 Test Method for Carbon Black in Olefin Plastics
5. D 3895 Standard Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry
6. D 4833 Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
7. D 5321 Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method
8. D 5397 Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test
9. D 5596 Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics
10. D 5994 Standard Test Method for Measuring Core Thickness of Textured Geomembranes
11. D 6392 Standard Test Method for Determining the Integrity of Non-reinforced Geomembrane Seams Produced Using Thermo-Fusion Methods
12. D 6693 Standard Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes

B. Geosynthetic Research Institute (www.geosynthetics-institute.org)

1. GRI GM-12, Asperity Measurement of Textured Geomembrane Using a Depth Gauge
2. GRI GM-14, Standard Guide for Selecting Variable Intervals for Taking Geomembrane Destructive Seam Samples Using the Method of Attributes, Adopted March 27, 1998.

1.04 DEFINITIONS

A. Lot - A quantity of resin (usually the capacity of one rail car) used in the manufacture of polyethylene geomembrane rolls. The finished roll will be identified by a roll number traceable to the resin lot used.

B. Construction Quality Assurance Consultant (CQA Consultant) - Party, independent from Manufacturer and Installer that is responsible for observing and documenting activities related to quality assurance during the lining system construction.

C. Geomembrane Manufacturer (Manufacturer) - The party responsible for manufacturing the geomembrane rolls.

D. Geosynthetic Quality Assurance Laboratory (Testing Laboratory) - Party, independent from the Manufacturer and Installer, responsible for conducting laboratory tests on samples of geosynthetics obtained at the site or during manufacturing, under the direction of the Engineer.

E. Installer - Party responsible for field handling, transporting, storing, deploying, seaming and testing of the geomembrane seams.

F. Panel - Unit area of a geomembrane that will be seamed in the field that is larger than 100 square feet.

G. Patch - Unit area of a geomembrane that will be seamed in the field that is less than 100 square feet.

H. Subgrade Surface - Soil layer surface which immediately underlies the geosynthetic material(s).

1.05 SUBMITTALS

A. See Section 01300 - Administrative Requirements, for submittal procedures.

B. Sample: Subcontractor shall submit one 8" x 10" sample of drainage geocomposite within 21 days of the Notice to Proceed.

C. Geomembrane Manufacturer Qualifications, within 21 days of Notice to Proceed.

D. Geomembrane Installer Qualifications, within 21 days of Notice to Proceed.

E. Manufacturer Quality Control Information: to be submitted to Engineer no late than 14 days prior to shipment of the material to the project site.

1. Copy of Manufacturer Quality Control Plan.
2. Copy of product specification sheet listing all test methods and property values as identified in this section.
3. Copies of quality control certificates issued by the raw material supplier.
4. Results of tests conducted to verify the quality of the resin used to manufacture the geomembrane rolls assigned to the project.
5. Certification that no post-consumer reclaimed polymer is added to the resin during the manufacture of the geomembrane.
6. Manufacturer quality control test results.

F. The Installer shall furnish the following information to the Engineer, prior to installation:

1. Installation layout drawings
   a. Must show proposed panel layout including field seams and details.
   b. Must be approved prior to installing the geomembrane.
      1) Approved drawings will be for concept only and actual panel placement will be determined by site conditions.

G. The Installer will submit the following to the Engineer, upon completion of installation:

1. Certificate stating the geomembrane has been installed in accordance with the Contract Documents.
2. Material and installation warranties.
3. As-built drawings showing actual geomembrane panel placement and locations of seams and repairs. All locations shall be surveyed per Section 01700 - Execution Requirements.
4. Results of all destructive tests including trial welds, vacuum tests of extrusion welds, air pressure tests of dual wedge fusion welds, and destructive tests on extrusion and fusion welds.

H. Interface Friction Sample: Submit to CQA Consultant the following:

1. One 6-foot by full roll width sample of geomembrane.
2. One 3-foot by full roll width sample of drainage geocomposite and two 5-gallon buckets of cover soil.
3. Two 5-gallon buckets of Gas Vent Sand.

I. Conformance Sample: Submit to CQA Consultant one 3-foot by full roll width sample of geomembrane for every 50,000 square feet of material.

1.06 QUALITY ASSURANCE

A. Manufacturer and Installer shall participate in and conform to all terms and requirements of the Engineer's Construction Quality Assurance (CQA) Plan. Subcontractor shall be responsible for assuring this participation.

B. Qualifications

1. Manufacturer
   a. Manufacturer shall have manufactured a minimum of 10,000,000 square feet of polyethylene geomembrane during the last year.
2. Installer
   a. Installer shall have installed a minimum of 5,000,000 square feet of LLDPE geomembrane during the last 10 years.
   b. Installer shall have worked in a similar capacity on at least 3 projects similar in complexity to the project described in the contract documents, and with at least 200,000 square feet of LLDPE geomembrane installation on each project.
   c. The Installation Supervisor shall have worked in a similar capacity on projects similar in size and complexity to the project described in the Contract Documents.
   d. The Installer shall provide a minimum of one Master Seamer for work on the project.
      1) Must have completed a minimum of 1,000,000 square feet of geomembrane seaming work using the type of seaming apparatus proposed for the use on this Project.

1.07 DELIVERY, STORAGE, AND PROTECTION

A. Labeling - Each roll of geomembrane delivered to the site shall be labeled by the Manufacturer. The label will identify:

1. manufacturer's name
2. product identification
3. thickness

4. length
5. width
6. roll number

B. Delivery - Rolls of liner will be prepared to ship by appropriate means to prevent damage to the material and to facilitate off-loading.

C. Storage - The on-site storage location for geomembrane material, provided by the Subcontractor to protect the geomembrane from punctures, abrasions and excessive dirt and moisture, shall have the following characteristics:

1. level (no wooden pallets)
2. smooth
3. dry
4. protected from theft and vandalism
5. adjacent to the area being lined

D. Handling - Materials are to be handled so as to prevent damage.

1.08 WARRANTY

A. Material shall be warranted, on a pro-rata basis against Manufacturer's defects for a period of 5 years from the date of geomembrane installation.

B. Installation shall be warranted against defects in workmanship for a period of 1 year from the date of geomembrane completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturer shall have manufactured a minimum of 10,000,000 square feet of polyethylene geomembrane during the last year.

2.02 LINEAR LOW DENSITY POLYETHYLENE (LLDPE)

A. Material shall be 40-mil textured (both sides) polyethylene geomembrane as shown on the drawings.

B. Resin

1. Resin shall be new, first quality, compounded and manufactured specifically for producing geomembrane.
2. Natural resin (without carbon black) shall meet the following additional minimum requirements:

Property	Test Method	Requirement
Density [g/cm3]	ASTM D 1505	0.915
Melt Flow Index [g/10 min.]	ASTM D 1238 (190/2.16)	< 1.0
OIT [minutes]	ASTM D 3895 (1 atm/200°C)	100

C. Geomembrane Rolls

1. Do not exceed a combined maximum total of 1 percent by weight of additives other than carbon black.
2. Geomembrane shall be free of holes, pinholes as verified by on-line electrical detection, bubbles, blisters, excessive contamination by foreign matter, and nicks and cuts on roll edges.
3. Geomembrane material is to be supplied in roll form. Each roll is to be identified with labels indicating both number, thickness, length, width and Manufacturer.
4. All liner sheets produced at the factory shall be inspected prior to shipment for compliance with the physical property requirements and be tested by an acceptable method of inspecting for pinholes. If pinholes are located, identified and indicated during manufacturing, these pinholes may be corrected during installation.

D. Textured surfaced geomembrane shall meet the requirements shown in the following table.

Property	Test Method	Requirement
Thickness, mil (mm)	ASTM D 5994	
Minimum Average		40 (1.0)
Lowest Individual Reading		36 (0.91)
Asperity Height, mils	GRI GM12	10
Density, g/cm3	ASTM D 1505	0.92
Carbon Black Content, %	ASTM D 1603, mod.	2.0
Carbon Black Dispersion	ASTM D 5596	A1, A2, B1 rating
Tensile Properties:	ASTM D 6693	
Strength at Break, lb/in		100 (each direction)
Elongation at Break, %		500 (2.0" gauge length)
Tear Resistance, lb	ASTM D 1004	22
Puncture Resistance, lb	ASTM D 4833	48
Oxidative Induction Time, min.	ASTM D 3895	100

E. Extrudate Rod or Bead

1. Extrudate material shall be made from same type resin as the geomembrane.
2. Additives shall be thoroughly dispersed.
3. Materials shall be free of contamination by moisture or foreign matter.

2.03 EQUIPMENT

A. Welding equipment and accessories shall meet the following requirements:

1. Gauges showing temperatures in apparatus (extrusion welder) or wedge (wedge welder) shall be present.
2. An adequate number of welding shall be available to avoid delaying work.

3. Power source capable of providing constant voltage under combined line load shall be used.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

3.02 DEPLOYMENT

A. Assign each panel a simple and logical identifying code. The coding system shall be subject to approval and shall be determined at the job site.

B. Visually inspect the geomembrane during deployment for imperfections and mark faulty or suspect areas.

C. Deployment of geomembrane panels shall be performed in a manner that will comply with the following guidelines:

1. Unroll geomembrane panels using methods that will not damage geomembrane and will protect underlying surface from damage (i.e., spreader bar, protected equipment bucket).

2. Place ballast (commonly sandbags) on geomembrane which will not damage geomembrane to prevent wind uplift.

3. Personnel walking on geomembrane shall not engage in activities or wear shoes that could damage the geomembrane. Smoking will not be permitted on the geomembrane.

4. Do not allow heavy vehicular traffic directly on geomembrane. Rubber-tired ATV's and trucks are acceptable if wheel contact is less than 6 psi.

5. Protect geomembrane in areas of heavy traffic by placing protective cover over the geomembrane.

D. Sufficient material (slack) shall be provided to allow for thermal expansion and contraction of the material.

3.03 SUBGRADE PREPARATION

A. Conditions: Surfaces to be covered with geomembrane shall be rolled, smooth and free of all vegetation, rocks, stones, sticks, roots, sharp objects or debris of any kind. Geomembrane shall not be installed on areas of standing water, snow, ice or where precipitation has increased the moisture content of the soil subgrade. The surface shall provide a firm, unyielding foundation with no sharp changes or abrupt breaks in grade. Rounded corners shall be provided at all directional changes to avoid sharp bends in the geomembrane.

B. Acceptance: The Installer shall certify in writing that the surface to be lined is acceptable. Submittal of the written acceptance may proceed incrementally according to the installation schedule. No geomembrane shall be placed on subgrade deemed unsuitable by the Installer and the Engineer.

3.04 FIELD SEAMING

A. Seams shall meet the following requirements:

1. To the maximum extent possible, orient seams parallel to line of slope, i.e., down and not across slope.

2. Minimize number of field seams in corners, odd-shaped geometric locations and outside corners.

3. Slope seams (panels) shall extend a minimum of five-feet beyond the grade break into the

flat area.

4. Use a sequential seam numbering system compatible with panel numbering system that is agreeable to the CQA Consultant and Installer.

5. Align seam overlaps consistent with the requirements of the welding equipment being used. Overlap shall be minimum of 6-inches.

B. During Welding Operations

1. Provide at least one Master Seamer who shall provide direct supervision over other welders as necessary.

C. Extrusion Welding

1. Hot-air tack adjacent pieces together using procedures that do not damage geomembrane.

2. Clean geomembrane surfaces by disc grinder or equivalent.

3. Purge welding apparatus of heat-degraded extrudate before welding.

D. Hot Wedge Welding

1. Welding apparatus shall be a self-propelled device equipped with an electronic controller which displays applicable temperatures.

2. Clean seam area of dust, mud, moisture and debris immediately ahead of hot wedge welder.

3. Protect against moisture build-up between sheets.

E. Seaming shall not proceed when ambient air temperature or adverse weather conditions jeopardize the integrity of the liner installation. Installer shall demonstrate that acceptable seaming can be performed by completing acceptable trial welds.

F. Defects and Repairs

1. Examine all seams and non-seam areas of the geomembrane for defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter.

2. Repair and non-destructively test each suspect location in both seam and non-seam areas. Do not cover geomembrane at locations that have been repaired until test results with passing values are available and reviewed by the CQA Consultant.

3.05 FIELD QUALITY ASSURANCE

A. Perform field inspection and testing in accordance with Section 01400 - Quality Requirements.

B. Interface Friction Testing

1. The Subcontractor shall provide interface friction test samples to the CQA Consultant.

2. Prior to construction and once materials have been selected from their appropriate sources, interface shear testing in accordance with ASTM D 5321 will be performed to determine interface friction values (degrees) and cohesion (psf) between geomembrane and:
   a. Underlying Gas Vent Sand;
   b. Overlying drainage geocomposite; and
   c. Overlying crushed gravel.

3. Following delivery of the geomembrane products to the project site, sample of material shall be obtained by the CQA Consultant to conduct one interface friction test per interface. Sample sizes shall be as follows:
   a. Gas Vent Sand: two 5-gallon buckets.

b. Geomembrane: 6 feet by full roll width, do not include the first 3 feet of the material on the roll.
c. Drainage geocomposite: 3 feet by full roll width, do not include the first 3 feet of the material on the roll.
d. Crushed Gravel: Two 5-gallon buckets.

4. Test will be performed at normal stresses of 100, 300, and 600 psf with a displacement rate of at least 0.2 in/min, under inundated conditions. Soil specimen shall be compacted as specified for final installation in Section 02316 - Fill and Backfill. Peak and residual values will be reported.

5. The interface friction test results shall demonstrate a minimum friction angle of 26 degrees or adequate interface friction and cohesion to provide an acceptable factor of safety as determined by the Engineer.

6. Any materials that have been placed and do not provide an adequate factor of safety, as determined by the Engineer, shall be removed or reworked by the Subcontractor at the Subcontractor's expense.

C. Conformance Testing

1. The Subcontractor shall provide conformance test samples to the CQA Consultant.

2. Following delivery of the geomembrane products to the project site, one sample for every 50,000 square feet of material, or one sample per lot, whichever is greater, shall be obtained by the CQA Consultant for conformance testing. Sample shall be 3 feet by full roll width, and shall not include the first 3 feet of the material on the roll.

3. The following testing shall be conducted on the conformance samples:
   a. Thickness, ASTM D 5994.
   b. Density, ASTM D 1505.
   c. Asperity, GRI GM12
   d. Carbon Black Content, ASTM D 1603, modified.
   e. Carbon Black Dispersion, ASTM D 5596.
   f. Tensile Characteristics, machine and cross-machine directions, ASTM D 6693.

4. Test Results: All test results will be made available to the Subcontractor, and reviewed by the Engineer prior to deployment of the materials. All test results must meet or exceed values specified for the material.

5. Retesting: In the event of failing conformance tests, the Subcontractor or Manufacturer may elect to retest the failed lot(s). All costs of retesting shall be the responsibility of the Subcontractor. Retesting shall consist of one of the following two options:
   a. The Engineer shall select and sample each lot of failed rolled goods, obtaining at least one sample for every 50,000 square feet of material. Samples will be retested at two different laboratories acceptable to the Engineer. If both laboratories produce passing results, the material lot will be accepted. If either lab produces failing results, the material lot will be rejected.
   b. The Engineer shall sample each roll within the failed lot. Testing will be performed at the independent laboratory, in the presence of a Manufacture representative (if desired). Rejection or acceptance of the retested materials in the lot shall be made on a roll by roll basis.

6. Any material not meeting the requirements specified herein will be rejected by the Engineer. The rejected material shall be replaced by the Subcontractor with suitable material at his cost.

3.06 FIELD QUALITY CONTROL

A. Field Testing of Seams

1. Non-destructive testing shall be carried out by the Installer as the seaming progresses.
   a. Vacuum Testing
      1) Shall be performed in accordance with ASTM D 5641, Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber.
   b. Air Pressure Testing
      1) Shall be performed in accordance with ASTM D 5820, Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes.
   c. Other approved methods.

2. Destructive Testing (performed by CQA Consultant with assistance from Installer)
   a. Location and Frequency of Testing
      1) Collect destructive test samples at a frequency of one per every 1,500 linear feet of seam length.
      2) Test locations will be determined after seaming.
   b. Sampling Procedures are performed as follows:
      1) Installer shall cut samples at locations designated by the CQA Consultant as the seaming progresses in order to obtain field laboratory test results before the geomembrane is covered.
      2) CQA Consultant will number each sample, and the location will be noted on the installation as-built.
      3) Samples shall be 12 inches wide 48 inches long with the seam centered lengthwise.
      4) Cut a 2-inch wide strip from each end of the sample for field-testing.
      5) Cut the remaining sample into three parts for distribution as follows:
         (a) One portion for Installer, 12 inches by 12 inches.
         (b) One portion for the Testing Laboratory, 12 inches by 18 inches.
         (c) One additional sample to be archived, 12 inches by 12 inches.
      6) Laboratory destructive testing shall be performed by the CQA consultant in accordance with ASTM D 6392, Standard Test Method for Determining the Integrity of Non-Reinforced Geomembrane Seams Produced Using Thermo-Fusion Methods.
      7) Installer shall conduct field testing of seam samples using a field tensiometer.
      8) Installer shall repair all holes in the geomembrane resulting from destructive sampling.
      9) Repair and test the continuity of the repair in accordance with these Specifications.
      10) Seam samples shall pass when the results shown in Table 02623-1 are achieved in both peel and shear test.

B. Trial Welds

1. Perform trial welds on geomembrane samples to verify welding equipment is operating properly.

2. Make trial welds under the same surface and environmental conditions as the production welds, i.e., in contact with subgrade and similar ambient temperature.

3. Minimum of two trial welds per day, per welding apparatus, one made prior to the start of work and one completed at mid shift.

4. Cut four, one-inch wide by six-inch long test strips from the trial weld.

5. Quantitatively test two specimens for peel adhesion, and two specimens for bonded seam

strength (shear) using a field tensiometer.

6. Trial weld specimens shall pass when the results shown in Table 02623-1 are achieved in both peel and shear test.

Table 02623-1

Property	Test Method	Requirement
Peel Strength (fusion & ext.), ppi	ASTM D 6392	48
Shear Strength (fusion & ext.), ppi	ASTM D 6392	56

   a. The break, when peel testing, occurs in the liner material itself, not through peel separation (FTB).
   b. The break is ductile.

7. Repeat the trial weld, in its entirety, when any of the trial weld samples fail in either peel or shear.

8. No welding equipment or welder shall be allowed to perform production welds until equipment and welders have successfully completed trial weld.

C. Failed Seam Procedures

1. The following procedures shall apply whenever a sample fails a destructive test, whether the test is conducted by Engineer, the Testing Laboratory, or by a field tensiometer. The Subcontractor shall have two options:
   a. Reconstruct the seam (e.g., remove the old seam and reseam) between any two passing test locations.
   b. Trace the welding path to intermediate locations, a minimum of 10 ft from the location of the failed test (in each direction) and take a small sample for an additional field destructive test at each location. If these additional samples pass the tests, then full laboratory samples shall be taken at each intermediate test location. If these laboratory samples pass the tests, then the seam shall be reconstructed between these locations. If either sample fails, then the process shall be repeated to establish the zone in which the seam should be reconstructed. In any case, all acceptable seams must be bounded by two locations from which samples passing laboratory destructive tests have been taken. In cases exceeding 150 feet of reconstructed seam, a sample taken from within the reconstructed zone must pass destructive testing.

3.07 REPAIR PROCEDURES

A. Remove damaged geomembrane and replace with acceptable geomembrane materials if damage cannot be satisfactorily repaired.

B. Repair any portion of unsatisfactory geomembrane or seam area failing a destructive or non-destructive test.

C. Installer shall be responsible for repair of defective areas.

D. Agreement upon the appropriate repair method shall be decided between CQA Consultant and Installer by using one of the following repair methods:

1. Patching - Used to repair large holes, tears, undispersed raw materials and contamination by foreign matter.

2. Abrading and Re-welding - Used to repair short section (10 feet or less) of a seam.

3. Spot Welding - Used to repair pinholes or other minor, localized flaws or where geomembrane thickness has been reduced.
4. Capping - Used to repair long lengths (greater than 10 feet) of failed seams.
5. Flap Welding - Used to extrusion weld the flap (excess outer portion) of a fusion weld in lieu of a full cap.
6. Remove the unacceptable seam and replace with new material.

E. The following procedures shall be observed when a repair method is used:

1. All geomembrane surfaces shall be clean and dry at the time of repair.
2. Surfaces of the polyethylene which are to be repaired by extrusion welds shall be lightly abraded to assure cleanliness.
3. Extend patches or caps at least 6 inches for extrusion welds and 4 inches for wedge welds beyond the edge of the defect, and around all corners of patch material.

F. Repair Verification

1. Number and log each patch repair.
2. Non-destructively test each repair using methods specified in this Specification.

END OF SECTION

SECTION 02625

GEOTEXTILES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Requirements for the purchase and installation of geotextile material.

1.02 RELATED SECTIONS

A. Section 01300 - Administrative Requirements

B. Section 01400 - Quality Requirements

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM)

1. D 5261 Standard Test Method for Measuring Mass per Unit Area of Geotextiles
2. D 4632 Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
3. D 4533 Standard Test Method for Index Trapezoidal Tearing Strength of Geotextiles
4. D 4833 Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products
5. D 4491 Standard Test Method for Water Permeability of Geotextiles by Permittivity
6. D 4751 Standard Test Method for Determining Apparent Opening Size of a Geotextile
7. D 4354 Standard Practice for Sampling of Geosynthetics for Testing
8. D 4759 Standard Practice for Determining the Specifications Conformance of Geosynthetics

B. American Association of State Highway and Transportation Officials (AASHTO)

1. M 288 Geotextile Specification for Highway Applications

1.04 DEFINITIONS

A. Lot - A quantity of resin (usually the capacity of one rail car) used in the manufacture of polyethylene geomembrane rolls. The finished roll will be identified by a roll number traceable to the resin lot used.

B. Construction Quality Assurance Consultant (CQA Consultant) - Party, independent from Manufacturer and Installer that is responsible for observing and documenting activities related to quality assurance during the lining system construction.

C. Geotextile Manufacturer (Manufacturer) - The party responsible for manufacturing the geotextile rolls.

D. Geosynthetic Quality Assurance Laboratory (Testing Laboratory) - Party, independent from the Manufacturer and Installer, responsible for conducting laboratory tests on samples of geosynthetics obtained at the site or during manufacturing, usually under the direction of the Engineer.

E. Installer - Party responsible for field handling, transporting, storing, deploying, seaming and testing of the geomembrane seams.

F. Subgrade Surface - Soil layer surface which immediately underlies the geosynthetic material(s).

1.05 SUBMITTALS

A. See Section 01300 - Administrative Requirements, for submittal procedures.

B. Prior to material delivery to project site, the Subcontractor shall provide the engineer with a written certification or manufacturers quality control data which displays that the geotextile meets or exceeds minimum average roll values (MARV) specified herein.

C. The Subcontractor shall submit to the Engineer manufacturer's quality control manual for the geotextile to be delivered to the site.

D. Conformance Sample: Submit to CQA Consultant one 3-foot by full roll width sample of geocomposite, if requested.

1.06 QUALITY ASSURANCE

A. Manufacturer and Installer shall participate in and conform to all terms and requirements of Section 01400 - Quality Requirements, including the Engineer's Construction Quality Assurance (CQA) Plan. Subcontractor shall be responsible for assuring this participation.

PART 2 PRODUCTS

2.01 GEOTEXTILE

A. The non-woven needle punched geotextile specified herein shall be made from polypropylene staple or continuous fiber.

B. The geotextile shall be manufactured from first quality virgin polymer.

C. The geotextile shall be able to withstand direct exposure to ultraviolet radiation from Sun for up to 15 days without any noticeable effect on index or performance properties.

D. Geotextile shall meet or exceed all of the following material properties.

GEOTEXTILE A (GENERAL GEOTEXTILE)

Property	Test Method	Value*	Test Frequency
Mass per Unit Area (oz./sq.yd.)	ASTM D 5261	6.0	1 per 90,000 sq. ft.
Grab Strength (lbs.)	ASTM D 4632	170	1 per 90,000 sq. ft.
Grab Elongation (%)	ASTM D 4632	50	1 per 90,000 sq. ft.
Trapezoidal Tear Strength (lbs.)	ASTM D 4533	70	1 per 90,000 sq. ft.
Puncture Strength (lbs.)	ASTM D 4833	90	1 per 90,000 sq. ft.
Apparent Opening Size (sieve #)	ASTM D 4751	70	1 per 540,000 sq. ft.

GEOTEXTILE B (GEOTEXTILE BENEATH RIPRAP)

Property	Test Method	Value*	Test Frequency
Grab Strength (lbs.)	ASTM D 4632	260	1 per 90,000 sq. ft.
Grab Elongation (%)	ASTM D 4632	50	1 per 90,000 sq. ft.
Trapezoidal Tear Strength (lbs.)	ASTM D 4533	100	1 per 90,000 sq. ft.
Puncture Strength (lbs.)	ASTM D 4833	165	1 per 90,000 sq. ft.
Apparent Opening Size (sieve #)	ASTM D 4751	100	1 per 90,000 sq. ft.

* All property values, with the exception of apparent opening size (AOS) represent minimum average roll values (MARV) in the weakest principal direction. Values for AOS represent maximum average roll values.

2.02 MANUFACTURE

A. All rolls of the geotextile shall be identified with permanent marking on the roll or packaging, with the manufacturers name, product identification, roll number and roll dimensions.

2.03 TRANSPORT

A. Transportation of the geotextile shall be the responsibility of the Subcontractor.

B. During shipment, the geotextile shall be protected from ultraviolet light exposure, precipitation, mud, dirt, dust, puncture, or other damaging or deleterious conditions.

C. Upon delivery at the job site, the Subcontractor shall ensure that the geotextile rolls are handled and stored in accordance with the manufacturer's instructions as to prevent damage.

PART 3 EXECUTION

3.01 INSTALLATION

A. Subcontractor shall furnish all geotextile, labor, incidental materials, tools, supervision, transportation, and installation equipment necessary for the installation of geotextile, as specified herein, and as shown on the drawings.

B. The geotextile shall be handled in such a manner as to ensure that it is not damaged in any way. Should the Subcontractor damage the geotextile to the extent that it is no longer usable as determined by these specifications or by the Engineer, the Subcontractor shall replace the geotextile at his own cost.

C. The geotextile shall be installed to the lines and grades as shown on the Drawings and as described herein.

D. The geotextile shall be rolled down the slope in such a manner as to continuously keep the geotextile in tension by self weight. The geotextile shall be securely anchored in an anchor trench where applicable, or by other approved or specified methods.

E. In the presence of wind, all geotextiles shall be weighted by sandbags or approved equivalent. Such anchors shall be installed during placement and shall remain in place until replaced with cover material.

F. The Subcontractor shall take necessary precautions to prevent damage to adjacent or underlying materials during placement of the geotextile. Should damage to such material occur due to the fault of the Subcontractor, the latter shall repair the damaged materials at his own cost and to the satisfaction of the Engineer.

G. During placement of the geotextile, care shall be taken not to entrap soil, stones or excessive moisture that could hamper subsequent seaming of the geotextile as judged by the Engineer.

H. The geotextile shall not be exposed to precipitation prior to being installed and shall not be exposed to direct Sun light for more than 15 days after installation.

I. The geotextile shall be seamed using heat seaming or stitching methods as recommended by the manufacturer and approved by the Engineer. Sewn seams shall be made using polymeric thread with chemical resistance equal to or exceeding that of the geotextile. All sewn seams shall be continuous. Seams shall be oriented down slopes perpendicular to grading contours

unless otherwise specified. For heat seaming, fusion welding techniques recommended by the manufacturer shall be used.

J. The Subcontractor shall not use heavy equipment to traffic above the geotextile without approved protection.

K. The geotextile shall be covered as soon as possible after installation and approval. Installed geotextile shall not be left exposed for more than 15 days.

L. Material overlying the geotextile shall be carefully placed to avoid wrinkling or damage to the geotextile. Free fall of riprap directly on top of the Geotextile shall not permitted.

3.02 FIELD QUALITY CONTROL

A. Perform field inspection and testing in accordance with Section 01400 - Quality Requirements.

B. The CQA Consultant shall examine the geotextile rolls upon delivery to the site and report any deviations from project specifications to the Subcontractor.

C. Conformance Testing

1. The Engineer may decide to arrange conformance testing of the rolls delivered to the job site. For this purpose, the engineer shall take a sample three feet (along roll length) by roll width according to ASTM Practice D 4354 The sample shall be properly marked, wrapped and sent to an independent laboratory for conformance testing at a frequency of one test per 50,000 sf of material. At a minimum, the following conformance tests shall be performed:
   a. Grab Strength.
   b. Grab Elongation.
   c. Tear Strength.
   d. Puncture Strength.

2. The pass or fail of the conformance test results shall be determined according to ASTM Practice D 4759.

3. If conformance testing results do not comply with the requirements of the geotextile specified herein, the frequency of sampling and testing may be increased. This additional testing shall be paid for by the Subcontractor.

4. Any geotextile not meeting the requirements of the geotextile specified herein will be rejected by the Engineer. The rejected material shall be replaced by the Subcontractor with suitable material at his cost.

END OF SECTION

SECTION 02627

GAS VENT PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Requirements for gas vent piping.

1.02 RELATED SECTIONS

A. Section 01400 - Quality Requirements

B. Section 02316 - Fill and Backfill

C. Section 02625 - Geotextiles

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM)

1. A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
2. F 405 - Standard Specification for Corrugated Polyethylene (PE) Tubing and Fittings.
3. F 667 - Standard Specification for Large Diameter Corrugated Polyethylene Pipe and Fittings.

B. American Association of State Highway and Transportation Officials (AASHTO)

1. M 252 Corrugated Polyethylene Drainage Tubing

PART 2 PRODUCTS

2.01 MATERIALS

A. Pipe and Fittings

1. General: Provide fittings of same type and class as material of pipe. Provide commercially-manufactured wyes and/or tees.
2. 4-inch Steel Gas Vent: ASTM A-53 steel vent piping
3. 4-inch Perforated Polyethylene Pipe: Corrugated polyethylene drainage pipe, meeting requirements of AASHTO M252, ASTM F405, equal to perforated N-12 produced by Advanced Drainage Systems, Inc.
4. Insect Screen: No. 40 mesh stainless steel screen.

B. Boot Materials

1. 40-mil textured Geomembrane in accordance with Specification Section 02623.

PART 3 EXECUTION

3.01 GAS VENT COLLECTION AND RISER PIPING

A. Install gas vent risers as shown in the Drawings.

B. Steel gas vent risers shall be cleaned to bare metal, primed, and painted with two coats of yellow safety paint.

3.02 INSECT SCREEN

A. The Subcontractor shall firmly attached insect screen to vent opening area.

3.03 GAS VENT LAYER

A. The Subcontractor shall carefully place gas vent layer material in accordance with Section 02316 - Fill and Backfill, protecting gas vent piping.

B. Fill under pipes must be placed such that no gaps remain between bedding and pipes.

3.04 FIELD QUALITY CONTROL

A. Perform field inspection and testing in accordance with Section 01400.

END OF SECTION

SECTION 02821

FENCES AND GATES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Installation of boulder barrier and gates.

B. Excavation for post bases; concrete foundation for posts.

C. Manual gates and related hardware.

1.02 RELATED SECTIONS

A. Section 01300 - Administrative Requirements

1.03 REFERENCES

A. ASTM B 210-00 Standard Specification for Aluminum and Aluminum-Alloy Drawn Seamless Tubes.

B. ASTM B 483/ B 483M-03 Standard Specification for Aluminum and Aluminum-Alloy Tubes for General Purpose Applications.

1.04 PERFORMANCE REQUIREMENTS

A. Installer Qualifications: Engage an experienced installer who has OSHA 40-hours training and has at least three years' experience. If an OSHA-trained installer cannot be located, the installation work must be performed under the direct supervision of a OSHA-trained individual with OSHA Supervisor training.

B. The scheduling of existing fencing removal and boulder barrier installation shall be conducted in a manner to prevent public access to the top of the landfill.

1.05 SUBMITTALS

A. See Section 01300 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide data on gate, posts, accessories, fittings and hardware.

1.06 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section, with not less than three years of documented experience.

PART 2 PRODUCTS

2.01 MATERIALS

A. Boulder Barrier

1. Boulders shall be sound, durable crystaline rock of igneous or gueisstic origin. Unacceptable rock includes mica shist, slate, micaceous or thinly-bedded sand stone, shale, coarse limestone gypsiferous rock, poorly cemented sandstone and couglomerate or soft or closely jointed rock of any sort.

B. Gates

1. Gate shall be Model CCIA Industrial Access Gate by Virginia Railing and Gates, LLC of Ashland, Virginia or approved equal.

2. Gate posts shall be four inch diameter schedule 40, 6061-T6 aluminum pipe.

3. Structural members for gates shall be 1 1/2" by 3", 6063-T52 rectangular aluminum tubing.
4. Gate hinges shall be constructed of block aluminum with 3" long stainless steel pins.
5. Gates and posts shall be painted with a minimum of 2 coats of white or yellow aliphatic acrylic urethane.

2.02 ACCESSORIES

A. Hardware for Single Swinging Gates: 180 degree hinges, 2 hinges per gate; slide bolt with lock tabs; keeper to hold gate in fully open position.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install posts and gates in accordance with manufacturer's instructions at location shown on Drawings.

B. Install boulder barrier at location identified by survey.

C. Place boulders in a stable position a maximum of 6" apart.

D. Set post plumb, in concrete footings with top of footing 2 inches above finish grade. Slope top of concrete for water runoff.

E. Upon installation, the Subcontractor shall give two sets of padlock keys to the Engineer.

3.02 ERECTION TOLERANCES

A. Maximum Variation From Plumb: 1/4 inch.

B. Maximum Offset From True Position: 1 inch.

C. Components shall not infringe adjacent property lines.

END OF SECTION

SECTION 02921

TOPSOIL AND SEEDING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Preparation of subsoil.

B. Placing topsoil.

C. Seeding, mulching and fertilizer.

D. Establishment.

1.02 RELATED SECTIONS

A. Section 01400 - Quality Requirements

B. Section 02316 - Fill and Backfill: Topsoil material.

1.03 REFERENCES

A. Agricultural Marketing Service (AMS)

1. AMS-01 (Amended thru: Aug 1988) Federal Seed Act Regulations (Part 201-202)

B. American Society for Testing and Materials (ASTM)

1. D 2607 Peats, Mosses, Humus, and Related Products

C. Commercial Item Descriptions (CID)

1. CID A-A-1909 (Basic; Notice 1) Fertilizer

D. Commonwealth of Massachusetts Department of Public Works

1. State Specifications (1988) Standard Specifications for Highways and Bridges. This publication will be referred to hereinafter as the "State Specifications"

E. United State Department of Agriculture

1. Soil Taxonomy, A Basic System of Soil Classification for Making and Interpreting Soil Surveys, second edition.

1.04 DEFINITIONS

A. Weeds: Include Dandelion, Jimsonweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Bermuda Grass, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Will, Bindweed, Bent Grass, Wild Garlic, Perennial Sorrel, and Brome Grass.

1.05 SUBMITTALS

A. See Section 01300 - Administrative Requirements, for submittal procedures.

B. Pesticide Treatment Plan - Submit if use of pesticide becomes necessary, with proposed sequence of pesticide treatment work. The pesticide trade name, chemical composition, formulation, concentration, application rate of active ingredients and method of application for all materials; and the name and state license number of the state certified applicator shall be included.

C. Prior to application, submit manufacturer's specifications and certificates of compliance for:

1. Seed mixes
2. Pesticide materials
3. Topsoil

D. Topsoil Test Results, including recommended lime and soil amendment application rates. Submit prior to application.

1.06 DELIVERY, INSPECTION, STORAGE, AND HANDLING

A. Delivery

1. Topsoil - A soil test shall be provided for topsoil delivered to the site.
2. Soil Amendments - Soil amendments shall be delivered to the site in the original, unopened containers bearing the manufacturer's chemical analysis. In lieu of containers, soil amendments may be furnished in bulk. A chemical analysis shall be provided for bulk deliveries.
3. Pesticide - Pesticide material shall be delivered to the site in the original, unopened containers bearing legible labels indicating the Environmental Protection Agency (EPA) registration number and the manufacturer's registered uses.

B. Inspection

1. Seed shall be inspected upon arrival at the job site by the Engineer for conformity to type and quality in accordance with paragraph MATERIALS. Other materials shall be inspected for meeting specified requirements and unacceptable materials shall be removed from the job site.

C. Storage

1. Materials shall be stored in areas designated by the Engineer. Seed, lime and fertilizer shall be stored in cool, dry locations away from contaminants. Chemical treatment materials shall not be stored with other landscape materials.

D. Handling

1. Except for bulk deliveries, materials shall not be dropped or dumped from vehicles.

PART 2 PRODUCTS

2.01 SEED

A. Seed Classification - State-approved seed of the latest season's crop shall be provided in original sealed packages bearing the producer's guaranteed analysis for percentages of mixture, purity, germination, hard seed, weed seed content, and inert material. Labels shall be in conformance with AMS-01 and applicable state seed laws.

B. Seed Mixture - Seed mixture shall be in accordance with Paragraph M6.03.0 "Seed, For Slopes and Shoulders", of the State Specifications, as follows:

Seed Type	Mixture Percent by Weight	Germination, Minimum	Purity, Minimum
Creeping Red Fescue	50	85	95
Kentucky 31	30	85	95
Domestic Rye	10	90	98
Red Top	5	85	92

Ladino Clover	5	85	96

C. Quality - Weed seed shall not exceed 1 percent by weight of the total mixture. Wet, moldy, or otherwise damaged seed shall be rejected.

D. Temporary Seed - The temporary seed for erosion control shall be as follows:

Botanical Name	Common Name	Live Seed
Lolium annualis	Annual Ryegrass	90

E. Seed Mixing - The field mixing of seed shall be performed on site in the presence of the Engineer.

2.02 TOPSOIL

A. Natural, fertile, agricultural soil typical of locality, capable of sustaining vigorous plant growth, obtained from well drained site free of flooding, not in frozen or muddy condition, between 6 and 20 percent organic matter, and pH value between 6.0 and 7.5. Free from subsoil, slag, lumps or clods of clay, stones 2 inches or greater, lumps, live plants, roots, sticks, crabgrass, noxious weed, and foreign matter.

B. Classification - Topsoil shall be classified as loam or sandy-loam per United States Department of Agriculture (USDA) with less than 10% gravel by weight. Loamy-sand will not be accepted.

2.03 SOIL AMENDMENTS

A. Lime - Lime shall be agricultural limestone and shall have a minimum calcium carbonate equivalent of 90 percent and shall be ground to such a fineness that at least 90 percent will pass a 10-mesh sieve and at least 50 percent will pass a 6 -mesh sieve.

B. Fertilizer - Fertilizer shall be commercial grade, granular, free flowing, uniform in composition, Conform to CID A-A-1909, and as recommended by each soil test.

C. Organic Soil Amendments

1. Sand: Clean, free of toxic materials; 95 percent by weight shall pass a No. 10 sieve and 10 percent by weight shall pass a No. 16 sieve.

2. Rotted Manure: Well rotted, horse or cattle manure containing a maximum 2 percent by volume of straw, sawdust, or other bedding materials free of stones, sticks, soil and containing no chemicals or ingredients harmful to plants.

3. Decomposed Wood Derivatives: Ground bark, sawdust, or other wood waste material free of stones, sticks, soil, and toxic substances harmful to plants, stabilized with nitrogen and having the following properties:

a. Particle Size: Minimum percent by weight passing:

Sieve Size	Percent
No. 4	80

b. Nitrogen Content: Minimum percent based on dry weight:

Material	Percent
Redwood Sawdust	0.5
Fir Sawdust	0.7
Fir or Pine Bark	1.0

4. Clay: Granular particles produced from montmorillonite clay calcined to minimum

temperature of 1,200 degrees F to the following gradation: minimum 90 percent passing No. 8, 99 percent retained in No. 60 sieve and maximum 2 percent passing No. 100 sieve. Bulk density: maximum 40 pounds per cubic foot.

D. Soil Conditioner - Soil conditioner shall be for single use or in combination to meet requirements for topsoil. Gypsum shall be commercially packaged, free flowing, minimum 95 percent calcium sulfate by volume.

2.04 MULCH

A. Mulch shall be free from weeds, mold, and other deleterious materials.

B. Straw - Straw shall be stalks from oats, wheat, rye, barley, or rice furnished in air-dry condition and with a consistency for placing with commercial mulch-blowing equipment.

C. Hay - Hay shall be native hay, sudan-grass hay, broomsedge hay, or other herbaceous mowings furnished in an air-dry condition suitable for placing with commercial mulch-blowing equipment.

D. Wood Cellulose Fiber - Wood cellulose fiber shall be used for hydroseed applications. Wood cellulose fiber shall not contain any growth or germination-inhibiting factors and hall be dyed an appropriate color to facilitate visual metering during application. Composition on air-dry weight basis: 9 to 15 percent moisture, pH range from 4.5 to 6.0.

2.05 WATER

A. Water shall be clean, fresh and free of substances or matter which could inhibit vigorous growth of grass.

2.06 PESTICIDE

A. Pesticide shall be insecticide, herbicide, fungicide, nematocide, rodenticide and miticide. For the purpose of this specification, soil fumigant shall have the same requirements as a pesticide. The pesticide material shall be EPA registered and approved.

2.07 EROSION CONTROL MATERIAL

Soil erosion control shall conform to the following:

A. Soil Erosion Control Blanket - Machine produced mat of wood excelsior formed from a web of interlocking wood fibers, covered on one side with either knitted straw blanket-like mat construction, covered with biodegradable plastic mesh, or interwoven biodegradable thread, plastic netting or twisted kraft paper cord netting.

B. Soil Erosion Control Fabric - Knitted construction of polypropylene yarn with uniform mesh openings 3/4 to 1 inch square with strips of biodegradable paper. Filler paper strips shall last 6 to 8 months.

C. Soil Erosion Control Net - Heavy, twisted jute mesh weighing approximately 1.22 pounds per linear yard and 4 feet wide with mesh openings of approximately 1 inch square.

D. Anchors - Erosion control anchor material shall be as recommended by the manufacturer.

2.08 SOURCE QUALITY CONTROL

A. See Section 01400 - Quality Requirements, for general requirements for testing and analysis.

B. Topsoil Testing Requirements

1. Perform testing of topsoil, and submit laboratory reports which state nutrient levels, pH in accordance with ASTM D 4972, organic matter content in accordance with ASTM D 2974, and recommendations for application rates of lime and fertilizer. Provide test results of one sample for every 2,500 cubic yards of topsoil.

C. Unsuitable material, including, but not limited to contaminated and/or hazardous material shall be removed and replaced by appropriate materials at the Subcontractor's expense.

PART 3 EXECUTION

3.01 SEEDING TIMES AND CONDITIONS

A. Seed shall be sown from 15 April to 1 June for spring planting and from 15 August to 1 October for fall planting.

B. Turf operations shall be performed only during periods when beneficial results can be obtained. When drought, excessive moisture or other unsatisfactory conditions prevail, the work shall be stopped when directed.

C. When special conditions warrant a variance to the turf operations, proposed times shall be submitted to and approved by the Designer.

3.02 TOPSOIL PLACEMENT PREPARATION

A. Place topsoil as indicated in the Drawings.

B. Grading - The Engineer shall verify that finished grades are as indicated on the contract drawings, and placing of topsoil and smooth grading has been complete.

C. Application of Soil Amendments

1. Soil Test - A soil test shall be performed on delivered topsoil for pH, chemical analysis and mechanical analysis to establish the quantities and type of soil amendments required to meet local growing conditions for the type and variety of turf specified.

2. Lime - Lime shall be applied at the rate recommended by the soil test. Lime shall be incorporated into the soil to a minimum depth of 3 inches or may be incorporated as part of the tillage operation.

3. Fertilizer - Fertilizer shall be applied at the rate recommended by the soil test. Fertilizer shall be incorporated into the soil to a minimum depth of 3 inches and may be incorporated as part of the tillage or hydroseeding operation.

4. Soil Conditioner - Soil Conditioner shall be applied at the rate recommended by the soil test and thoroughly incorporated by tillage into the soil to a minimum depth of 3 inches.

D. Finished Grading

1. Preparation - Turf areas shall be filled as needed or have surplus soil removed to attain the finished grade. Drainage patterns shall be maintained as indicated on the contract drawings. Turf areas compacted by construction operations shall be completely pulverized by tillage.

2. Turf Area Debris - Turf areas shall have debris and stones larger than two inches in any dimension removed from the surface.

E. Apply soil amendments after smooth raking of topsoil and prior to roller compaction.

1. Protection - Finished graded areas shall be protected from damage by vehicular or pedestrian traffic and erosion.

F. Apply fertilizer in accordance with manufacturer's instructions.

3.03 SEEDING

A. General

1. Prior to seeding, any previously prepared seedbed areas compacted or damaged by interim

rain, traffic or other cause, shall be reworked to restore the ground condition previously specified. Seeding operations shall not take place when the wind velocity or precipitation will prevent uniform seed distribution.

B. Equipment Calibration

1. The equipment to be used and the methods of turfing shall be subject to the inspection an approval of the Engineer prior to commencement of turfing operations. Immediately prior to the commencement of turfing operations, the Subcontractor shall conduct turfing equipment calibration tests in the presence of the Engineer.

C. Applying Seed

1. The Subcontractor shall have the option of broadcast seeding, drill seeding, or hydroseeding.
   a. Broadcast Seeding - Seed shall be uniformly broadcast at the rate of 6 pounds per 1000 square feet using broadcast seeders. Half of seed shall be broadcast in one direction, an the remainder at right angles to the first direction.
   b. Drill Seeding - Seed shall be uniformly drilled to an average depth of 1/2 inch and at the rate of 6 pounds per 1000 square feet using equipment having drills not more than 6-1 2 inches apart. Row markers shall be used with the drill seeder.
   c. Rolling for Broadcast and Drill Seeding - Immediately after broadcast or drill seeding, except for slopes 3-horizontal-to-1 vertical and greater, the entire area shall be firmed with a roller not exceeding 90 pounds for each foot of roller width. Areas seeded with seed drills equipped with rollers shall not be rolled.
   d. Hydroseeding - Seed and fertilizer shall be added to water and thoroughly mixed at the rates specified. Wood cellulose fiber mulch shall be added at the rates recommended b the manufacturer after the seed, fertilizer and water have been thoroughly mixed, to produce a homogeneous slurry. Slurry shall be uniformly applied under pressure over the entire area. The hydroseeded area shall not be rolled. Seed shall be applied at a rate of 8 pounds per 1,000 square feet.

D. Mulch

1. Straw or Hay Mulch for Broadcast and Drill Seeding
   a. Straw or hay mulch shall be spread uniformly at the rate of 2 tons per acre. Mulch shall be spread by hand, blower-type mulch spreader or other approved method. Mulching shall be started on the windward side of relatively flat areas or on the upper part of a steep slope and continued uniformly until the area is covered. The mulch shall not be bunched. All seeded areas shall be mulched on the same day as the seeding.

2. Mechanically Anchoring of Straw and Hay Mulch
   a. Immediately following spreading, the mulch shall be anchored to the soil by a V-type-wheel land packer, a scalloped-disk land packer designed to force mulch into the soil surface, or other suitable equipment.

3. Wood Cellulose Fiber Mulch for Hydroseeding
   a. Wood cellulose fiber mulch for use with the hydraulic application of seed and fertilizer shall be applied as part of the hydroseeding operation.

3.04 EROSION CONTROL

A. Erosion Control Material

1. Erosion control material, where indicated or required, shall be installed in accordance with manufacturer's instructions. Placement of the erosion control material shall be accomplished without damage to installed material or without deviation to finished grade.

B. Temporary Turf Cover

1. General
   a. When there are contract delays in the turfing operation or a quick cover is required to prevent erosion, the areas designated for turf shall be seeded with the temporary seed specified as directed by the Engineer.

2. Application
   a. When no other turfing materials have been applied, the quantity of one half of the required soil amendments shall be applied and the area tilled. Seed shall be uniformly broadcast and applied at the rate of 5 pounds per 1000 square feet. The area shall be watered as required.

3.05 RESTORATION AND CLEANUP

A. Restoration - Existing turf areas, pavements and facilities that have been damaged from the turfing operation shall be restored to original condition.

B. Clean Up - Excess and waste material shall be removed from the planting operation and shall be dispensed of off the site. Adjacent paved areas shall be cleaned.

3.06 PROTECTION OF TURFED AREAS

A. Immediately after turfing, the area shall be protected against traffic or other use by erecting barricades and providing signage as required, or as directed by the Engineer.

3.07 TURF ESTABLISHMENT PERIOD

A. The Turf Establishment Period for establishing a healthy stand of turf shall begin on the first day of work under this contract and shall end three (3) months after the last day of turfing operations required by this contract. Written calendar time period shall be furnished to the Engineer for the Turf Establishment Period. When there is more than one turf establishment period, describe the boundaries of the turfed area covered or each period.

B. A satisfactory stand of turf from the seeding operation for is defined as a minimum of 15 grass plants per square foot. Bare spots shall be no larger than 25 square feet. The total bare spots shall not exceed 2 percent of the total seeded area.

C. Maintenance During Establishment Period

1. General - Maintenance of the turfed areas shall include eradicating weeds, eradicating Insects and diseases, protecting embankments and ditches from erosion, maintaining erosion control materials and mulch, protecting turfed areas from traffic, mowing, and watering.

2. Mowing - Turf areas shall be mowed to a minimum height of 3 inches when the average height of the turf becomes 4 Inches. Clippings shall be removed when the amount of cut turf is heavy enough to damage the turfed areas.

3. Watering - Watering shall be at intervals to obtain a moist soil condition to a minimum depth of 1 inch. Frequency of watering and quantity of water shall be adjusted in accordance with the growth of the turf. Run-off, puddling and wilting shall be prevented.

3.08 FINAL ACCEPTANCE

A. Pesticide - Treatment for disease or pest shall be in accordance with this specification.

1. Repair - The Subcontractor shall re-establish as specified herein, eroded, damaged or barren areas. Mulch shall also be repaired or replaced as required.

B. Preliminary Inspection

1. Prior to the completion of the Turf Establishment Period, a preliminary inspection shall be held by the Engineer. Time for the inspection shall be established in writing. The acceptability of the turf in accordance with the Turf Establishment Period shall be determined. An unacceptable stand of turf shall be repaired as soon as turfing conditions permit.

2. Maintenance Report - A written record shall be furnished to the Engineer of the maintenance work performed.

C. Final Inspection

1. A final inspection shall be held by the Engineer to determine that deficiencies noted in the preliminary inspection have been corrected. Time for the inspection shall be established in writing.

END OF SECTION

SECTION 02950

RIPARIAN BUFFER ZONE PLANTINGS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Requirements for furnishing and installing trees, shrubs, and ground cover in the Riparian Buffer Zone.

B. Establishment of plantings.

C. Maintenance and Warranty.

1.02 RELATED SECTIONS

A. Section 01300 - Administrative Requirements

B. Section 02921 - Topsoil and Seeding

1.03 REFERENCES

A. The American Standards for Nursery Stock, American Association of Nurserymen, Inc.

1.04 SUBMITTALS

A. See Section 01300 - Administrative Requirements, for submittal procedures.

B. Product Data: Submit copy of supplier's invoice for New England Conservation/Wildlife seed mix which shows the quantity, by weight, purchased for the project.

C. Submit for review proposed schedule of seeding and planting activities.

D. Planting Plan: At least one month prior to commencing seeding and planting in the Riparian Buffer Zone, the Subcontractor shall submit sketch of Riparian Buffer Zone planting plan. Include all products to be used. Species type and density shall be consistent with those shown in the Drawings.

1.05 QUALITY ASSURANCE

A. Provide seeding and planting work by a nursery or lands construction firm having a minimum of 5 years experience within the last 10 years. The Subcontractor shall have access to equipment of proper size and capacity to provide work specified herein.

B. Replanting

1. Replanting operations to be as originally specified.

2. Over seed or completely reseed unaccepted seeded areas as required by the Engineer. Unless otherwise permitted by the Engineer, reseeding will be performed during the next planting season.

3. Trees and shrubs that show signs of substantial dessication, as evident by loss of color and distinct yellowing, will be considered as failed and shall be replanted and continue to be replanted until acceptable by Engineer

4. The Subcontractor shall be liable for any damage to structures and surface treatments resulting from replacement operations.

5. Supply water for replacements as well as hoses and other equipment or methods for application.

1.06 DELIVERY, STORAGE, AND PROTECTION

A. Packaging and Shipping

1. Delivered packaged materials in containers showing weight, analysis, and name of manufacturer.

2. Delivery of plants and seeding shall be made on the project site, within one week of planting.

B. Storage and Protection

1. Protect materials from deterioration during delivery and while stored at the project site.

2. All plants shall be packed so as to arrive at the delivery point in good growing condition.

1.07 PROJECT CONDITIONS

A. Environmental Requirements:

1. Do not perform any work during periods of severe drought, high winds, excessive moisture, frozen or snow covered ground as determined by the Engineer.

2. Restoration work will be done during seasonal planting time from April 1 to June 1 or from September 1 to October 15.

B. Existing Conditions:

1. Do not start restoration work until earthwork in area is complete.

2. Allow backfills and fills to settle and complete final grading and mechanical compaction prior to initiating work.

3. Maintain established grades, as indicated on drawings.

4. Fill eroded areas and areas having inadequate drainage or ponding of water to satisfaction of Engineer.

5. Eliminate ruts, deep tracks, furrows, and ridges.

1.08 MAINTENANCE SERVICE

A. Maintain restored area until final acceptance of Work by the Engineer.

B. In absence of adequate rainfall, water all seeded areas and plants as often as necessary to maintain viability and acceptability of work.

PART 2 PRODUCTS

2.01 MATERIALS

A. New England Conservation/Wildlife Seed Mix, or approved equal.

1. Manufacturer: New England Wetland Plants, Inc., 820 West Street, Amherst, MA 01002.

2. Included Species: Big Bluestem (Andropogon gerardii), Switchgrass (Panicum virgatum), Little Bluestem (Schizachyrium scoparium), Canada Wild Rye (Elymus canadensis), Fox Sedge (Carex vulpinoidea), Partridge Pea (Chamaecrista fasciculata), Fringed Bromegrass (Bromus ciliatus), Pennsylvania Smartweed (Polygonum pensylvanicum), Common Milkweed (Asclepias syriaca), Nodding Bur-marigold (Bidens cernua), Showy Tick-Trefoil (Desmodium canadense), Silky Smooth Aster (Aster laevis), Flat-top Aster (Aster umbellatus).

3. Apply at a rate of 25 pounds per acre.

B. Trees and Shrubs

1. Materials to be used in this work shall conform to "The American Standards for Nursery Stock" as sponsored by the American Association of Nurserymen, Inc. This standard shall determine all requirements of acceptable shrub and seeding nursery stock.

2. All nursery stock shall be grown at nurseries in the northeastern area of the United States.

3. All nursery stock shall conform to the "American Standards for Nursery Stock" as sponsored by the American Association of Nurserymen, Inc. U.S. Patent Office Z60-1969.

4. All plants shall be fully representative of their normal species or varieties unless otherwise specified. All plants must have a good, healthy, well-formed upper growth; a fibrous compact root system; and must be free from disease, injurious insects, mechanical wounds either fresh or healed, broken branches, decay or any other defect; and shall be legibly tagged with their proper names.

5. All plant materials shall be dug with reasonable care and skill immediately previous to shipment. Special precautions shall be taken to avoid any unnecessary injury to or removal of fibrous roots. Each species or variety shall be handled and packed in the approved Manner for that particular plant, having regard to the soil and climatic condition at the time and place of digging, transit and delivery, and to the time that will be consumed in transit. All precautions that are customary in good trade practice shall be taken to insure the arrival of the plants at the site of the project in good condition for successful growth.

6. All plants which are to be balled and burlapped previous to shipment are designated: "B & B". Balled and burlapped plants shall be lifted so as to retain as many fibrous roots as possible. The burlap shall be untreated 8-ounce burlap and firmly held in place by a stout cord or wire. Nails shall not be used except in the case of broad-leafed evergreens or other similar plants. All plants that are balled and burlapped shall come from soil which will hold a firm ball and the solidity of the ball shall be carefully preserved.

7. The roots of bare rooted material shall be carefully protected with wet straw, moss or other suitable material which will insure the arrival of the plants at the site of the work in good condition.

8. Deciduous shrubs shall be fully representative of their species and variety. They shall have been transplanted twice; the last transplanting within 2 years. They shall have 4 to 6 branches conning from the roots, and shall have a well-branched root system and shall be a good weight for the height specified.

9. Evergreen trees shall have been transplanted 3 times, the last transplanting within 2 years. They shall have a good colored top growth and shall be balled and burlapped and kept moist for delivery. Pyramidal type evergreen trees shall have a spread equal to 1/3 of their height. Cone type evergreen trees shall have a spread equal to 3/4 of their height.

10. Evergreen shrubs shall have been transplanted twice and shall have a heavy dark green foliage. They shall be of the size indicated on the plans and, except where noted, each clump shall have not less than 4 stems. Plants shall be balled and burlapped and kept moist for delivery.

C. Soil and soil amendments conforming to the requirements of Section 02921 - Topsoil and Seeding, including:

1. Topsoil.

2. Fertilizer.

3. Composted manure or vegetable mulch.

D. Fertilizer for plant materials

1. Use slow-release fertilizer packets which are designed and certified by the manufacturer to provide controlled release of fertilizer over a minimum five (5) year period. Each packet shall consist of four ounces of water soluble fertilizer with a minimum guaranteed analysis of available elements as follows:

Nitrogen	16%
Phosphoric Acid	8%
Potash	16%

2. Fertilizer packets may be obtained from ADCO Works, P.O. Box 310, Hollis, NY 11423, telephone (718) 739-0701, or from Unique Fertilizers Inc., P.O. Box 99, Deptford, NJ 08096, telephone (609) 848-4444, or from Bigelow Nurseries, Northboro, MA.

E. Tree Paint

1. The paint furnished under this specification shall be suitable for application by brushing on sawed, cut or bruised surfaces of living trees, for the purpose of disinfection and protection of these surfaces.

PART 3 EXECUTION

3.01 PREPARATION

A. Spread topsoil and apply additives in Riparian Buffer Zone in accordance with Section 02921 - Topsoil and Seeding.

3.02 PLANTING

A. Trees and shrubs shall be arranged in accordance with the Riparian Buffer Zone planting schedule, after review by the Engineer.

B. Furnishing and planting of any plant material includes the digging of the holes for individual plants and local excavation required for planting beds, provision of planting soil mix, furnishing the plants of specified size with roots in the specified manner, the labor of planting, fertilizing, mulching, guying and staking where called for, and maintenance.

C. The Subcontractor shall locate plant material sources and ensure that plants are shipped in timely fashion for installation.

D. Planting

1. Locations for all plants and outlines for planting areas shall be staked by the Subcontractor on the ground in accordance with the Riparian Buffer Zone planting plan. The Engineer shall approve staked locations before any plant pits are dug.

2. Plant pits shall be excavated with vertical sides. Holes for trees shall be at least two feet (2') greater in diameter than the ball and one foot (1') deeper than the ball.

3. Topsoil and organic material for planting soil mix shall be thoroughly premixed in the proportions of one (1) part of composted manure or composted vegetable mulch, one (1) part fertilizer with five (5) parts of topsoil. Maintain at all times during the planting operations one or more stockpiles of quality planting soil mix.

4. All plant roots and earth balls must be damp and thoroughly protected from sun and wind from the beginning of the digging operation, during transportation and on the ground until the final planting. Shrubs shall be planted in the center of the holes and at the same depth as they previously grew. Trees shall be planted by placing the root collar even with ground level. Before the final layer of backfilling, remove burlap, rope, wires, etc. from the upper

quarter of the root balls. Do not pull burlap out from the sides or under root balls. Planting soil mix shall be backfilled in layers of not more than six inches (6") and each layer watered sufficiently to settle before the next layer is put in place. Enough planting soil mix shall be used to bring the surface to finished grade when settled. A saucer shall be formed around each plant at a depth of six inches (6") for trees and four inches (4") for shrubs.

5. At the time of planting, install fertilizer packets at a depth of six (6) to eight (8) inches equally spaced around the plant as it is being backfilled. Packets shall be placed approximately three (3) inches away from the plant roots or plant ball. Packets shall not be cut, ripped or damaged. If it becomes necessary to remove and replace dead or unhealthy plants, any damaged or broken packets shall be replaced with new packets. The application rates for fertilizer packets shall be as follows:

Type of Plant	Rate
Trees	One packet for each eighteen (18) inches of height
Shrubs	One packet for each twelve (12) inches of height

E. All plants shall be watered immediately following planting and thereafter shall be inspected frequently for watering needs and watered, as required, to provide adequate moisture in the planting pit.

F. Pruning

1. Each plant shall be pruned in accordance with the workmanship requirements of Pruning Standards to preserve the natural character of the plant.

2. Tree pruning shall be undertaken to the full height of affected trees.

3. All dead wood or suckers and all broken or badly bruised branches shall be removed. In addition, up to one-fourth (1/4) of the wood shall be removed by thinning out and shortening branches to balance root loss due to re-transplanting. Never cut a leader.

4. Cuts over one inch (1") in diameter shall be painted with a tree paint. Paint shall cover all exposed living tissue.

G. Antidesiccant shall be applied to all plants before digging at the nursery and/or as directed by the Engineer once the plants have been delivered to the site.

H. If planting is done after seed and mulch installation, proper protection of seeded areas shall be provided and any damage resulting from planting operations shall be repaired immediately at at the Subcontractor's expense.

3.03 CLEAN-UP

A. Upon completion of planting, remove excess soil, stones and debris which has not previously been cleaned up and disposed of.

B. Prepare seeded areas for final inspection.

C. Protect slopes and embankments against erosion until work is accepted. Repair eroded portions of seeded areas by refilling, remulching and reseeding, at Subcontractor's expense.

3.04 MAINTENANCE

A. Begin maintenance immediately after each planting, seeding and continue a minimum of one year until final acceptance of work.

B. Maintenance shall consist of keeping the plants in a healthy growing condition and shall include but is not limited to re-seeding, watering, removal of dead material, and resetting plants to proper grades or upright position.

1. Plants shall be inspected for watering needs at least twice each week during the growing

season and watered as necessary to promote plant growth and vitality.

2. Plants that die during the maintenance or guarantee period shall be removed and replaced at once, unless designated otherwise by the Engineer.

C. During the maintenance period, any decline in the condition of plantings shall require the Subcontractor to take immediate action to identify potential problems and undertake corrective measures. If required, the Subcontractor shall engage professional arborists and/or horticulturalists to inspect plant materials and to identify problems and recommend corrective procedures.

D. Watering

1. Provide all labor and arrange for watering plant materials and seeded areas.

2. Water in manner which will provide uniform coverage, prevent erosion due to application of excessive quantities over small areas, and prevent damage to the finished surface by the watering equipment. Furnish watering equipment to apply one (1) complete coverage to the seeded areas in an eight (8) hour period.

3.05 ACCEPTANCE

A. Prior to the maintenance period the Subcontractor shall request, in writing to the Engineer, for the provisional acceptance of the seeding and planting. Provisional acceptance will in no way relieve the Subcontractor of his obligations specified herein.

B. Following a minimum one-year maintenance period after provisional acceptance, the Subcontractor shall request the Engineer in writing for a formal inspection of the planting work.

C. If plant materials and workmanship are acceptable at the end of the guarantee period, written notice will be given to the Subcontractor stating that the work has received final acceptance.

D. If a number of plants are sickly or dead at the time of inspection, or if in the Engineer's opinion, workmanship is unacceptable, written notice will be given by the Engineer to the Subcontractor in the form of a punch list, which itemizes necessary planting replacements and/or other deficiencies to be remedied. The Subcontractor's responsibility for maintenance of all the plants shall be extended until replacements are made or other deficiencies are corrected. All dead and unsatisfactory plants shall be removed promptly from the project. Replacements shall conform in all respects to the Contract Document for new plants and shall be planted in the same manner.

E. Final acceptance of the planting work shall be established by the Engineer in writing, following the completion of all maintenance work and guarantee requirements as specified herein, and following the correction of all punch list deficiencies by the Subcontractor.

3.06 GUARANTEE

A. Plants shall be guaranteed for a period of one year after provisional acceptance and shall be alive and in satisfactory growth at the end of the guarantee period.

B. At the end of the guarantee period, a final inspection will be held to determine whether any plant material replacements are required. A survival rate of 75% is required. Each surviving plant shall show at least 75% healthy growth and shall have the natural character of the plant of its species as determined by the Engineer. Plants found unacceptable shall be removed promptly from the site and replaced during the normal planting season. A final inspection for acceptance will be made after the replacement plantings have lived through one year.

C. All replacements shall be plants of the same kind and size specified. The cost shall be borne by the Subcontractor, except for possible replacements due to vandalism or neglect on the part of others.

END OF SECTION