Responses to TDEC Comments Dated October 18, 2006

To facilitate review of our revisions made following receipt of TDEC's comments dated October 18, 2006, we have provided the following responses and revised documents.

Comment 1:

Rule 1200-1-7-.04 (9) (b) 1. (ix) requires the applicant to clearly show, in the engineering plans, how run-on will be diverted from, and run-off will be removed from, the work areas, illustrating the locations and slopes of ditches, dikes, etc., to be utilized for such diversion/removal and the direction of flow.

The Plans show the outlet pipes for a stormwater interceptor ditch located above the landfill, for the purpose of collecting the surface runoff from the adjacent hillsides, to pass beneath the sediment pond for the landfill. We do not favor this design because if there is ever a failure of one of these pipes for any reason (and the system must remain in place for a long period of time), it would be likely that this would result in a localized collapse of the pond bottom resulting in a discharge of the pond through the stormwater bypass pipe, directly into the lake rather than through the intended NPDES permit outfall. The stormwater outlet should be routed in a different manner, which bypasses the sediment pond.

Response 1:

The stormwater outlet referenced in the comment has been routed to bypass the sediment pond. Drawing Nos. 10W427-4, 5, 6, 7, 8, 11, 12, and 13 have been updated to present the revised grading for the stormwater outlet channels. Drawing No. 10W427-23 has been updated to remove Detail C23 for Stormwater Run-on Drop Inlet and Detail D23for Stormwater Culvert Under Pond, as these details are no longer applicable. For completeness, Drawing No. 10W427-13, Surface Water Management Plan, was updated to include names of each ditch segment. Drawing No. 10W427-21 was updated to include a table to present details of each ditch shown on the Surface Water Management Plan. It is noted that this information was previously presented in Appendix B titled "Design and Analysis of the Surface Water management System" but was not shown on the Design Drawings. Surface water calculations have been updated to include the new stormwater outlet channels and are presented in the revised Appendix B.

Comment 2:

For the downdrain inlets on final cover benches (as shown in "Details #C, D, E, and F-22" on Drawing #10W427-22 of the construction plans), we recommend that the elevated standpipes shown be replaced with grated inlets at the bench channel grade level, to prevent stormwater from building up over the benches and possibly washing out the *berms. Low check dams may be placed above the grated inlets to prevent clogging with sediment.*

Response 2:

Detail Nos. A, B, C, D, E, and F on Drawing No. 10W427-22 have been revised to replace the elevated standpipe inlets with grated inlets. The following note has been added: "Low check dams may be placed above the grated inlets to prevent clogging with sediment".

Comment 3:

Rule 1200-1-7-.04 (9) (d) requires the applicant to include, with the "Part 2" permit application, a copy of the closure/post-closure care plan. The plan must include a closure and post-closure cost estimate.

In the post-closure cost estimate (Item #IV-B, "Maintenance of Leachate Collection System"), no cost figures are allocated to "repairs/materials-pumps and cleaning out system". Leachate collected in the underdrain system is removed and pumped to the sediment pond through a lift station. This will have to be maintained through the post-closure period. There is also a possibility that clogging will have to be alleviated in the underdrain and/or slope drain systems. Cost figures need to be provided for these items, as well as for maintaining the lift station that is necessary for maintaining the water level in the sediment pond.

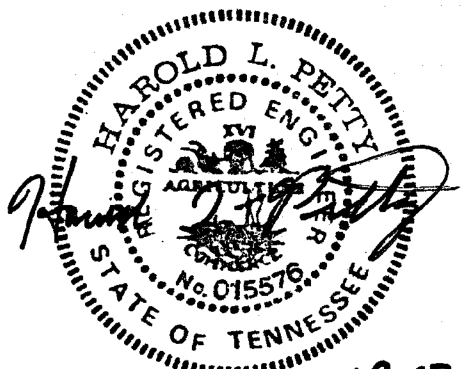
Response 3:

Item #IV-B has been updated to include costs for repairs/materials for pumps and the cleaning out system. Also, the cost for maintaining the lift station is now included. A revised copy of Worksheet B is provided with this submittal.1

Title: OPERATIONS MANUAL COAL COMBUSTION BYPRODUCT DISPOSAL FACILITY—PENINSULA SITE			DCN # Plant/Unit: KINGSTON FOSSIL PLANT
Vendor	Contract No.	Key Nouns: Permit, Closure/Post-Closure Plan KIF450	

Applicable Design Documents / References	REV	RIMS NUMBER	DESCRIPTION
Applicable Design Documents	R0		June, 2006 GeoSyntec Permit Application to TDEC Gypsum Disposal Area
References	R1		January, 2007 GeoSyntec Revisions in response to TDEC NODs
	R2		

TENNESSEE VALLEY AUTHORITY
FOSSIL POWER GROUP
FOSSIL ENGINEERING SERVICES
SITE AND ENVIRONMENTAL ENGINEERING



1-19-07

	Revision 0	R1	R2
Date	June, 2006	Jan, 2007	
Prepared	Neil Davies	Neil Davies	
Checked	T. Y. Elkady & L. C. Bowers	L. C. Bowers	
Supervised	Harold L. Petty	Harold L. Petty	

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Appendix F	Material Specifications and Construction Quality Assurance and Quality Control Plan
Appendix G	DSWM Policy Memorandum SW-91-2

TVA

Tennessee Valley Authority
Kingston Fossil Plant

OPERATIONS MANUAL

COAL COMBUSTION BYPRODUCT DISPOSAL FACILITY - PENINSULA SITE

KIF450

Prepared By:

Tennessee Valley Authority
Fossil Engineering Services
1101 Market Street
Chattanooga, TN 37401-2801

May 2006

Title: OPERATIONS MANUAL COAL-COMBUSION BYPRODUCT DISPOSAL FACILITY – PENINSULA SITE.				DCN# Plant/Unit: Kingston Fossil Plant
Vendor	Contract No.		Key Nouns:	
Applicable Design Documents	REV	EDMS NUMBER	DESCRIPTION	
	R0			
References	R1			
	R2			

TENNESSEE VALLEY AUTHORITY
FOSSIL POWER GROUP
FOSSIL ENGINEERING SERVICES
SITE AND ENVIRONMENTAL ENGINEERING

	Revision 0	R1	R2
Date	May 2006		
Prepared	R.N. Davies		
Checked	T.Y. Elkady		
Supervised	Harold L. Petty		

OPERATIONS MANUAL
COAL COMBUSTION BYPRODUCT DISPOSAL FACILITY – PENINSULA SITE

Prepared By:
Tennessee Valley Authority
1101 Market Street
Chattanooga, TN 37401-2801

Revision 0
May 2006

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Note:
(1) The hydrogeological report was submitted under separate cover to TDEC on November 29, 2005. A Notice of Completeness was received from TDEC on December 16, 2005. Appendix B only includes supplemental data used in the design that was not included in the previous submittal.

1 SITE INFORMATION

1.1 Overview and Introduction

This Operations Manual has been prepared in support of a Part II Permit application for a coal-combustion byproduct (CCB) disposal facility to be located at Tennessee Valley Authority's (TVA's) Kingston Fossil Plant (KIF), located near Harriman, Tennessee. The proposed disposal facility is to be located on lands currently owned by TVA located within the KIF reservation. The CCB disposal facility is an integral part of a project to install a flue gas desulfurization (FGD) system at KIF. When operational, the FGD system will reduce sulfur dioxide emissions through the use of wet limestone forced oxidation technology. Gypsum will be produced as a byproduct of the FGD operations. TVA intends to market the resulting gypsum for beneficial re-use by private companies. However, the proposed CCB disposal facility described herein is needed for the on-site disposal of gypsum materials that cannot be marketed.

This Operations Manual has been developed in accordance with rules published by the Tennessee Department of Environment and Conservation (TDEC), specifically Rule 1200-1-.04. TVA is requesting that TDEC issue a permit for the construction and operation of the CCB disposal facility as a Class II facility. TVA also requests that TDEC issue certain waivers, as specifically identified in this O&M Plan, that are needed to address TVA's operational needs and the inert nature of the materials to be disposed.

Information presented in this document has been organized and presented consistent with the permit application requirements presented in Rule 1200-1-.04 (9). Sections within this application have been titled and enumerated consistent with the regulations to facilitate the review process. Additional information developed in support of this Operations Manual and the permit application has been presented as Appendices or attachments as listed below:

Appendix A	Hydrogeologic Report
Appendix B	Design Calculations
Appendix C	Gypsum Testing and Physical Properties
Appendix D	Groundwater Monitoring Plan

Appendix E	Closure and Post-Closure Plan
Appendix F	Material Specifications and Construction Quality Assurance and Quality Control Plan
Appendix G	DSWM Policy Memorandum dated September 7, 2001

1.2 Hydrogeological Report (ref. 1200-1-7-.04 (9) (a))

The Hydrogeological Report supporting this application is titled *"Kingston Fossil Plant – Peninsula Site, Hydrogeologic Evaluation of Coal-Combustion Byproduct Disposal Facility"* (October 2005) and is presented as Appendix A. This document was submitted to TDEC as a stand alone document on November 29, 2005. Based on TDEC's review, a Notice of Completeness was received by TVA on December 16, 2005. No changes have been made to this document since its submittal to TDEC.

1.3 Engineering Plans (ref. 1200-1-7-.04 (9) (b))

The Engineering Drawings that support this application are presented as Attachment 1 to this Operations Manual. The drawing set is titled, *"Coal-Combustion By-product (Gypsum) Disposal Facility, Kingston Fossil Plant – Peninsula Site"*. The following drawings are included:

Table 1
List of Drawings

Drawing No.	Title
10W427-1	Cover Sheet
10W427-2	Existing Site Conditions and Boring Locations
10W427-3	Site Development Plan
10W427-4	Phase I Initial Grading Plan and Soil Dikes
10W427-5	Phase I Top of Geologic Buffer
10W427-6	Phase I, Stage 1A
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10W427-8	Phase II Initial Grading Plan and Soil Dikes
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10W427-11	Phase I and II Final Cover Grading Plan (Wet Stack)
10W427-12	Phase I and II Final Cover Grading Plan (Dry Stack)
10W427-13	Surface Water Management Plan
10W427-14	Cross Section I
10W427-15	Cross Section II
10W427-16	Operational and Typical Details I
10W427-17	Operational and Typical Details II
10W427-18	Drainage System Details I
10W427-19	Drainage System Details II
10W427-20	Final Cover System Details
10W427-21	Surface Water Management System Details I (Downdrain Channel Option)
10W427-22	Surface Water Management System Details II (Downdrain Pipe Option)
10W427-23	Surface Water Management System Details III
10W427-24	Underdrain Lift Station
10W427-25	Stormwater Lift Station

2. NARRATIVE DESCRIPTION OF FACILITY OPERATIONS

The following section of this Operations Manual presents a narrative description of the development and operation of the planned CCB disposal facility. To facilitate the review of this document, regulatory requirements are cited in italics at the start of each section followed by a text description indicating how the specific requirement has been addressed. Where appropriate, the text also references engineering drawings or other supporting information that has been developed in support of the Operations Manual and permit application.

2.1 Site Information

2.1.1 Responsible Officials (ref. 1200-1-7-.04 (9) (c) 1)

Regulatory requirement:

1. Identifies the name of the individual responsible for operation and maintenance of the facility;

The following is a list of responsible parties involved in the permitting, design, operation, maintenance, quality control and quality assurance of the CCB disposal facility at TVA's Kingston Fossil Plant.

1. Owner: Tennessee Valley Authority (TVA)
   Contact: Plant Manager
   Tennessee Valley Authority
   Kingston Fossil Plant
   714 Swan Pond Road
   Harriman, Tennessee 37748
   Phone (865) 717-2501

As of the date of this revision, the plant manager is Mr. Michael T. Beckham.

Please direct any correspondence in regards to this document to the designated Solid Waste Specialist. The Solid Waste Specialist for Kingston Fossil Plant is:

Larry C. Bowers
1101 Market Street, LP 5D-C
Chattanooga, Tennessee 37402-2801
Phone:(423)751-4947
Fax:(423)751-7011

2. State: Tennessee Department of Environment and Conservation
Division of Solid Waste Management
Tennessee Department of Environment and Conservation
2700 Middlebrook Pike, Suite 220
Knoxville, Tennessee 37921-5602
Phone:(865) 594-6035
Fax:(865) 594-6115
Contact as of the date of this manual is Mr. Larry Cook, Environmental Field Office Manager.

Tennessee Department of Conservation
Division of Solid Waste Management
Central Office
401 Church Street
5th Floor, L&C Tower
Nashville, TN 37243-1533
Phone:(615) 532-0780
Fax:(615) 532-0886

Contact as of the date of this manual is Mr. Mike Apple, Division Director.

2.1.2 Site Location (ref. 1200-1-7-.04 (9) (c) 2)

Regulatory requirement:

2. *Describes the location of the facility using roads and highways;*

The Site is located on land currently owned by TVA at the Kingston Fossil Plant (KIF). The specific area proposed for the disposal facility is commonly referred to as the "Peninsula Site". KIF is located near the city of Harriman in Roane County, TN. Access to the Site is via the plant main entrance which is located on Swan Pond Road. Swan Pond Road is located off Highway 70 between the cities of Kingston and Harriman. A site location map is provided on Drawing No. 10W427-1 (Cover Sheet).

2.1.3 Site Description (ref. 1200-1-7-.04 (9) (c) 3)

Regulatory requirement:

3. *Describes its compliance with all applicable buffer zone standards listed in paragraph (3) of this Rule. Each buffer zone standard must be specifically addressed referencing the closest property lines, residences, wells, and bodies of water as appropriate, and maps may be attached for easy descriptions and reference or otherwise demonstrate compliance.*

KIF is located at the base of a peninsula formed by the Clinch and Emory River embayments of Watts Bar Lake. Construction of KIF began in 1951 and commercial operation began in 1955. Land acquisition for KIF included approximately 550 acres east of the current plant operational area, commonly referred to as the KIF Peninsula Site. The area was originally devoted to agricultural and residential use. These cultivated fields are currently used by the Tennessee Wildlife Resources Agency (TWRA) to support an onsite wildlife management program (i.e., hunting).

The proposed CCB facility will be located on a peninsula landform at the confluence of the Clinch and Emory Rivers in Roane County, Tennessee. The Emory River enters the Clinch River at Clinch River Mile (CRM) 4.36 along the eastern margin of the peninsula. Existing ground surface across the proposed disposal site ranges from approximately elevation 735 to 860 ft. msl, and the 100-year flood stage elevation is 747.6 ft. Modern day floods near the mouth of the Clinch River (CRM 0.7) suggest that the highest modern (1903) flood stage was near 746 ft. msl.

The CCB disposal facility proposed at KIF will occur in two separate phases. Both phases would involve disposal of gypsum derived from flue-gas desulfurization (FGD). Phase I would be constructed pending successful marketing of the FGD derived gypsum. The footprint for Phase I includes an area of approximately 51 acres. If efforts to market the gypsum are unsuccessful, the disposal facility will be expanded laterally under Phase II. Phase II includes additional area adjacent to the site and encompasses an additional area of approximately 41 acres (note: areas are measured to limits of waste).

2.1.4 Compliance with Buffer Zones (ref. 1200-1-7-.04 (3) (a)

Regulatory requirement:

Disposal facilities must be located, designed, constructed, operated, and maintained such that the fill areas are, at a minimum:

1. *100 feet from all property lines*

The proposed CCB disposal facility is located on the KIF reservation. No property lines are within 100 ft.

2. *500 feet from all residences, unless the owner of the residential property agrees in writing to a shorter distance*

There are no residences within 500 ft. of the proposed CCB disposal facility.

3. *500 feet from all wells determined to be down gradient and used as a source of drinking water by humans or livestock*

There are no wells downgradient of the site that are used as a source of drinking water by humans or livestock.

4. *200 feet from normal boundaries of springs, streams, lakes (except that this standard shall not apply to any wet weather conveyance nor to bodies of water constructed and designed to be part of the facility)*

The disturbance footprint of the disposal facility is located within 200 ft. of the normal boundary of Watts Bar Lake-Clinch River. However, as indicated on Drawing No. 10W427-3 (Site Development Plan), waste limits shall be maintained beyond the required 200 ft. buffer zone. Only soil starter dikes will be located within the buffer. Prior to construction, TVA will obtain permits required under Section 404 of the Clean Water Act and an Aquatic Resource Alteration Permit (ARAP) to address construction activities within the buffer area.

TVA requests that TDEC issue a waiver of the 200 ft. buffer requirement to allow construction of the soil starter dikes within the buffer zone as indicated on the engineering drawings.

2.1.5 Compliance with Siting Requirements for Fault Areas (ref. 1200-1-7-.04 (9) (c) 4)

Regulatory requirement:

4. Describes its compliance with applicable siting requirements for fault areas.

   Rule 1200-1-7-.04 (u) New Class I and II SWLF units and lateral extensions shall not be located within 200 feet (60 meters) of a fault that has had displacement in Holocene time unless the owner or operator demonstrates in the Narrative Description of the Facility and Operations Manual that an alternative setback distance of less than 200 feet (60 meters) will prevent damage to the structural integrity of the SWLF unit and will be protective to human health and the environment.

As part of the planning and design of the proposed facility, TVA has completed an extensive hydrogeologic evaluation of the site. Based on the investigations performed to date, there is no evidence of Holocene-age faulting within the 200 ft. facility exclusion zone although the Kingston fault (a thrust fault) crosses the southeastern margin of the site. The Kingston fault is an ancient structure that, along with associated faults, were formed approximately 300 million years ago and further movement along these faults is highly improbable (Julian and Boggs, 2005).

2.1.6 Compliance with Siting Requirements for Seismic Impact Zones (ref. 1200-1-7-.04 (9) (c) 5)

Regulatory requirement:

5. *Describes its compliance with applicable siting requirements for seismic impact zones.*

   Rule 1200-1-7-.04 (v) New Class I and II SWLF units and lateral extensions shall not be located in seismic impact zones unless the owner or operator demonstrates that all containment structures including liners, leachate collection systems and surface water control systems are designed to resist the maximum acceleration in lithified earth material for the site. The owner or operator must place the demonstration in the Narrative Description of the Facility and Operations Manual.

The Site lies within a seismic impact zone, defined by TDEC Rule 1200-1-7-.04 as being an area with a 10 percent or greater probability of being subject to an earthquake ground acceleration of at least 0.10g within 250 years. The Site falls within an area characterized by a maximum horizontal acceleration of 0.25g within 250 years. In accordance with TDEC regulations, "*all containment structures including liners, leachate collection systems, and surface water control systems are to be designed to resist the maximum horizontal acceleration in lithified earth material for the site*".

In accordance with the TDEC regulations, engineering analyses were performed for critical components of the facility considering both static and seismic conditions. Seismic evaluations were performed using a maximum horizontal ground acceleration of 0.25g in 250 years. Calculation packages detailing assumptions and procedures, analyzed cross sections, and material properties for the aforementioned analyses are presented in Appendix B. Results indicate that the proposed facility has adequate factors of safety under both operational and final facility configurations.

2.1.7 Compliance with Siting Requirements for Unstable Areas (ref. 1200-1-7-.04 (9) (c) 6)

Regulatory requirement:

4. *Describes its compliance with applicable siting requirements for unstable areas.*

   Rule 1200-1-7-.04 (2) (w) Owners or operators of new Class I and II SWLF units, existing Class I and lateral expansions located in an unstable area must demonstrate that engineering measures have been incorporated into the SWLF units designed to ensure that the integrity of the structural components of the SWLF unit will not be disrupted. The owner or operator must place the demonstration in the Description of the Facility and Operations Manual operating record. The owner or operator must consider the following factors at a minimum, when determining whether an area is unstable:

1. *On-site local soil conditions that may result in significant differential settlement.*
2. *On-site or local geologic or geomorphologic features; and*
3. *On-site or local human-made features or event (both surface and subsurface).*

Topographic depressions or dolines are exhibited at the site. These features do not possess open throats or avenues for reception of incipient recharge. Rather, the dolines are thickly mantled by soil thicknesses ranging from about 35 to 75 ft. Visual and laboratory classifications of these soils indicate that they are of residual origin except in the area of the site pond where alluvial deposition has occurred. Based on the hydrogeologic evaluation, there were no voids detected immediately above bedrock that would indicate staging of soil into the deeper bedrock system. There are no natural karst features (i.e., sinkholes, sinking streams, and springs) directly integrated into the subsurface. Coring of the bedrock at the site exhibits slight to highly fractured conditions. Most cavities and joints were also observed to be completely or partially filled with clays and sand. Some topographic depressions coincide with bedrock depressions but no active karst features were observed at these locations.

The only man made feature is the former farm pond located in the center of the site. This feature will be filled in during construction of the facility and therefore will not affect the integrity of the facility. TVA will obtain the necessary permits for this work in advance of proceeding with the work.

A central drainage corridor (150 ft. wide drainage blanket) is included in the design to remove liquids from lower portions of the CCB disposal facility during normal operations and during the post-closure period. As part of the engineering design, differential settlements were estimated along the axis of the corridor to ensure that positive drainage would be maintained under post-settlement conditions. This evaluation is presented in Appendix B and illustrates that positive gravity drainage will be maintained after settlement under the final configuration of the disposal facility.

2.1.8 Access Control (ref. 1200-1-7-.04 (9) (c) 7)

Regulatory requirement:

7. *Describes the barriers, signs, procedures and other measures to be used to control access to and use of the facility;*

Phases I and II of the proposed CCB facility are located within the TVA KIF Reservation. Access to this facility is via the plant entrance and internal plant roads. During normal operations, plant personnel will be at the site performing disposal operations, inspections and maintenance as required. TVA also maintains 24-hour security at the plant.

Temporary signage and barriers will be erected on an as-required basis during construction operations to route construction-related traffic to designated areas.

3 FACILITY OPERATIONS

3.1 Overview

This Section of the Operations Manual provides a description of the normal operations anticipated for the planned CCB facility. Section 3 provides a description of operational procedures and specifically addresses the required elements of Rule 1200-1-7-.04 (9) (c) parts 8 through 18.

3.2 General Sequence of Operations (ref. 1200-1-7-.04 (9) (c) 8)

Regulatory Requirement

8. Describes the methods and sequence of operation;

The proposed CCB disposal facility is intended for the disposal of gypsum derived from flue-gas desulfurization (FGD). While it is TVA's intent to market the resulting gypsum materials for beneficial re-use, the disposal facility is required as a back-up to normal operations. At a minimum, it is anticipated that the facility will be used to dispose of materials resulting from periodic by-passes that will occur during routine maintenance of equipment that will be used as part of the planned marketing activities. In addition, periodic disposal of gypsum materials may be required if market conditions or other external factors result in reduced demand for gypsum materials. Accordingly, the proposed CCB disposal facility has been conservatively sized and designed to handle 100 percent of the anticipated gypsum production once the FGD project is brought on-line.

Figure 1 presents an overall site plan identifying key elements of the proposed CCB disposal facility. Initial activities (prior to waste disposal) will involve construction of the stormwater pond, geologic buffer, central drainage corridor, initial soil dikes, and associated stormwater diversion features associated with development of the Phase I area of the Site.

The disposal footprint of Phase I is approximately 51 acres. The initial soil dikes will be constructed as indicated on Drawing No. 10W427-4 (Phase I Initial Grading

Plan and Soil Dikes). The geologic buffer consisting of a three-foot thickness of re-compacted soil with a specified hydraulic conductivity of no more than 1 x 10^{-7} cm/sec will be constructed and the central drainage corridor will be added as depicted on Drawing No. 10W427-5 (Phase I Top of Geologic Buffer). The soil dikes will form the boundary of an initial wet pond operation and will also provide a means of access for construction equipment around the initial pond perimeter. It is TVA's intent that this layer will meet or exceed the regulatory requirements of a geologic buffer, as defined in the TDEC regulations.

The geologic buffer will be graded towards the center of the disposal area with the central channel graded towards the low point of the Phase I area at the southwest corner of the site. The central drainage corridor consists of a 150 ft. wide drainage blanket constructed of crushed stone wrapped in a geotextile filter fabric with interior perforated pipes. This drainage corridor will be used to collect internal drainage resulting from the consolidation of the disposed gypsum and will convey this water to a sump (underdrain lift station). The contents will be pumped to the stormwater pond and will subsequently be pumped to the plant's discharge channel for discharge in accordance with the plant's NPDES permit.

Phase I will be initially operated as a wet pond, as subsequently described. It is anticipated that operations will transition from a wet pond operation to a Rim Ditch operation if the volume of material being disposed becomes significant. TVA may construct the Phase II area at any time during the operation of Phase I. It is anticipated that TVA will review the timing for the implementation of Phase II once sufficient operational experience has been gathered regarding the efficiency of gypsum byproduct marketing activities. Other external factors such as market demand for gypsum materials may also factor into the need for, and timing of construction of Phase II.

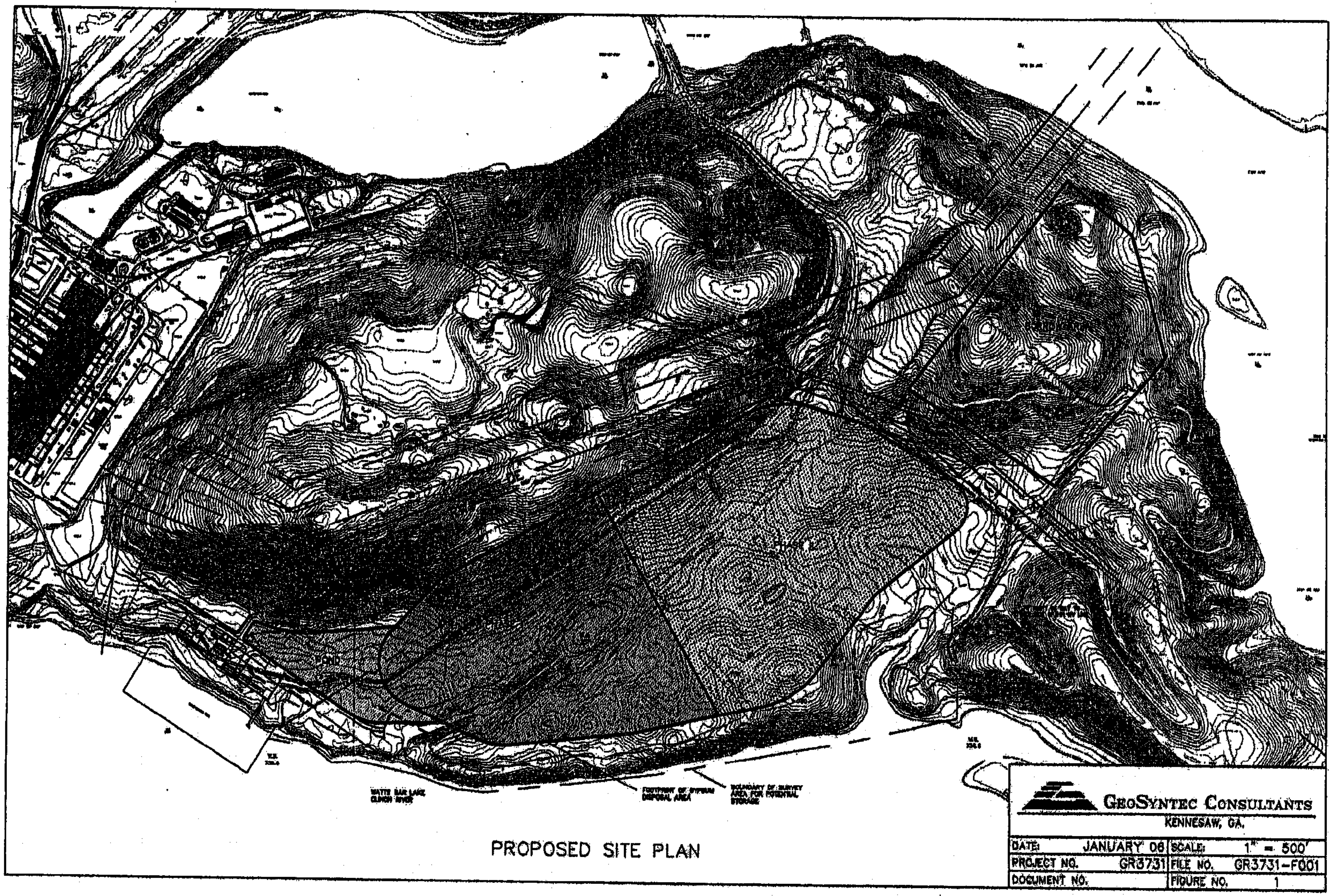

Figure 1 – Site Plan

After completion of initial construction activities to prepare the Phase I area, gypsum will be sluiced to the upper (northern) end of the Phase I wet pond. The wet pond will be decanted at the lower end using a conventional pond decant structure (See Drawing No. 10W427-19, Drainage System Details II) located adjacent to the stormwater pond, with decant water being discharged into the stormwater pond. Temporary diversion berms may be required to promote settling of the coarser gypsum particles. The number and location of these berms (if used) will be field determined based on operational needs. Coarser material will be removed from the pond area and used to progressively raise the elevation of the outer dikes using a conventional wet cast operation.

The outer dikes will be raised progressively during the operation of the wet pond. The dike construction procedure is depicted on Drawing No. 10W427-16 (Operational and Typical Details I). It is estimated that the disposal facility can be operated in this manner for a period of approximately 2 years prior to transitioning to a Rim Ditch operation. However, the actual time period will be highly dependant upon the efficiency of planned marketing operations. Transition to a Rim Ditch operation can occur once sufficient pond capacity is provided to allow for efficient operations.

Once the disposal operation has transitioned to a Rim Ditch operation, gypsum will be sluiced to a Rim Ditch located around the interior of the perimeter dikes rather than directly to the wet pond. The Rim Ditch would discharge to the central pond, with coarser gypsum particles being deposited in the Rim Ditch. The general procedure for raising the elevation of the dikes using a Rim Ditch operation is depicted on Drawing No. 10W427-17 (Operational and Typical Details II). As sufficient materials are deposited, the outer dikes will be raised in elevation using the upstream method of construction. Decant water will continue to be discharged from the central pond to the stormwater pond. Stormwater and decant water collected in the stormwater pond will be pumped to TVA's existing NPDES permitted discharge located at the plant discharge channel.

Once sufficient operational experience has been gained, TVA may elect to expand into the Phase II area. This may be done at any point during the operation of Phase I. The disposal footprint of Phase II is approximately 41 acres. If expansion into Phase II occurs early in the operation of Phase I, it may be possible to operate Phases I and II simultaneously. If expansion into Phase II occurs at a later time, the Phase II area would lean into and "piggyback" the previously constructed sideslope of Phase I that is common to the two areas.

Phase II of the disposal area will be developed in a similar manner to Phase I, i.e., first as a wet pond operation, raising the dikes by a wet casting operation; then as a Rim Ditch operation with a central pond.

The CCB disposal facility design has been developed assuming wet disposal up to an approximate elevation of 900 ft. msl. Dry stack disposal can be performed above this elevation. The estimated airspace available for disposal of gypsum is as follows:

- Phase I – 6,513,000 cubic yards (cy) for wet stack operation (i.e., up to approximate elevation 900 ft. msl);
- Phase I and II – 13,371,000 cy for combined wet stack (i.e., up to elevation 900 ft. msl); and an additional 2,634,000 cy capacity for dry stack operations.

3.3 <u>Type and Volume of Waste (ref. 1200-1-7-.04 (9) (c) 9)</u>

Regulatory requirement:

> 9. *Describes the types and anticipated volumes of solid wastes to be disposed of and the sources which generate the waste, and for special wastes, the physical and chemical characteristics of the wastes and any special handling procedures to be utilized;*

TVA is proposing to construct and operate a wet scrubber system to reduce sulfate (SO_3) emissions from the flue gas emissions at the Kingston Plant. The system is expected to become operational in FY2009. The only wastes that will be disposed of in this facility will be gypsum resulting from the operation of the proposed FGD system. Relatively small quantities of fly ash and/or bottom ash may be used from time to time as construction materials (e.g., road base) during operation of the facility.

Wet gypsum will be pumped from the power generation area to the marketing area, to be located just west of the proposed disposal facility (Figure 1). A by-pass valve will be located at this location. Depending on market conditions, TVA may be able to market up to 90 percent or more of the gypsum generated at KIF to private companies involved in the manufacture of various products. Since there are a variety of uncertainties associated with the actual percentage of gypsum that can be marketed, all life projections included in this Operations Manual have been developed based on worst case (i.e., no marketing) projections.

The design has been developed assuming that gypsum will be wet sluiced or slurried to the CCB disposal facility. Wet disposal operations will continue until approximate elevation 900 feet above mean sea level (msl) has been attained. Above this elevation, it is assumed that any further disposal will be performed as a dry stacking operation since the footprint of the wet pond will be significantly reduced at this point. Drawing No. 10W427-11 illustrates the grades upon completion of wet disposal operations and

Drawing No. 10W427-12 illustrates the final cover grades upon completion of both wet disposal and dry stacking activities.

Gypsum is an inert, non-combustible material and does not decay biologically. It is primarily utilized in the manufacture of gypsum wallboard, but can also be used as a soil amendment and in other products. When slurried, the gypsum slurry will have a pH in the range 6.7 to 7.8 (Law, 1995). Additional data regarding the typical characteristics of gypsum and the typical chemical composition (based on data from TVA's Cumberland Fossil Plant) is included in Appendix C.

Since wet sluicing of gypsum is integral to TVA's gypsum disposal practices, TVA requests a waiver of Rule 1200-1-7-.04 (2), regarding disposal of bulk non-containerized liquids in a landfill.

TVA estimates that approximately 547,500 cy of settled gypsum will be produced each year. Under worst case conditions (i.e., no marketing), TVA has developed the stage-storage capacity estimates presented in Table 2.

Table 2
Stage-Storage Capacity Estimates

Description	Disposal Volume (cy)	Highest Elevation (ft. msl)	Minimum Anticipated Life [(1)] (years)
Phase 1 – completion of wet stacking	6,513,000	900	12
Phase I and II combined – completion of wet stacking	13,371,000	900	24.5
Phase I and II combined – completion of wet and dry stacking	16,005,000	984	29.25

Notes:
(1) – assumes no marketing

3.4 Areas to be Filled and Permitted (ref. 1200-1-7-.04 (9) (c) 10)

Regulatory requirement:

10. Identifies the number of acres to be filled and the total number of acres to be permitted, including buffer zone acreage (Note: If the site is to be developed in accordance with a phased development plan, each parcel must be separately addressed. If minimum closure areas are to be utilized such proposal must be described here and delineated in the closure plans)

Table 3 provides a summary of the areas to be filled and permitted. The Phases of work and major areas of the site are illustrated on Figure 1 and on Drawing No. 10W427-3 (Site Development Plan).

Table 3
Areas to be Filled and Permitted

Description	Area to Limit of Waste	Area to Limit of Disturbance
Phase I (including Stormwater Pond)	51.24	83.36
Phase I and II (including Stormwater Pond)	92.7	153.74

3.5 Waste Handling and Covering (ref. 1200-1-7-.04 (9) (c) 11)

Regulatory requirement:

11. Describes the waste handling and covering program, to include but not necessarily be limited to, descriptions of:

(i) Unloading, spreading, and compacting operations;
(ii) The frequencies and depths of initial, intermediate, and final cover; and
(iii) The cover material(s) to be utilized, including the estimated volumes to be needed (show initial, intermediate, and final earthwork calculations) and their sources and availability.

3.5.1 Waste Handling Operations

Phase I will be ready to receive waste following completion of the construction activities illustrated on Drawing No. 10W427-4 (Phase I – Initial Grading Plan and Soil Dikes) and Drawing No. 10W427-5 (Phase I – Top of Geologic Buffer). At this point, the disposal area will be bounded around the perimeter with soil dikes; and a geologic buffer consisting of a 3 ft. thick layer of compacted clay having a hydraulic conductivity of not greater than 1 x 10^{-7} cm/sec. The central internal drainage corridor will also be in place consisting of a 150 ft. wide blanket drain running along the axis of the disposal facility. The central drainage corridor will provide internal drainage to lower portions of the disposal area during operation of the facility and throughout the post-closure period. Drainage collected by the central drainage corridor will be discharged by gravity to the underdrain lift station illustrated on Drawing No. 10W427-24. Further details of the design and operation of the central drainage corridor are provided in Appendix B.

After completion of initial construction activities to prepare the Phase I area, gypsum will be sluiced to the upper (northern) end of the Phase I wet pond. The discharge point may be moved periodically to facilitate distribution of the gypsum materials. The wet pond will be decanted at the lower end using a pond decant structure (see Drawing No. 10W427-19) located adjacent to the stormwater pond, with decant water being discharged into the stormwater pond. Temporary diversion berms may be required to promote settling of the coarser gypsum particles. The number and location of these berms (if used) will be field determined based on operational needs.

The outer dikes will be raised progressively using the upstream method of construction, commencing at the downgradient end (west end) of the Phase I area. The dikes will be raised using settled gypsum that will be excavated from the pond using a long-reach backhoe, drag-line or other conventional earthmoving equipment. The stages of construction are illustrated on Drawing No. 10W427-6 (Phase I Stage 1A) and Drawing No. 10W427-7 (Phase I Stage 1B). Operational details are also illustrated on Drawing No. 10W427-16 and 10W427-17 (Operational Details). Depending on the rate of filling and other operational considerations, TVA may transition to a Rim Ditch operation to facilitate raising of the outer dikes. Operational details for a Rim Ditch operation are illustrated on Drawing No. 10W427-17.

Once the disposal operation has transitioned to a Rim Ditch operation, gypsum will be sluiced to a Rim Ditch located around the interior of the perimeter of the stack rather than directly to the wet pond. The Rim Ditch will discharge to the central pond, with coarser gypsum particles being deposited in the Rim Ditch. As sufficient materials are deposited, the outer dikes will be raised in elevation using the upstream method of construction. Decant water will continue to be discharged from the central pond to the stormwater pond. Stormwater and decant water collected in the stormwater pond will be pumped to TVA's existing NPDES permitted discharge located at the plant discharge channel.

Settled gypsum in the interior of the disposal facility will consolidate as a result of the decanting operations and drainage of free liquids through the perimeter drains and central drainage corridor. Coarse gypsum materials used for the construction of the outer dikes of the disposal facility will be spread in uniform layers and compacted.

Internal drainage features and surface water conveyance ditches will be constructed concurrently as the outer dikes are raised in elevation. Perimeter drains will be installed each time the dike is raised by approximately 10 ft. in elevation. Details are indicated on Drawing Nos. 10W427-18 and -19 (Drainage System Details) and Drawing Nos. 10W427-21 through -23 (Surface Water Management system Details).

An intermediate soil cover will be constructed progressively over the outer dikes as they are raised in elevation. The intermediate soil cover consists of one foot thickness of soil capable of sustaining vegetation. Intermediate cover soils for Phase I will be obtained from either the footprint of Phase II or from the designated borrow area.

Depending on operational needs, TVA may elect to expand the disposal area by implementing Phase II. The decision to implement Phase II will be made based on operational needs and the success of gypsum marketing activities. Prior to placement of waste in Phase II, construction activities illustrated on Drawing Nos. 10W427-8 (Initial Grading Plan and Soil Dikes) and Drawing No. 10W427-9 (Phase II – Top of Geologic Buffer) will be implemented. Waste placement activities in Phase II will be essentially similar to Phase I operations, i.e., the area will initially be operated as a wet pond; outer dikes will be raised in elevation using wet-cast gypsum; and operations may transition to a Rim Ditch operation once sufficient pond capacity has been developed. If TVA elects to expand into Phase II early in the life of the facility, it will be possible to operate Phase I and II as a single cell. However, if Phase II lags Phase I, operations within Phase I may be suspended temporarily until Phase II reaches a similar elevation to Phase I.

3.5.2 Daily and Intermediate Cover

No daily or intermediate cover (other than intermediate cover soil placed on the outer dikes) will be required for this facility. Since gypsum is inert, physically stable, does not biodegrade, and does not attract animals, vector control is not needed. Intermediate soil cover and vegetation will be established progressively on the outer sideslopes as the disposal facility is developed. Water spraying or other dust suppression techniques will be used as needed to control fugitive dust in periods of dry weather.

Due to the physical properties of gypsum and the nature of the proposed operations, TVA requests a waiver to the typical initial and intermediate cover requirements of Rule 1200-1-7-.04 (6) (b) since this requirement typically applies to municipal solid waste facilities where vector control is required.

3.5.3 Final cover

Final closure of the CCB disposal facility will be undertaken as described in the Closure Plan for this facility. Drawing Nos. 10W427-11 and 10W427-12 depict the final closure contours (including the thickness of the final cover). Final cover grades shown on Drawing No. 10W427-12 will be used in the event that TVA elects to use a dry stacking process above elevation 900 ft. msl. If TVA elects to close the facility upon completion of wet stacking operations, the grades shown on Drawing No. 10W427-11 will be the final cover grades.

The final cover will be constructed once disposal activities have been completed. Drawing No. 10W427-20 (Final Cover System Details) depicts details of two alternative cover systems. Soils for the construction of the low permeability soil layer of the final cover system will be obtained from the designated on-site borrow area. Soil balance estimates indicate that sufficient materials will be available from on-site sources. The vegetative soil layer will also be constructed using locally available soils from the KIF reservation, or from off-reservation sources provided the soil meets the requirements contained on the drawings and in the specifications. Following placement of the vegetative soil layer, the soil will be prepared and seeded using appropriate methods outlined in the specifications. Additional provisions for quality assurance and quality control are also contained in the Material Specifications and Quality Assurance and Quality Control (QA/QC) plan for this facility included as Appendix F of this permit application.

The design of the final cover system meets or exceeds the requirements contained in TDEC Policy Memorandum dated September 7, 2001 item 4 for coal ash facilities (see Appendix G).

3.6 Operating Equipment (ref. 1200-1-7-.04 (9) (c) 12)

Regulatory requirement

12. Describes the operating equipment to be utilized (including back-up equipment), and their source and availability

TVA will utilize equipment and resources of its Heavy Equipment Division (HED) for the construction and operation of the CCB disposal facility. It is likely that the following pieces of equipment will be used at this facility:

- Long-reach track-hoes or draglines (hydraulic excavators);
- Bulldozers;
- Compactors;
- Scrapers;
- Water pumps;
- Solids handling pumps;
- Water trucks; and

- Other conventional earthmoving equipment.

TVA can provide additional equipment within 24 hours for construction or disposal operations in the event of a breakdown.

3.7 Control and collection of Litter (ref. 1200-1-7-.04 (9) (c) 13)

Regulatory requirement

13. Describes the structures and procedures to be used in controlling and collecting litter

Litter control is not applicable to this facility. During normal operations, gypsum will be slurried to the disposal facility as previously described.

3.8 Stormwater Run-on and Run-off Control (ref. 1200-1-7-.04 (9) (c) 14)

Regulatory requirement

14. Describes how run-on and run-off collection and holding and erosion control facilities will be managed, including the disposition of collected waters and residues and a comparison of before and after flows in drainageways leaving the site

Also Rule 1200-1-7-.04 (2) (i) Run-on, Run-off, and Erosion Control

1. The operator must design, construct, and maintain a run-on control system capable of plow onto the active portion of the facility for all flow up to and including peak discharge from a 24-hour, 25-year storm.

Soil starter dikes will be used to form the initial footprint of both phases of construction and effectively isolate the waste disposal areas from stormwater run-on. Run-on diversion ditches and associated culverts are provided to intercept and divert stormwater from upgradient slopes along the north side of Phase I and Phase II. The locations of drainage features are shown on Drawing Nos. 10W427-4 (Phase I Initial Grading Plan and Soil Dikes) and 10W427-8 (Phase II Initial Grading Plan and Soil Dikes). Run-on conveyance structures have been designed to handle the peak discharge from a 24-hour, 25-year storm event. Supporting calculations are presented in Appendix B.

2. *The operator must design, construct, and maintain a run-off management system to collect and control at least the peak flow volume resulting from a 24-hour, 25-year storm.*

The run-off management system for the site includes stormwater drainage control structures and features designed to minimize erosion, minimize the conveyance of sediment laden stormwater, and minimize the potential for water pollution. The outer slopes of the CCB disposal facility have been designed with terraces spaced every 90 ft. of slope length (30 ft. vertical spacing) that will be constructed progressively as the elevation of the disposal facility is raised. A network of conveyance channels and downchutes will convey surface water run-off by gravity to a single stormwater pond, located at the west of the facility. The stormwater pond has been designed to collect and control the peak flow volume resulting from a 24-hour, 25-year storm. A stormwater lift station is provided to convey stormwater from the stormwater pond to KIF's plant discharge channel where it will be discharged under the plants existing NPDES permit. The surface water management system is depicted on Drawing No. 10W427-13 (Surface Water Management Plan), and the lift station is depicted on Drawing No. 10W427-25 (Stormwater Lift Station). Calculations supporting the design of the stormwater management systems are presented in Appendix B.

3. *Holding facilities (e.g., sediment basins) associated with run-on and run-off control systems must be designed to detain at least the water volume resulting from a 24-hour, 25-year storm and to divert through emergency spillways at least the peak flow resulting from a 24-hour, 100-year storm.*

The stormwater pond will accommodate a flow volume greater than that resulting from a 24-hour, 25-year storm event. The emergency overflow for the stormwater pond has been sized to convey at least the peak flow from a 24-hour, 100-year storm event without overtopping of the stormwater pond. Two alternative details of the emergency overflow are presented on Drawing No. 10W427-23 (Surface Water Management Details III). Calculations supporting the design of the holding facility and emergency overflow are presented in Appendix B.

4. *Collection and holding facilities associated with run-on and run-off control systems must be emptied or otherwise managed expeditiously after storms to maintain design capacity of the system*

Three vertical turbine pumps will be installed to remove water from the stormwater pond during and after a storm event. The pumps have been sized such that the volume of water resulting from a 24-hour, 10-year storm event can be removed within a 24-hour period. The stormwater lift station is depicted on Drawing No. 10W427-25 (Stormwater Lift Station). Supporting calculations are presented in Appendix B.

> 5. *Run-on and run-off must be managed separately from leachate unless otherwise approved by the Commissioner.*

As described above, stormwater run-on will be diverted around the footprint of the disposal facility prior to discharge to the river. Leachate from this facility will consist of consolidation water resulting from the self-weight consolidation of the gypsum material. Consolidation water will be collected using the perimeter drains depicted on Drawing No. 10W427-16 (Operational and Typical Details I) and the central drainage corridor depicted on Drawing No. 10W427-18 (Drainage System Details I). Consolidation water will be managed together with stormwater run-off and will be routed through the stormwater pond prior to being pumped (with stormwater) to the plant's discharge channel for discharge under KIF's existing NPDES permit. In addition, decant water from the sluicing operations will also be routed to the stormwater pond.

Both consolidation water and decant water will have been in contact with gypsum due to the nature of the anticipated disposal operations. Contact water is expected to contain trace levels of inorganic constituents and exhibit a pH value in the range 5.5 to 7.5. However, the anticipated levels are not considered problematic and should be within allowable discharge limits.

Due to the nature of the disposal operations, TVA requests that TDEC issue a waiver of the requirement to manage run-off separately from leachate.

> 6. *The operator must take other erosion control measures (e.g., temporary mulching or seeding, silt barriers) as necessary to control erosion at the site.*

Prior to any grubbing or land disturbance activities, silt fences (Filtrex ® SiltSoxx, or equivalent), cut-off trenches, and other erosion control measures will be implemented. Other erosion control measures may include temporary sedimentation ponds, surface water ditches, and establishment of temporary and permanent vegetation on exposed soil slopes. If the length of exposed area exceeds 150 ft., a series of barriers at no more than 100 ft. spacing may be required. Erosion control measures will meet or exceed those prescribed within the Tennessee Erosion and Sediment Control Handbook.

3.9 Leachate Collection and Management (ref. 1200-1-7-.04 (9) (c) 15)

Regulatory requirement

> 15. *Describes how leachate collection and holding facilities will be managed, including the disposition of collected leachate*

A mantle of predominantly residual soil of relatively low permeability is present above bedrock at the location of the proposed CCB disposal facility. The soil thickness is variable, but ranges from 8.5 to 120 ft. averaging 40.5 ft. based on available data. The residuum primarily consists of clay and silt with variable chert gravel content. The base of the disposal facility will consist of a geologic buffer constructed of a three-foot thick layer of re-compacted soil having a hydraulic permeability of not more than 1×10^{-7} cm/sec. A central drainage corridor consisting of a 150 ft. wide drainage blanket running along the axis of the facility will be constructed above the geologic buffer to collect and remove free liquids from the base of the facility. The floor of the disposal area will be graded toward the central drainage corridor to promote removal of free liquids. The drainage corridor will operate under gravity flow and will convey collected liquids to an underdrain lift station, depicted on Drawing No. 10W427-24 (Underdrain Lift Station). Calculations were performed to demonstrate that the drainage corridor would maintain gravity flow conditions without grade reversal under anticipated post-settlement conditions. These calculations are presented in Appendix B. Water collected in the underdrain lift station will be pumped to the stormwater management pond and subsequently discharged at the KIF discharge channel under an existing NPDES permit as described in Section 3.8.

TDEC regulations require that the leachate collection system is designed, constructed, operated, and maintained such that the leachate depth over the liner does not exceed one foot as calculated referencing the infiltration volume of the 25-year, 24-hour storm through the intermediate cover. Since this requirement is intended for solid waste facilities and does not contemplate the operation of wet disposal (sluice) operation, TVA requests a waiver of this requirement for this facility.

In support of this request, TVA has performed the following analyses (presented in Appendix B):

- SEEP/W analyses have been performed to illustrate the effectiveness of the central drainage corridor in terms of reducing water levels in the stack during and after of disposal operations. The analyses indicate that the rate at which water levels within the stack will be lowered will be considerably enhanced through the use of the central drainage corridor (when compared to no internal drainage).

- Slope stability analyses have been performed to demonstrate that the stack will attain acceptable factors of safety with regard to slope stability under anticipated short-term and long-term conditions. Stability analyses evaluated both static stability and seismic stability.

TVA representatives met with Mr. Rick Brown of TDEC on March 7, 2006 to discuss this issue. TVA is requesting this waiver consistent with these discussions.

3.10 Dust Control (ref. 1200-1-7-.04 (9) (c) 16)

Regulatory requirement

16. Describes the dust control measures to be taken and when they would be implemented

During wet stacking operations a significant portion of the facility footprint will consist of a wet pond, minimizing the need for dust suppression. Dust control measures will consist of water spraying on access roads and exposed gypsum surfaces and will be implemented on an as needed basis during periods of dry weather. Dust and erosion control for the outer sideslopes will be addressed by the installation of the intermediate cover described in Section 2.5.2.

3.11 Fire Safety (ref. 1200-1-7-.04 (9) (c) 17)

Regulatory requirement

17. Describes the fire safety precautions and procedures to be taken, the types and availability of on-site fire suppression equipment, and/or the arrangements made with the local fire protection agency.

Gypsum material is an inert material derived from limestone, is not combustible, and therefore poses no threat as a potential fire hazard. However, properly maintained fire suppression equipment will be provided for disposal equipment and vehicles. This will consist of fire extinguishers of the appropriate size and type.

3.12 Personnel facilities and Services (ref. 1200-1-7-.04 (9) (c) 18)

Regulatory requirement

18. Describes the facilities and services available to facility personnel, including shelter, drinking water, handwashing and toilet facilities, and communications equipment

Facilities and services that are available and readily accessible to personnel at the KIF plant site, include the following:

- A utility building is on-site for equipment maintenance and yard operations personnel that is accessible by any facility personnel and has adequate screening, heating facilities, and lighting.
- Safe drinking water.
- Sanitary hand-washing facilities.
- Toilet facilities.
- A two-way radio and/or telephone for communications.
- A first aid kit.

3.13 Quality Assurance Plan (ref. 1200-1-7-.04 (9) (c) 19)

Regulatory requirement

19. Describes in a construction quality assurance plan:

(i) How each new "as built" solid waste landfill unit(s) and/or lateral expansion liner(s) and cover system(s) will be inspected and/or tested by a registered engineer as required at rule 1200-1-7-.04(1)(c) during construction or installation for uniformity, damage, and imperfections, and

(ii) How each constructed section of the liner system or final cover system will be certified by a registered engineer.

Procedures for the construction of components of the proposed disposal facility are presented in QA/QC Plan included as Appendix F of this permit application. This QA/QC plan also outlines procedures to verify that proper materials, construction techniques, and installation procedures are used by the constructor and the design intent is met.

3.14 Control of Gas Migration (ref. 1200-1-7-.04 (9) (c) 20)

Regulatory requirement

20. Describes how the migration of explosive gases will be controlled and monitored

Since gypsum is an inert, non-combustible material and does not decay biologically, no gas migration controls are needed. TVA requests a waiver to this requirement consistent with DSWM Policy dated September 7, 2001, item 3 (presented as Appendix G).

3.15 Groundwater Monitoring Program (ref. 1200-1-7-.04 (9) (c) 21)

Regulatory requirement:

> *21. Describes the planned ground water monitoring program, to include but not necessarily be limited to, descriptions of:*
>
> *(i) The number and location of wells or other monitoring points;*
> *(ii) Monitoring well construction;*
> *(iii) The parameters to be monitored for and the frequency they will be checked.*

The Groundwater Monitoring Plan is included as Appendix D of this permit application.

3.16 Location in Floodplains (ref. 1200-1-7-.04 (9) (c) 22)

Regulatory requirement:

> *22. Include an engineering statement of the site flood frequency exposure and describes flood protection measures to be taken.*

Filling operations will be required within the 100-year floodplain. TVA will obtain the appropriate permits required for this work (e.g., Aquatic Resource Alteration Permit (ARAP) under Section 404 of the Clean Water Act) and will provide mitigation measures for impacts to wetland areas. The 100-year flood elevation taken from TVA data is 747.6 ft. msl. Once site preparation activities have been completed, waste limits will be above the 100-year flood elevation. The lower elevations of the soil starter dike in localized areas will be slightly below the 100-year flood elevation. However, these are minor and the impact of a flood event on the facility would be negligible.

3.17 Other Environmental Impacts (ref. 1200-1-7-.04 (9) (c) 23)

Regulatory requirement:

> *23. Describes the impact the facility will have on endangered or threatened species of plants, fish, or wildlife or their habitat.*

As part of the planning process for the FGD project, TVA conducted an Environmental Assessment (TVA, 2006). The EA concluded that the FGD project (which includes the CCB disposal facility) will have no significant impacts on animals, plants, or aquatic life. In addition, no state or federally protected species were identified during the field investigations of the project area. These field investigations were conducted in 2005.

3.18 Random Inspection Program

Regulatory requirement:

24. Describes the random inspection program required under rule 1200-1-7-.04-(2)(s)

A random inspection program for this facility is not required. This disposal facility will only dispose of gypsum from TVA facilities. In addition, minor quantities of bottom ash and fly ash (for use in construction) may be co-disposed. Therefore, a random inspection program for unauthorized wastes is not required. See DSWM Policy, September 7, 2001 Item 5 (Appendix G).

4 CLOSURE/POST-CLOSURE PLAN

A Closure/Post-Closure (C/PC) Plan for this facility is presented as Appendix E. The C/PC plan was prepared to meet the requirements of Rule 1200-1-7-.03 (2).

5. REFERENCES

Julian, Hank E. and Boggs, Mark J 2005, *Kingston Fossil Plant Peninsula Site – Hydrogeologic Evaluation of Coal-Combustion Byproduct Disposal Facility,* October 2005

TVA, 2005, Environmental Assessment – *Installation of Flue Gas Desulfurization System at Kingston Fossil Plant, Roane County, Tennessee,* February 2006

Law, 1995, *Use of Coal Combustion Byproducts as Engineered Fills,* November 10, 1995

REPORT OF
ADDITIONAL GEOTECHNICAL EXPLORATION

PROPOSED GYPSUM DISPOSAL AREA
KINGSTON FOSSIL PLANT
KINGSTON, TENNESSEE

Prepared For:

TENNESSEE VALLEY AUTHORITY

Chattanooga, Tennessee

Prepared By:

MACTEC ENGINEERING AND CONSULTING, INC.

Knoxville, Tennessee

MACTEC Project 3043051064.01

February 24, 2006

MACTEC

MACTEC

engineering and constructing a better tomorrow

February 24, 2006

Mr. Ron Purkey
Tennessee Valley Authority
1101 Market Street, LP-2G
Chattanooga, TN 37402
repurkey@tva.gov

Subject: **Report of Additional Geotechnical Exploration**
Proposed Gypsum Disposal Area
TVA Kingston Fossil Plant
Kingston, Tennessee
MACTEC Project 3043051064.01

Dear Mr. Purkey:

We at MACTEC Engineering and Consulting, Inc., (MACTEC) are pleased to submit this Report of Additional Geotechnical Exploration for your project. Our services, as authorized through TAO No. MAC-0738-00096 were provided in general accordance with our proposal number Prop05Knox/329, Revision 1 dated October 25, 2005.

This report reviews the information provided to us, discusses the site and subsurface conditions, and presents the results of our field and laboratory testing for the materials at the proposed gypsum disposal area. The Appendices contain a brief description of the Field Exploratory Procedures, a Key Sheet and Test Boring Records, Monitoring Well Installation Logs, the Laboratory Test Procedures, and the Laboratory Test Results.

We anticipate further dialog and interaction with the designers as the design proceeds and will be happy to provide any additional information or interpretation of the data presented here in which may be necessary.

We will be pleased to discuss our data with you and would welcome the opportunity to provide the engineering and material testing services needed to successfully complete your project.

Sincerely,
MACTEC ENGINEERING AND CONSULTING, INC.

C. Todd Justice, P.E.
Project Engineer

Samuel D. Stone, P.E. by SDM with permission
Senior Principal Engineer

CLINTON TODD JUSTICE
REGISTERED ENGINEER
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REPORT OF
ADDITIONAL GEOTECHNICAL EXPLORATION

PROPOSED GYPSUM DISPOSAL AREA
KINGSTON FOSSIL PLANT
KINGSTON, TENNESSEE

Prepared For:

TENNESSEE VALLEY AUTHORITY

Chattanooga, Tennessee

Prepared By:

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EXECUTIVE SUMMARY

MACTEC was selected by the Tennessee Valley Authority (TVA) to perform an additional geotechnical exploration for the proposed Gypsum Disposal Area at the Kingston Fossil Plant in Kingston, Tennessee. The objectives of our additional exploration were to determine the general subsurface conditions, to obtain data to evaluate the engineering characteristics of the on-site soils, and to install monitoring wells.

The exploration consisted of drilling 26 soil test borings, 9 offset geotechnical borings for undisturbed sampling, and installing 3 monitoring wells. Bedrock was cored in one of the monitoring well locations. The major findings of our geotechnical exploration are as follows:

- The test borings drilled in the proposed Gypsum Disposal Area typically encountered residual soils and very minor amounts of alluvium and fill. The bedrock encountered in the test borings typically was composed of light gray to medium gray dolomite.

- Ground- water measurements were performed in all test borings at the time of drilling. Ground-water measurements were also conducted in the test borings at least 24 hours after completion of drilling. Long-term measurements for the presence or absence of ground water were not obtained during this exploration. Table 3 presents the ground-water data obtained during the exploration.

- Three monitoring wells were installed to total depths ranging from about 25.5 feet (MW-N) to 60.5 feet (MW-P). Monitoring well MW-P was installed in bedrock (i.e., bedrock well) and monitoring wells MW-M and MW-N were installed within the overburden soils (i.e., overburden wells). Each well consisted of a 2-inch diameter, schedule 40 PVC pipe with double-density, 0.010-inch, slotted screen. A summary of the monitoring well installation is given in Section 7.0. The Monitoring Well Installation Logs are presented in Appendix C.

- Laboratory tests were performed on selected bulk, undisturbed, and standard penetration test (SPT) samples. A summary of the tests performed and the test results is presented in Section 8.0. The test results are presented in Appendix D.

This summary is only an overview and should not be used as a separate document or in place of reading the entire report, including the appendices.

1.0 INTRODUCTION

This report presents the findings of our additional geotechnical exploration and laboratory testing recently performed for the Proposed Gypsum Disposal Area at the TVA Kingston Fossil Plant. Our services were authorized by Mr. Ron Purkey of TVA.

2.0 OBJECTIVES OF EXPLORATION

The objectives of our exploration were to determine general subsurface conditions, to obtain data to evaluate the engineering characteristics of the on-site soils, and to install monitoring wells. An assessment of site environmental conditions, or an assessment for the presence or absence of pollutants in the soil, bedrock, surface water, or ground water of the site was beyond the proposed objectives of our exploration.

3.0 SCOPE OF EXPLORATION

The scope of our exploration was based on our proposal number Prop05Knox/329 dated October 25, 2005, and the geotechnical scope of work outlined in the project's scope of work prepared by Parsons E&C. It includes the following:

- Reconnaissance of the immediate site.
- Drilling 26 soil test borings which ranged in depth from about 11.0 feet (K-15) to 60.5 feet (MW-P).
- Drilling 9 offset geotechnical borings to obtain additional undisturbed samples
- Installing 3 ground water monitoring wells to total depths ranging from about 25.5 feet (MW-N) to 60.5 feet (MW-P).
- Conducting laboratory testing on SPT, bulk, and undisturbed samples from the on-site soils.
- Preparing a geotechnical report summarizing the field and laboratory test results

The drilling and sampling were performed in general accordance with ASTM procedures included in Appendix A. The drilling was performed during the period from November 9, 2005 to January 17, 2006. The equipment used consisted of a CME Model 550 ATV (all-terrain-vehicle) mounted drill rig equipped with a manual hammer, a CME Model 55 ATV mounted drill rig equipped with a manual hammer, and a CME Model 75 truck-mounted drill rig equipped with an automatic hammer.

Standard penetration tests (SPTs) were performed in all of the test borings and within the borings performed during the monitoring well installation. In addition to the SPT samples, bulk and relatively undisturbed Shelby tube samples were obtained from selected test borings for laboratory testing.

Ground-water levels were measured during drilling in each boring. Ground-water measurements were also made in the borings at approximately 24 hours or later after the completion of the borings. Ground water monitoring wells were installed at locations MW-M, MW-N, and MW-P (see Figure 2, Boring Location Plan). The monitoring well installation program was completed on January 17, 2006. The well development field work was completed on January 27, 2006.

Upon completion of drilling, the test borings were plugged and abandoned by backfilling the full depth with cement grout.

All samples were transported to our laboratories in Knoxville, Tennessee and Charlotte, North Carolina. The testing program for this project consisted of the following:

- 35 Plasticity Index (Atterberg Limits) Tests
- 26 Grain Size Distribution Tests
- 21 Natural Moisture Content Tests
- 7 Standard Proctor Compaction Tests
- 26 Specific Gravity Tests
- 8 Unit Weight and Natural Moisture Content Tests for Undisturbed Samples
- 18 Consolidated Undrained Triaxial Compression (CU) Tests
- 9 Unconsolidated Undrained Triaxial Compression (UU) Tests
- 18 Permeability Tests

Subsurface conditions encountered in the borings are presented on the Test Boring Records in Appendix B. The Monitoring Well Installation Logs are presented in Appendix C. The laboratory testing results are presented in Appendix D.

4.0 PROJECT INFORMATION AND SITE CONDITIONS

Project information was provided to us by Mr. Daniel Smith with Parsons E&C in the form of a Geotechnical Investigation Scope of Work and a proposed boring location plan. The site of the proposed gypsum disposal area is located east of the Kingston Fossil Plant site. The ground surface elevations varied by as much as about 115 feet (NB-77B to NB-K) in the areas explored. The northern portion of the site is located within a wooded hillside. The remainder of the site is covered with grass and some tree lines.

5.0 AREA AND SITE GEOLOGY

Kingston, Tennessee, is located in the Appalachian Valley and Ridge Physiographic Province. This province extends as a continuous belt from central Alabama, through Georgia and Tennessee, northward into Pennsylvania. The formations that underlie this province consist primarily of limestone, dolostone, shale, and sandstone, which have been folded and faulted in the geologic past. These formations range in age from Cambrian to Pennsylvanian and have been subject to at least one extensive period of erosion since their structural deformation. The erosion has produced a series of subparallel, alternating ridges and valleys. The valleys are formed over more soluble bedrock (interbedded limestone and limestone), whereas bedrock more resistant to solution weathering forms ridges (sandstone, shale, and cherty dolostone).

In particular, the site is geologically mapped to be underlain by the Knox Group. The Knox Group is mainly composed of light gray to dark gray and olive-gray, siliceous dolomite with a few limestone layers in the upper part. The rock usually weathers to reddish orange residuum containing chert fragments.

Dolostone and limestone, such as the strata underlying this site, are of great geologic age and have been subject to solution weathering for many years. Rainwater falling onto the surface and percolating downward through the soil and into cracks and fissures gradually dissolves the rock, producing insoluble impurities such as chert and clay. Since limestone and dolostone vary greatly in their resistance to weathering, the soil/bedrock contact may be extremely irregular. More soluble bedrock develops a thicker soil cover and a more irregular bedrock surface, with pinnacles and slots and less soluble bedrock usually develops a thinner soil cover and a less irregular soil-bedrock surface. Because of the geologic history of the area and the difference in weathering, it is not uncommon to encounter rock at depths varying by as much as 50 feet in borings as close as 10 feet apart in some areas.

These large variations in bedrock depth are greatly enhanced by the presence of fractures, bedding planes, and faults, which provide an increased opportunity for a greater influx of percolating water. The weaknesses may form clay-filled cavities or enlarge into caves and may be connected by a network of passageways. If a cave forms close to the bedrock surface, its roof may collapse and the overlying soils may erode into the cave. Once the weight of the overlying soil exceeds the soil's arching strength, the soil collapses and an open hole or depression may appear at the ground surface. Such a feature is termed a sinkhole.

6.0 SUBSURFACE CONDITIONS

Subsurface conditions at the site of the proposed gypsum disposal area were explored with 26 soil test borings (including the monitoring well locations) and 9 offset geotechnical borings. The offset geotechnical borings were drilled in order to obtain additional undisturbed Shelby tube samples for laboratory testing purposes. The locations for all the borings and monitoring wells were proposed by Parsons E&C and TVA. The locations were established in the field by TVA. The boring locations were surveyed and we were provided with the surveyed coordinate locations. Because of access restrictions, some of the borings were offset from the originally proposed location. Offset distances with bearing information were recorded in the field and noted on the field logs.

Subsurface conditions encountered at each boring location are shown on the Soil Test Boring Records in Appendix B. The Test Boring Records represent our interpretation of the subsurface conditions, based on the field logs and visual examination of the samples by one of our geotechnical engineers. The lines designating the interfaces between various strata on the Test Boring Records represent the approximate interface locations. Ground surface elevations were not provided with the survey information, therefore the elevations listed on the Soil Test Boring Records should be considered approximate.

The test borings performed at this site typically encountered residual soils and minor amounts of fill and alluvial materials. Residual soils are soils that have developed from the in-place weathering of the underlying parent bedrock. Fill soils are soils which have been transported to their current location by man. Alluvial soils are soils that have been transported to their present location by running water. Bedrock was cored in one of the test boring / monitoring well locations (MW-P). A summary of the soil test boring depths is presented in Table 1.

Table 1
Soil Test Boring Summary

Boring Number	Ground Elevation msl (Feet)	Auger Refusal Depth (Feet)	Refusal Elevation msl (Feet)	Boring Termination Depth (Feet)	Boring Termination Elevation msl (Feet)
NB-21B*	757.0[1]	NE	-	38.5	718.5
NB-47B*	762.8[1]	NE	-	26.0	736.8
NB-47BA*	762.8[1]	NE	-	28.5	734.3
NB-73WB*	749.7[1]	NE	-	45.4	704.3
NB-73WBA*	749.7[1]	NE	-	42.0	707.7
NB-73WBB*	749.7[1]	NE	-	28.0	721.7
NB-77B*	749.3[1]	NE	-	17.7	731.6
NB-77BA*	749.3[1]	NE	-	15.0	734.3
NB-85B*	761.1[1]	NE	-	33.5	727.6
NB-90	752.0[2]	34.1	717.9	34.1	717.9
NB-91	759.5[2]	38.9	720.6	38.9	720.6
NB-92	760.0[2]	24.0	736.0	24.0	736.0
NB-K	864.0[2]	40.1	823.9	40.1	823.9
MW-M	762.0[2]	NE	-	35.5	726.5
MW-N	755.0[2]	NE	-	25.5	729.5
MW-P	792.0[2]	35.0	757.0	60.5	731.5
K-1	756.0[2]	NE	-	15.5	740.5
K-2	755.0[2]	NE	-	15.5	739.5
K-3	792.0[2]	NE	-	15.5	776.5
K-4	750.0[2]	NE	-	15.5	734.5
K-5	752.0[2]	NE	-	15.5	736.5
K-6	766.0[2]	NE	-	15.5	750.5
K-7	767.0[2]	NE	-	15.5	751.5
K-8	764.0[2]	NE	-	15.5	748.5
K-9	756.0[2]	NE	-	15.5	740.5
K-10	756.0[2]	NE	-	15.5	740.5
K-11	749.5[2]	NE	-	15.5	734.0
K-12	762.0[2]	NE	-	15.5	746.5

Table 1

Soil Test Boring Summary

Boring Number	Ground Elevation msl (Feet)	Auger Refusal Depth (Feet)	Refusal Elevation msl (Feet)	Boring Termination Depth (Feet)	Boring Termination Elevation msl (Feet)
K-13	778.0$^{(2)}$	NE	-	15.5	762.5
K-14	757.0$^{(2)}$	NE	-	15.5	741.5
K-15	775.0$^{(2)}$	11.0	764.0	11.0	764.0
K-15A	775.0$^{(2)}$	13.0	762.0	13.0	762.0
K-16	781.0$^{(2)}$	NE	-	15.5	765.5
K-17	787.0$^{(2)}$	NE	-	15.5	771.5
K-18	785.0$^{(2)}$	NE	-	17.0	768.0

NE - Not Encountered

* offset geotechnical boring drilled to obtain additional undisturbed Shelby tube samples

(1) - Elevation determined from data provided from previous exploration survey

(2) – Elevation estimated from the contours of a topographic map of the site

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6.1 FILL

Fill soils were encountered underlying a thin veneer of topsoil in test borings NB-90 and K10, and at the ground surface in test borings K-1 and K-18. The fill extended to depths of about 2.5 to 3.5 feet. The fill soils consisted primarily of brown, red brown, and reddish orange, silty clay with gravel and a few chert fragments. The SPT resistance value in the fill interval varied from 8 to 32 blows per foot (bpf), indicating firm to hard consistency.

6.2 ALLUVIUM

Possible alluvial soils were encountered in test borings NB-92 and K-11. The possible alluvial soils were encountered at ground surface or underlying topsoil near the ground surface and extended to depths ranging from about 6.0 (NB-92) to 2.5 feet (K-11). The soils consisted primarily of dark brown silty clay with sand and silt with chert fragments and roots. The SPT resistance values in the alluvium ranged from 5 (K-11) to 12 (NB-92) bpf, indicating firm to stiff consistencies.

6.3 RESIDUUM

Residual materials were encountered in all of the test borings. The residual soils were encountered below the fill, alluvium, or topsoil and extended to refusal. The residuum encountered in the borings consisted of red-brown, reddish-orange, orange-brown, brown and tan, clay, silt, and sand with varying amounts of chert fragments. The SPT resistance values in the residuum ranged from 0 to 33 bpf, indicating very soft to hard consistencies.

6.4 BEDROCK

Bedrock was cored approximately 25.5 feet in test boring / monitoring well location MW-P. The bedrock encountered in the test boring typically was composed of light gray to medium gray dolomite. The recovered bedrock was observed to be hard to very hard. The core recovery ratio for the various core runs ranged from about 80 to 100 percent. The rock quality designation (RQD) values for the various rock core runs ranged from 8 to 100 percent The core recovery ratios and RQD values for each individual core run are shown on the Test Boring Records in Appendix B. Detailed descriptions including structural and mineralogical features for the recovered rock core are also presented on the Test Boring Records in Appendix B.

7.0 MONITORING WELL INSTALLATION

Three monitoring wells were installed at the site as part of our field exploration. One of the monitoring wells was installed into bedrock, (i.e., bedrock well) (MW-P). The remaining monitoring wells were installed within the overburden soils, (i.e., overburden wells) (MW-M and MW-N). Each monitoring well consisted of a 2-inch I.D., schedule 40 PVC pipe with double-density, 0.010-inch slotted 4.3-foot screens. A summary of the well installation is presented in Table 2. The Monitoring Well Installation Logs are included in Appendix C.

Table 2
Monitoring Well Summary

Well Number	Ground Surface Elevation* (feet msl)	Total Depth (feet)	Screen Depth		Screen Elevation	
			Top (feet)	Bottom (feet)	Top(feet msl)	Bottom (feet msl)
MW-N	755.0	25.5	20.6	24.9	734.4	730.1
MW-P	792.0	60.5	55.6	59.9	736.4	732.1
MW-M	762.0	35.0	30.1	34.4	731.9	727.6

* - Elevations estimated from the contours of a topographic map of the site

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8.0 LABORATORY TESTING AND DISCUSSION OF TEST RESULTS

This section describes the geotechnical laboratory testing program and summarizes the test results. The laboratory testing procedures and laboratory test results are included in Appendix D. The laboratory tests were performed on split-soon, undisturbed, and bulk soil samples obtained during drilling and sampling. The following paragraphs provide a short discussion of the general types of testing conducted and the test results.

8.1 INDEX PROPERTIES, SPECIFIC GRAVITY AND UNIT WEIGHTS

Natural moisture contents, liquid limit, plastic limit, and plasticity index tests (collectively referred to herein as Atterberg limits); specific gravity tests; and grain size distributions with hydrometer analyses were performed on selected undisturbed, bulk, and SPT samples. These tests were used to confirm our visual-manual classifications.

Liquid limits for the soil samples tested ranged from 26 to 81; plastic limits ranged from 16 to 42; and plasticity indices ranged from 7 to 47. The tested soils were classified as MH, CL, CH, ML, SM, SC, SC-SM, and GM soils in accordance with the Unified Soil Classification System (USCS).

The natural moisture content of the soils ranged from 14.6 percent (boring NB-92) to 46.8 percent (boring NB-47BA).

Specific gravities of the soils tested ranged from 2.62 to 2.78.

8.2 MOISTURE-DENSITY RELATIONSHIP

Standard Proctor compaction tests were performed on seven soil samples obtained from auger cuttings at boring locations K-3, K-6, K-7, K-8, K-16, K-17, and K-18. The results of the compaction tests performed indicated that the maximum dry densities ranged from 91.1 to 109.6 pcf, and the optimum moisture contents ranged from 29.5 to 16.0 percent, respectively. Table D-1 (located in Appendix D) lists the standard Proctor compaction test results. The standard Proctor test data sheets are in Appendix D.

8.3 STRENGTH

8.3.1 Consolidated Undrained (CU) Triaxial

Undisturbed

A total of nineteen consolidated undrained (CU) triaxial compression tests were performed on undisturbed and bulk soil samples obtained from the site.

Sixteen CU triaxial compression tests were performed on specimens obtained from undisturbed soil samples. Two CU tests were performed on samples obtained from each of borings NB-21A, NB-47A, NB-77, NB-85A/B, NB-85B; one CU test was performed on samples obtained from each of borings NB-18, NB-21B, NB-44, NB-47B / NB-47BA, NB-73 WB / NB-73WBA, and NB-77B.

Results from ten of the sixteen CU triaxial compression tests performed on the undisturbed samples were considered questionable. The Mohr's circles generated from these (ten) tests did not produce recognizable failure envelopes which made it impossible to accurately determine strength parameters. As a result, the strength parameters for these ten triaxial tests were not determined.

The results of the CU tests performed on the undisturbed sample specimens indicated that the tested samples had a total friction angle ranging from 5.9 to 19.9 degrees and a total cohesion intercept from 760 to 2,347 pounds per square foot (psf). The tests also indicated that the effective friction angle ranged from 31.0 to 38.5 degrees and the effective cohesion intercept ranged from 0 to 455 psf.

Remolded

Three CU triaxial compression tests were performed on remolded bulk soil samples. Testing was performed on representative CL, CH, and ML soils obtained from borings NB-22, NB-25, and NB-76, respectively.

The results of the CU tests performed on the remolded sample specimens indicated that the tested samples had a total friction angle ranging from 11.6 to 14.8 degrees and a total cohesion intercept from 707 to 1,081 pounds per square foot (psf). The tests also indicated that the effective friction angle ranged from 24.6 to 33.6 degrees and the effective cohesion intercept ranged from 123 to 530 psf.

A summary of the test results obtained from the CU triaxial testing is found in Table D-2 (located in Appendix D). The CU triaxial test reports are also found in Appendix D.

8.3.2 Unconsolidated Undrained (UU) Triaxial

Nine unconsolidated undrained (UU) triaxial compression tests were performed on undisturbed soil samples. Two UU tests were performed on samples obtained from each of borings NB-47A, NB-77, and NB-85 A/B; one UU test was performed on samples obtained from each of borings NB-18, NB-21A, and NB-44.

Results from seven of the nine CU triaxial compression tests performed on the undisturbed samples were considered questionable. The Mohr's circles generated from these (seven) tests did not produce recognizable failure envelopes which made it impossible to accurately determine strength parameters. As a result, the strength parameters for these seven triaxial tests were not determined.

The results of the UU tests performed indicated that the tested samples had a friction angle ranging from 2.9 to 4.6 degrees and a cohesion intercept ranging from 1,500 to 2,200 psf.

A summary of the test results obtained from the UU triaxial testing is found in Table D-2 (located in Appendix D). The UU triaxial test reports are found in Appendix D.

8.4 PERMEABILITY

Eleven constant head permeability tests were performed in the laboratory on undisturbed soil samples obtained from the borings. The results of the permeability testing performed on the undisturbed specimens indicated that the permeabilities ranged from 1.7 x 10^{-8} cm/sec to 1.8 x 10^{-5} cm/sec for the soil samples tested.

Seven constant head permeability tests were performed on bulk samples obtained from the borings. The bulk samples were remolded to about 95 percent of the soils respective standard Proctor maximum dry density and at moisture contetns2 percent greater than its optimum moisture content.

The results of the permeability testing performed on the remolded bulk specimens indicated that the permeabilities ranged from 1.3 x 10^{-8} cm/sec to 2.7 x 10^{-6} cm/sec for the soil samples tested.

All of the permeability tests were performed on soil samples that had been consolidated at effective confining pressures of about 12.5 to 13 pounds per square inch (psi).

9.0 GROUND-WATER CONDITIONS

Ground-water levels were measured in all test borings at the time of drilling. Further, ground-water measurements were performed approximately 24 hours or later after the completion of drilling in the test borings. The recorded ground-water levels are presented in Table 3. For safety reasons, the borings were backfilled promptly; consequently, long-term measurements for the presence or absence of ground water were not obtained.

Fluctuations in the ground-water level occur because of variation in rainfall, evaporation, construction activity, surface run-off, and other site-specific factors such as fluctuation of water levels in the adjacent Watts Bar Lake.

Table 3
Ground-Water Data

Boring Number	Ground Surface Elevation (Feet msl)	Depth to Ground Water at Time of Drilling (Feet)	Ground-Water Elevation at Time of Drilling (Feet msl)	Depth to Ground Water 24 Hours After Drilling (Feet)	Ground-Water Elevation 24 Hours After Drilling (Feet msl)
NB-21B	757.0(1)	NE	-	NE	-
NB-47B	762.8(1)	23.9	738.9	NM*	-
NB-47BA	762.8(1)	NE	-	NE	-
NB-73WB	749.7(1)	23.3	726.4	NM*	-
NB-73WBA	749.7(1)	NE	-	NE	-
NB-73WBB	749.7(1)	NE	-	NE	-
NB-77B	749.3(1)	NE	-	10.7	738.6
NB-77BA	749.3(1)	NE	-	NE	-
NB-85B	761.1(1)	NE	-	20.8	740.3
NB-90	752.0	23.2	728.8	NM*	-
NB-91	759.5	25.0	734.5	24.5	735.0

Table 3

Ground-Water Data

Boring Number	Ground Surface Elevation (Feet msl)	Depth to Ground Water at Time of Drilling (Feet)	Ground-Water Elevation at Time of Drilling (Feet msl)	Depth to Ground Water 24 Hours After Drilling (Feet)	Ground-Water Elevation 24 Hours After Drilling (Feet msl)
NB-92	760.0	17.0	743.0	NM*	-
NB-K	864.0	NE		NM	-
MW-M	762.0	24.9	737.1	NM	-
MW-N	755.0	18.8	736.2	NM	-
MW-P	792.0	NM	-	NM	-
K-1	756.0	NE	-	NE	-
K-2	755.0	NE	-	NE	-
K-3	792.0	NE	-	NE	-
K-4	750.0	15.0	735.0	NM*	-
K-5	752.0	NE	-	NE	-
K-6	766.0	NE	-	NE	-
K-7	767.0	NE	-	NE	-
K-8	764.0	NE	-	NE	-
K-9	756.0	NE	-	NE	-
K-10	756.0	NE	-	NE	-
K-11	749.5	NE	-	NE	-
K-12	762.0	NE	-	NE	-
K-13	778.0	NE	-	NE	-
K-14	757.0	NE	-	NE	-
K-15	775.0	NE	-	NE	-
K-15A	775.0	NE	-	NE	-
K-16	781.0	NE	-	NE	-
K-17	787.0	NE	-	NE	-
K-18	785.0	NE	-	NE	-

NE – Not Encountered
NM – Not Measured
* - Borehole Collapsed

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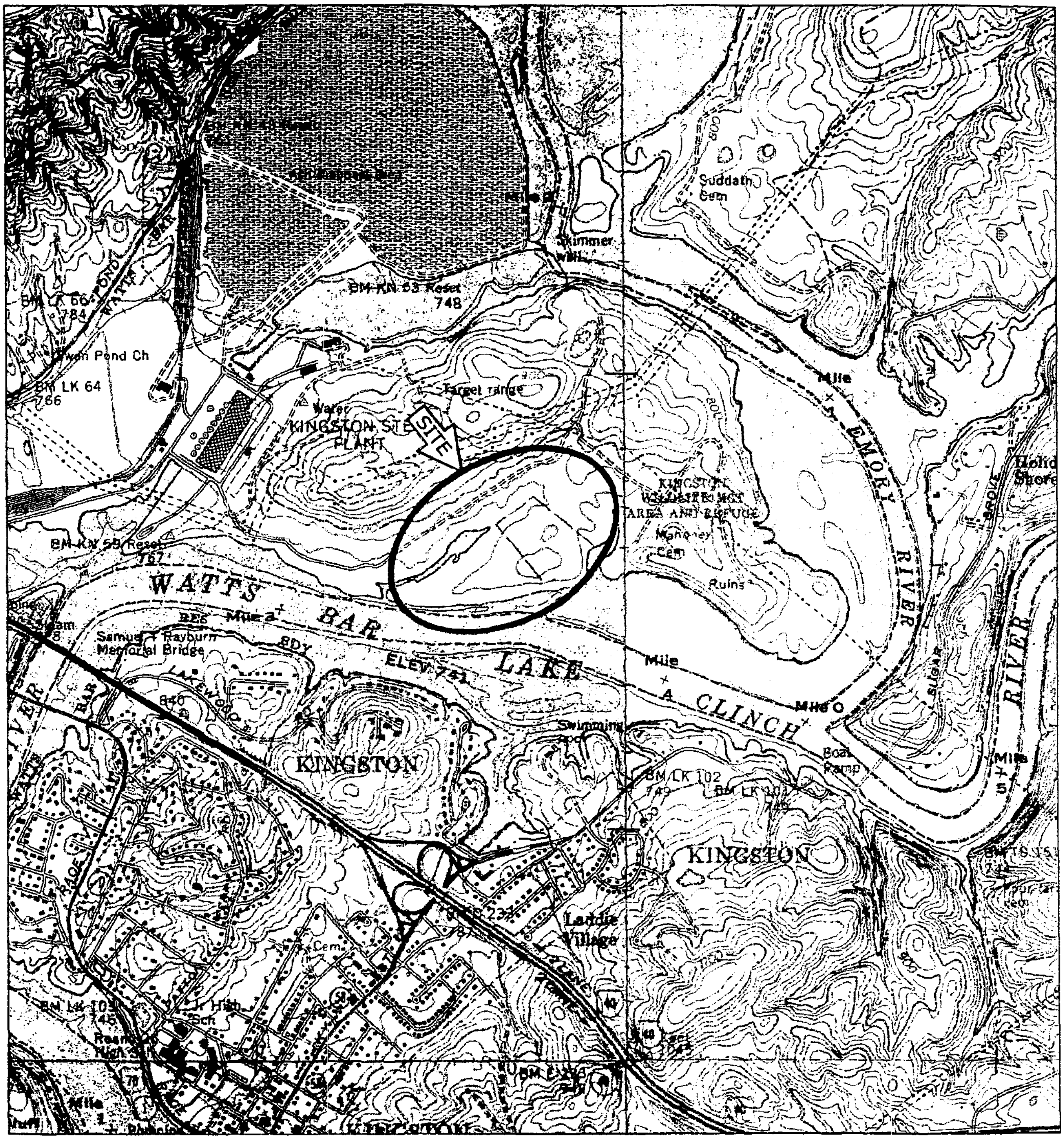
10.0 BASIS OF RESULTS

The results provided herein are based on the encountered subsurface conditions related to the specific project and site discussed in this report.

Regardless of the thoroughness of a field exploration, there is always a possibility that conditions between test locations will differ from those at specific test locations, and that conditions may not be anticipated. In addition, interpretation of the data is critical to the intended design and/or analysis. Therefore, experienced geotechnical engineers should interpret the field data and review any site-specific analysis or design that incorporates the field data. We recommend that TVA retain MACTEC to provide this service, based upon our familiarity with the subsurface conditions, the field and laboratory data, and our geotechnical experience.

Our exploration services include storing the collected samples and making them available for inspection for a period of 30 days. The samples are then discarded unless you request otherwise.

FIGURES



SOURCE: USGS TOPOGRAPHIC MAPS OF HARRIMAN AND ELVERTON, TN QUADRANGLES

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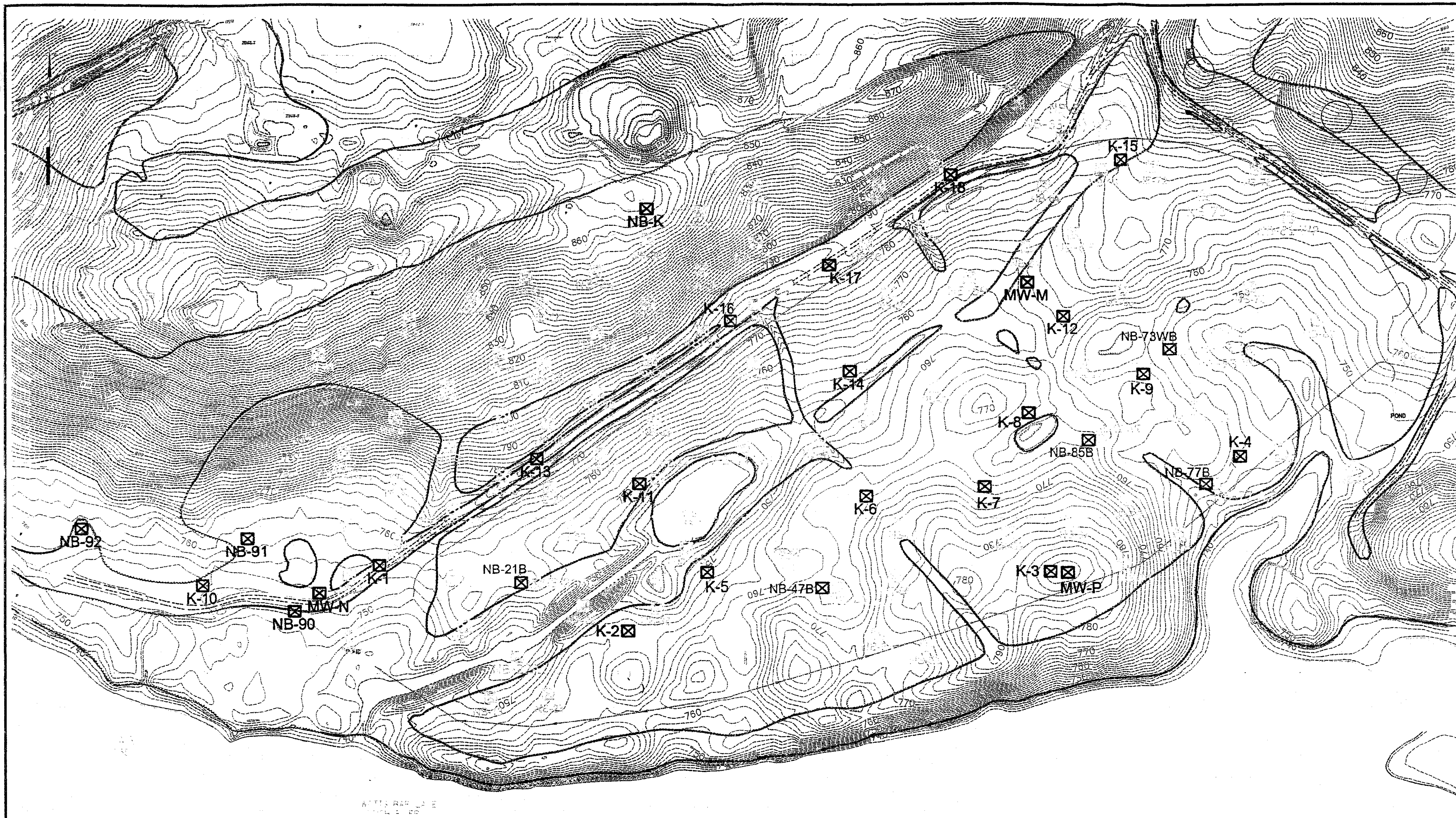
FIGURE 1: SITE LOCATION MAP
PROPOSED GYPSUM DISPOSAL AREA - ADDITIONAL GEOTECHNICAL
KINGSTON, TENNESSEE

DRAFTING BY:	PREPARED BY:	CHECKED BY:
JOB NUMBER: 3043051064/0001	DATE: DECEMBER 22, 2005	SCALE: 0 — 2000'

COORDINATES: N 35°53'39" W 84°31'13"

3043051 wg Thu, 22 Dec 2005 – 4:06pm REVERENC



LEGEND

- ⊠ K-1 — BORING LOCATION AND IDENTIFICATION
- ⊠ NB-21B — OFFSET GEOTECHNICAL BORING LOCATION AND IDENTIFICATION
- ⊠ MW-J — MONITORING WELL AND BORING LOCATION AND IDENTIFICATION
- NB-2 — PREVIOUSLY DRILLED SOIL TEST BORINGS, CONE PENTROMETERS TEST PROBES, MONITORING WELLS, AND GEOPROBE LOCATIONS AND IDENTIFICATION

MACTEC

MACTEC Engineering and Consulting, Inc.
1725 Louisville Drive
Knoxville, Tennessee 37921-5904
865-588-8544 • Fax: 865-588-8026

FIGURE 2: BORING LOCATION PLAN PROPOSED GYPSUM DISPOSAL AREA - ADDITIONAL GEOTECHNICAL KINGSTON, TENNESSEE

DRAFTING BY:	PREPARED BY:	CHECKED BY:
JOB NUMBER: 3043051064/0001	DATE: JANUARY 19, 2006	SCALE: 0 300'

COORDINATES: N XX°XX'XX" W XX°XX'XX"

3043051064_01_FIG2 19 Jan 2006 - 9:45am REVERENC

APPENDIX A

FIELD EXPLORATORY PROCEDURES

FIELD EXPLORATORY PROCEDURES

Soil Test Boring (Hollow Stem)

All boring and sampling operations were conducted in general accordance with ASTM D 1586. The borings were advanced by mechanically twisting continuous steel hollow-stem auger flights into the ground. At regular intervals, soil samples were obtained with a standard 1.4-inch I.D., 2-inch O.D., split-tube sampler. The sampler was first seated six inches to penetrate any loose cuttings and then driven an additional foot with blows of a 140-pound hammer falling 30 inches. The number of hammer blows required to drive the sampler the final foot of penetration was recorded and is designated the "standard penetration resistance (SPT)". Proper evaluation of the penetration resistance provides an index to the soil's strength, density, and ability to support foundations.

Representative portions of the soil samples obtained from the split-tube sampler were sealed in glass jars and transported to our laboratory, where they were examined by our engineer to verify the driller's field classifications. Test Boring Records are attached, graphically showing the soil descriptions and penetration resistances.

Undisturbed Sampling

The relatively undisturbed samples were obtained by pushing a section of 3-inch O.D., 16-gauge steel tubing into the soil at the desired sampling level. The sampling was performed in general accordance with ASTM D-1587. The tube, together with the encased soils, was carefully removed from the ground, made airtight, and transported to our laboratory.

Boring Backfill

The borings were backfilled to the ground surface with cement grout. The owner is advised that, even with this backfill technique, there is the possibility of future borehole subsidence depending on actual subsurface conditions, surface drainage, etc. The property owner should monitor the boring locations over time to discover subsidence and make the necessary repairs.

Rock Coring

Prior to coring, casing is set in the hole drilled through the overburden soils, if necessary, to keep the hole from caving. Refusal materials are then cored according to ASTM D 2113, using a diamond-studded bit fastened to the end of a hollow, double-tube core barrel. This device is rotated at high speeds, and the cuttings are brought to the surface by circulating water. Core samples of the material penetrated are protected and retained in the swivel-mounted inner tube. Upon completion of each core run, the core barrel is brought to the surface, the core recovery is measured, the samples are removed, and the core is placed in boxes for transportation and storage.

The core samples are returned to the laboratory where the refusal material is identified, and the percent core recovery and rock quality designation are determined by a soils engineer or geologist. The percent core recovery is the ratio of the sample length obtained to the depth drilled, expressed as a percent. The rock quality designation (RQD) is obtained by summing up the length of core recovered, including only the pieces of core that are 4 inches or longer, and divided by the total length drilled. The percent core recovery and RQD are related to the soundness and continuity of the refusal material. Refusal material descriptions, recoveries, and the bit size used are shown on the "Test Boring Records."

The NQ and HQ sizes designate bits that obtain rock cores 1-7/8 and 2-1/2 inches in diameter, respectively.

APPENDIX B

KEY TO SYMBOLS AND DESCRIPTIONS

SOIL TEST BORING RECORDS

GROUP SYMBOLS	TYPICAL NAMES	GROUP SYMBOLS	TYPICAL NAMES
	TOPSOIL		**CONCRETE**
	ASPHALT		**DOLOMITE**
	GRAVEL		**LIMESTONE**
	FILL		**SHALE**
	SUBSOIL		**LIMESTONE/SHALE** - Limestone with shale interbeds
	ALLUVIUM		**SANDSTONE**
	COLLUVIUM		**SILTSTONE**
	RESIDUUM - Soft to firm		**AUGER BORING**
	RESIDUUM - Stiff to very hard		**UNDISTURBED SAMPLE ATTEMPT**

Undisturbed Sample 1.5-2.0 = Recovered (ft) / Pushed (ft)	
Split Spoon Sample	Auger Cuttings
Rock Core 60-100 = RQD / Recovery	Dilatometer
No Sample	Crandall Sampler
Rotary Drill	Pressure Meter
Water Table at time of drilling	No Recovery
	Water Table after 24 hours

BOUNDARY CLASSIFICATIONS: Soils possessing characteristics of two groups are designated by combinations of group symbols.

SILT OR CLAY	SAND			GRAVEL		Cobbles	Boulders
	Fine	Medium	Coarse	Fine	Coarse		

No.200 No.40 No.10 No.4 3/4" 3" 12"

U.S. STANDARD SIEVE SIZE

Reference: The Unified Soil Classification System, Corps of Engineers, U.S. Army Technical Memorandum No. 3-357, Vol. 1, March, 1953 (Revised April, 1960)

Correlation of Penetration Resistance with Relative Density and Consistency

SAND & GRAVEL		SILT & CLAY	
No. of Blows	Relative Density	No. of Blows	Consistency
0 - 4	Very Loose	0 - 2	Very Soft
5 - 10	Loose	3 - 4	Soft
11 - 20	Firm	5 - 8	Firm
21 - 30	Very Firm	9 - 15	Stiff
31 - 50	Dense	16 - 30	Very Stiff
Over 50	Very Dense	31 - 50	Hard
		Over 50	Very Hard

KEY TO SYMBOLS AND DESCRIPTIONS

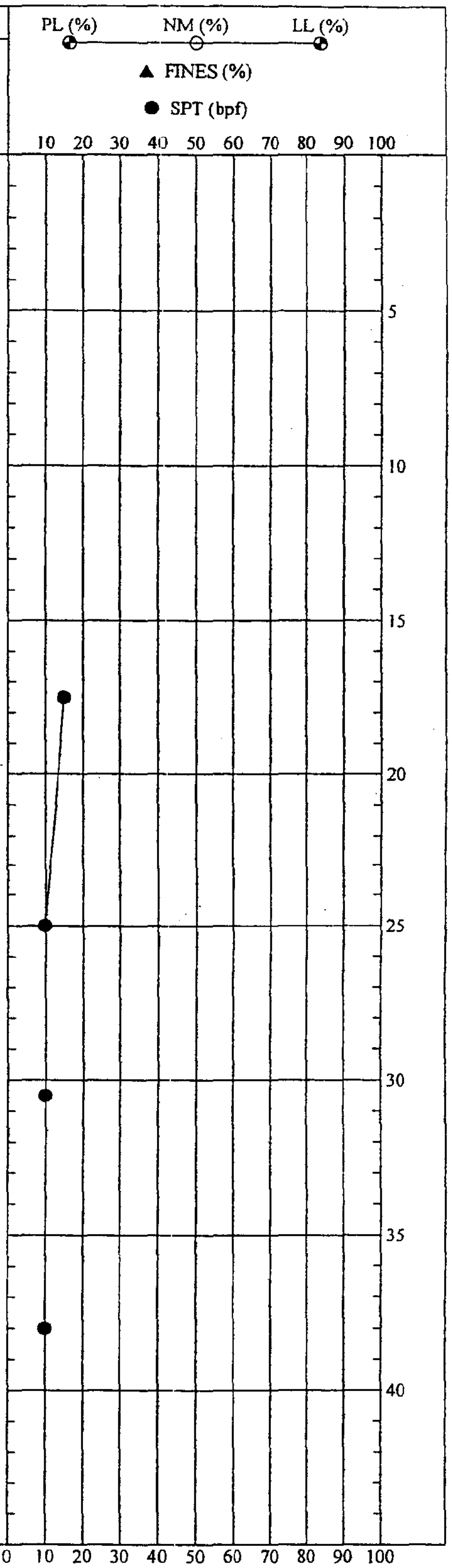
MACTEC

MACTEC Engineering and Consulting of Georgia, Inc.
1725 Louisville Drive
Knoxville, Tennessee 37921-5904
865-588-8544 • Fax: 865-588-8026

SOIL TEST BORING RECORD

SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS	ELEV (ft)	SAMPLE IDENT	N-COUNT (1st 6" - 2nd 6" - 3rd 6")
0	AUGER BORING FROM GROUND SURFACE TO 16.5'	757.0		
5		752.0		
10		747.0		
15		742.0		
	FIRM, REDDISH ORANGE TO TAN, SLIGHTLY MOIST, SANDY SILT - RESIDUUM		SPT-1	7-6-9
	STIFF, REDDISH ORANGE, SLIGHTLY MOIST, SILTY CLAY - RESIDUUM		UD-1	1.7-2.0
20		737.0	UD-2	2.0-2.0
			UD-3	1.1-2.0
	STIFF, ORANGE, WET, SILTY SAND - RESIDUUM			
25	STIFF, ORANGE TO BROWN, WET, SILTY CLAY - RESIDUUM	732.0	SPT-2	2-4-6
	STIFF, MOTTLED RED TO GRAY, MOIST, SILTY CLAY - RESIDUUM			
30	STIFF, MOTTLED GRAY TO BROWN, MOIST, SILTY CLAY WITH RELIC BEDDING - RESIDUUM	727.0	SPT-3	8-6-4
			UD-4	2.0-2.0
			UD-5	0.4-2.0
35		722.0	UD-6	1.2-2.0
	LOOSE, ORANGE, WET, SILTY SAND - RESIDUUM		SPT-4	3-2-8
	BORING TERMINATED AT 38.5'			
40		717.0		
45		712.0		



REMARKS: STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING AN AUTOMATIC HAMMER. NO GROUND WATER ENCOUNTERED AT TIME OF EXPLORATION.

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL

Driller : Marshall
Prepared By: M.O.
Checked By: [signature]

PROJECT: TVA Kingston

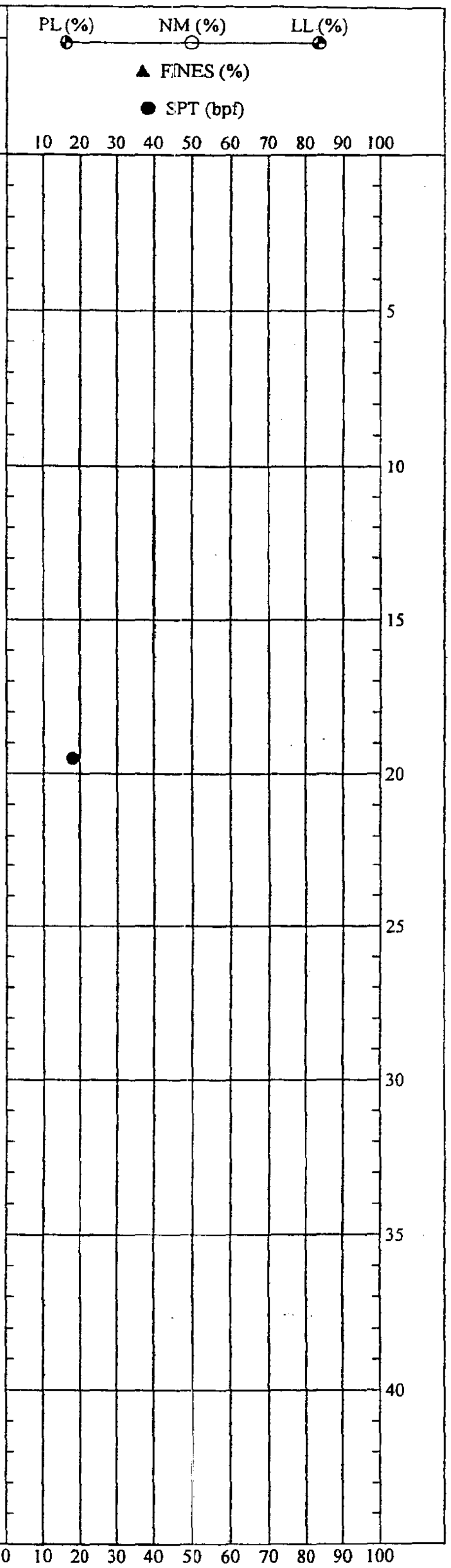
DRILLED: November 11, 2005 **BORING NO.:** NB-21B

PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

MACTEC

SOIL 3047051064_01.GPJ LAW_GIBB.GDT 1/11/06

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	ELEV (ft)	IDENT	N-COUNT (1st 6" 2nd 6" 3rd 6")
0	AUGER BORING FROM GROUND SURFACE TO 18.5'	762.8		
5		757.8		
10		752.8		
15		747.8		
	VERY STIFF, REDDISH ORANGE TO ORANGE BROWN, SLIGHTLY MOIST TO MOIST, SILTY CLAY WITH A FEW CHERT FRAGMENTS - RESIDUUM		SPT-1	6-9-9
20		742.8	UD-1	1.1-2.0
	FROM 22.0' TO 22.9' AUGERED THROUGH VERY CHERTY ZONE			
			UD-2	0.4-2.0
25		737.8	UD-3	0.3-2.0
	BORING TERMINATED AT 26.0'			
30		732.8		
35		727.8		
40		722.8		
45		717.8		



SOIL 3047051064_01.GPJ LAW_GIBB.GDT 1/11/06

REMARKS: STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING AN AUTOMATIC HAMMER. BORING NB-47B WAS DRILLED APPROXIMATELY 14 FEET S 75°W OF MW-47.

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

Driller: Marshall
Prepared By: Justice
Checked By: [signature]

SOIL TEST BORING RECORD

PROJECT: TVA Kingston

DRILLED: November 10, 2005 **BORING NO.:** NB-47B

PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

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DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	ELEV (ft)	SAMPLES IDENT	TYPE	N-COUNT (1st 6" 2nd 6" 3rd 6")
0	AUGER BORING FROM GROUND SURFACE TO 20.0'.	762.8			
5		757.8			
10		752.8			
15		747.8			
20		742.8	UD-1		1.7-2.0
			UD-2		0.7-2.0
25		737.8			
	STIFF, BROWN, VERY MOIST TO WET, SILTY CLAY AND CHERT FRAGMENTS - RESIDUUM		UD-3		0.4-1.0
			SPT-1		4-3-6
	BORING TERMINATED AT 28.5'				
30		732.8			
35		727.8			
40		722.8			
45		717.8			

PL (%) NM (%) LL (%)

▲ FINES (%)

● SPT (bpf)

10 20 30 40 50 60 70 80 90 100

REMARKS: STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING AN AUTOMATIC HAMMER. NO GROUND WATER ENCOUNTERED AT TIME OF EXPLORATION. BORING NB-47BA WAS DRILLED APPROXIMATELY 14 FEET S20°E OF MW-47.

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE TRANSITIONS BETWEEN STRATA MAY BE GRADUAL

Driller : Marshall

Prepared By: Justice

Checked By: [signature]

SOIL TEST BORING RECORD

PROJECT: TVA Kingston

DRILLED: November 10, 2005 **BORING NO.:** NB-47BA

PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

MACTEC

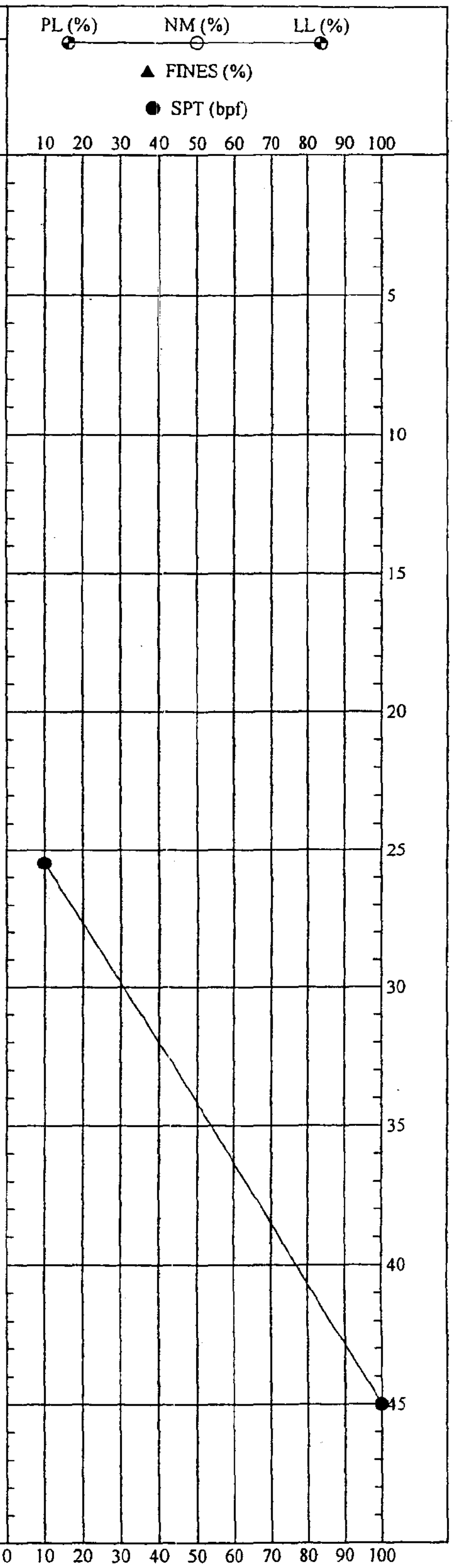
SOIL 3047051064_01.GPJ LAW_GIBB.GDT 1/11/06

SOIL TEST BORING RECORD

SOIL CLASSIFICATION AND REMARKS

SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS	ELEV (ft)	SAMPLES IDENT	TYPE	N-COUNT (1st 6" / 2nd 6" / 3rd 6")
0	AUGER BORING FROM GROUND SURFACE TO 24.5'	749.7			
5		744.7			
10		739.7			
15		734.7			
20		729.7			
25	STIFF, REDDISH-ORANGE, MOIST TO WET, CLAYEY SILT WITH SAND AND CHERT FRAGMENTS - RESIDUUM	724.7	SPT-1		3-6-4
			UD-1		0.9-2.0
			UD-2		1.1-2.0
30	AUGER BORING FROM 30.0' TO 38.0'	719.7			
35		714.7			
			UD-3		0-2.0
40		709.7			
			UD-4		1.5-2.0
			UD-5		0.3-2.0
45	STIFF, BROWN, MOIST TO WET, CLAYEY SILT WITH SAND AND CHERT FRAGMENTS - RESIDUUM	704.7	SPT-2		7-8-50/0.4
	BORING TERMINATED AT 45.4'				
50		699.7			



REMARKS: STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING AN AUTOMATIC HAMMER.

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

Driller : Marshall
Prepared By: Justice
Checked By: [signature]

PROJECT: TVA Kingston

DRILLED: November 10, 2005 **BORING NO.:** NB-73WB

PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

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SOIL 3047051064_01.GPJ LAW_GIBB.GDT 1/11/06

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	ELEV (ft)	IDENT	TYPE	N-COUNT (1st 6" / 2nd 6" / 3rd 6")
0	AUGER BORING FROM GROUND SURFACE TO 38.0'	749.7			
5		744.7			
10		739.7			
15		734.7			
20		729.7			
25		724.7			
30		719.7			
35		714.7			
			UD-1		0.0-2.0
40		709.7	UD-2		0.7-2.0
	BORING TERMINATED AT 42.0'				
45		704.7			

PL (%) NM (%) LL (%)
▲ FINES (%)
● SPT (bpf)
10 20 30 40 50 60 70 80 90 100

REMARKS: NO GROUND WATER ENCOUNTERED AT TIME OF EXPLORATION. BORING NB-73WBA WAS DRILLED APPROXIMATELY 8 FEET S30°E OF NB-73WB.

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE TRANSITIONS BETWEEN STRATA MAY BE GRADUAL

Driller : Marshall
Prepared By: Justice
Checked By: SDI

SOIL TEST BORING RECORD

PROJECT: TVA Kingston

DRILLED: November 10, 2005 **BORING NO.:** NB-73WBA

PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

MACTEC

SOIL 3047051064_01.GPJ LAW_GIBB.GDT 2/21/06

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	TYPE	N-COUNT 1st 6" / 2nd 6" / 3rd 6"	PL (%) / NM (%) / LL (%); ▲ FINES (%); ● SPT (bpf) 10 20 30 40 50 60 70 80 90 100
0	AUGER BORING FROM GROUND SURFACE TO 26.0'		749.7				
5			744.7				5
10			739.7				10
15			734.7				15
20			729.7				20
25			724.7				25
				UD-1		0.9-2.0	
	BORING TERMINATED AT 28.0'						
30			719.7				30
35			714.7				35
40			709.7				40
45			704.7				

0 10 20 30 40 50 60 70 80 90 100

SOIL 3047051064_01.GPJ LAW_GIBB.GDT 2/21/06

REMARKS: NO GROUND WATER ENCOUNTERED AT TIME OF EXPLORATION.

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

Driller : Marshall
Prepared By: M.O.
Checked By: [signature]

SOIL TEST BORING RECORD

PROJECT: TVA Kingston

DRILLED: November 11, 2005 **BORING NO.:** NB-73WBB

PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

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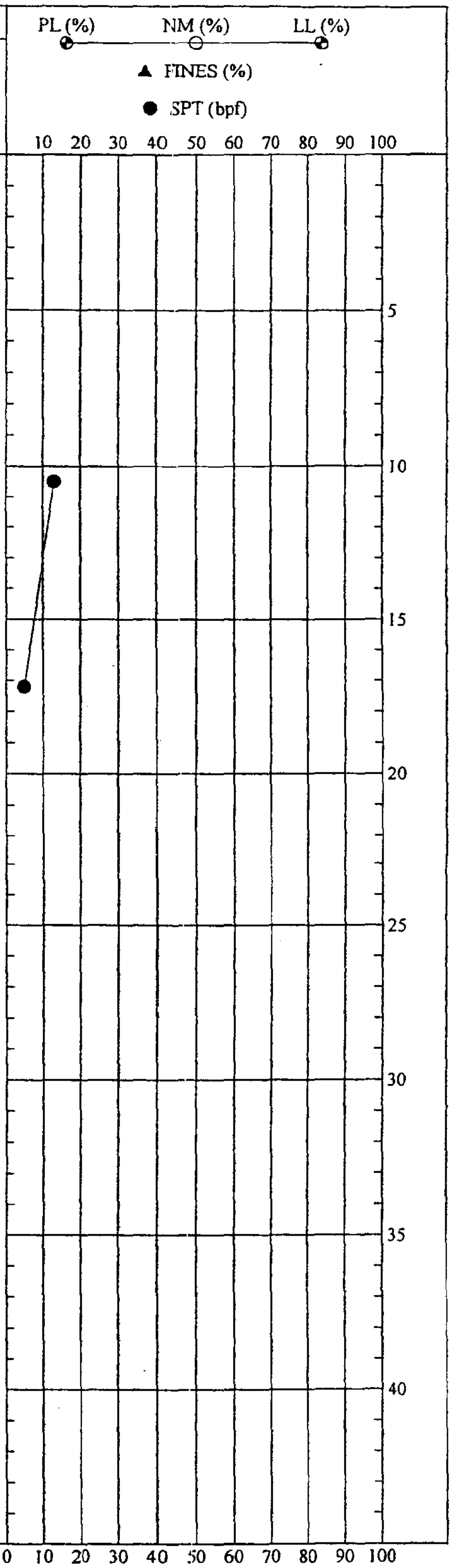
DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	ELEV (ft)
0	AUGER BORING FROM GROUND SURFACE TO 9.5'	749.3
5		744.3
10	STIFF, REDDISH BROWN, SLIGHTLY MOIST, CLAYEY SILT - RESIDUUM	739.3
	FIRM, YELLOWISH BROWN, SLIGHTLY MOIST, SILTY SAND WITH SANDSTONE FRAGMENTS - RESIDUUM	
15		734.3
	FIRM, WET, WEATHERED CHERT - RESIDUUM	
	FIRM, YELLOWISH BROWN, SLIGHTY MOIST TO MOIST, FAT CLAY WITH CHERT FRAGMENTS - RESIDUUM	
	BORING TERMINATED AT 17.7'	
20		729.3
25		724.3
30		719.3
35		714.3
40		709.3
45		704.3

SAMPLES

IDENT	TYPE	N-COUNT (1st 6" / 2nd 6" / 3rd 6")
SPT-1		5-5-8
UD-1		1.5-2.0
UD-2		1.4-2.0
UD-3		1.2-1.2
SPT-2		8-2-3



REMARKS: STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING AN AUTOMATIC HAMMER. GROUNDWATER MEASUREMENT WAS OBTAINED FROM MW-77. BORING NB-77B WAS DRILLED APPROXIMATELY 15 FEET N65°E OF MW-77.

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

Driller : Marshall
Prepared By: Justice
Checked By: [signature]

SOIL TEST BORING RECORD

PROJECT: TVA Kingston

DRILLED: November 9, 2005 **BORING NO.:** NB-77B

PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

MACTEC

SOIL 3047051064_01.GPJ LAW_GIBB.GDT 1/11/06

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	TYPE	N-COUNT 1st 6" 2nd 6" 3rd 6"	PL (%) NM (%) LL (%) ▲ FINES (%) ● SPT (bpf)
0	AUGER BORING FROM GROUND SURFACE TO 13.0'		749.3				
5			744.3				
10			739.3				
				UD-1		1.5-2.0	
15	BORING TERMINATED AT 15.0'		734.3				
20			729.3				
25			724.3				
30			719.3				
35			714.3				
40			709.3				
45			704.3				

Chart scale: 0 10 20 30 40 50 60 70 80 90 100

SOIL 3047051064_01.GPJ LAW_GIBB.GDT 2/21/06

REMARKS: NO GROUND WATER ENCOUNTERED AT TIME OF EXPLORATION. BORING NB-77BA WAS DRILLED APPROXIMATELY 6 FEET N65°E OF NB-77B.

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

Driller : Marshall
Prepared By: Justice
Checked By: [signature]

SOIL TEST BORING RECORD

PROJECT: TVA Kingston

DRILLED: November 9, 2005 **BORING NO.:** NB-77BA

PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

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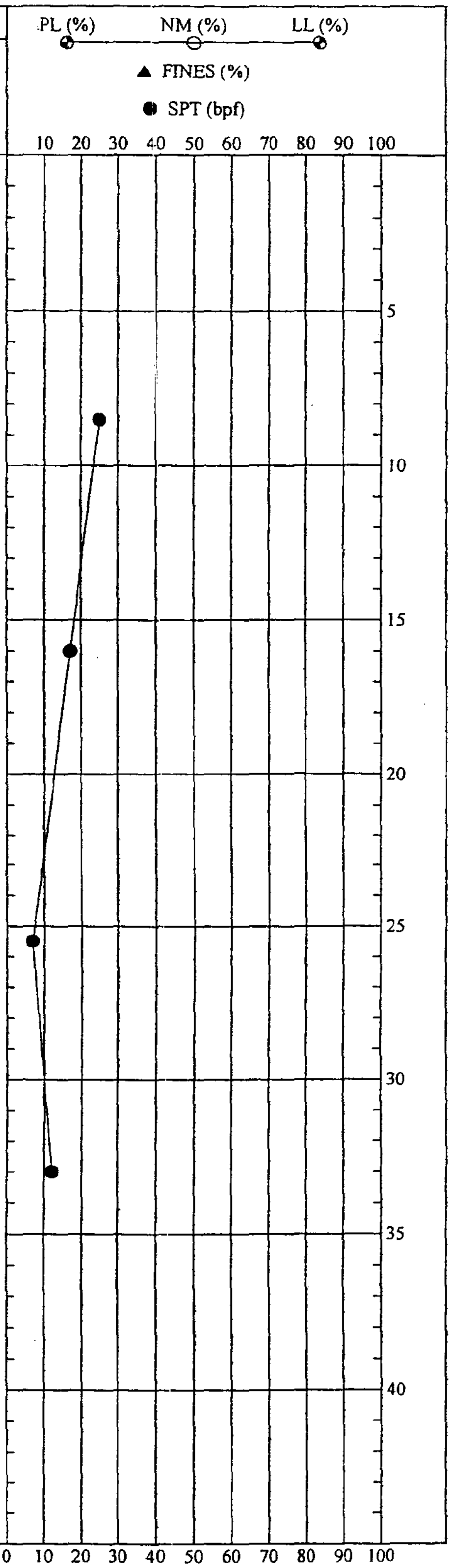
DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	ELEV (ft)	IDENT	N-COUNT (1st 6" / 2nd 6" / 3rd 6")
0	AUGER BORING FROM GROUND SURFACE TO 7.5'	761.1		
5		756.1		
	VERY STIFF, ORANGE BROWN, DRY TO SLIGHTLY MOIST, SILTY CLAY WITH CHERT FRAGMENTS - RESIDUUM		SPT-1	9-12-13
	VERY STIFF, GRAY, CHERT FRAGMENTS - RESIDUUM			
10		751.1	UD-1	1.3-2.0
			UD-2	1.3-2.0
			UD-3	1.3-2.0
15	VERY STIFF, ORANGE BROWN, SLIGHTLY MOIST, SILTY CLAY WITH CHERT FRAGMENTS - RESIDUUM	746.1	SPT-2	5-8-9
	AUGER BORING FROM 16.5' TO 24.5'			
20		741.1		
25	FIRM, REDDISH BROWN MOTTLED, MOIST, SILTY CLAY WITH CHERT FRAGMENTS - RESIDUUM	736.1	SPT-3	3-3-4
			UD-4	1.75-2.0
			UD-5	1.9-2.0
30		731.1	UD-6	2.0-2.0
	STIFF, REDDISH BROWN, WET, FAT CLAY WITH CHERT FRAGMENTS - RESIDUUM		SPT-4	4-6-6
	BORING TERMINATED AT 33.5'			
35		726.1		
40		721.1		
45		716.1		



REMARKS: STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING AN AUTOMATIC HAMMER.

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

Driller : Marshall
Prepared By: M.O.
Checked By: ADL

SOIL TEST BORING RECORD

PROJECT: TVA Kingston

DRILLED: November 9, 2005 **BORING NO.:** NB-85B

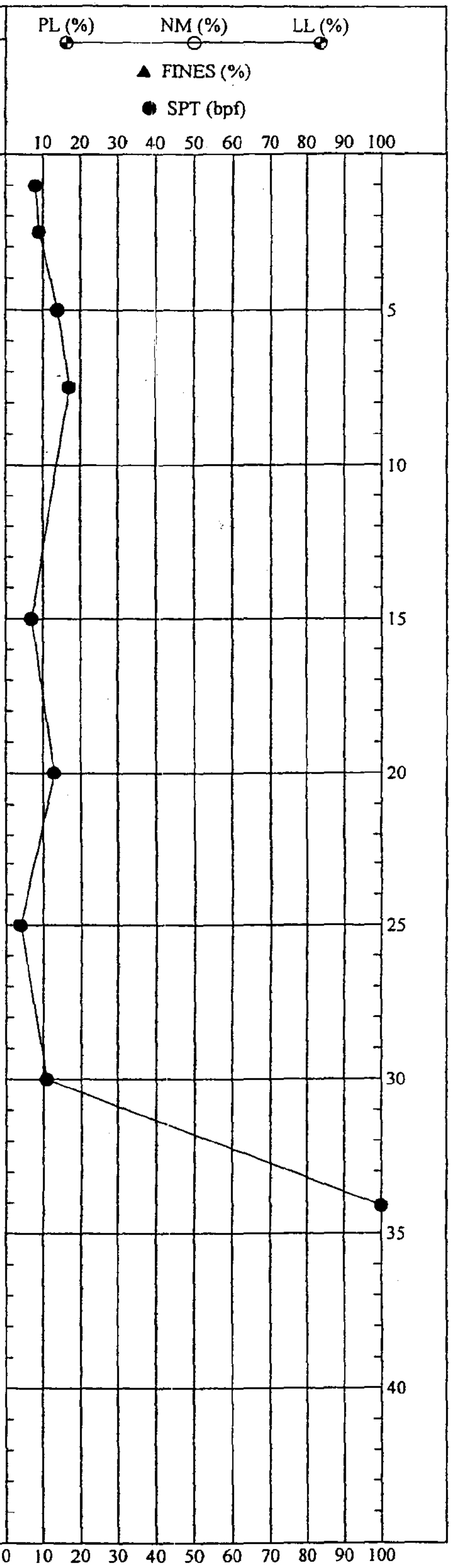
PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

MACTEC

SOIL 3047051064_01.GPJ LAW_GIBB.GDT 1/11/06

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)
0	TOPSOIL (0.5')
	FIRM, DARK RED BROWN, MOIST, SILTY CLAY WITH CHERT FRAGMENTS - FILL
	STIFF, DARK BROWN, CLAYEY SILT WITH SAND - RESIDUUM / POSSIBLE FILL
	STIFF TO VERY STIFF, DARK RED CLAY - RESIDUUM
	FIRM, RED BROWN, MOIST, SILTY CLAY WITH SAND - RESIDUUM
	STIFF, RED BROWN, MOIST TO WET, SANDY CLAYEY SILT - RESIDUUM
	SOFT, RED BROWN, MOIST TO WET, CLAYEY SILT WITH SAND AND WEATHERED SANDSTONE FRAGMENTS - RESIDUUM ▽
	STIFF, DARK BROWN, MOIST TO WET, SILTY CLAY WITH SAND AND DOLOMITE FRAGMENTS - RESIDUUM
	VERY HARD GRAY DOLOMITE FRAGMENTS - RESIDUUM
	AUGER REFUSAL AT 34.1'

DEPTH (ft)	ELEV (ft)	SAMPLE IDENT	N-COUNT (1st 6" 2nd 6" 3rd 6")
0	752.0		
		SPT-1	2-3-5
		SPT-2	4-3-6
5	747.0	SPT-3	7-6-8
		SPT-4	5-8-9
10	742.0	UD-1	1.9-2.0
15	737.0	SPT-5	3-4-3
		UD-2	2.0-2.0
20	732.0	SPT-6	4-7-6
25	727.0	SPT-7	4-2-2
30	722.0	SPT-8	WOH-4-7
		SPT-9	50/0.1
35	717.0		
40	712.0		
45	707.0		



REMARKS: STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING AN AUTOMATIC HAMMER.

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

Driller : Warren
Prepared By: Justice
Checked By: [signature]

SOIL TEST BORING RECORD

PROJECT: TVA Kingston

DRILLED: November 29, 2005 **BORING NO.:** NB-90

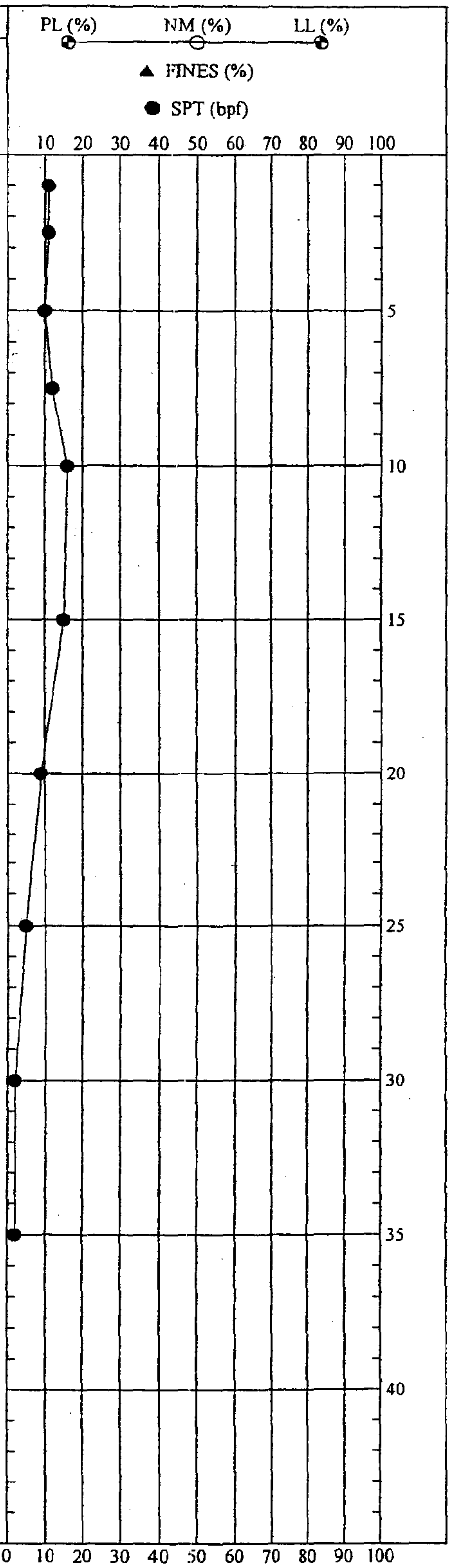
PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

MACTEC

SOIL 3047051064_01.GPJ LAW_GIBB.GDT 1/11/06

SOIL 3043051065401.GPJ LAW_GIBB.GDT 1/20/06

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	ELEV (ft)	IDENT	N-COUNT (1st 6" / 2nd 6" / 3rd 6")
0	TOPSOIL (0.3')	759.5		
	STIFF, RED BROWN, SLIGHTLY MOIST, CLAYEY SILT WITH SAND AND A FEW CHERT FRAGMENTS AND MANGANESE NODULES - RESIDUUM		SPT-1	7-5-6
			SPT-2	3-5-6
5		754.5	SPT-3	3-4-6
			SPT-4	4-5-7
	VERY STIFF, RED BROWN, SLIGHTLY MOIST, FAT CLAY WITH SAND AND A FEW CHERT FRAGMENTS - RESIDUUM			
10		749.5	SPT-5	4-7-9
	STIFF, BROWN AND YELLOWISH BROWN, SLIGHTLY MOIST, CLAYEY SILT WITH SAND AND A FEW CHERT FRAGMENTS - RESIDUUM		UD-1	2.0-2.0
15		744.5	SPT-6	4-7-8
20		739.5	SPT-7	3-4-5
	VERY SOFT TO FIRM, RED BROWN TO BROWN, MOIST TO WET, SILTY CLAY WITH OCCASIONAL CHERTY AND WEATHERED DOLOMITE ZONES - RESIDUUM			
25		734.5	SPT-8	3-2-3
30		729.5	SPT-9	1-1-1
35		724.5	SPT-10	1-1-1
	AUGER REFUSAL AT 38.9'			
40		719.5		
45		714.5		



REMARKS: STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING AN AUTOMATIC HAMMER.

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

Driller : Akins
Prepared By: Justice
Checked By: [signature]

SOIL TEST BORING RECORD

PROJECT: TVA Kingston Additional Geotech

DRILLED: January 12, 2006 **BORING NO.:** NB-91

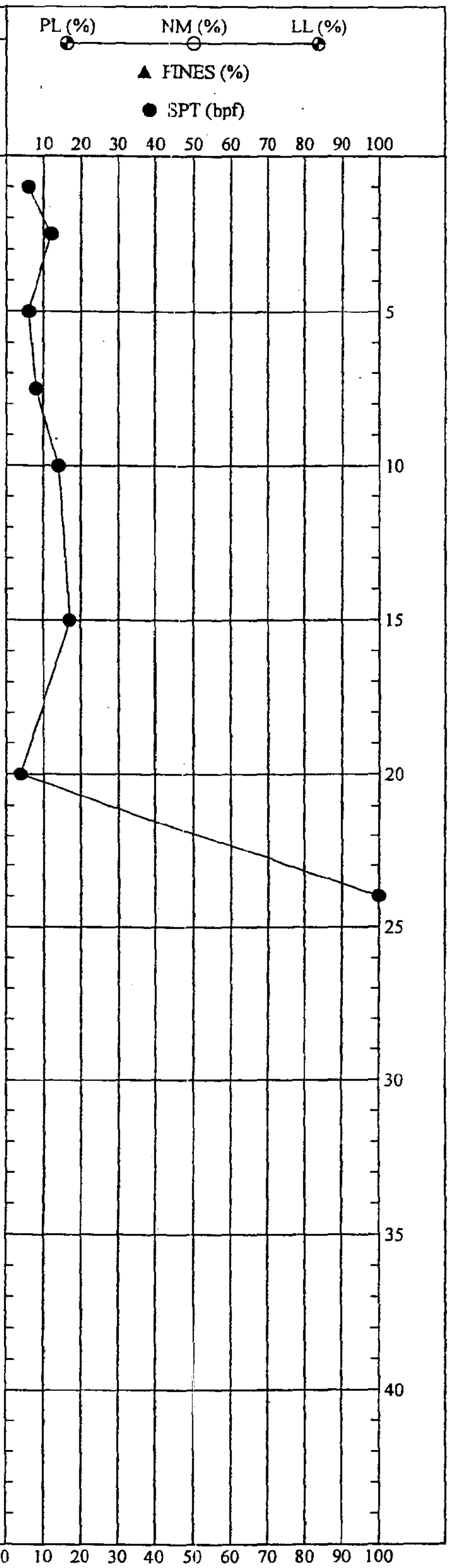
PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

MACTEC

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	ELEV (ft)
0	FIRM TO STIFF, DARK BROWN, SLIGHTLY MOIST, CLAYEY SILT WITH SAND AND CHERT FRAGMENTS - RESIDUUM / POSSIBLE ALLUVIUM	760.0
5		755.0
	FIRM, RED BROWN, SLIGHTLY MOIST, SILTY CLAY WITH CHERT FRAGMENTS - RESIDUUM	
	STIFF, RED BROWN, MOIST, SANDY CLAYEY SILT - RESIDUUM	
10		750.0
	VERY STIFF, RED BROWN, SLIGHTLY MOIST TO MOIST, SILTY CLAY WITH CHERT FRAGMENTS - RESIDUUM	
15		745.0
	∇	
	SOFT, DARK BROWN, MOIST TO WET, SILTY CLAY AND CHERT FRAGMENTS - RESIDUUM	
20		740.0
	AUGER REFUSAL AT 24.0'	
25		735.0
30		730.0
35		725.0
40		720.0
45		715.0

SAMPLES

IDENT	N-COUNT (1st 6" / 2nd 6" / 3rd 6")
SPT-1	9-4-2
SPT-2	4-7-5
SPT-3	5-2-4
SPT-4	4-4-4
SPT-5	5-6-8
UD-1	2.0-2.0
SPT-6	6-8-9
SPT-7	4-2-2
SPT-8	50/0.0



REMARKS: STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING AN AUTOMATIC HAMMER.

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Driller: Warren
Prepared By: Justice
Checked By: *[signature]*

SOIL TEST BORING RECORD

PROJECT: TVA Kingston

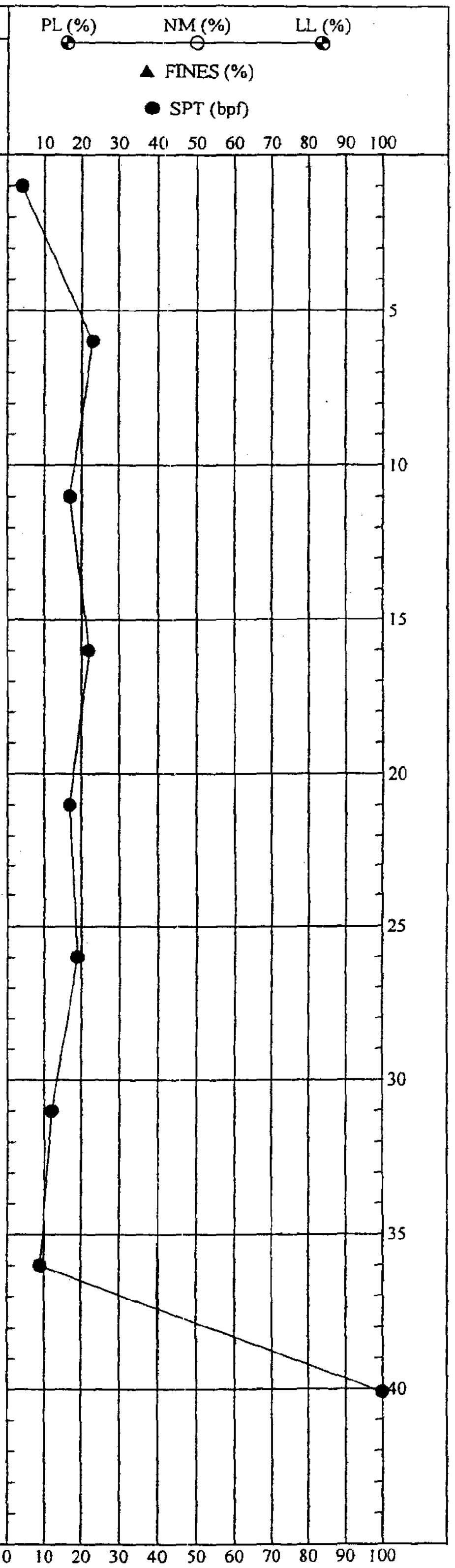
DRILLED: November 29, 2005 **BORING NO.:** NB-92

PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

MACTEC

SOIL 3047051064 01.GPJ LAW_GIBB.GDT 1/11/06

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	ELEV (ft)	SAMPLES IDENT	N-COUNT (1st 6" 2nd 6" 3rd 6")
0	TOPSOIL (0.2')	864.0		
	SOFT, RED, SLIGHTLY MOIST TO MOIST, CLAYEY SILT WITH A FEW FINE ROOTS - RESIDUUM		SPT-1	3-1-3
	STIFF TO VERY STIFF, REDDISH BROWN, REDDISH YELLOW TO BROWN, SLIGHTLY MOIST TO MOIST, FAT CLAY WITH A FEW CHERT FRAGMENTS AND BLACK MANGANESE STAINING - RESIDUUM			
5		859.0	SPT-2	3-11-12
10		854.0	SPT-3	8-6-11
15		849.0	SPT-4	8-9-13
20		844.0	SPT-5	7-8-9
25		839.0	SPT-6	6-9-10
30		834.0	SPT-7	4-6-6
35		829.0	SPT-8	4-4-5
40	VERY HARD, BROWN, WEATHERED DOLOMITE - RESIDUUM	824.0	SPT-9	50/0.1
	AUGER REFUSAL AT 40.1'			
45		819.0		



REMARKS: STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING AN AUTOMATIC HAMMER. NO GROUND WATER ENCOUNTERED AT TIME OF EXPLORATION.

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

Driller : Akins
Prepared By: Justice
Checked By: [signature]

SOIL TEST BORING RECORD

PROJECT: TVA Kingston Additional Geotech

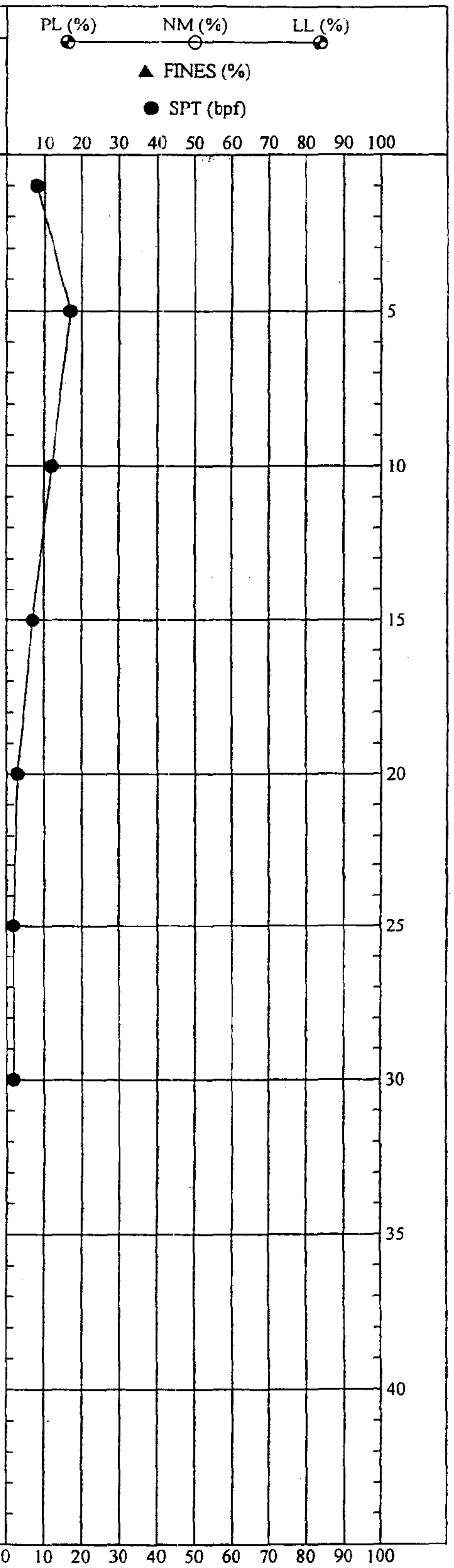
DRILLED: January 17, 2006 **BORING NO.:** NB-K

PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

MACTEC

SOIL 30430510654_01.GPJ LAW_GIBB.GDT 1/19/06

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	ELEV (ft)	SAMPLES IDENT	N-COUNT (1st 6" 2nd 6" 3rd 6")
0	TOPSOIL (0.2')	762.0		
	FIRM TO VERY STIFF, REDDISH BROWN TO REDDISH ORANGE, SLIGHTLY MOIST, CLAYEY (ELASTIC SILT) WITH A TRACE OF CHERT FRAGMENTS AND BLACK MANGANESE NODULES - RESIDUUM		SPT-1	2-3-5
5		757.0	SPT-2	6-7-10
	STIFF, REDDISH YELLOW, SLIGHTLY MOIST, CLAYEY (ELASTIC) SILT WITH SAND - RESIDUUM			
10		752.0	SPT-3	4-5-7
	SOFT TO FIRM, REDDISH YELLOW, SLIGHTLY MOIST TO MOIST, SANDY SILT WITH A TRACE OF BLACK MANGANESE STAINING - RESIDUUM			
15		747.0	SPT-4	3-3-4
20		742.0	SPT-5	1-2-1
	VERY SOFT, BROWN, VERY MOIST TO WET, SANDY SILT WITH CHERT FRAGMENTS - RESIDUUM			
25	∇	737.0	SPT-6	2-1-1
30		732.0	SPT-7	1-1-1
35		727.0	SPT-8	WOH-WOH-1
	BORING TERMINATED AT 35.5'			
40		722.0		
45		717.0		



REMARKS: STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING AN AUTOMATIC HAMMER.

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Driller : Akins
Prepared By: Justice
Checked By: [signature]

SOIL TEST BORING RECORD

PROJECT: TVA Kingston Additional Geotech

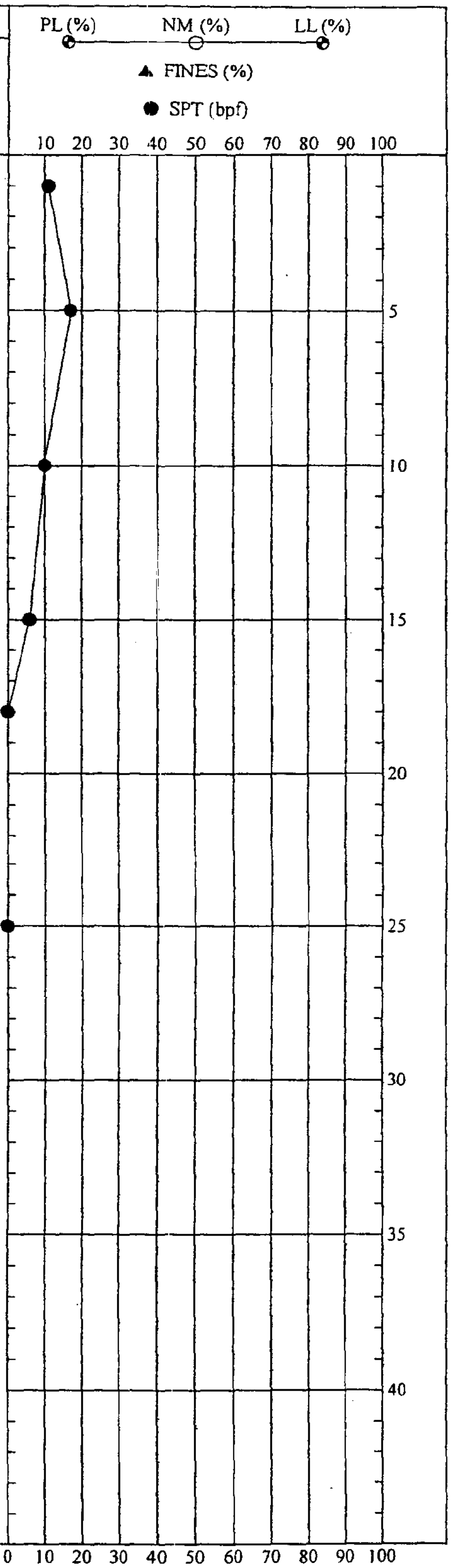
DRILLED: January 16, 2006 **BORING NO.:** MW-M

PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

MACTEC

SOIL 3043051064_01.GPJ LAW_GIBB.GDT 1/19/06

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	ELEV (ft)	IDENT	N-COUNT (1st 6" / 2nd 6" / 3rd 6")
0	TOPSOIL (0.3')	755.0		
	STIFF TO VERY STIFF, RED BROWN TO REDDISH ORANGE, SLIGHTLY MOIST, CLAYEY SILT WITH SAND - RESIDUUM		SPT-1	2-4-7
5		750.0	SPT-2	5-8-9
	FIRM TO STIFF, REDDISH-ORANGE TO YELLOW, SLIGHTLY MOIST TO MOIST, SANDY CLAYEY SILT - RESIDUUM			
10		745.0	SPT-3	3-5-5
15	VERY SOFT TO FIRM, BROWN, MOIST TO WET, SILTY CLAY WITH OCCASIONAL CHERT AND GRAVEL FRAGMENTS - RESIDUUM	740.0	SPT-4	3-3-3
			SPT-5	WOH
20		735.0		
25		730.0	SPT-6	WOH
	BORING TERMINATED AT 25.5'			
30		725.0		
35		720.0		
40		715.0		
45		710.0		



SOIL 30430510654_01.GPJ LAW_GIBB.GDT 1/20/06

REMARKS: STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING AN AUTOMATIC HAMMER.

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Driller : Akins
Prepared By: Justice
Checked By: [signature]

SOIL TEST BORING RECORD

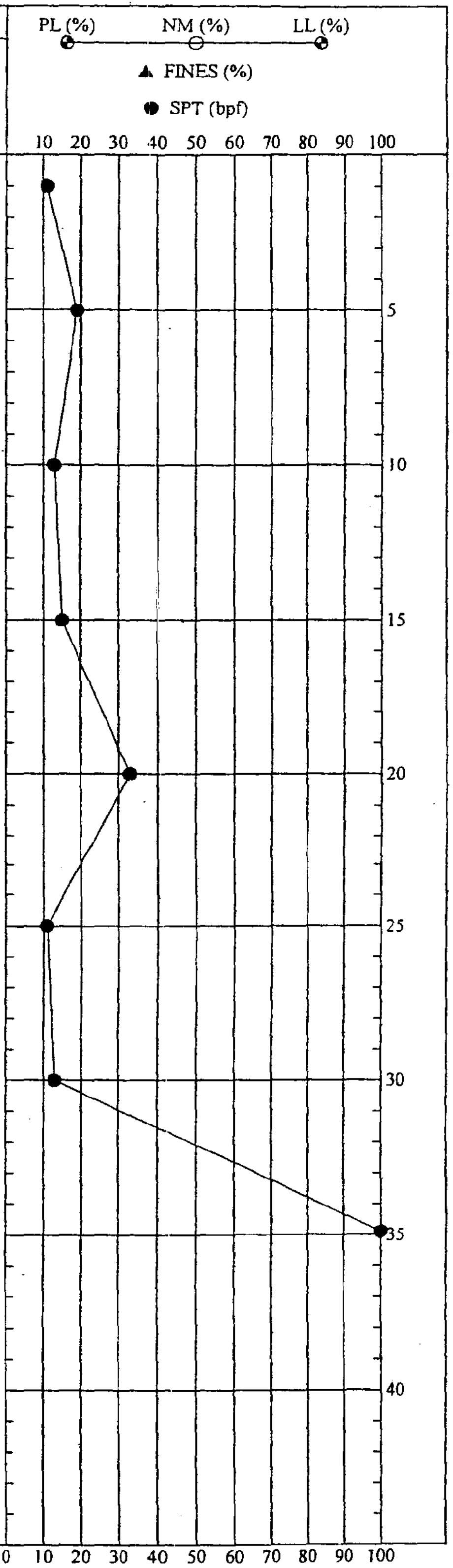
PROJECT: TVA Kingston Additional Geotech

DRILLED: January 12, 2006 **BORING NO.:** MW-N

PROJ. NO.: 3043051064/0001 **PAGE 1 OF 1**

MACTEC

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	ELEV (ft)	SAMPLES IDENT	N-COUNT (1st 6" / 2nd 6" / 3rd 6")
0	STIFF TO VERY STIFF, RED BROWN TO REDDISH ORANGE, SLIGHTLY MOIST, CLAYEY SILT - RESIDUUM	792.0	SPT-1	3-5-6
5		787.0	SPT-2	5-9-10
	STIFF, REDDISH ORANGE AND REDDISH YELLOW, SLIGHTLY MOIST, FAT CLAY WITH CHERT FRAGMENTS - RESIDUUM			
10		782.0	SPT-3	4-6-7
15		777.0	SPT-4	3-8-7
20	HARD, WHITE CHERT FRAGMENTS - RESIDUUM	772.0	SPT-5	6-20-13
	STIFF, BROWN TO YELLOW BROWN, SLIGHTLY MOIST TO MOIST, FAT CLAY WITH A FEW CHERT FRAGMENTS AND BLACK MANGANESE STAINING - RESIDUUM			
25		767.0	SPT-6	8-6-5
30		762.0	SPT-7	6-6-7
	VERY HARD, BROWNISH GRAY, DRY, DOLOMITE FRAGMENTS WITH SAND - RESIDUUM			
35	AUGER REFUSAL AT 35.0' BEGAN HQ CORING AT 35.0'	757.0	SPT-8	5-50/0.4
	SLIGHTLY TO MODERATELY WEATHERED, CLOSELY JOINTED, FINE GRAINED, GRAY TO DARK GRAY, HARD SILICEOUS **DOLOMITE**. SEVERAL JOINTS SETS OBSERVED, SOME OF WHICH GIVE THE CORE AN APPEARANCE OF HIGHLY FRACTURED ZONES.		RC-1	8-100
40	VERY SLIGHTLY WEATHERED, FINE GRAINED, LIGHT GRAY, HARD TO VERY HARD, **DOLOMITE**. OPEN JOINT SETS DISAPPEAR, A FEW BEDDING PLANE FRACTURES OBSERVED. BEDDING IS AT AN APPARENT DIP OF 30°.	752.0	RC-2	54-80
45		747.0		



SOIL 30430510654_01.GPJ LAW_GIBB.GDT 1/20/06

REMARKS: STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING AN AUTOMATIC HAMMER. NO GROUND WATER ENCOUNTERED AT TIME OF EXPLORATION.

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

Driller : Akins
Prepared By: Justice
Checked By: 𝒳OL

SOIL TEST BORING RECORD

PROJECT: TVA Kingston Additional Geotech

DRILLED: July 12, 2006 **BORING NO.:** MW-P

PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 2

MACTEC

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	ELEV (ft)	SAMPLES IDENT	N-COUNT (1st 6" 2nd 6" 3rd 6")
45	VERY SLIGHTLY WEATHERED, FINE GRAINED, LIGHT GRAY, HARD TO VERY HARD, **DOLOMITE**. OPEN JOINT SETS DISAPPEAR, A FEW BEDDING PLANE FRACTURES OBSERVED. BEDDING IS AT AN APPARENT DIP OF 30°.	747.0	RC-3	100-100
50		742.0		
55		737.0	RC-4	98-98
60	CORING TERMINATED 60.5'	732.0		
65		727.0		
70		722.0		
75		717.0		
80		712.0		
85		707.0		
90		702.0		

PL (%) NM (%) LL (%)
▲ FINES (%)
● SPT (bpf)
0 10 20 30 40 50 60 70 80 90 100

REMARKS: STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING AN AUTOMATIC HAMMER. NO GROUND WATER ENCOUNTERED AT TIME OF EXPLORATION.

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Driller : Akins
Prepared By: Justice
Checked By: [signature]

SOIL TEST BORING RECORD

PROJECT: TVA Kingston Additional Geotech

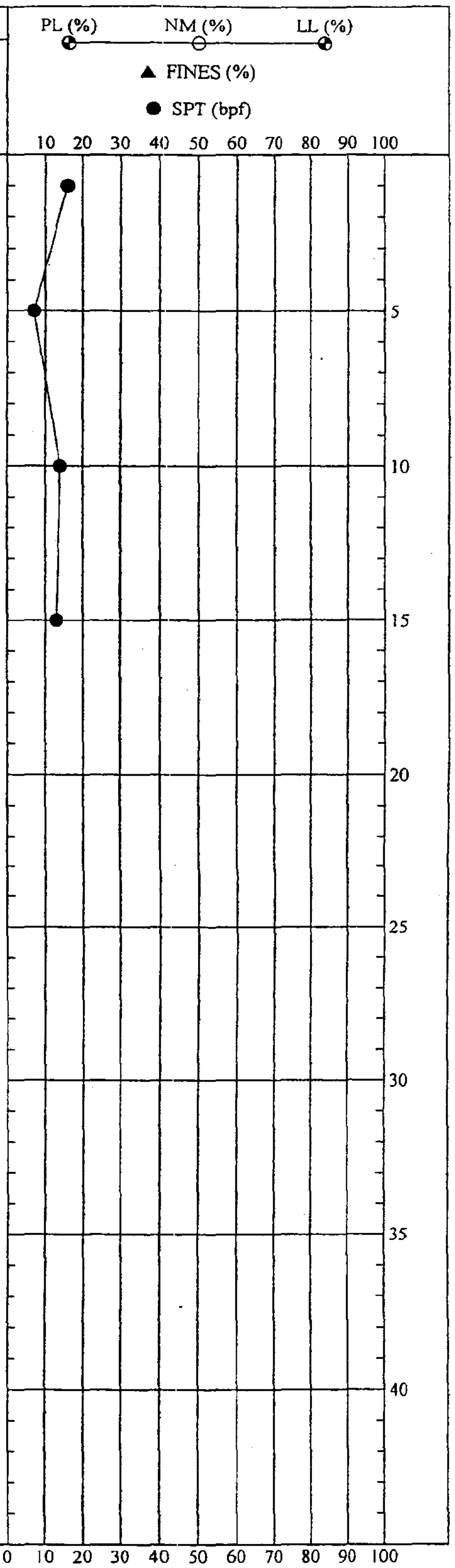
DRILLED: July 12, 2006 **BORING NO.:** MW-P

PROJ. NO.: 3043051064/0001 **PAGE** 2 **OF** 2

MACTEC

SOIL 3043051064 01.GPJ LAW GIBB.GDT 1/20/06

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	ELEV (ft)	SAMPLES IDENT	N-COUNT 1st 6" 2nd 6" 3rd 6"
0	VERY STIFF, RED BROWN, SLIGHTLY MOIST, SILTY CLAY WITH GRAVEL - FILL	756.0	SPT-1	4-9-7
	FIRM, RED, SLIGHTLY MOIST, CLAY - RESIDUUM			
5		751.0	SPT-2	4-3-4
	STIFF, RED, SLIGHTLY MOIST, CLAY - RESIDUUM			
10		746.0	SPT-3	4-7-7
			UD-1	2.0-2.0
15		741.0	SPT-4	4-6-7
	BORING TERMINATED AT 15.5'			
20		736.0		
25		731.0		
30		726.0		
35		721.0		
40		716.0		
45		711.0		



SOIL 3047051064 01.GPJ LAW_GIBB.GDT 1/11/06

REMARKS: STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING AN AUTOMATIC HAMMER. NO GROUND WATER ENCOUNTERED AT TIME OF EXPLORATION.

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Driller : Marshall
Prepared By: M.O.
Checked By: [signature]

SOIL TEST BORING RECORD

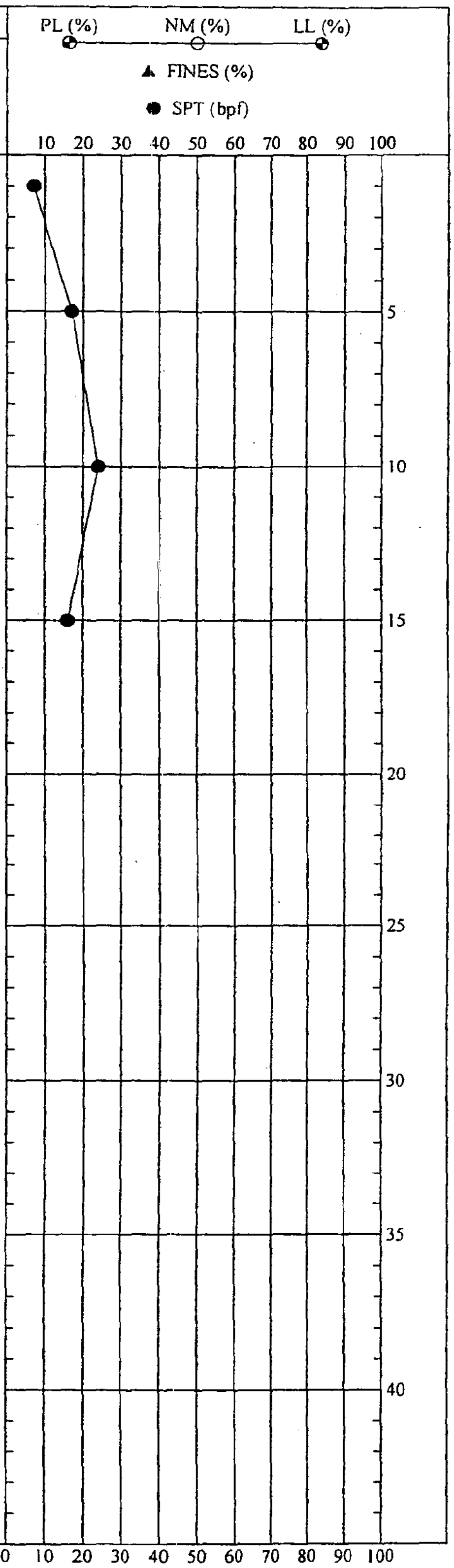
PROJECT: TVA Kingston

DRILLED: November 18, 2005 **BORING NO.:** K-1

PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

MACTEC

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	ELEV (ft)	SAMPLES IDENT	TYPE	N-COUNT (1st 6" - 2nd 6" - 3rd 6")
0	TOPSOIL (0.3')	755.0			
	FIRM, RED, SLIGHTLY MOIST, SILTY CLAY - RESIDUUM		SPT-1		3-3-4
	VERY STIFF, RED TO ORANGE, SLIGHTLY MOIST, SILTY CLAY WITH CHERT FRAGMENTS - RESIDUUM				
5		750.0	SPT-2		5-7-10
	VERY STIFF, ORANGE TO TAN MOTTLED, SLIGHTLY MOIST, SILTY CLAY - RESIDUUM				
10		745.0	SPT-3		8-11-13
	VERY STIFF, RED TO ORANGE TO BROWN MOTTLED, SLIGHTLY MOIST, CLAYEY SILT WITH WEATHERED CHERT FRAGMENTS AND SOME SAND LAYERS - RESIDUUM		UD-1		1.8-2.0
15		740.0	SPT-4		7-7-9
	BORING TERMINATED AT 15.5'				
20		735.0			
25		730.0			
30		725.0			
35		720.0			
40		715.0			
45		710.0			



SOIL 3047051064 01.GPJ LAW_GIBB.GDT 1/11/06

REMARKS: STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING AN AUTOMATIC HAMMER. NO GROUND WATER ENCOUNTERED AT TIME OF EXPLORATION.

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Driller : Marshall
Prepared By: M.O.
Checked By: [signature]

SOIL TEST BORING RECORD

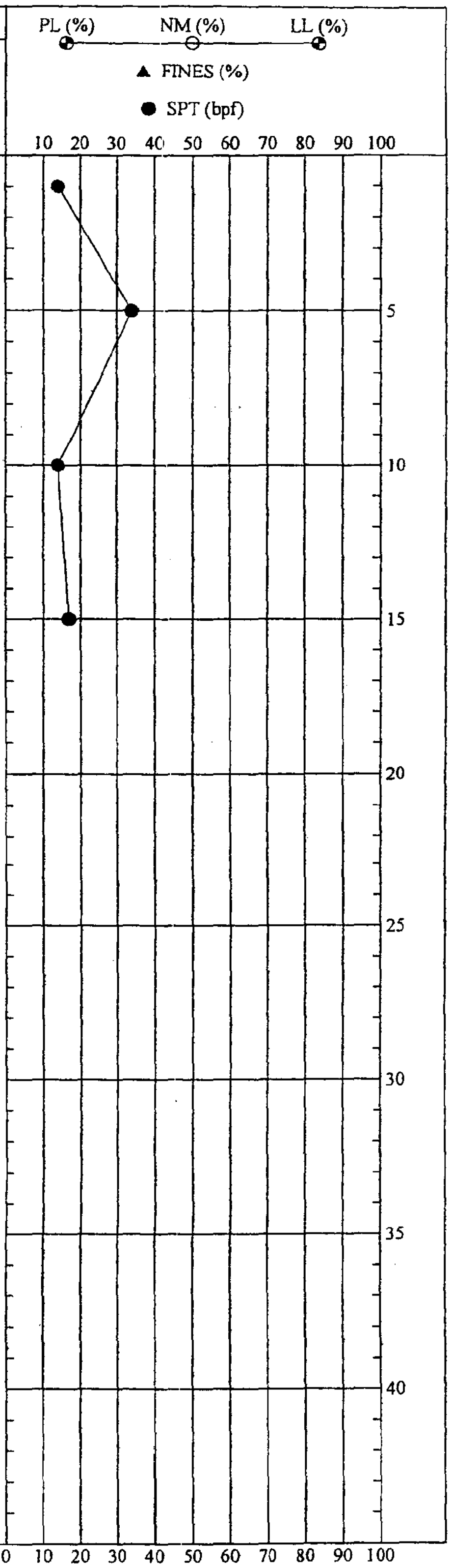
PROJECT: TVA Kingston

DRILLED: November 23, 2005 **BORING NO.:** K-2

PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

MACTEC

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	TYPE	N-COUNT (1st 6" / 2nd 6" / 3rd 6")
0	TOPSOIL (0.2')		792.0			
	STIFF, REDDISH TO ORANGE, SLIGHTLY MOIST, SILTY CLAY - RESIDUUM			SPT-1		5-5-9
	HARD, REDDISH ORANGE TO TAN MOTTLED, DRY TO SLIGHTLY MOIST, SILTY CLAY WITH CHERT FRAGMENTS - RESIDUUM					
5			787.0	SPT-2		7-11-23
	STIFF, RED AND BROWN, DRY TO SLIGHTLY MOIST, SILTY CLAY WITH CHERT FRAGMENTS - RESIDUUM					
10			782.0	SPT-3		6-6-8
	VERY STIFF, REDDISH BROWN MOTTLED, SLIGHTLY MOIST CLAYEY SILT WITH CHERT FRAGMENTS - RESIDUUM					
15			777.0	SPT-4		6-7-10
	BORING TERMINATED AT 15.5'					
20			772.0			
25			767.0			
30			762.0			
35			757.0			
40			752.0			
45			747.0			



REMARKS: STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING AN AUTOMATIC HAMMER. NO GROUND WATER ENCOUNTERED AT TIME OF EXPLORATION.

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Driller : Marshall
Prepared By: M.O.
Checked By: [signature]

SOIL TEST BORING RECORD

PROJECT: TVA Kingston

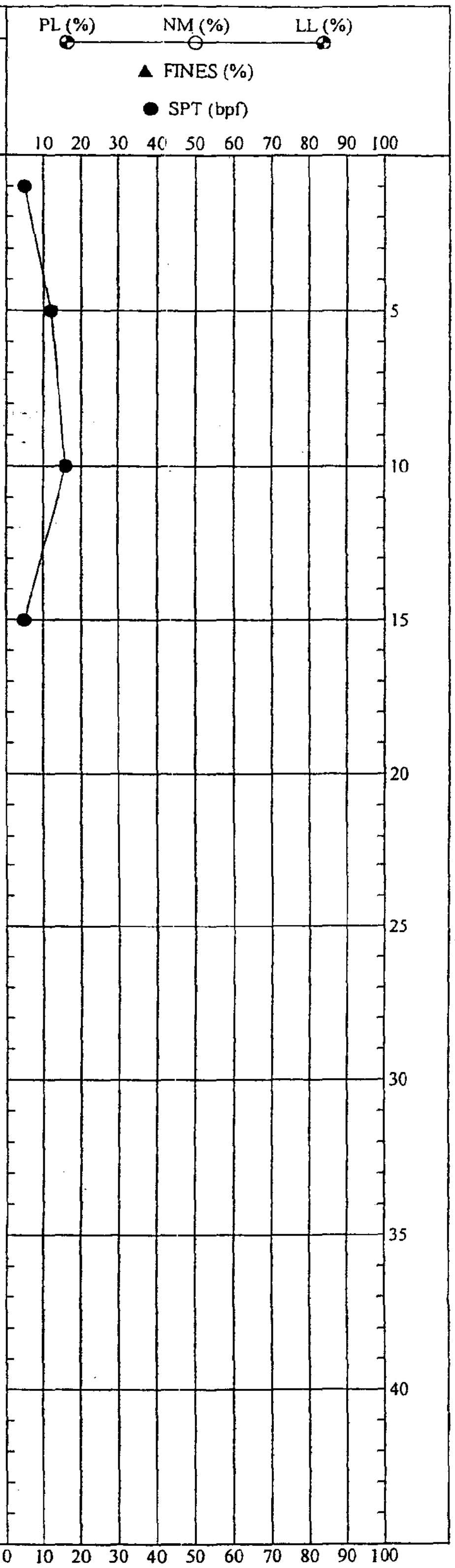
DRILLED: November 15, 2005 **BORING NO.:** K-3

PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

MACTEC

SOIL_3047051064_01.GPJ LAW_GIBB.GDT 1/11/06

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	ELEV (ft)	SAMPLES IDENT	N-COUNT (1st 6" - 2nd 6" - 3rd 6")
0	TOPSOIL (0.4')	750.0		
	FIRM, BROWN, MOIST, SILTY CLAY - RESIDUUM		SPT-1	3-2-3
	STIFF, RED, ORANGE, TAN MOTTLED, MOIST, SILTY CLAY WITH MANGANESE - RESIDUUM			
5		745.0	SPT-2	4-5-7
	VERY STIFF, ORANGE, SLIGHTLY MOIST, SANDY SILT - RESIDUUM			
10		740.0	SPT-3	6-7-9
	LOOSE, TAN, VERY WET, SILTY SAND - RESIDUUM		UD-1	1.7-2.0
15	∇	735.0	SPT-4	2-2-3
	BORING TERMINATED AT 15.5'			
20		730.0		
25		725.0		
30		720.0		
35		715.0		
40		710.0		
45		705.0		



SOIL 3047051064_01.GPJ LAW_GIBB.GDT 1/11/06

REMARKS: STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING AN AUTOMATIC HAMMER.

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

Driller : Marshall
Prepared By: M.O.
Checked By: [signature]

SOIL TEST BORING RECORD

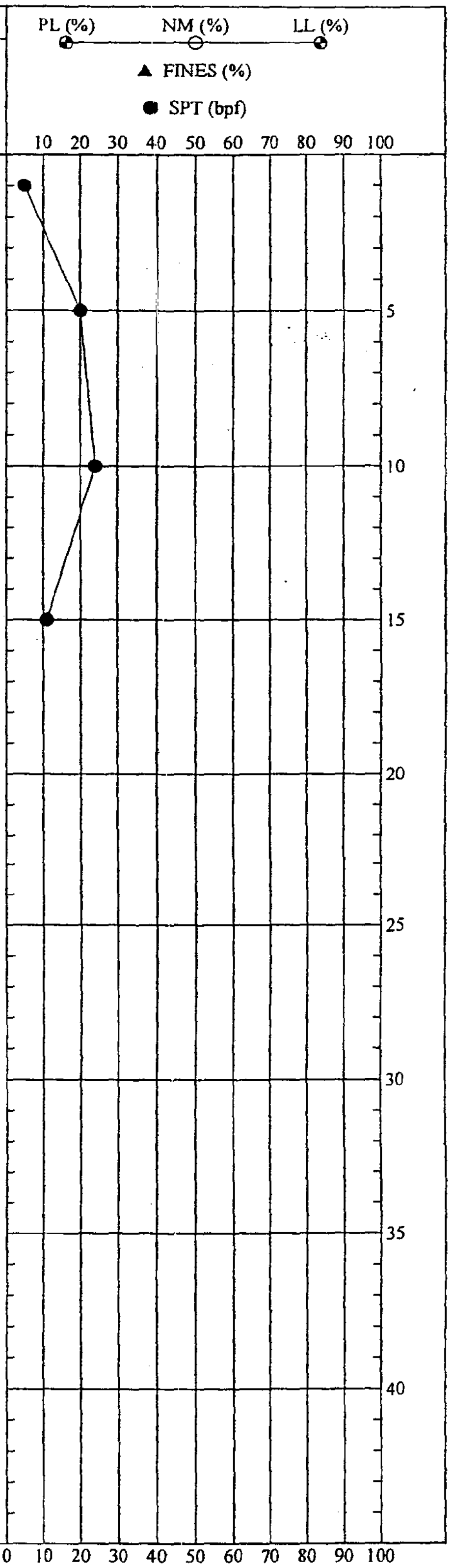
PROJECT: TVA Kingston

DRILLED: November 22, 2005 **BORING NO.:** K-4

PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

MACTEC

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	ELEV (ft)	SAMPLES IDENT	N-COUNT (1st 6" 2nd 6" 3rd 6")
0	TOPSOIL (0.6')	752.0		
	FIRM, ORANGE TO BROWN, MOIST, SILTY CLAY - RESIDUUM		SPT-1	2-2-3
	VERY STIFF, ORANGE TO BROWN, SLIGHTLY MOIST, SILTY CLAY - RESIDUUM			
5		747.0	SPT-2	6-9-11
	VERY STIFF, BROWN TO RED, SLIGHTLY MOIST, SILTY CLAY WITH CHERT FRAGMENTS - RESIDUUM			
10		742.0	SPT-3	10-11-13
	STIFF, BROWN TO RED MOTTLED, SLIGHTLY MOIST, CLAYEY SILT WITH CHERT FRAGMENTS AND MANGANESE STAINING - RESIDUUM		UD-1	1.5-2.0
15		737.0	SPT-4	7-5-6
	BORING TERMINATED AT 15.5'			
20		732.0		
25		727.0		
30		722.0		
35		717.0		
40		712.0		
45		707.0		



REMARKS: STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING AN AUTOMATIC HAMMER. NO GROUND WATER ENCOUNTERED AT TIME OF EXPLORATION.

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Driller : Marshall
Prepared By: M.O.
Checked By: [signature]

SOIL TEST BORING RECORD

PROJECT: TVA Kingston

DRILLED: November 23, 2005 **BORING NO.:** K-5

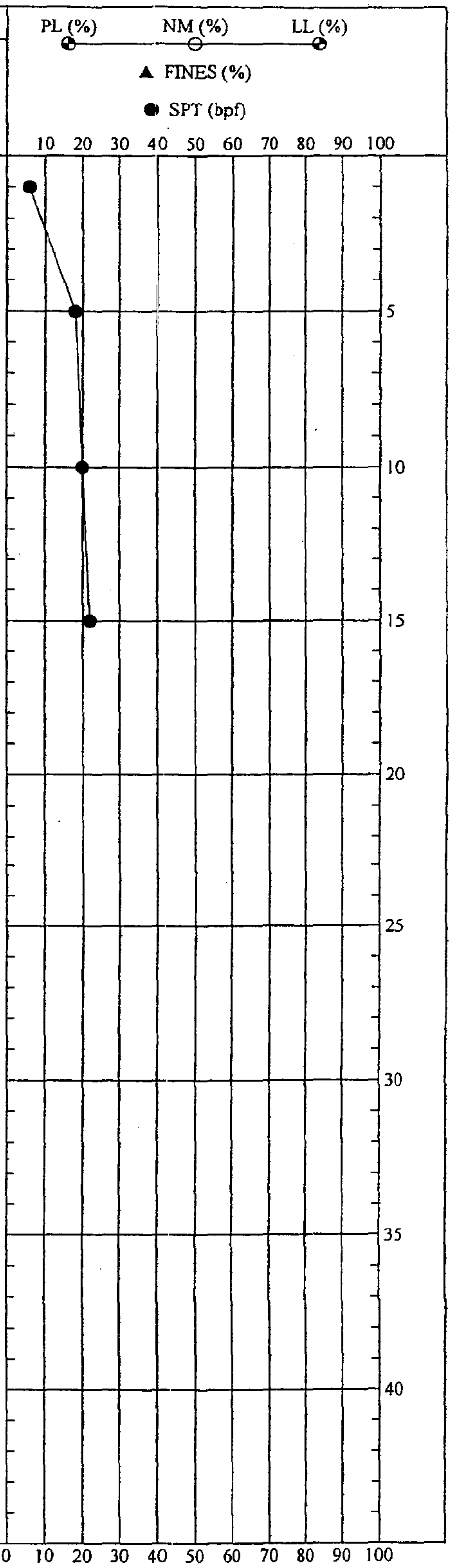
PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

MACTEC

SOIL 3047051064_01.GPJ LAW_GIBB.GDT 1/11/06

SOIL TEST BORING RECORD

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	ELEV (ft)	SAMPLES IDENT	N-COUNT (1st 6" - 2nd 6" - 3rd 6")
0	TOPSOIL (0.2')	766.0		
	FIRM, DARK BROWN, SLIGHTLY MOIST, SILTY CLAY WITH ROOTS - RESIDUUM		SPT-1	3-3-3
	VERY STIFF, RED, DRY TO SLIGHTLY MOIST, SILTY CLAY - RESIDUUM			
5		761.0	SPT-2	5-8-10
	VERY STIFF, RED, SLIGHTLY MOIST, SILTY CLAY - RESIDUUM			
10		756.0	SPT-3	7-9-11
	VERY STIFF, RED, SLIGHTLY MOIST, CLAYEY SILT WITH CHERT FRAGMENTS - RESIDUUM			
15		751.0	SPT-4	8-10-12
	BORING TERMINATED AT 15.5'			
20		746.0		
25		741.0		
30		736.0		
35		731.0		
40		726.0		
45		721.0		



SOIL_3047051064_01.GPJ LAW_GIBB.GDT 1/11/06

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Driller : Marshall
Prepared By: M.O.
Checked By: [signature]

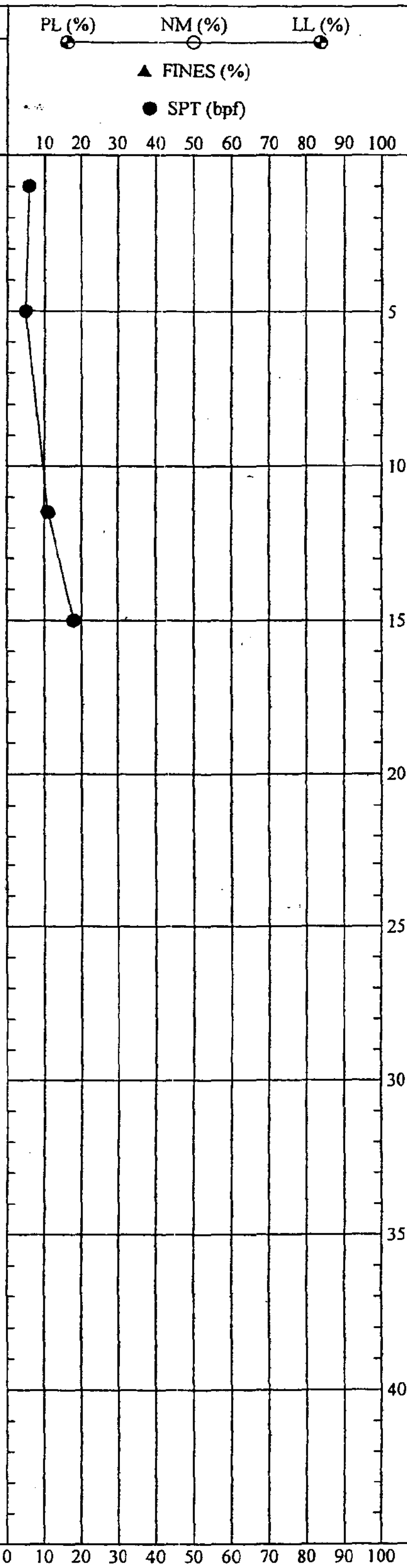
PROJECT: TVA Kingston

DRILLED: November 15, 2005 **BORING NO.:** K-6

PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

MACTEC

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	ELEV (ft)	SAMPLES IDENT	N-COUNT (1st 6" - 2nd 6" - 3rd 6")
0	TOPSOIL (0.5')	767.0		
	FIRM, BROWN, SLIGHTLY MOIST TO MOIST, SILTY CLAY - RESIDUUM		SPT-1	3-3-3
5		762.0	SPT-2	3-2-3
	STIFF TO VERY STIFF, REDDISH ORANGE, MOIST, SILTY CLAY - RESIDUUM			
10		757.0		
			SPT-3	3-5-6
15		752.0	SPT-4	9-9-9
	BORING TERMINATED AT 15.5'			
20		747.0		
25		742.0		
30		737.0		
35		732.0		
40		727.0		
45		722.0		



SOIL 3047051064_01.GPJ LAW_GIBB.GDT 1/11/06

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Driller : Marshall
Prepared By: M.O.
Checked By: [signature]

SOIL TEST BORING RECORD

PROJECT: TVA Kingston

DRILLED: November 22, 2005 **BORING NO.:** K-7

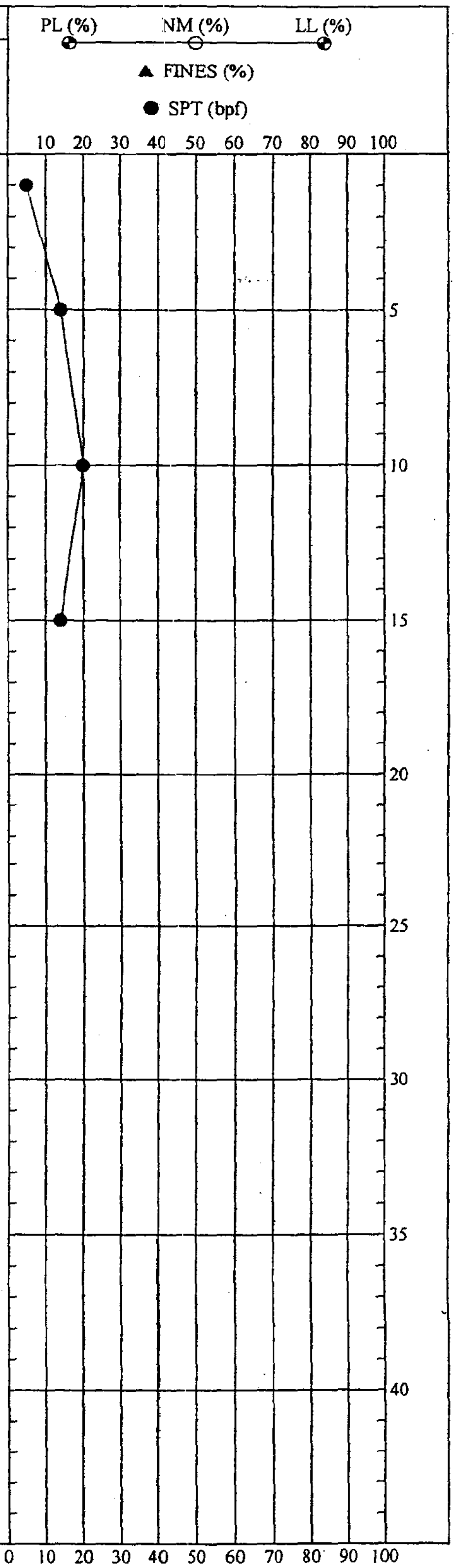
PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

MACTEC

SOIL TEST BORING RECORD

SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS	ELEV (ft)	SAMPLES IDENT	N-COUNT (1st 6" - 2nd 6" - 3rd 6")
0	TOPSOIL (0.8')	764.0		
	FIRM, RED,MOIST, SILTY CLAY - RESIDUUM		SPT-1	3-2-3
	STIFF, ORANGE TO TAN MOTTLED, SLIGHTLY MOIST, SILTY CLAY WITH WEATHERED CHERT FRAGMENTS- RESIDUUM			
5		759.0	SPT-2	3-8-6
	VERY STIFF, ORANGE, SLIGHTLY MOIST TO MOIST, SILTY CLAY WITH CHERT FRAGMENTS - RESIDUUM			
10		754.0	SPT-3	6-8-12
	STIFF, RED, SLIGHTLY MOIST, CLAY WITH CHERT FRAGMENTS AND MANGANESE LAYERS - RESIDUUM			
15		749.0	SPT-4	4-5-9
	BORING TERMINATED AT 15.5'			
20		744.0		
25		739.0		
30		734.0		
35		729.0		
40		724.0		
45		719.0		



SOIL 3047051064_01.GPJ LAW_GIBB.GDT 1/11/06

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Driller : Marshall
Prepared By: M.O.
Checked By: [signature]

SOIL TEST BORING RECORD

PROJECT: TVA Kingston

DRILLED: November 22, 2005 **BORING NO.:** K-8

PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

MACTEC

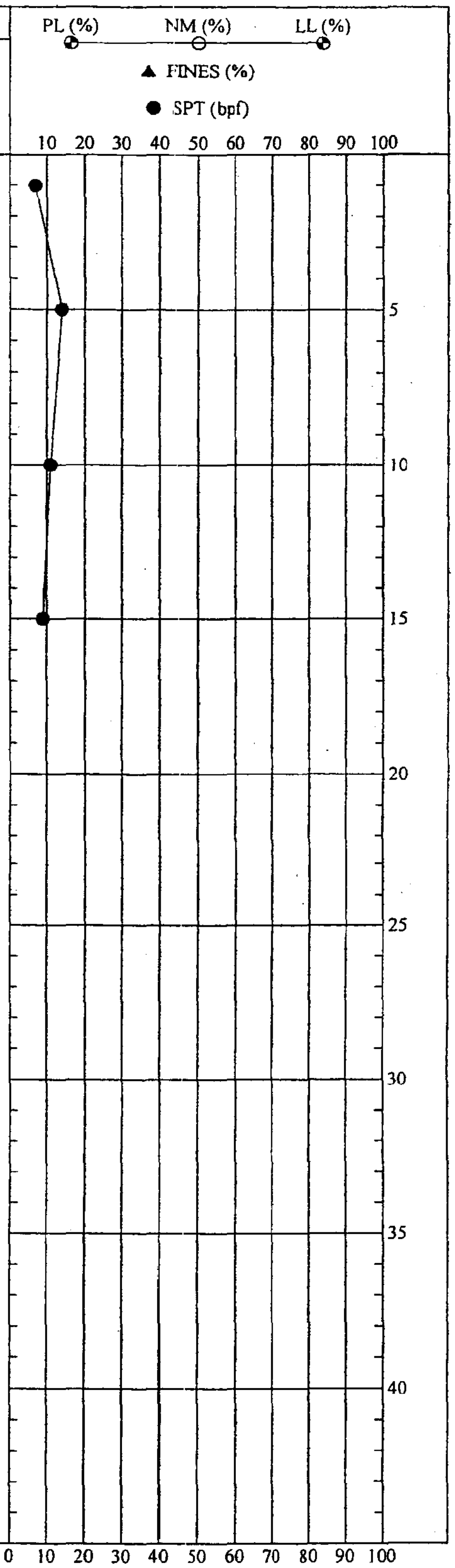
SOIL CLASSIFICATION AND REMARKS

SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS	ELEV (ft)
0	TOPSOIL (0.2')	756.0
	FIRM, RED, SLIGHTLY MOIST, SILTY CLAY WITH ROOTS - RESIDUUM	
	STIFF, RED, SLIGHTLY MOIST, SILTY CLAY - RESIDUUM	
5		751.0
	STIFF, REDDISH ORANGE TO TAN, SLIGHTLY MOIST, SILTY CLAY - RESIDUUM	
10		746.0
	STIFF, REDDISH ORANGE TO TAN, MOIST, CLAY WITH WEATHERED CHERT FRAGMENTS - RESIDUUM	
15		741.0
	BORING TERMINATED AT 15.5'	
20		736.0
25		731.0
30		726.0
35		721.0
40		716.0
45		711.0

SAMPLES

IDENT	N-COUNT (1st 6" - 2nd 6" - 3rd 6")
SPT-1	3-3-4
SPT-2	5-6-8
SPT-3	5-6-5
UD-1	1.6-2.0
SPT-4	3-3-6



REMARKS: STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING AN AUTOMATIC HAMMER. NO GROUND WATER ENCOUNTERED AT TIME OF EXPLORATION.

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Driller : Warren
Prepared By: M.O.
Checked By: [signature]

SOIL TEST BORING RECORD

PROJECT: TVA Kingston

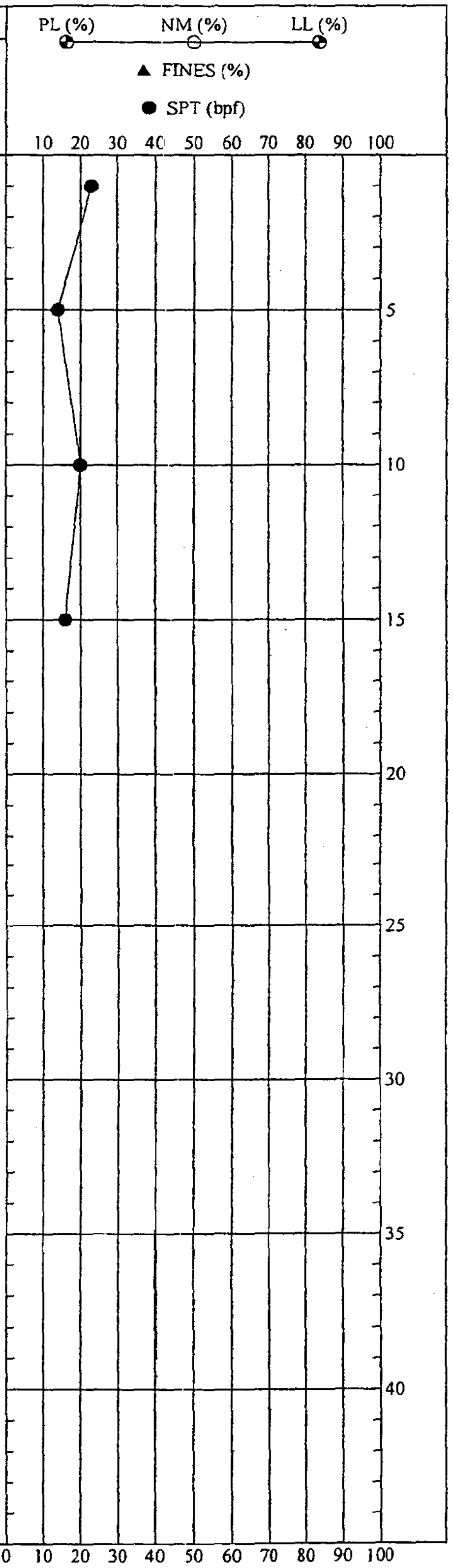
DRILLED: November 18, 2005 **BORING NO.:** K-9

PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

MACTEC

SOIL 3047051064_01.GPJ LAW_GIBB.GDT 1/11/06

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	ELEV (ft)	SAMPLES IDENT	N-COUNT (1st 6" 2nd 6" 3rd 6")
0	TOPSOIL (0.2')	756.0		
	VERY STIFF, REDDISH ORANGE, SLIGHTLY MOIST, SILTY CLAY WITH GRAVEL - FILL		SPT-1	5-11-12
	STIFF, REDDISH ORANGE, SLIGHTLY MOIST, CLAY - RESIDUUM			
5		751.0	SPT-2	6-7-7
	VERY STIFF, REDDISH ORANGE TO TAN MOTTLED, MOIST, SILTY CLAY - RESIDUUM			
10		746.0	SPT-3	6-9-11
			UD-1	1.7-2.0
15		741.0	SPT-4	6-8-8
	BORING TERMINATED AT 15.5'			
20		736.0		
25		731.0		
30		726.0		
35		721.0		
40		716.0		
45		711.0		



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Driller : Marshall
Prepared By: M.O.
Checked By: [signature]

SOIL TEST BORING RECORD

PROJECT: TVA Kingston

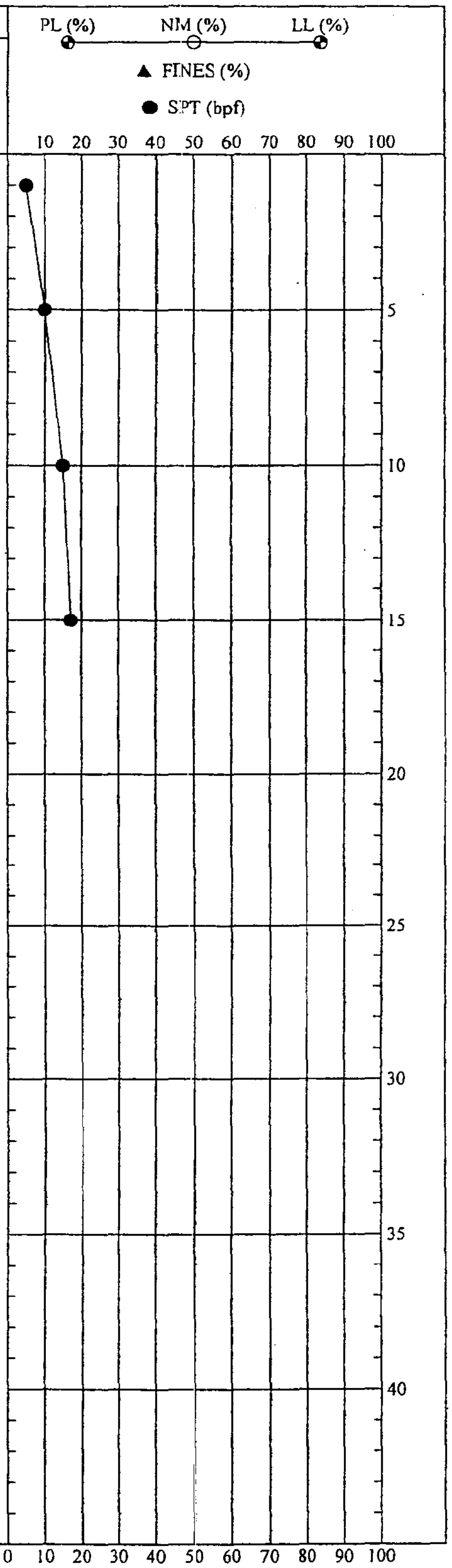
DRILLED: November 22, 2005 **BORING NO.:** K-10

PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

MACTEC

SOIL 3047051064 01.GPJ LAW GIBB.GDT 1/11/06

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	ELEV (ft)	SAMPLES IDENT	N-COUNT (1st 6" - 2nd 6" - 3rd 6")
0	TOPSOIL (0.5')	749.5		
	FIRM, DARK BROWN, SILT WITH FINE ROOTS - RESIDUUM / POSSIBLE ALLUVIUM		SPT-1	4-2-3
	STIFF, RED BROWN, SLIGHTLY MOIST, SILTY CLAY WITH SAND - RESIDUUM			
5		744.5	SPT-2	4-6-4
	STIFF, RED BROWN, SLIGHTLY MOIST TO MOIST, SILTY CLAY - RESIDUUM			
10		739.5	SPT-3	5-8-7
	VERY STIFF, DARK BROWN AND BROWN, SANDY CLAY - RESIDUUM		UD-1	1.45-2.0
15		734.5	SPT-4	7-8-9
	BORING TERMINATED AT 15.5'			
20		729.5		
25		724.5		
30		719.5		
35		714.5		
40		709.5		
45		704.5		



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Driller : Warren
Prepared By: Justice
Checked By: [signature]

SOIL TEST BORING RECORD

PROJECT: TVA Kingston

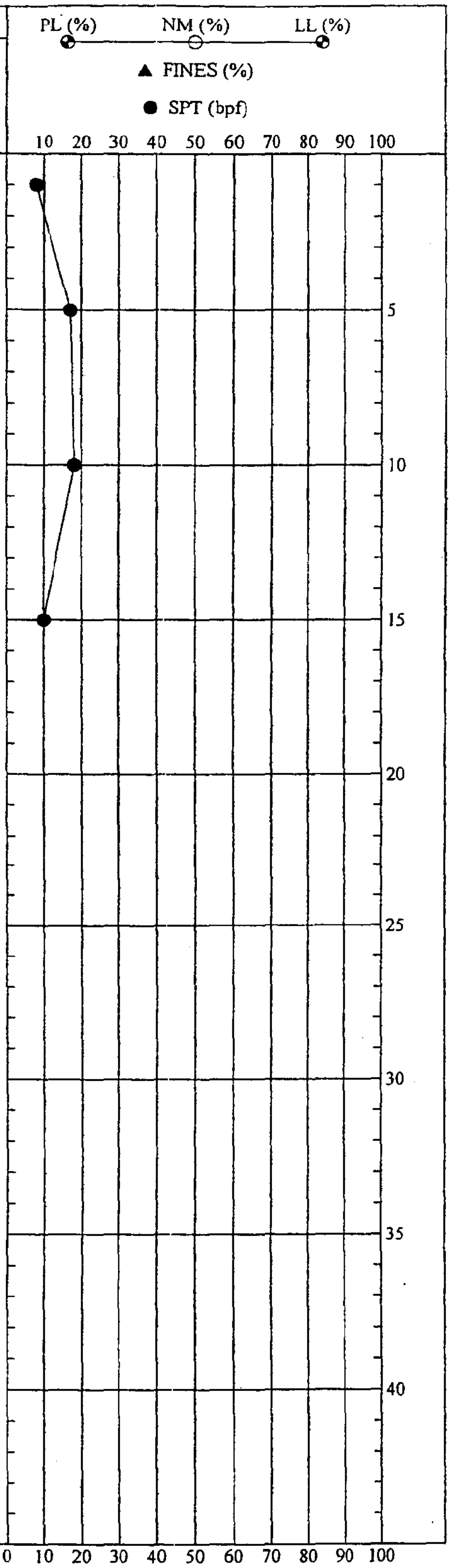
DRILLED: November 30, 2005 **BORING NO.:** K-11

PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

MACTEC

SOIL 3047051064_01.GPJ LAW GIBB.GDT 1/11/06

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	TYPE	N-COUNT (1st 6" 2nd 6" 3rd 6")
0	TOPSOIL (0.5')		762.0			
	FIRM TO STIFF, RED, SLIGHTLY MOIST, SILTY CLAY - RESIDUUM			SPT-1		2-3-5
	VERY STIFF, RED, SLIGHTLY MOIST, SILTY CLAY WITH CHERT FRAGMENTS - RESIDUUM					
5			757.0	SPT-2		3-9-8
	VERY STIFF, RED TO TAN MOTTLED, SLIGHTLY MOIST, SILTY CLAY WITH CHERT FRAGMENTS - RESIDUUM					
10			752.0	SPT-3		5-9-9
	STIFF, ORANGE TO TAN, SLIGHTLY MOIST, SILTY CLAY - RESIDUUM			UD-1		1.9-2.0
15			747.0	SPT-4		3-4-6
	BORING TERMINATED AT 15.5'					
20			742.0			
25			737.0			
30			732.0			
35			727.0			
40			722.0			
45			717.0			



SOIL 3047051064_01.GPJ LAW_GIBB.GDT 1/11/06

REMARKS: STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING AN AUTOMATIC HAMMER. NO GROUND WATER ENCOUNTERED AT TIME OF EXPLORATION.

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Driller: Warren
Prepared By: M.O.
Checked By: [signature]

SOIL TEST BORING RECORD

PROJECT: TVA Kingston

DRILLED: November 18, 2005 **BORING NO.:** K-12

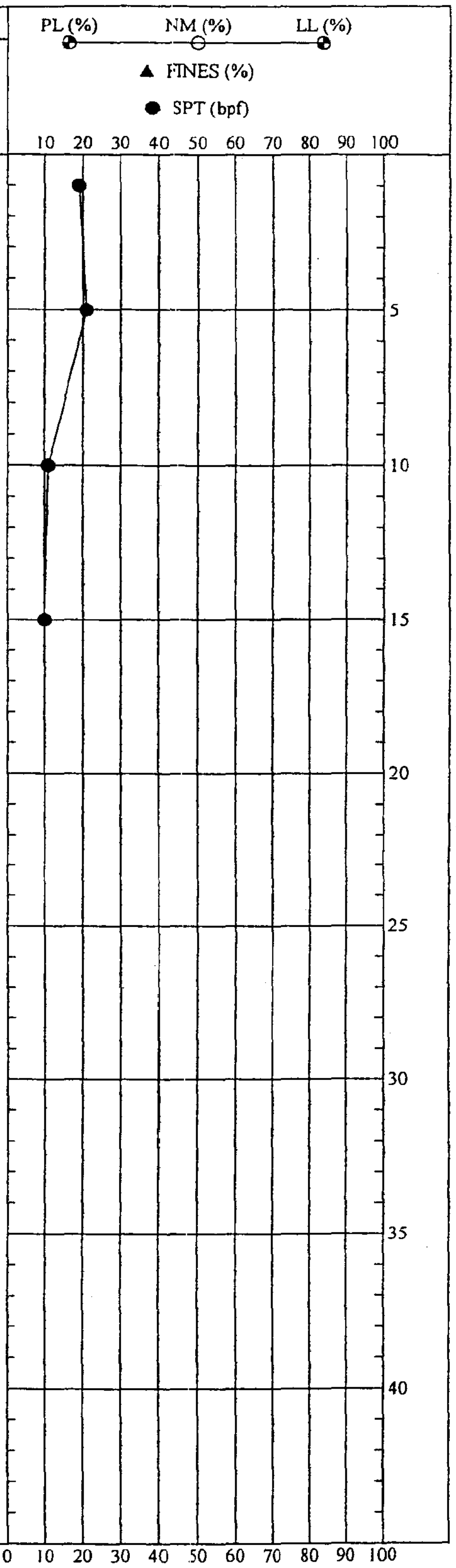
PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

MACTEC

SOIL TEST BORING RECORD

SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS	ELEV (ft)	IDENT	N-COUNT (1st 6" - 2nd 6" - 3rd 6")
0	VERY STIFF, RED, DRY TO SLIGHLTY MOIST, CLAY WITH CHERT FRAGMENTS - RESIDUUM	778.0	SPT-1	10-9-10
	VERY STIFF, RED TO ORANGE, DRY TO SLIGHTLY MOIST, SILTY CLAY WITH CHERT FRAGMENTS - RESIDUUM			
5		773.0	SPT-2	10-9-12
	STIFF, RED, SLIGHTLY MOIST, SILTY CLAY WITH CHERT FRAGMENTS - RESIDUUM			
10		768.0	SPT-3	4-6-5
	STIFF, RED TO ORANGE, SLIGHTLY MOIST, CLAYEY SILT WITH CHERT FRAGMENTS - RESIDUUM		UD-1	1.5-2.0
15		763.0	SPT-4	4-5-5
	BORING TERMINATED AT 15.5'			
20		758.0		
25		753.0		
30		748.0		
35		743.0		
40		738.0		
45		733.0		



REMARKS: STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING AN AUTOMATIC HAMMER. NO GROUND WATER ENCOUNTERED AT TIME OF EXPLORATION.

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Driller : Warren
Prepared By: M.O.
Checked By: [signature]

PROJECT: TVA Kingston

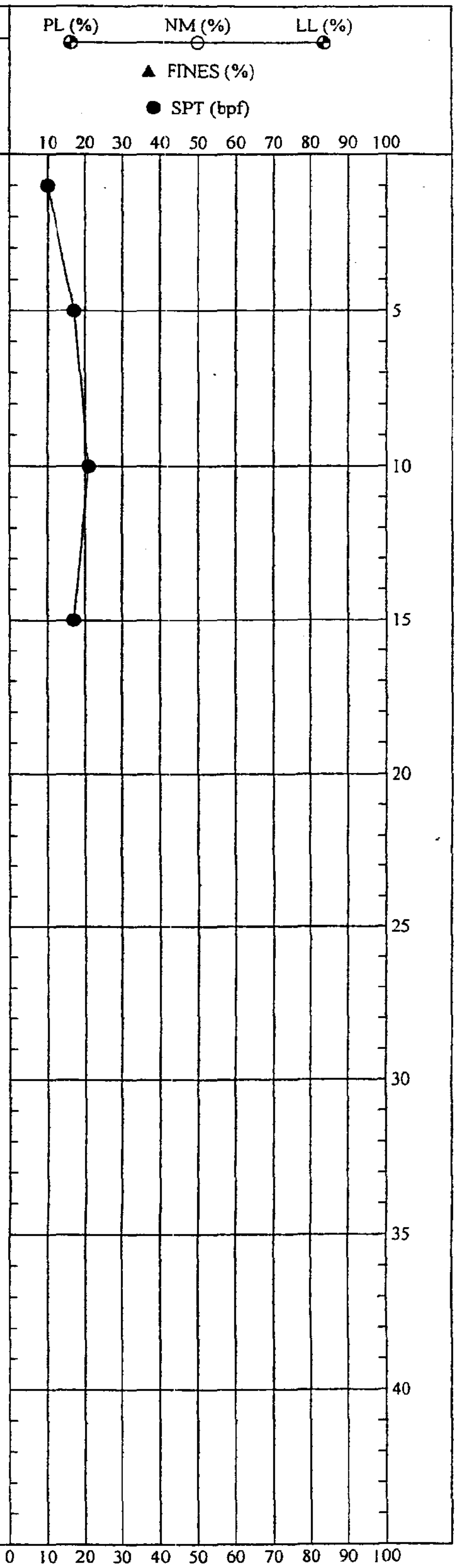
DRILLED: November 18, 2005 **BORING NO.:** K-13

PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

MACTEC

SOIL 3047051064_01.GPJ LAW_GIBB.GDT 1/11/06

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	ELEV (ft)	SAMPLES IDENT	N-COUNT (1st 6" / 2nd 6" / 3rd 6")
0	TOPSOIL (0.8')	757.0		
	STIFF TO VERY STIFF, RED,MOIST, SILTY CLAY - RESIDUUM		SPT-1	4-5-5
5		752.0	SPT-2	6-8-9
10		747.0	SPT-3	6-10-11
	VERY STIFF, RED TO TAN, SLIGHTLY MOIST, CLAYEY SILT WITH MANGANESE STAINING - RESIDUUM		UD-1	2.0-2.0
15		742.0	SPT-4	6-8-9
	BORING TERMINATED AT 15.5'			
20		737.0		
25		732.0		
30		727.0		
35		722.0		
40		717.0		
45		712.0		



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Driller : Marshall
Prepared By: M.O.
Checked By: [signature]

SOIL TEST BORING RECORD

PROJECT: TVA Kingston

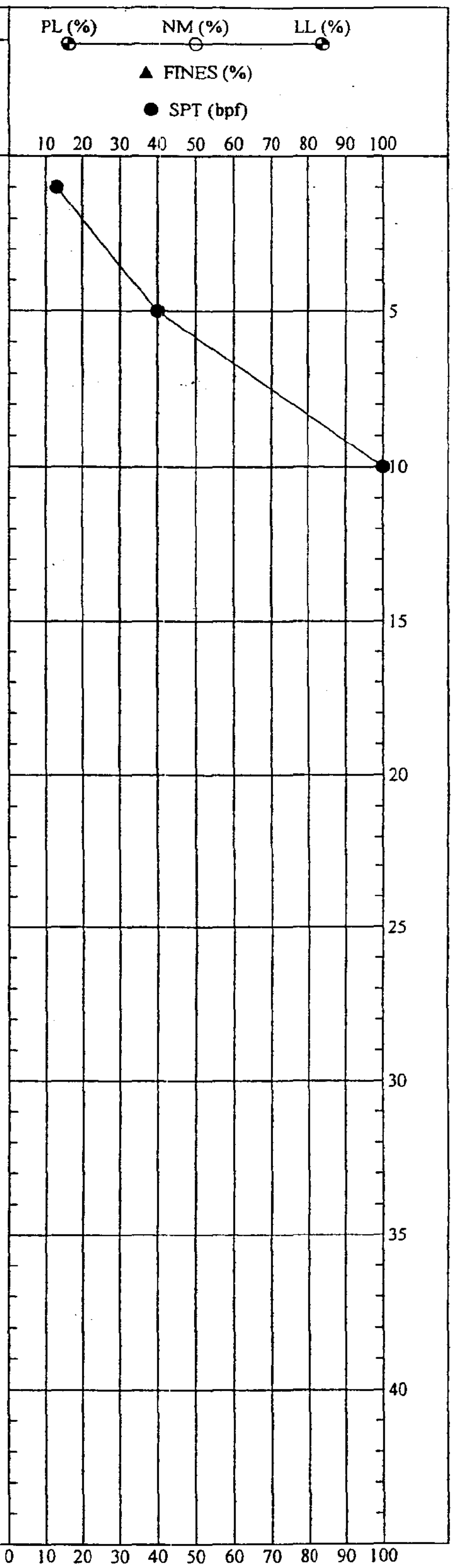
DRILLED: November 22, 2005 **BORING NO.:** K-14

PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

MACTEC

SOIL 3047051064 01.GPJ LAW_GIBB.GDT 1/11/06

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	ELEV (ft)	SAMPLES IDENT	TYPE	N-COUNT (1st 6", 2nd 6", 3rd 6")
0	TOPSOIL (0.5')	775.0			
	STIFF, RED, SLIGHTLY MOIST, SILTY CLAY WITH CHERT FRAGMENTS - RESIDUUM		SPT-1		6-6-7
	HARD, RED, DRY, SILTY CLAY AND GRAY DOLOMITE FRAGMENTS - RESIDUUM				
5		770.0	SPT-2		14-26-14
	VERY HARD, GRAY, DOLOMITE FRAGMENTS - RESIDUUM				
10		765.0	SPT-3		14-7-50/.5
	AUGER REFUSAL AT 11.0'				
15		760.0			
20		755.0			
25		750.0			
30		745.0			
35		740.0			
40		735.0			
45		730.0			



REMARKS: STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING AN AUTOMATIC HAMMER. NO GROUND WATER ENCOUNTERED AT TIME OF EXPLORATION.

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

Driller : Marshall
Prepared By: M.O.
Checked By: [signature]

SOIL TEST BORING RECORD

PROJECT: TVA Kingston

DRILLED: November 22, 2005 **BORING NO.:** K-15

PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

MACTEC

SOIL 3047051064_01.GPJ LAW_GIBB.GDT 1/11/06

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	TYPE	N-COUNT 1st 6" 2nd 6" 3rd 6"
0	AUGERED FROM GROUND SURFACE TO 8.0'		775.0			
5			770.0			
				UD-1		0.6-0.8
10			765.0			
				UD-2		0.6-1.0
13	AUGER REFUSAL AT 13.0'					
15			760.0			
20			755.0			
25			750.0			
30			745.0			
35			740.0			
40			735.0			
45			730.0			

PL (%) NM (%) LL (%)
▲ FINES (%)
● SPT (bpf)
10 20 30 40 50 60 70 80 90 100

SOIL 3047051064_01.GPJ LAW_GIBB.GDT 2/21/06

REMARKS: NO GROUND WATER ENCOUNTERED AT TIME OF EXPLORATION.

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Driller : Marshall
Prepared By: M.O.
Checked By: [signature]

SOIL TEST BORING RECORD

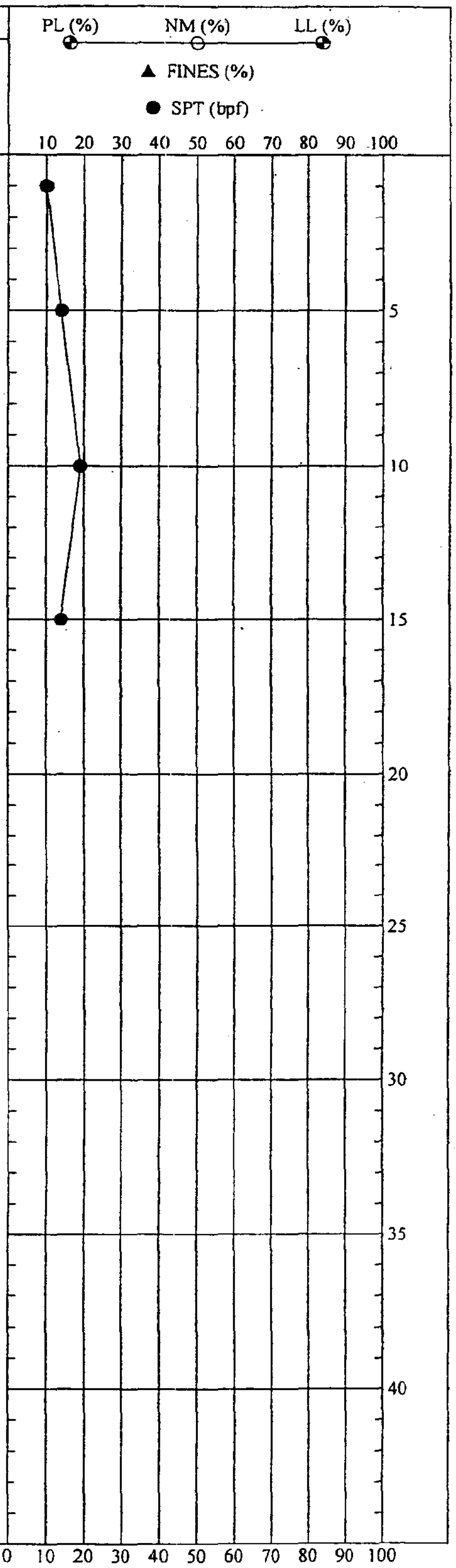
PROJECT: TVA Kingston

DRILLED: November 22, 2005 **BORING NO.:** K-15A

PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

MACTEC

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS (SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.)	ELEV (ft)	SAMPLES IDENT	N-COUNT (1st 6" - 2nd 6" - 3rd 6")
0	TOPSOIL (0.15')	781.0		
	STIFF, RED TO BROWN, SLIGHTLY MOIST, SILTY CLAY WITH ROOTS - RESIDUUM		SPT-1	3-6-4
	STIFF, RED, SLIGHTLY MOIST, SILTY CLAY WITH CHERT FRAGMENTS - RESIDUUM			
5		776.0	SPT-2	4-6-8
	STIFF TO VERY STIFF, RED, SLIGHTLY MOIST, CLAYEY SILT WITH CHERT FRAGMENTS AND MANGANESE - RESIDUUM			
10		771.0	SPT-3	5-8-11
15		766.0	SPT-4	5-6-8
	BORING TERMINATED AT 15.5'			
20		761.0		
25		756.0		
30		751.0		
35		746.0		
40		741.0		
45		736.0		



REMARKS: STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING AN AUTOMATIC HAMMER. NO GROUND WATER ENCOUNTERED AT TIME OF EXPLORATION.

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Driller : Marshall
Prepared By: M.O.
Checked By: [signature]

SOIL TEST BORING RECORD

PROJECT: TVA Kingston

DRILLED: November 16, 2005 **BORING NO.:** K-16

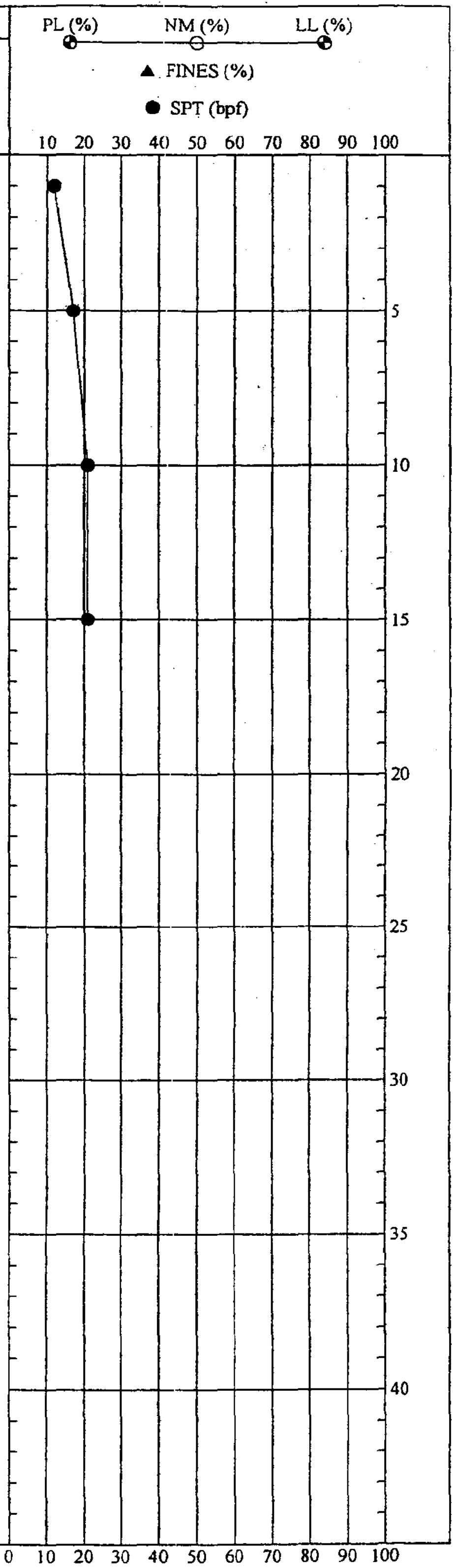
PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

MACTEC

SOIL 3047051064_01.GPJ LAW GIBB.GDT 1/11/06

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS	ELEV (ft)	SAMPLES IDENT	N-COUNT (1st 6" - 2nd 6" - 3rd 6")
0	STIFF, REDDISH BROWN TO BROWN, SLIGHTLY MOIST, SILTY CLAY WITH ROOTS AND CHERT FRAGMENTS - RESIDUUM	787.0	SPT-1	3-4-8
	VERY STIFF, RED TO ORANGE, DRY TO SLIGHTLY MOIST, CLAY TO SILTY CLAY WITH A WEATHERED CHERT LAYER AT 5.2' - RESIDUUM			
5		782.0	SPT-2	6-7-10
	VERY STIFF, RED TO ORANGE, DRY TO SLIGHTLY MOIST, CLAY WITH CHERT FRAGMENTS - RESIDUUM			
10		777.0	SPT-3	7-8-13
	VERY STIFF, RED TO ORANGE, SLIGHTLY MOIST, CLAYEY SILT WITH CHERT FRAGMENTS - RESIDUUM			
15		772.0	SPT-4	6-9-12
	BORING TERMINATED AT 15.5'			
20		767.0		
25		762.0		
30		757.0		
35		752.0		
40		747.0		
45		742.0		

SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.



SOIL 3047051064_01.GPJ LAW_GIBB.GDT 1/11/06

REMARKS: STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING AN AUTOMATIC HAMMER. NO GROUND WATER ENCOUNTERED AT TIME OF EXPLORATION.

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Driller : Marshall
Prepared By: M.O.
Checked By: [signature]

SOIL TEST BORING RECORD

PROJECT: TVA Kingston

DRILLED: November 16, 2005 **BORING NO.:** K-17

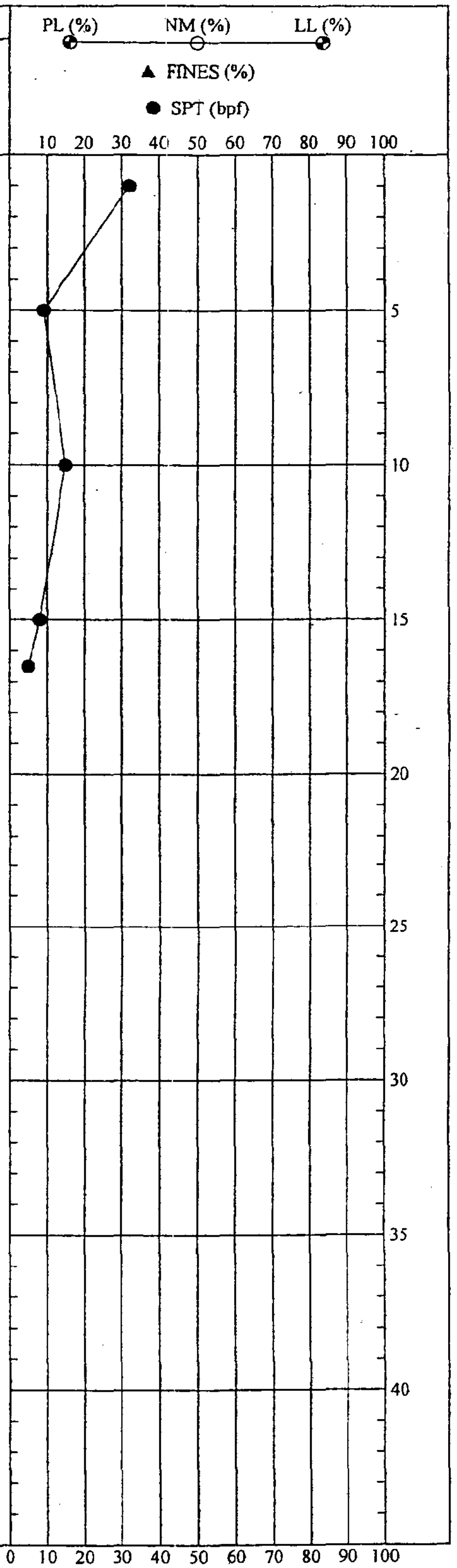
PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

MACTEC

SOIL CLASSIFICATION AND REMARKS

SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS	ELEV (ft)	IDENT	N-COUNT (1st 6" / 2nd 6" / 3rd 6")
0	HARD, RED TO BROWN, DRY, SILTY CLAY WITH GRAVEL - FILL	785.0		
	HARD, RED, DRY TO SLIGHTLY MOIST, CLAY - RESIDUUM		SPT-1	10-18-14
	STIFF TO VERY STIFF, REDDISH ORANGE, SLIGHTLY MOIST, CLAY WITH CHERT FRAGMENTS - RESIDUUM			
5		780.0	SPT-2	3-4-5
10		775.0	SPT-3	5-6-9
	FIRM, REDDISH ORANGE, MOIST, CLAYEY SILT - RESIDUUM			
15		770.0	SPT-4	5-3-5
			SPT-5	3-2-3
	BORING TERMINATED AT 17.0'			
20		765.0		
25		760.0		
30		755.0		
35		750.0		
40		745.0		
45		740.0		



SOIL 3047051064 01.GPJ LAW_GIBB.GDT 1/11/06

REMARKS: STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING AN AUTOMATIC HAMMER. NO GROUND WATER ENCOUNTERED AT TIME OF EXPLORATION.

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Driller : Marshall
Prepared By: M.O.
Checked By: [signature]

SOIL TEST BORING RECORD

PROJECT: TVA Kingston

DRILLED: November 16, 2005 **BORING NO.:** K-18

PROJ. NO.: 3043051064/0001 **PAGE** 1 **OF** 1

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APPENDIX C

MONITORING WELL INSTALLATION LOGS

OVERBURDEN MONITORING WELL INSTALLATION RECORD

JOB NAME TVA KINGSTON GYPSUM DISPOSAL AREA

JOB NUMBER 3043051064.01

TVA WELL NUMBER MW-M

INSTALLATION DATE 01/16/2006

BOREHOLE DIAMETER 7.25" (SOIL)

DRILLED BY G. AKINS

TOTAL DEPTH 35.0'

RISER/SCREEN

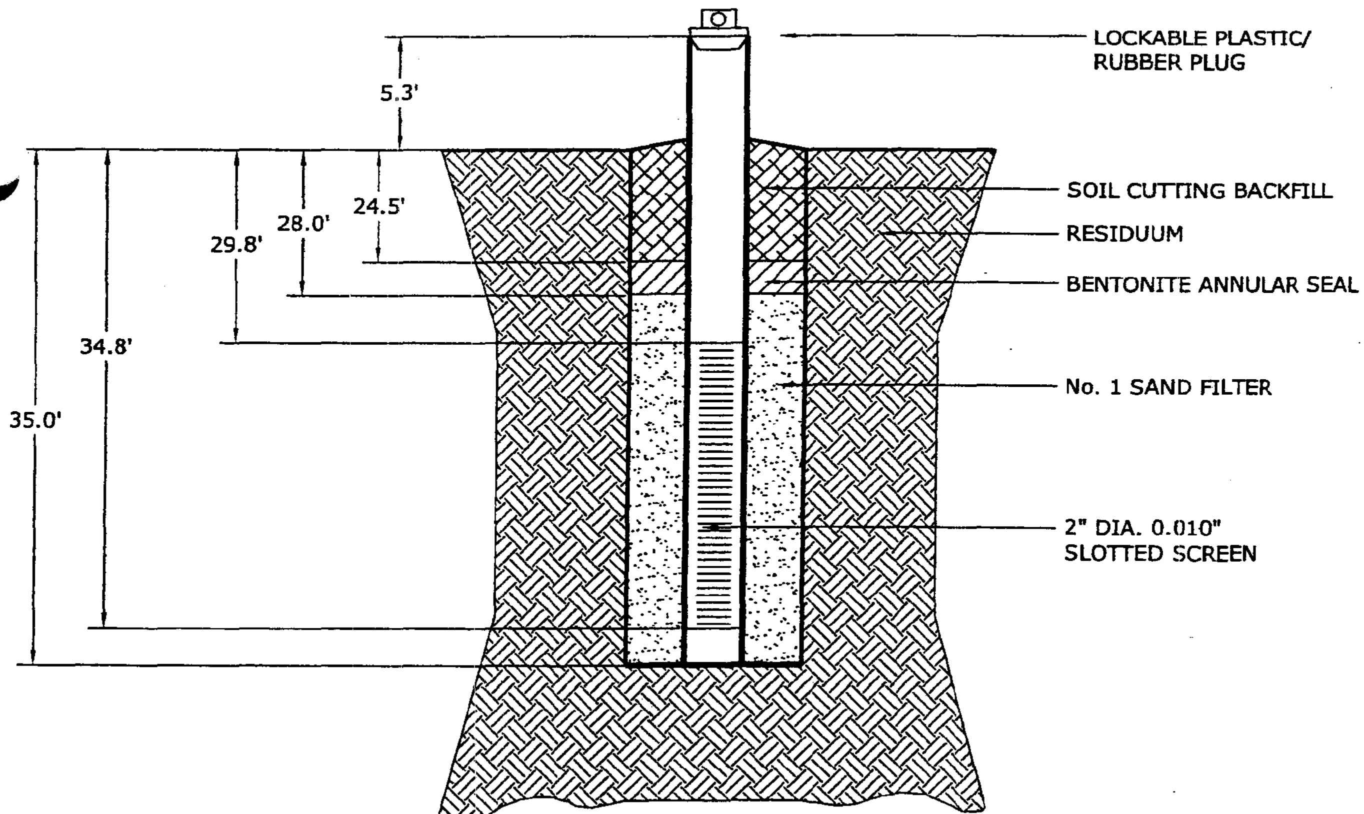
MATERIAL SCHEDULE 40 PVC

FIELD REPRESENTATIVE T. JUSTICE

DIAMETER 2.0"

SLOT SIZE 0.010"

CTJ



(NOT TO SCALE)

MACTEC

TVA-00020821

OVERBURDEN MONITORING WELL INSTALLATION RECORD

JOB NAME: TVA KINGSTON GYPSUM DISPOSAL AREA

JOB NUMBER: 3043051064.01

TVA WELL NUMBER: MW-N

INSTALLATION DATE: 01/12/2006

BOREHOLE DIAMETER: 7.25" (SOIL)

DRILLED BY: G. AKINS

TOTAL DEPTH: 25.5'

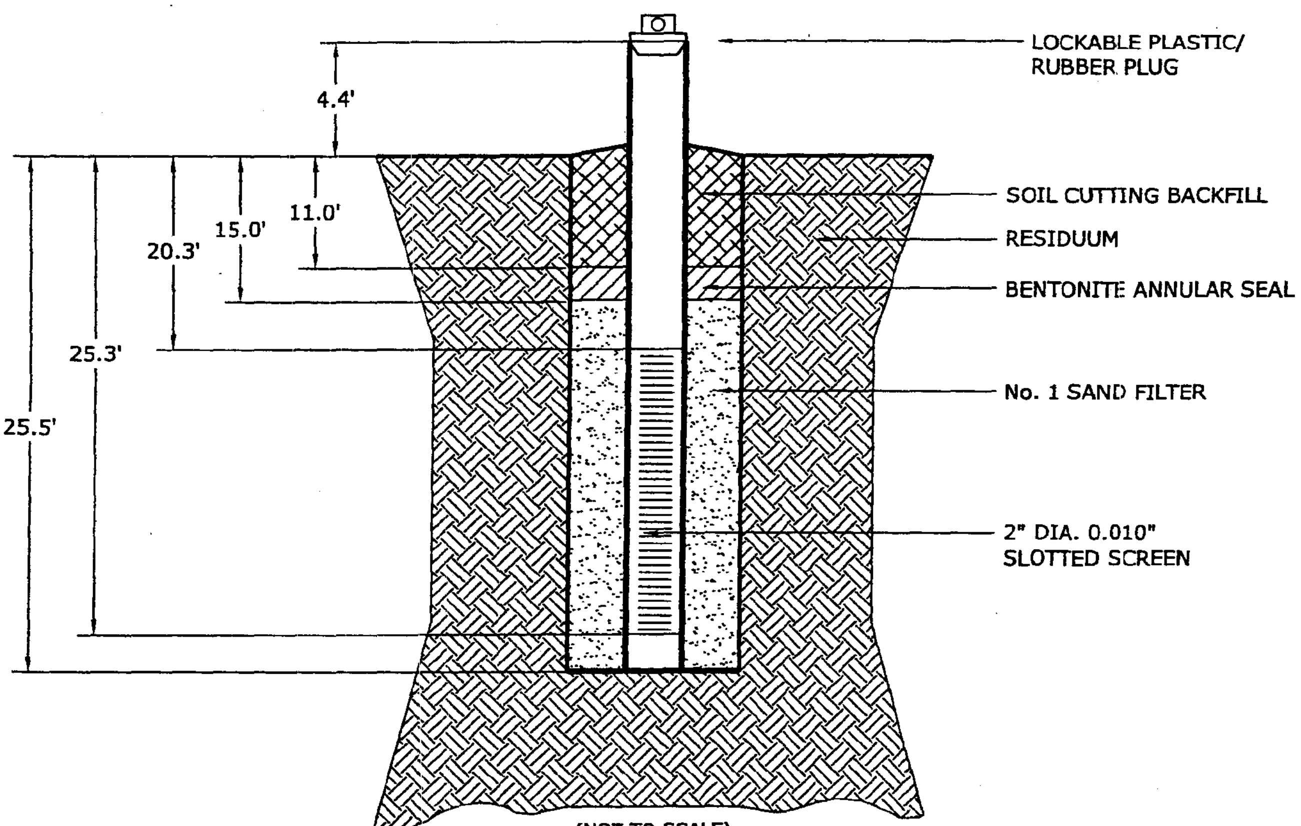
RISER/SCREEN

MATERIAL: SCHEDULE 40 PVC

FIELD REPRESENTATIVE: T. JUSTICE

DIAMETER: 2.0"

SLOT SIZE: 0.010"



(NOT TO SCALE)

MACTEC

BEDROCK MONITORING WELL INSTALLATION RECORD

JOB NAME: TVA KINGSTON GYPSUM DISPOSAL AREA

TVA WELL NUMBER: MW-P

BOREHOLE DIAMETER: 7.25" (SOIL); 3.78" (BEDROCK)

TOTAL DEPTH: 60.5'

FIELD REPRESENTATIVE: T. JUSTICE

CTJ

JOB NUMBER: 3043051064.01

INSTALLATION DATE: 01/16/2006

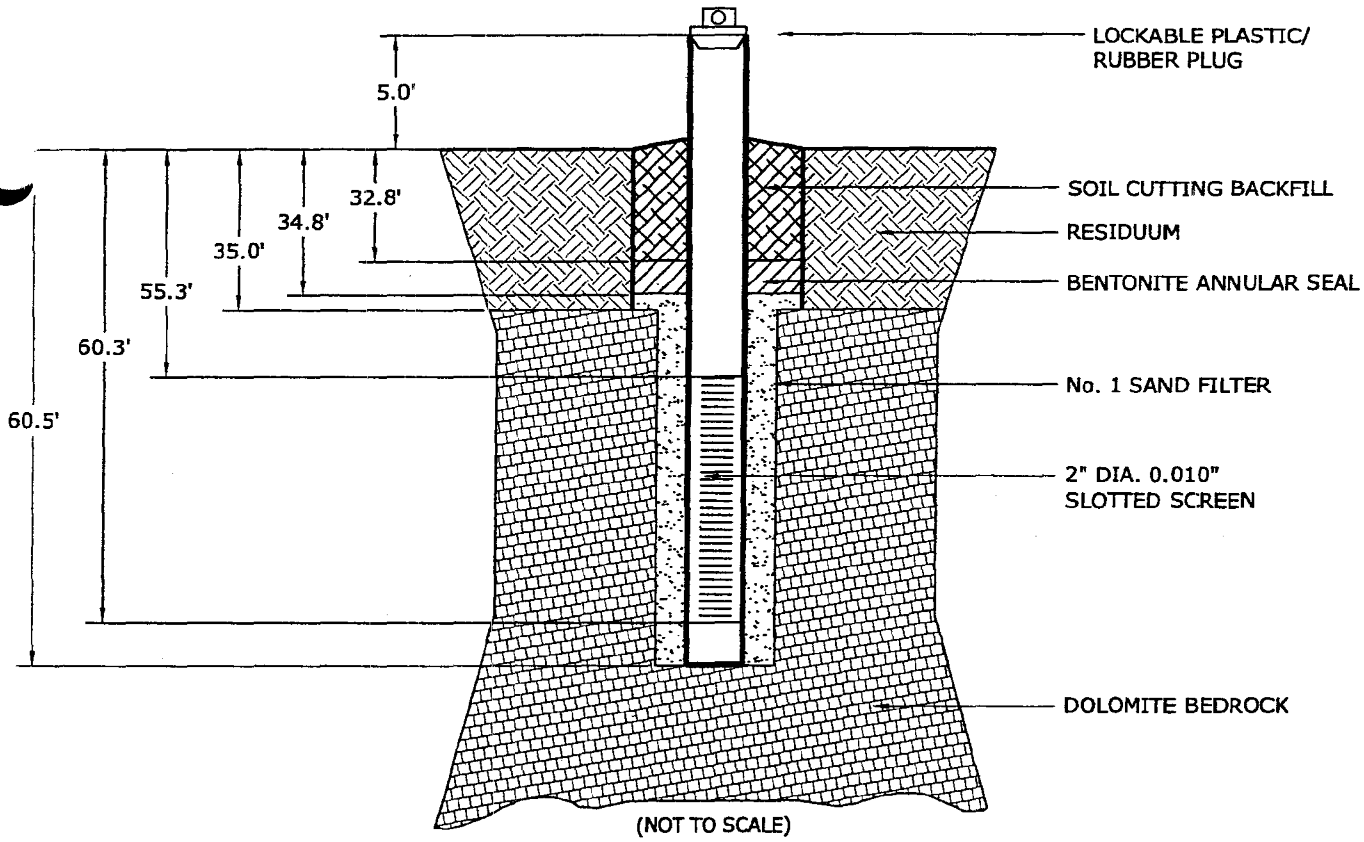
DRILLED BY: G. AKINS

RISER/SCREEN

MATERIAL: SCHEDULE 40 PVC

DIAMETER: 2.0"

SLOT SIZE: 0.010"



(NOT TO SCALE)

MACTEC

APPENDIX D

LABORATORY TEST PROCEDURES

TABLES

LABORATORY TEST RESULTS

LABORATORY TEST PROCEDURES

Moisture Content

The moisture content in a given mass of soil is the ratio, expressed as a percentage, of the weight of the water to the weight of the solid particles. This test was conducted in accordance with ASTM D-2216.

Atterberg Limits (Plasticity Index)

Originally, the Atterberg Limits consisted of seven "limits of consistency" of fine-grained soils. In current engineering usage, the term usually refers only to the liquid limit (LL) and plastic limit (PL). The LL (between the liquid and plastic states) is the water content at which a trapezoidal groove of specified shape, cut in moist soil held in a special cup, is closed after 25 taps on a hard rubber plate. The PL (between plastic and semi-solid states) is the water content at which the soil crumbles when rolled into threads of 1/8-inch in diameter.

The LL has been found to be proportional to the compressibility of the normally consolidated soil. The Plasticity Index (PI) is the calculated difference in water contents between the LL and PL. Together the LL and PI are used to classify silts and clays according to the Unified Soils Classification System (ASTM D 2487). The PI is used to predict the potential for volume changes in confined soils beneath foundations or grade slabs. The LL, PL, and PI are determined in accordance with ASTM D 4318.

Triaxial Shear Tests

Triaxial shear tests are used to determine the strength characteristics (cohesion and friction angle) of a given soil sample. Triaxial tests are also used to determine the elastic properties of the soil specimen.

Triaxial shear tests are performed on several sections of a relatively undisturbed sample extruded from the sampling tube or on remolded samples. The samples are trimmed into cylinders 1.4 to 2.8 inches in diameter and encased in rubber membranes. Each is then placed in a compression chamber and confined by all-around air pressure. The test results are presented in the form of stress-strain curves and Mohr envelopes, or p-q plots on the accompanying Triaxial Shear Test Sheets.

One of three types of triaxial tests is normally performed, the most suitable type being determined by the loading conditions imposed on the soil in the field and the soil characteristics.

1. Consolidated-Undrained (Designated as a CU or R Test)
2. Consolidated-Drained (designated as a CD or S Test)
3. Unconsolidated-Undrained (designated as a UU or Q Test)

Grain Size Distribution

Grain size tests are performed to aid in determining the soil classification and the grain size distribution. The soil samples are prepared for testing according to ASTM D 421 (dry preparation) or ASTM D 2217 (wet preparation). If only the grain size distribution of soils coarser than a number 200 sieve (0.074-mm opening) is desired, the grain size distribution is determined by washing the sample over a number 200 sieve and, after drying, passing the samples through a standard set of nested sieves. If the grain size distribution of the soils finer than the number 200 sieve is also desired, the grain size distribution of the soils coarser than the number 10 sieve is determined by passing the sample through a set of nested sieves. Materials passing the number 10 sieve are dispersed with a dispersing agent and suspended in water, and the grain size distribution calculated from the measured settlement rate of the particles. These tests are conducted in accordance with ASTM D 422. The percentage of clay, silt, sand, and gravel which are given on the individual particle size analysis sheets presented later in this appendix, were obtained on particle size boundaries in accordance with AASHTO M145-94 (1995).

Specific Gravity

The specific gravity of soil solids is the ratio of the mass of a unit volume of a soil solids to the mass of the same volume of gas-free distilled water at 20C. The test method for determining the specific gravity of soil solids that passes the 4.75-mm (No. 4) sieve using a water pycnometer is described in ASTM D 854, Method B, "Test Methods for Specific Gravity of Soil Solids by Water Pycnometer".

Compaction Tests (Moisture-Density Relationship)

Compaction tests are performed on representative soil samples to determine the maximum dry density and optimum moisture content. The results of the tests are used in conjunction with other tests to determine engineering properties relating to settlement, bearing capacity, shear strength, and permeability. The results may also be used as a standard to determine the percent compaction of any soil embankment.

The two most commonly used compaction tests are the standard Proctor test and the modified Proctor test. They are performed in accordance with ASTM D 698 and D 1557, respectively. Generally, the standard Proctor compaction test is run on samples from building areas and areas where moderate loads are anticipated. The modified Proctor compaction test is generally used for analyses of highways and other areas where large building loads are expected. Both tests have three procedures, depending upon soil particle size:

Test	Procedure	Hammer Weight (Pounds)	Hammer Fall (Inches)	Mold Diameter (Inches)	Screen Size (Material Finer Than)	Number of Layers	Number of Blows per Layer
Standard (D 698)	A	5.5	12	4	No. 4 sieve	3	25
	B	5.5	12	4	No. 3/8" sieve	3	25
	C	5.5	12	6	3/4" sieve	3	56
Modified (D 1557)	A	10	18	4	No. 4 sieve	5	25
	B	10	18	4	No. 3/8" sieve	5	25
	C	10	18	6	3/4" sieve	5	56

Test results are presented as a curve depicting dry unit weight versus moisture content. The compaction method used and any deviations from the recommended procedures are noted in the report.

Unit Weights

The moist or dry unit weight of a given soil mass is obtained by dividing the weight of the soil mass by the volume. Selected portions of the Shelby tube samples obtained during the exploration were measured and weighed in our laboratory to determine sample unit weights.

Constant Head Permeability Test

The test was performed on undisturbed and remolded samples. The physical dimensions and weight were obtained and the sample was encased in a rubber membrane and placed in a triaxial chamber. The sample was then back-pressure saturated until a B value of 0.95 or greater was reached. After saturation was obtained, the sample was consolidated under 10-psi confining stress, or, if requested, another confining stress. Upon completion of consolidation, a constant head permeability test was performed.

TABLE D-1
Index Property and Moisture-Density Test Results
TVA Kingston Gypsum Disposal Area - Additional Geotechnical
MACTEC Project 3043051064/01

					Atterberg Limits						Compaction Tests	
Boring Number	Sample Depth (Feet)	Sample Type	Natural Moisture Content %	Unit Weight pcf	Liquid Limit	Plastic Limit	Plasticity Index	Percent Finer Than No. 200 Sieve	USCS Classification	Specific Gravity	Standard Proctor Max Dry Density pcf	Opt. Moisture Content %
NB-18*	6.5 - 18.5	UD	-	-	81	42	39	95.5	MH	2.62	-	-
NB-21A*	15 - 23	UD	-	-	53	28	25	83.8	CH	2.65	-	-
NB-21A*	30 - 38	UD	-	-	36	21	15	84.8	CL	2.66	-	-
NB-21B	31 - 33	UD	30.0	120.5	34	22	12	-	-	-	-	-
NB-21B*	31 - 33	UD	-	-	27	16	11	73.9	CL	2.69	-	-
NB-22	2 - 10	Bulk	30.7	-	40	22	18	81.1	CL	2.63	107.6	17.7
NB-25	2 - 10	Bulk	33.1	-	72	25	47	85.2	CH	2.74	95.1	26.0
NB-44*	19 - 28.5	UD	-	-	54	24	30	-	-	-	-	-
NB-47A*	9 - 17	UD	-	-	51	30	21	79.2	MH	2.72	-	-
NB-47A*	18 - 27	UD	-	-	58	34	24	62.8	MH	2.72	-	-
NB-47BA	20 - 22	UD	46.8	108.5	79	40	39	-	-	-	-	-
NB-47BA*	20 - 22	UD	-	-	80	40	40	44.1	GM	2.72	-	-
NB-73WB	40 - 42	UD	32.8	120.0	51	24	27	-	-	-	-	-
NB-73WBA	40 - 42	UD	29.6	124.3	54	24	30	-	-	-	-	-
NB-73WB*	40 - 42	UD	-	-	42	23	19	69.5	CL	2.74	-	-
NB-76	5 - 15	Bulk	25.3	-	48	28	20	70.0	ML	2.65	100.7	21.7
NB-77*	4 - 14	UD	-	-	41	25	16	55.3	CL	2.66	-	-
NB-77*	15 - 26	UD	-	-	53	29	24	57.5	MH	2.64	-	-
NB-77B	11 - 12.8	UD	28.7	118.8	50	24	26	-	-	-	-	-
NB-77B*	11 - 15	UD	-	-	49	29	20	60.7	ML	2.75	-	-
NB-77B	13 - 15	UD	30.7	118.9	75	31	44	-	-	-	-	-
NB-85A/B*	13 - 19	UD	-	-	59	30	29	45.4	SC	2.66	-	-
NB-85A/B*	23 - 29	UD	-	-	50	24	26	68.7	CH	2.64	-	-
NB-85B*	28 - 32	UD	-	-	66	28	38	54.5	CH	2.73	-	-
NB-85B	28 - 30	UD	39.0	113.3	74	36	38	-	-	-	-	-
NB-85B	30 - 32	UD	30.0	120.2	53	27	26	-	-	-	-	-
NB-90	9 - 11	UD	27.7	-	44	22	22	77.3	CL	2.73	-	-

TVA-00020829

TABLE D-1
Index Property and Moisture-Density Test Results
TVA Kingston Gypsum Disposal Area - Additional Geotechnical
MACTEC Project 3043051064/01

					Atterberg Limits						Compaction Tests	
Boring Number	Sample Depth (Feet)	Sample Type	Natural Moisture Content, %	Unit Weight, pcf	Liquid Limit	Plastic Limit	Plasticity Index	Percent Finer Than No. 200 Sieve	USCS Classification	Specific Gravity	Std Proctor Max Dry Density, pcf	Opt Moisture Content, %
NB-90	17 - 19	UD	24.8	-	30	21	9	54.0	CL	2.71	-	-
NB-92	11 - 13	UD	14.6	-	26	19	7	26.8	SC-SM	2.71	-	-
NB-92	1.5 - 5.5	SPT	-	-	32	21	11	-	-	-	-	-
K-1	12 - 14	UD	29.0	119.1	54	24	30	96.4	CH	2.73	-	-
K-2	12 - 14	UD	27.9	122.7	50	31	19	57.3	MH	2.67	-	-
K-3	10 - 15	Bulk	34.7	-	56	37	19	75.0	MH	2.69	92.1	27.8
K-4	12 - 14	UD	19.4	128.1	NV	NP	NP	25.2	SM	2.67	-	-
K-5	12 - 14	UD	26.6	122.2	65	39	26	45.1	MH	2.71	-	-
K-6	10 - 15	Bulk	25.6	-	43	29	14	75.0	ML	2.65	101.3	22.1
K-7	10 - 15	Bulk	22.3	-	31	21	10	70.5	CL	2.64	109.6	16.0
K-8	10 - 15	Bulk	22.4	-	51	27	24	53.0	CH	2.67	102.6	20.6
K-9	12 - 14	UD	26.9	119.0	50	28	22	75.9	CH	2.71	-	-
K-10	12 - 14	UD	26.1	123.7	47	26	21	62.7	CL	2.66	-	-
K-11	12 - 14	UD	22.9	125.8	NV	NP	NP	25.7	SM	2.71	-	-
K-12	12 - 14	UD	24.3	119.5	48	26	22	63.8	CL	2.71	-	-
K-13	12 - 14	UD	29.9	113.5	69	37	32	87.8	MH	2.69	-	-
K-14	12 - 14	UD	29.4	121.9	65	41	24	95.1	MH	2.73	-	-
K-15A	12 - 13	UD	37.3	110.3	60	42	18	66.0	MH	2.71	-	-
K-16	10 - 15	Bulk	28.3	-	52	29	23	78.9	MH	2.75	100.8	22.8
K-17	10 - 15	Bulk	30.6	-	75	40	35	89.0	MH	2.70	91.1	29.5
K-18	10 - 15	Bulk	31.3	-	71	37	34	79.4	MH	2.78	91.4	29.2

UD - Undisturbed Shelby Tube Sample

Bulk - Bulk Soil Sample

SPT - Standard Penetration Test Soil Sample

* - Classification, Atterberg Limits, and grain size test results listed were obtained from testing performed on combined triaxial specimen samples

Prepared/Date: CTJ 02/08/06
Checked/Date: SDS 02/21/06

TABLE D-2
Triaxial Compression Laboratory Test Results
TVA Kingston Gypsum Disposal Area - Additional Geotechnical
MACTEC Project 3043051064/01

Boring Number	Sample Depth (Feet)	Sample Type	USCS Classification*	CU Triaxial Test						UU Triaxial Test			
						Total Stress		Effective Stress					
				Average Dry Density (pcf)	Average Moisture Content (%)	Cohesion C (psf)	Friction Angle φ (degrees)	Cohesion c' (psf)	Friction Angle φ' (degrees)	Average Dry Density (pcf)	Average Moisture Content (%)	Cohesion C (psf)	Friction Angle φ (degrees)
NB-18	6.5 - 18.5	UD	MH	87.6	29.4	ND	ND	ND	ND	–	–	–	–
NB-18	9 - 18.5	UD	–	–	–	–	–	–	–	79.9	38.4	ND	ND
NB-21A	15 - 23	UD	CH	91.8	28.8	760	19.9	160	34.8	91.6	29.1	ND	ND
NB-21A	30 - 38	UD	CL	92.7	27.0	ND	ND	ND	ND	–	–	–	–
NB-21B	31 - 33	UD	CL	96.4	26.8	1,071	14.8	318	31.0	–	–	–	–
NB-22	2 - 10	Bulk	CL	101.9	19.7	891	14.8	259	32.3	–	–	–	–
NB-25	2 - 10	Bulk	CH	90.4	27.5	1,081	11.6	530	24.6	–	–	–	–
NB-44	19 - 28.5	UD	-	84.1	34.0	ND	ND	ND	ND	82.9	35.0	ND	ND
NB-47A	9 - 17	UD	MH	91.1	30.1	ND	ND	ND	ND	99.2	23.8	2,200	2.9
NB-47A	18 - 27	UD	MH	85.5	31.8	ND	ND	ND	ND	91.1	28.2	ND	ND
NB-47BA	20 - 22	UD	GM	78.3	42.3	893	15.4	0	38.5	–	–	–	–
NB-73WB	40 - 42	UD	CL	98.2	27.3	1,345	11.9	256	32.8	–	–	–	–
NB-76	5 - 15	Bulk	ML	95.8	23.0	707	14.8	123	33.6	–	–	–	–
NB-77	4 - 14	UD	CL	97.1	24.6	ND	ND	ND	ND	95.0	25.6	ND	ND
NB-77	15 - 26	UD	MH	91.7	29.1	ND	ND	ND	ND	89.7	27.4	ND	ND
NB-77B	11 - 15	UD	ML	93.8	27.5	2,347	5.9	455	31.2	–	–	–	–
NB-85A/B	13 - 19	UD	SC	103.5	20.4	ND	ND	ND	ND	98.3	25.0	1,500	4.6
NB-85A/B	23 - 29	UD	CH	91.3	30.2	ND	ND	ND	ND	93.6	28.7	ND	ND
NB-85B	28 - 32	UD	CH	86.6	36.9	818	17.5	279	32.9	–	–	–	–

ND - Strength parameters were "not determined" due to suspect laboratory results

* Classification results are based on the combined triaxial sample specimens Atterberg Limit and Grain Size laboratory test results

Prepared/Date: CTJ 02/06/06
Checked/Date: SDS 02/21/06

TVA-00020831

TABLE D-3
Hydraulic Conductivity Laboratory Test Results
TVA Kingston Gypsum Disposal Area - Additional Geotechnical
MACTEC Project 3043051064/01

Boring Number	Sample Depth (Feet)	Sample Type	USCS Classification	Moisture Content (%)	Dry Density (pcf)	Effective Confining Pressure (psi)	Hydraulic Conductivity (cm/sec)
K-1	12 - 14	UD	CH	29.0	92.3	13.0	8.4×10^{-7}
K-2	12 - 14	UD	MH	27.9	95.9	13.0	1.4×10^{-7}
K-3	10 - 15	Bulk	MH	29.0	87.3	12.5	3.0×10^{-7}
K-4	12 - 14	UD	SM	19.4	107.3	13.0	1.2×10^{-5}
K-5	12 - 14	UD	MH	26.6	96.5	13.0	1.5×10^{-7}
K-6	10 - 15	Bulk	ML	24.1	96.2	12.5	7.4×10^{-8}
K-7	10 - 15	Bulk	CL	17.7	104.3	12.5	1.4×10^{-7}
K-8	10 - 15	Bulk	CH	22.2	97.3	12.5	2.7×10^{-6}
K-9	12 - 14	UD	CH	26.9	93.8	13.0	1.8×10^{-5}
K-10	12 - 14	UD	CL	26.1	98.1	13.0	9.1×10^{-8}
K-11	12 - 14	UD	SM	22.9	102.4	13.0	9.1×10^{-7}
K-12	12 - 14	UD	CL	24.3	96.1	13.0	7.6×10^{-6}
K-13	12 - 14	UD	MH	29.9	87.4	13.0	1.6×10^{-6}
K-14	12 - 14	UD	MH	29.4	94.2	13.0	1.7×10^{-8}
K-15A	12 - 13	UD	MH	37.3	80.3	13.0	2.2×10^{-6}
K-16	10 - 15	Bulk	MH	24.6	95.7	12.5	2.6×10^{-8}
K-17	10 - 15	Bulk	MH	31.7	86.6	12.5	1.3×10^{-8}
K-18	10 - 15	Bulk	MH	31.6	87.1	12.5	2.7×10^{-8}

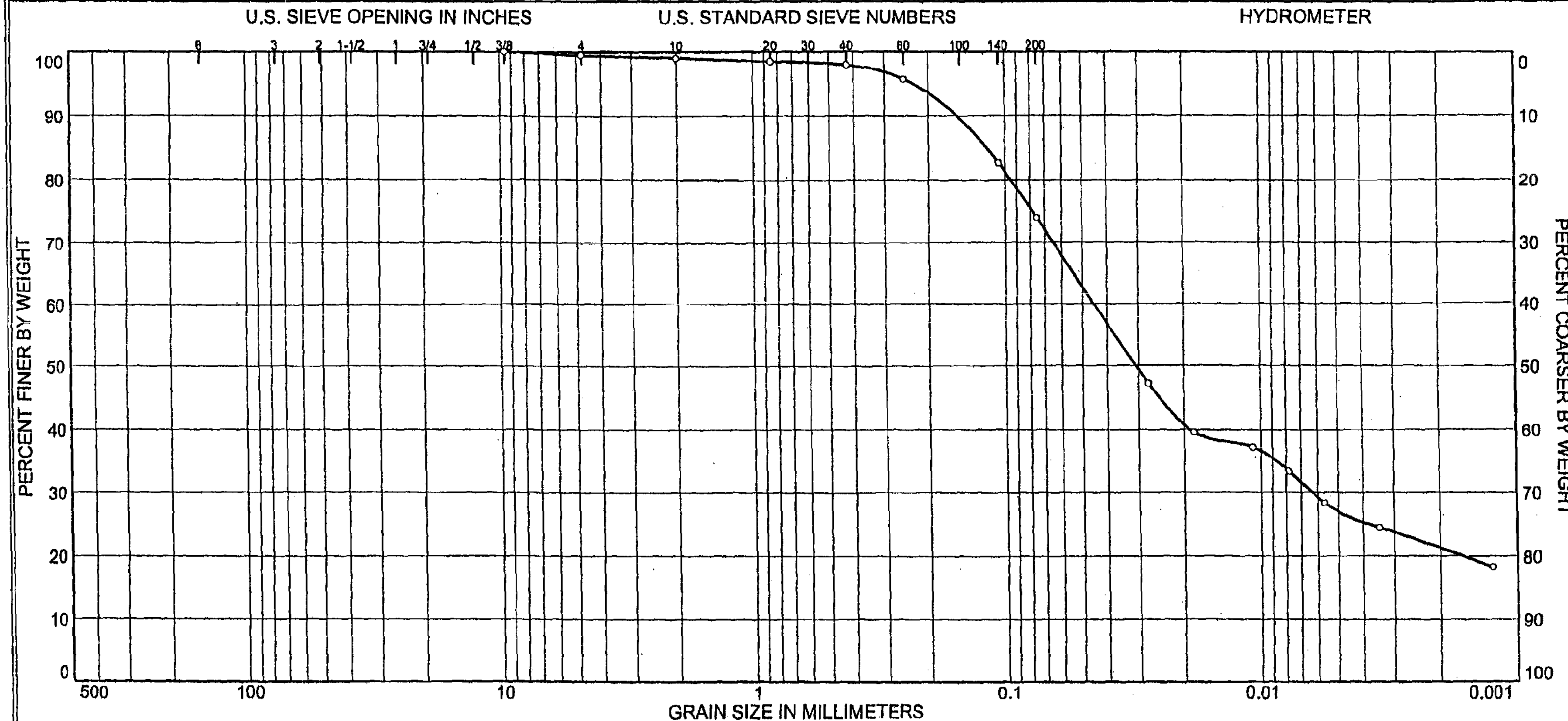
UD = Undisturbed Shelby Tube Sample

Note: Bulk soil samples were remolded to approximately 95% of their respective standard Proctor maximum dry densities and 2% over optimum moisture content.

Prepared/Date: CTJ 02/06/06
Checked/Date: SDS 02/21/06

GRAIN SIZE ANALYSIS TEST RESULTS

Particle Size Distribution Report ASTM D422/ASTM D1140



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
○	0.0	0.6	25.5	47.0	26.9

	SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PL
○	NB-21B	Composite	31 - 33	1/5/06	CL	Lean clay with sand		27	16

Client Mactec

Project TVA Kingston Proposed Gypsym Stack

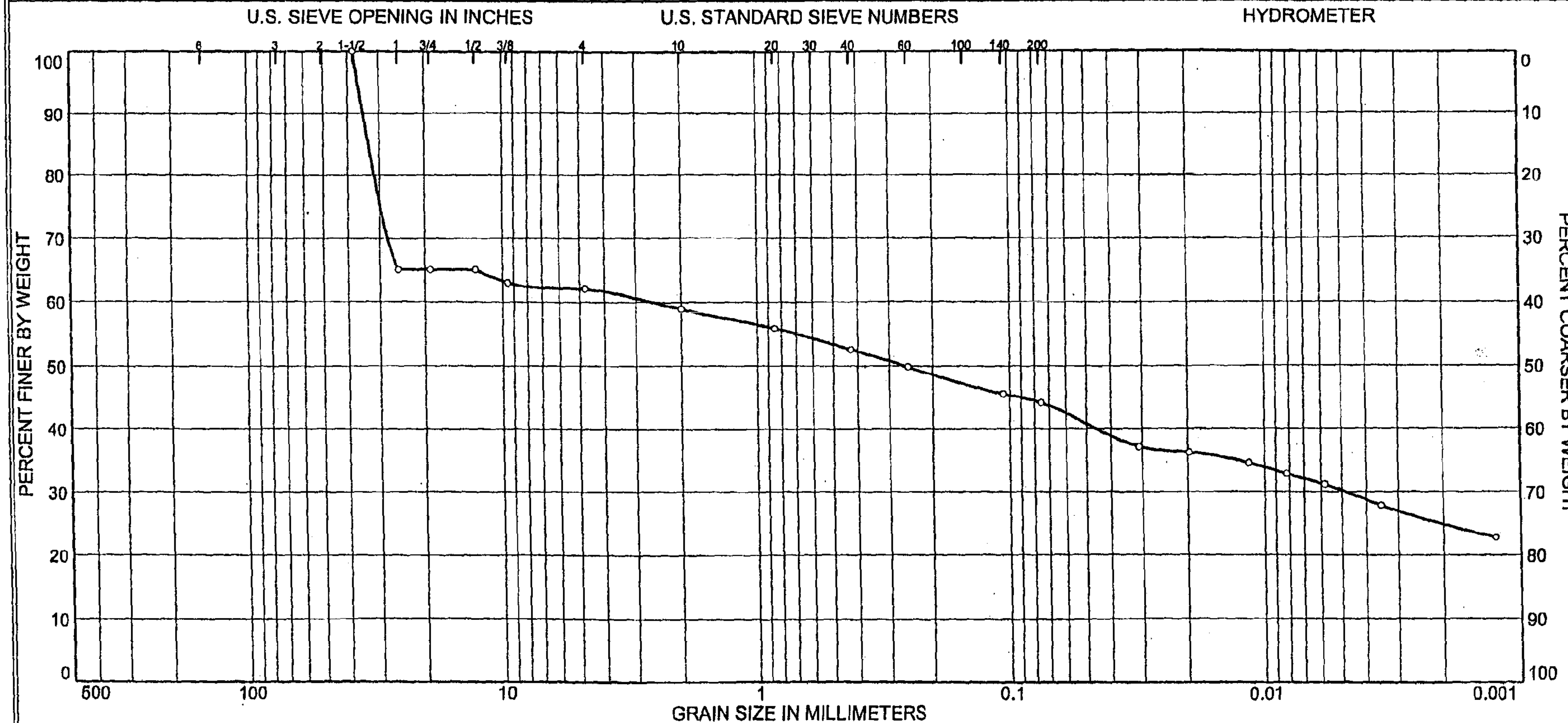
Project No. GTX G0959 Figure

GeoTesting Express Inc.

○ Tested by: HJ Reviewed by JW

TVA-00020834

Particle Size Distribution Report ASTM D422/ASTM D1140



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
○	0.0	38.0	17.9	13.9	30.2

	SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PL
○	NB-47BA	Composite	20-22 Ft.	1/5/06	GM	Silty gravel with sand		80	40

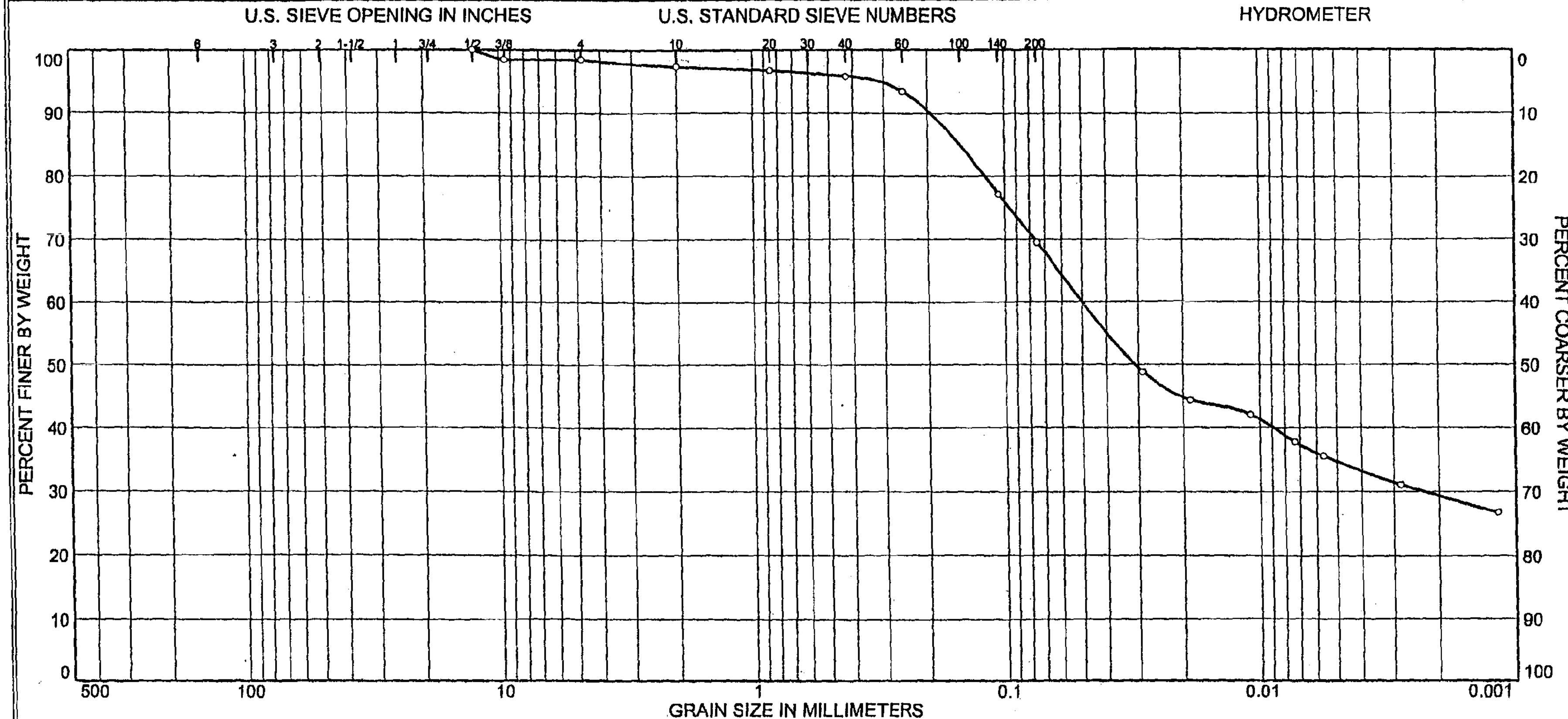
Client Mactec
Project TVA Kingston Proposed Gypsym Stack
Project No. GTX G0959 Figure

GeoTesting Express Inc.

○ Tested by: HJ Reviewed by: JW

TVA-00020835

Particle Size Distribution Report ASTM D422/ASTM D1140



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
O	0.0	1.6	28.9	34.9	34.6

	SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PL
O	NB-73WB	UD-3 & 1	Composite	12/15/05	CL	SANDY LEAN CLAY		42	23

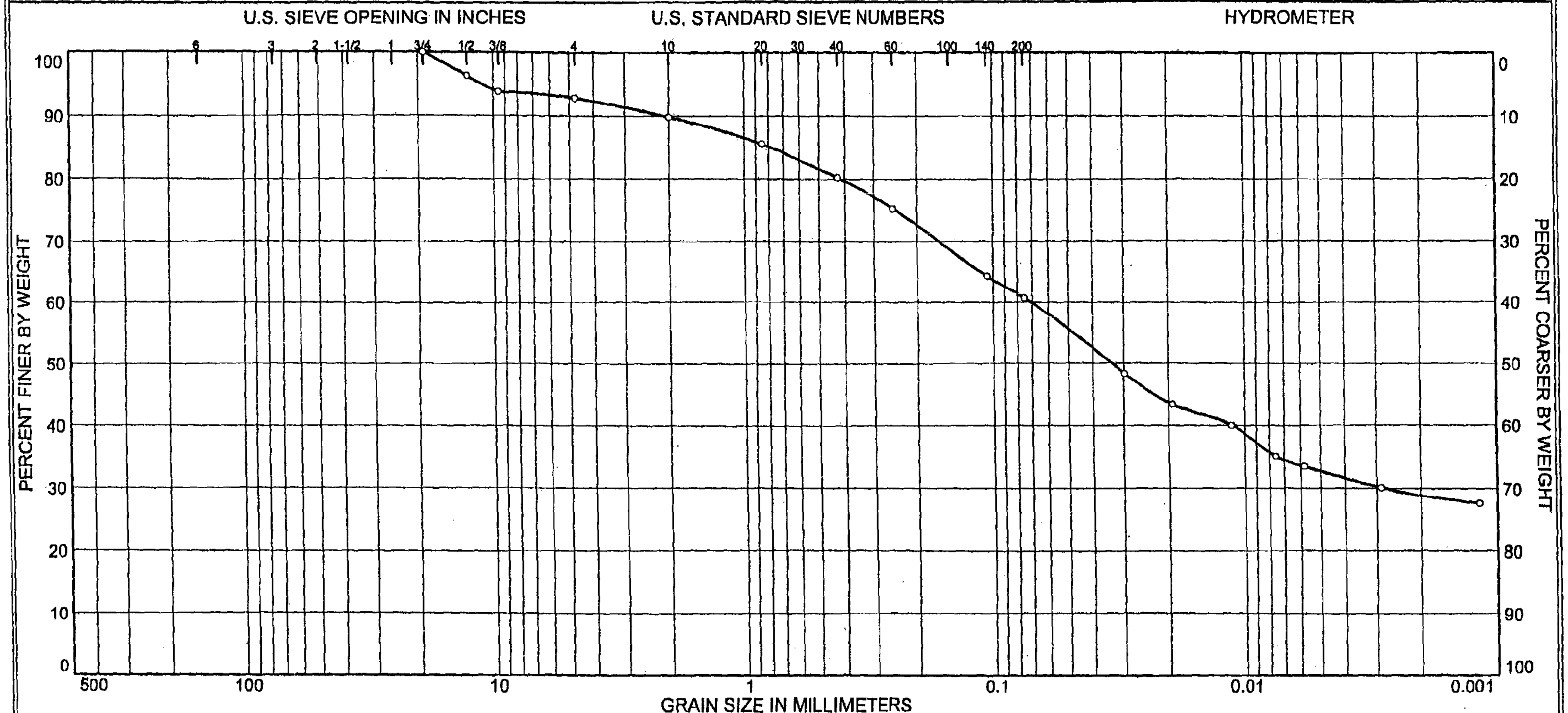
Client Mactec
Project TVA Kingston Proposed Gypsym Stack
Project No. GTX G0959 Figure

GeoTesting Express Inc.

O Tested by: LJ Reviewed by: HJ

TVA-00020836

Particle Size Distribution Report ASTM D422/ASTM D1140



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
○	0.0	7.1	32.2	28.0	32.7

	SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PL
○	NB-77B	Ud 1 & Ud 2	Composite	12/15/05	ML	SANDY SILT		49	29

Client Mactec

Project TVA Kingston Proposed Gypsym Stack

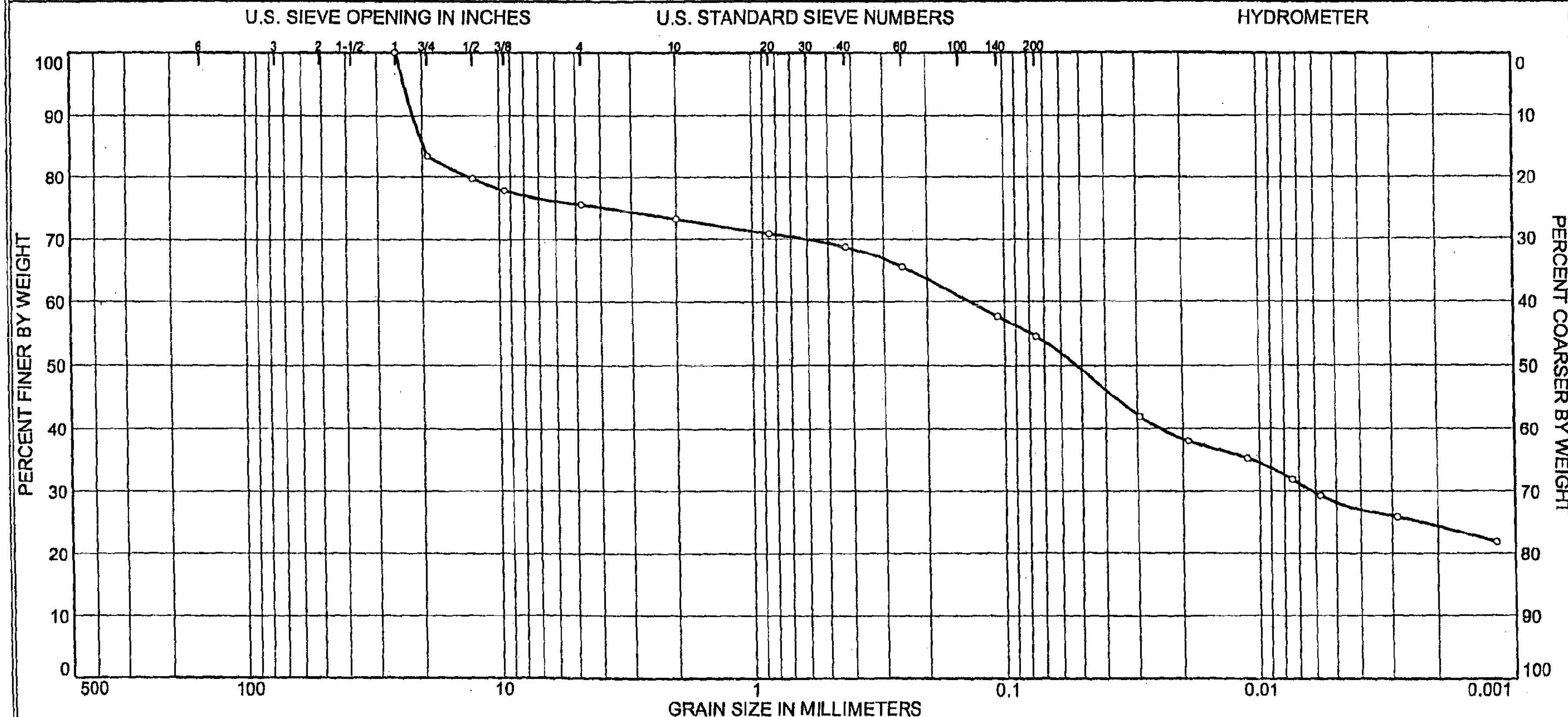
Project No. GTX G0959 Figure

GeoTesting Express Inc.

○ Tested by: LJ Reviewed by: HJ

TVA-00020837

Particle Size Distribution Report ASTM D422/ASTM D1140



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
○	0.0	24.4	21.1	26.4	28.1

	SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PL
○	NB-85B	UD 5 & 6	Composite	12/15/05	CH	Gravelly fat clay with sand		66	28

Client Mactec

Project TVA Kingston Proposed Gypsym Stack

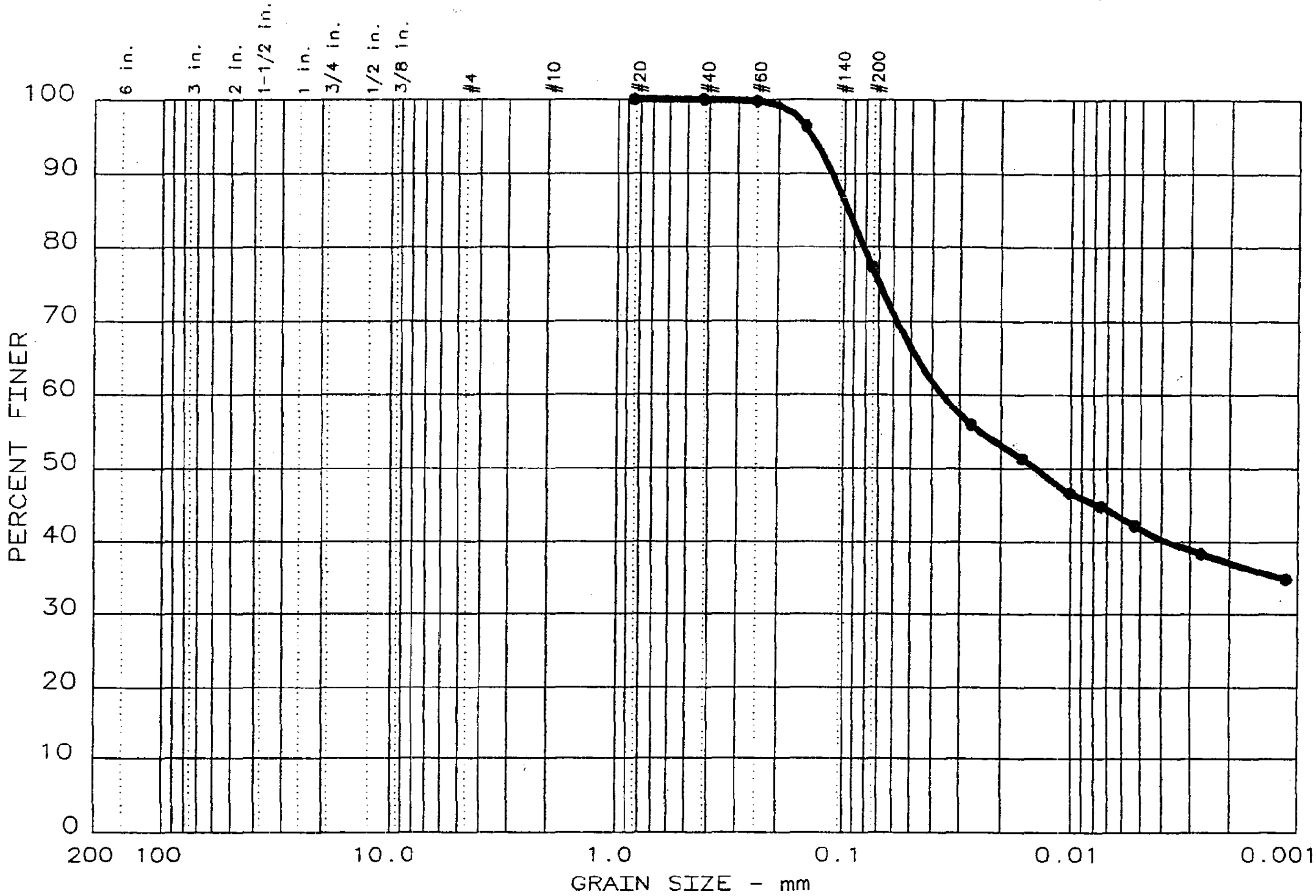
Project No. GTX G0959 Figure

GeoTesting Express Inc.

○ Tested by: HJ Reviewed by: JW

TVA-00020838

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	18	0.0	0.0	22.7	35.6	41.7	CL	44	22

SIEVE inches size	PERCENT FINER ●		

	GRAIN SIZE		
D_{60}	0.0359		
D_{30}			
D_{10}			

	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ●		
20	100.0		
40	99.9		
60	99.7		
100	96.4		
200	77.3		

Sample information:
● Boring NB-90, UD 9-11'
Orange brown to yellow tan lean clay with sand

Remarks:
Methods: Particle Size: ASTM D 422-63; Sieve Analysis: AASHTO T27-99; Specific Gravity: 2.73

Project No.: 3043051064.0001
Project: TVA Kingston- Proposed Gypsum Stack

Date: January 23, 2006

GRAIN SIZE DISTRIBUTION TEST DATA   Test No.: 18

` ᵗe: January 23, 2006
ⁱect No.: 3043051064.0001
ject: TVA Kingston- Proposed Gypsum Stack

Sample Data

Location of Sample: Boring NB-90,UD 9-11'
Sample Description 1: Orange brown to yellow
Sample Description 2: tan lean clay with sand
JSCS Class: CL   Liquid limit: 44   Plasticity index: 22

Notes

Remarks: Methods: Particle Size: ASTM D 422-63; Sieve
Analysis: AASHTO T27-99; Specific Gravity: 2.73
Fig. No.: B90

Mechanical Analysis Data

Initial
Dry sample and tare= 885.68
Tare = 0.00
Dry sample weight = 885.68
Sample split on number 40 sieve
it sample data:
nple and tare = 73.57 Tare = 0 Sample weight = 73.57
umulative weight retained tare= 0
Tare for cumulative weight retained= 0

Sieve	Cumul. Wt. retained	Percent finer
# 20	0.16	100.0
# 40	0.54	99.9
# 60	0.16	99.7
# 100	2.60	96.4
# 200	16.64	77.3

Hydrometer Analysis Data

Separation sieve is number 40
Percent -# 40 based on complete sample= 99.9
Weight of hydrometer sample: 74.38
Hygroscopic moisture correction:
Moist weight & tare = 52.92
Dry weight & tare = 52.58
Tare = 21.96
Hygroscopic moisture= 1.1 %
Calculated biased weight= 73.61
Table of composite correction values:
Temp, deg C: 20.0 20.5 21.0 21.5 22.0

Comp. corr: - 6.7 - 6.5 - 6.4 - 6.3 - 6.1
Meniscus correction only= 0
Specific gravity of solids= 2.734
Specific gravity correction factor= 0.982
rometer type: 152H Effective depth L= 16.294964 - 0.164 x Rm

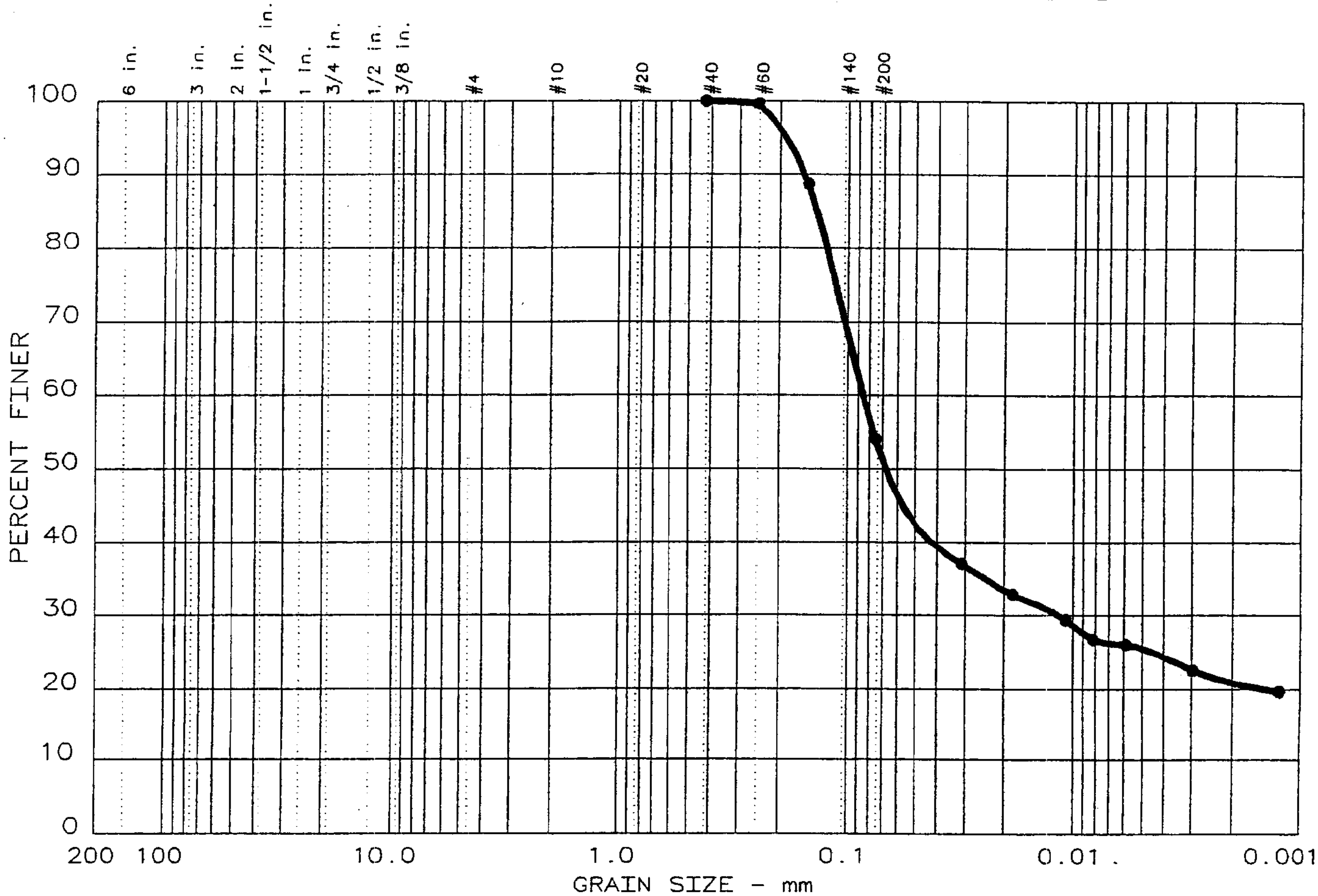
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
2.0	20.5	48.5	42.0	0.0132	48.5	8.3	0.0270	56.0
6.0	20.5	45.0	38.5	0.0132	45.0	8.9	0.0161	51.3
16.0	20.5	41.5	35.0	0.0132	41.5	9.5	0.0102	46.7
30.0	21.0	40.0	33.6	0.0131	40.0	9.7	0.0075	44.8
62.0	21.0	38.0	31.6	0.0131	38.0	10.1	0.0053	42.1
250.0	21.5	35.0	28.7	0.0131	35.0	10.6	0.0027	38.3
1488.0	21.0	32.5	26.1	0.0131	32.5	11.0	0.0011	34.8

Fractional Components

Gravel/Sand based on #4 sieve
Sand/Fines based on #200 sieve
% + 3 in. = 0.0 % GRAVEL = 0.0 % SAND = 22.7
% SILT = 35.6 % CLAY = 41.7

D85= 0.10 D60= 0.036 D50= 0.014

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	19	0.0	0.0	46.0	28.5	25.5	CL	30	9

SIEVE inches size	PERCENT FINER ●		

	GRAIN SIZE		
D_{60}	0.0852		
D_{30}			
D_{10}			

	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ●		
40	100.0		
60	99.6		
100	88.7		
200	54.0		

Sample information:
● Boring NB-90,UD 17-19'
Orange tan sandy lean clay

Remarks:
Methods: Particle Size: ASTM D 422-63; Sieve Analysis: AASHTO T27-99; Specific Gravity: 2.71

Project No.: 3043051064.0001
Project: TVA Kingston- Proposed Gypsum Stack

Date: January 23, 2006

GRAIN SIZE DISTRIBUTION TEST DATA Test No.: 19

D te: January 23, 2006
ect No.: 3043051064.0001
ect: TVA Kingston- Proposed Gypsum Stack

Sample Data

Location of Sample: Boring NB-90,UD 17-19'
Sample Description 1: Orange tan sandy lean
Sample Description 2: clay
JSCS Class: CL Liquid limit: 30 Plasticity index: 9

Notes

Remarks: Methods: Particle Size: ASTM D 422-63; Sieve
Analysis: AASHTO T27-99; Specific Gravity: 2.71
Fig. No.: B90

Mechanical Analysis Data

	Initial
Dry sample and tare=	963.32
Tare =	0.00
Dry sample weight =	963.32

Sample split on number 40 sieve
t sample data:
ple and tare = 70.56 Tare = 0 Sample weight = 70.56
umulative weight retained tare= 0
Tare for cumulative weight retained= 0

Sieve	Cumul. Wt. retained	Percent finer
# 40	0.33	100.0
# 60	0.25	99.6
# 100	7.93	88.7
# 200	32.41	54.0

Hydrometer Analysis Data

Separation sieve is number 40
Percent -# 40 based on complete sample= 100.0
Weight of hydrometer sample: 71.05
Hygroscopic moisture correction:
Moist weight & tare = 52.69
Dry weight & tare = 52.48
Tare = 22.24
Hygroscopic moisture= 0.7 %
Calculated biased weight= 70.58
Table of composite correction values:

Temp, deg C:	20.0	20.5	21.0	22.0	23.0
Comp. corr:	- 6.7	- 6.5	- 6.4	- 6.1	- 5.8

Meniscus correction only= 0
Specific gravity of solids= 2.71
Specific gravity correction factor= 0.987
Hydrometer type: 152H   Effective depth L= 16.294964 - 0.164 x Rm

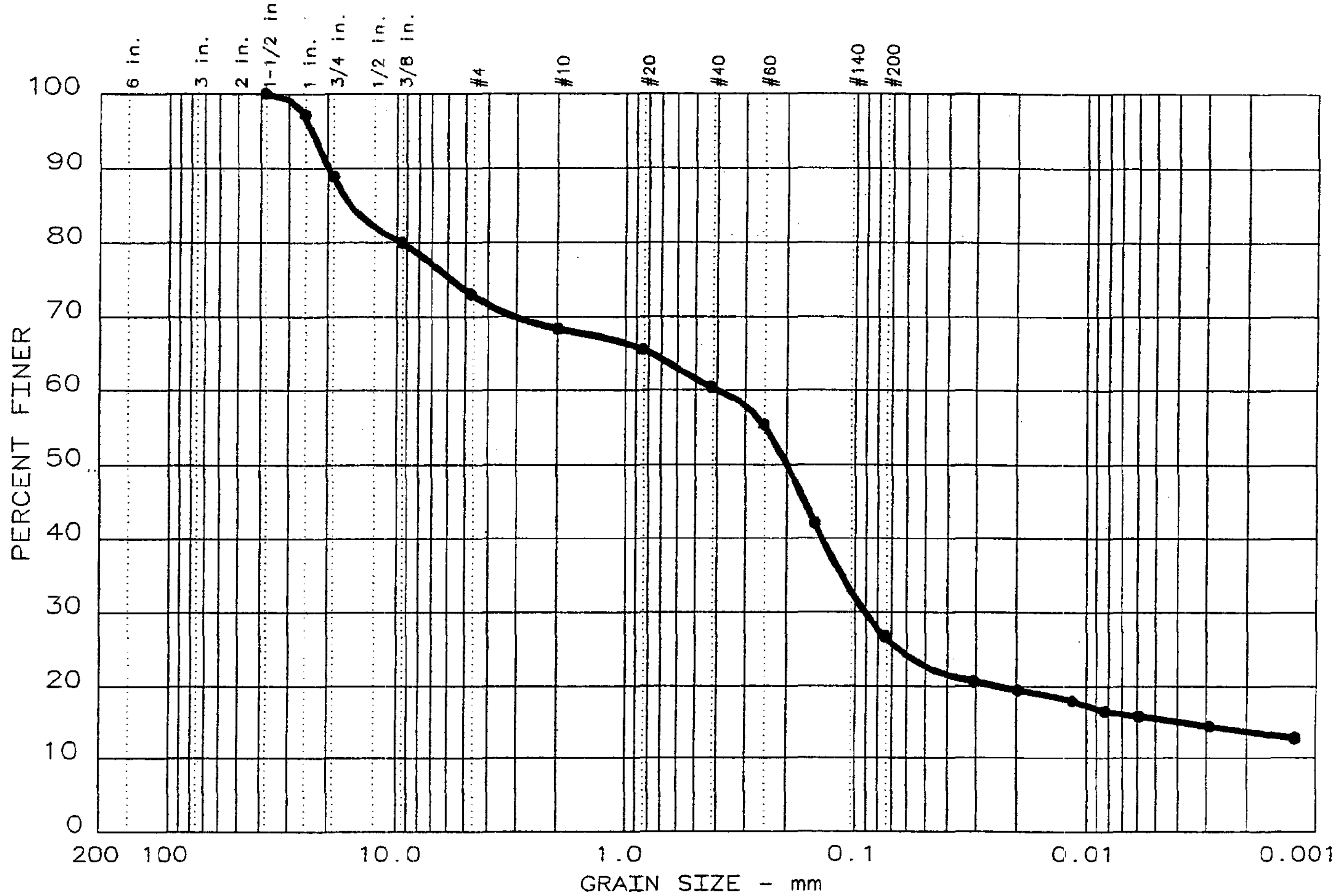
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
2.0	20.5	33.0	26.5	0.0133	33.0	10.9	0.0311	37.0
6.0	20.5	30.0	23.5	0.0133	30.0	11.4	0.0183	32.9
18.0	20.5	27.5	21.0	0.0133	27.5	11.8	0.0108	29.4
32.0	21.0	25.5	19.1	0.0132	25.5	12.1	0.0081	26.7
62.0	21.0	25.0	18.6	0.0132	25.0	12.2	0.0059	26.0
250.0	21.0	22.5	16.1	0.0132	22.5	12.6	0.0030	22.5
1464.0	21.0	20.5	14.1	0.0132	20.5	12.9	0.0012	19.7

Fractional Components

Gravel/Sand based on #4 sieve
Sand/Fines based on #200 sieve
% + 3 in. = 0.0   % GRAVEL = 0.0   % SAND = 46.0
% SILT = 28.5   % CLAY = 25.5

D85= 0.14   D60= 0.085   D50= 0.067
D30= 0.0114

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	20	0.0	26.9	46.3	11.4	15.4	SC-SM	26	7

SIEVE inches size	PERCENT FINER ●		
1.5	100.0		
1	97.2		
0.75	88.9		
0.375	80.0		
	GRAIN SIZE		
D_{60}	0.398		
D_{30}			
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ●		
4	73.1		
10	68.4		
20	65.6		
40	60.4		
60	55.4		
100	42.1		
200	26.8		

Sample information:
● Boring NB-92,UD 11-13'
Red brown silty, clayey sand with gravel

Remarks:
Methods: Particle Size: ASTM D 422-63; Sieve Analysis: AASHTO T27-99; Specific Gravity: 2.71

Project No.: 3043051064.0001
Project: TVA Kingston- Proposed Gypsum Stack

Date: January 23, 2006

GRAIN SIZE DISTRIBUTION TEST DATA   Test No.: 20

Date: January 23, 2006
Project No.: 3043051064.0001
Project: TVA Kingston- Proposed Gypsum Stack

Sample Data

Location of Sample: Boring NB-92,UD 11-13'
Sample Description 1: Red brown silty, clayey
Sample Description 2: sand with gravel
USCS Class: SC-SM   Liquid limit: 26   Plasticity index: 7

Notes

Remarks: Methods: Particle Size: ASTM D 422-63; Sieve
Analysis: AASHTO T27-99; Specific Gravity: 2.71
Fig. No.: B92

Mechanical Analysis Data

Initial
Dry sample and tare= 1089.89
Tare = 0.00
Dry sample weight = 1089.89
Sample split on number 40 sieve
Split sample data:
Sample and tare = 78.24   Tare = 0   Sample weight = 78.24
Cumulative weight retained tare= 0
Tare for cumulative weight retained= 0

Sieve	Cumul. Wt. retained	Percent finer
1.5 inches	0.00	100.0
1 inches	30.50	97.2
0.75 inches	121.10	88.9
0.375 inches	217.90	80.0
# 4	293.60	73.1
# 10	344.90	68.4
# 20	375.30	65.6
# 40	431.50	60.4
# 60	6.54	55.4
# 100	23.76	42.1
# 200	43.59	26.8

Hydrometer Analysis Data

Separation sieve is number 40
Percent -# 40 based on complete sample= 60.4
Weight of hydrometer sample: 78.79
Hygroscopic moisture correction:
Moist weight & tare = 53.58

Dry weight & tare = 53.35
Tare = 22.37
Hygroscopic moisture= 0.7 %
Calculated biased weight= 129.47
Table of composite correction values:
Temp, deg C: 20.0 21.0 21.5 22.0 23.0
Comp. corr: - 6.7 - 6.4 - 6.3 - 6.1 - 5.8
Meniscus correction only= 0
Specific gravity of solids= 2.71
Specific gravity correction factor= 0.987
Hydrometer type: 152H Effective depth L= 16.294964 - 0.164 x Rm

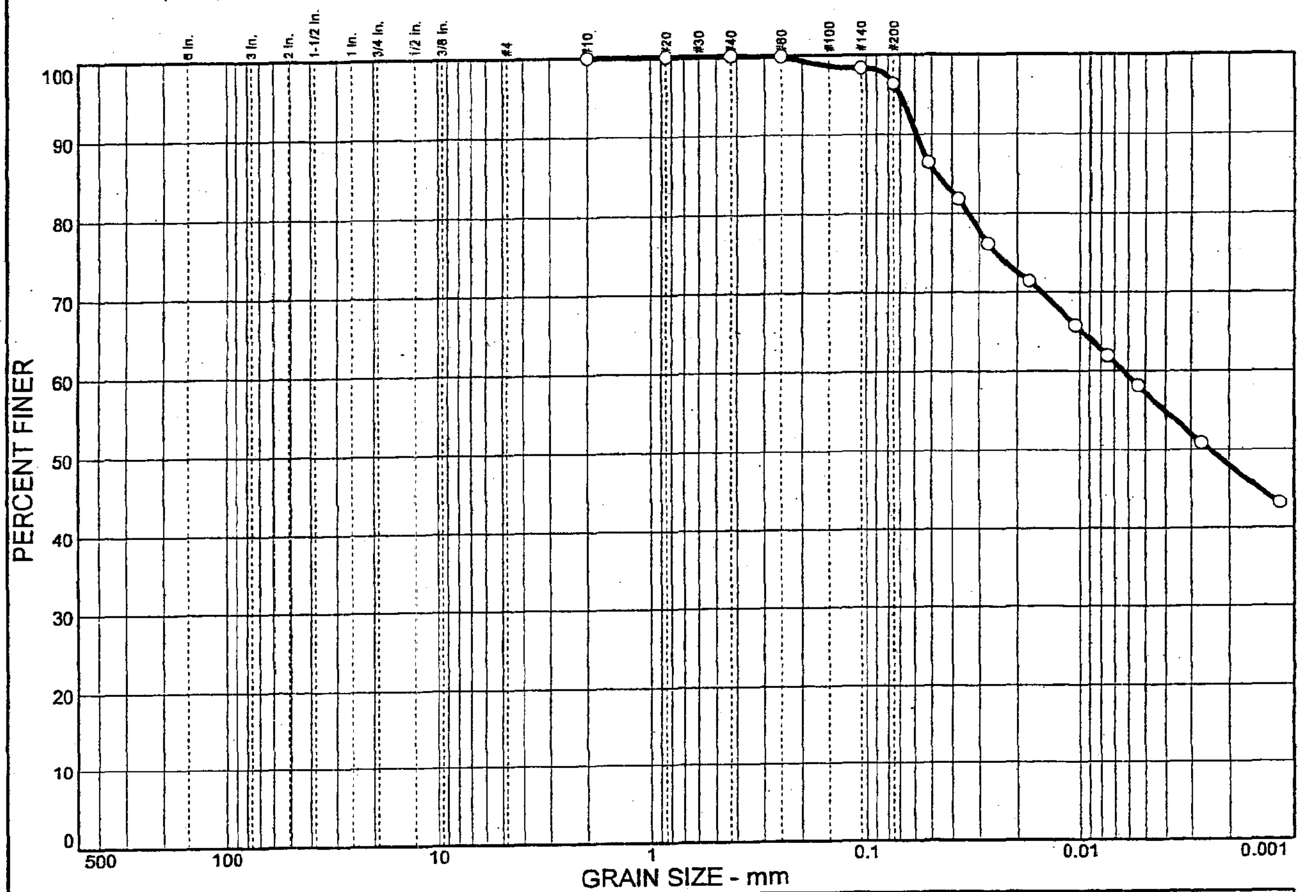
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
2.0	21.0	33.5	27.1	0.0132	33.5	10.8	0.0308	20.7
5.0	21.0	32.0	25.6	0.0132	32.0	11.0	0.0197	19.5
15.0	21.0	30.0	23.6	0.0132	30.0	11.4	0.0115	18.0
30.0	21.0	28.0	21.6	0.0132	28.0	11.7	0.0083	16.5
60.0	21.0	27.0	20.6	0.0132	27.0	11.9	0.0059	15.7
250.0	21.5	25.0	18.7	0.0132	25.0	12.2	0.0029	14.3
1443.0	21.0	23.0	16.6	0.0132	23.0	12.5	0.0012	12.7

Fractional Components

Gravel/Sand based on #4 sieve
Sand/Fines based on #200 sieve
% + 3 in. = 0.0 % GRAVEL = 26.9 % SAND = 46.3
% SILT = 11.4 % CLAY = 15.4

= 15.85 D60= 0.398 D50= 0.197
0.0902 D15= 0.00407

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	3.6	39.0	57.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	100.0		
#40	100.0		
#60	99.9		
#140	98.4		
#200	96.4		

* (no specification provided)

Material Description

Fat clay

Atterberg Limits

PL= 24 LL= 54 PI= 30

Coefficients

D_{85}= 0.0475 D_{60}= 0.0063 D_{50}= 0.0025
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= CH AASHTO=

Remarks

Sample No.:
Location: K-1

Source of Sample:

Date: 1-20-06
Elev./Depth: 12'-14'

MACTEC, INC.
Charlotte, North Carolina

Client: TVA
Project: TVA Kingston - Gypsum Disposal
Project No: 3043-05-1064 **Figure**

GRAIN SIZE DISTRIBUTION TEST DATA

Client: TVA
Project: TVA Kingston - Gypsum Disposal
roject Number: 3043-05-1064

Sample Data

Source:
Sample No.:
Elev. or Depth: 12'-14' **Sample Length(in./cm.):**
Location: K-1
Description: Fat clay
Date: 1-20-06 **PL:** 24 **LL:** 54 **PI:** 30
USCS Classification: CH **AASHTO Classification:**
Testing Remarks:

Mechanical Analysis Data

	Initial
Dry sample and tare=	396.76
Tare =	0.00
Dry sample weight =	396.76

Sample split on number 10 **sieve**
Split sample data:
Sample and tare = 52.10 **Tare =** .00 **Sample weight =** 52.10
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
# 10	0.00	100.0
# 20	0.00	100.0
# 40	0.00	100.0
# 60	0.03	99.9
# 140	0.85	98.4
# 200	1.89	96.4

Hydrometer Analysis Data

Separation sieve is #10
Percent -#10 based upon complete sample= 100.0
Weight of hydrometer sample: 52.86
Hygroscopic moisture correction:
Moist weight & tare = 40.07
Dry weight & tare = 39.65
Tare = 10.74
Hygroscopic moisture= 1.5 %
Calculated biased weight= 52.10
Table of composite correction values:

Temp, deg C:	10.7	23.1	40.2
Comp. corr:	-7.0	-4.0	0.0

Meniscus correction only= 1
Specific gravity of solids= 2.728
Specific gravity correction factor= 0.983
ydrometer type: 152H
Effective depth L= 16.294964 - 0.164 x Rm

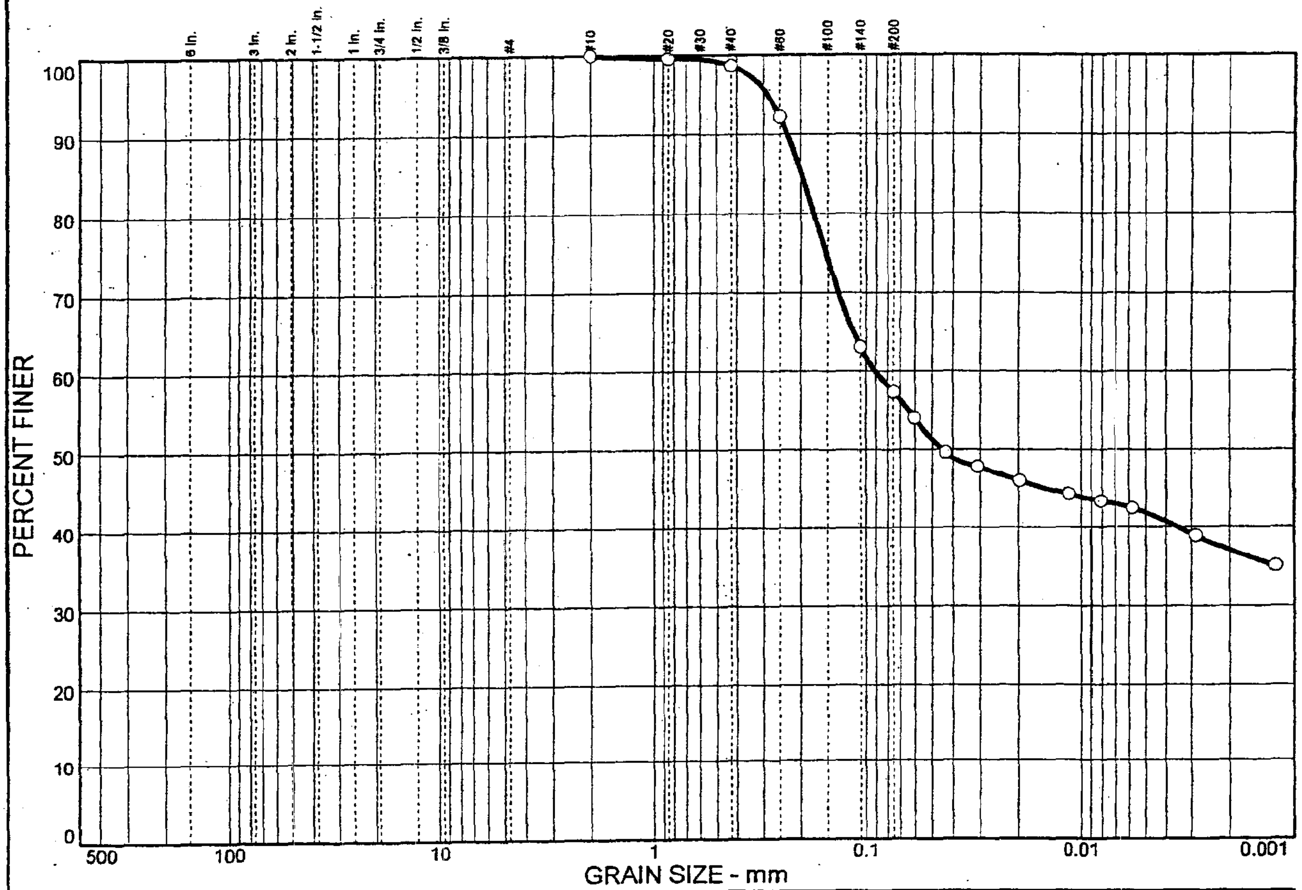
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
0.50	22.5	50.0	45.9	0.0129	51.0	7.9	0.0515	86.5
1.00	22.5	47.5	43.4	0.0129	48.5	8.3	0.0373	81.8
2.00	22.5	44.5	40.4	0.0129	45.5	8.8	0.0272	76.1
5.00	22.5	42.0	37.9	0.0129	43.0	9.2	0.0176	71.4
15.00	22.5	39.0	34.9	0.0129	40.0	9.7	0.0104	65.8
30.00	22.5	37.0	32.9	0.0129	38.0	10.1	0.0075	62.0
60.00	22.5	35.0	30.9	0.0129	36.0	10.4	0.0054	58.2
250.00	23.0	31.0	27.0	0.0129	32.0	11.0	0.0027	50.9
1440.00	22.6	27.0	22.9	0.0129	28.0	11.7	0.0012	43.2

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = **% GRAVEL =** **% SAND =** 3.6
% SILT = 39.0 **% CLAY =** 57.4

D_{85}= 0.05 D_{60}= 0.01 D_{50}= 0.00

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	42.7	15.4	41.9

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	99.6		
#40	98.7		
#60	92.2		
#140	63.1		
#200	57.3		

* (no specification provided)

Material Description

Sandy elastic silt

Atterberg Limits

PL= 31 LL= 50 PI= 19

Coefficients

D_{85}= 0.198 D_{60}= 0.0905 D_{50}= 0.0451
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= MH AASHTO=

Remarks

Sample No.: **Source of Sample:** **Date:** 1-20-06
Location: K-2 **Elev./Depth:** 12'-14'

MACTEC, INC.
Charlotte, North Carolina

Client: TVA
Project: TVA Kingston - Gypsum Disposal
Project No: 3043-05-1064 **Figure**

GRAIN SIZE DISTRIBUTION TEST DATA

Client: TVA
Project: TVA Kingston - Gypsum Disposal
roject Number: 3043-05-1064

Sample Data

Source:
Sample No.:
Elev. or Depth: 12'-14' **Sample Length(in./cm.):**
Location: K-2
Description: Sandy elastic silt
Date: 1-20-06 **PL:** 31 **LL:** 50 **PI:** 19
USCS Classification: MH **AASHTO Classification:**
Testing Remarks:

Mechanical Analysis Data

	Initial
Dry sample and tare=	417.74
Tare =	0.00
Dry sample weight =	417.74

Sample split on number 10 **sieve**
Split sample data:
Sample and tare = 55.92 **Tare =** .00 **Sample weight =** 55.92
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
# 10	0.00	100.0
20	0.24	99.6
# 40	0.73	98.7
# 60	4.36	92.2
# 140	20.65	63.1
# 200	23.88	57.3

Hydrometer Analysis Data

Separation sieve is #10
Percent -#10 based upon complete sample= 100.0
Weight of hydrometer sample: 56.98
Hygroscopic moisture correction:
Moist weight & tare = 51.34
Dry weight & tare = 50.60
Tare = 10.80
Hygroscopic moisture= 1.9 %
Calculated biased weight= 55.94
Table of composite correction values:

Temp, deg C:	10.7	23.1	40.2
Comp. corr:	-7.0	-4.0	0.0

Meniscus correction only= 1
Specific gravity of solids= 2.673
Specific gravity correction factor= 0.995
ydrometer type: 152H
ffective depth L= 16.294964 - 0.164 x Rm

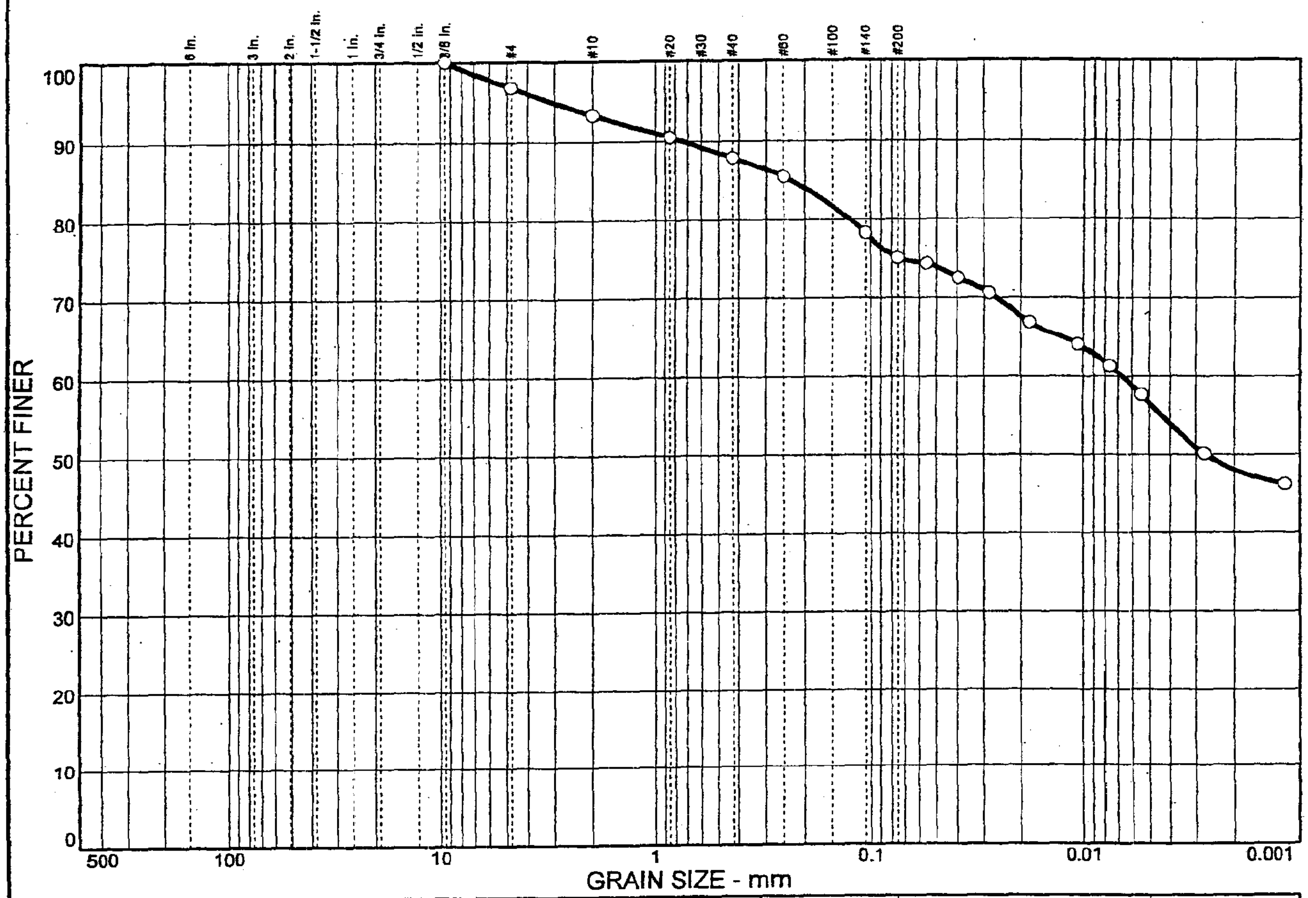
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
0.50	22.6	34.5	30.4	0.0131	35.5	10.5	0.0601	54.0
1.00	22.6	32.0	27.9	0.0131	33.0	10.9	0.0433	49.6
2.00	22.6	31.0	26.9	0.0131	32.0	11.0	0.0308	47.8
5.00	22.6	30.0	25.9	0.0131	31.0	11.2	0.0197	46.0
15.00	22.6	29.0	24.9	0.0131	30.0	11.4	0.0114	44.3
30.00	22.6	28.5	24.4	0.0131	29.5	11.5	0.0081	43.4
60.00	22.6	28.0	23.9	0.0131	29.0	11.5	0.0058	42.5
250.00	22.6	26.0	21.9	0.0131	27.0	11.9	0.0029	38.9
1440.00	21.9	24.0	19.7	0.0132	25.0	12.2	0.0012	35.1

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = **% GRAVEL =** **% SAND =** 42.7
% SILT = 15.4 **% CLAY =** 41.9

D_{85}= 0.20 D_{60}= 0.09 D_{50}= 0.05

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	3.2	21.8	18.4	56.6

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.375 in.	100.0		
#4	96.8		
#10	93.3		
#20	90.5		
#40	87.8		
#60	85.4		
#140	78.2		
#200	75.0		

* (no specification provided)

Material Description

Elastic silt with sand

Atterberg Limits

PL= 37 LL= 56 PI= 19

Coefficients

D_{85}= 0.234 D_{60}= 0.0067 D_{50}= 0.0027
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= MH AASHTO=

Remarks

Sample No.: **Source of Sample:** **Date:** 1-20-06
Location: K-3 **Elev./Depth:** 10'-15'

MACTEC, INC. Charlotte, North Carolina	**Client:** TVA **Project:** TVA Kingston - Gypsum Disposal **Project No:** 3043-05-1064 **Figure**

GRAIN SIZE DISTRIBUTION TEST DATA

Client: TVA
Project: TVA Kingston - Gypsum Disposal
roject Number: 3043-05-1064

Sample Data

Source:
Sample No.:
Elev. or Depth: 10'-15'
Sample Length(in./cm.):
Location: K-3
Description: Elastic silt with sand
Date: 1-20-06 **PL:** 37 **LL:** 56 **PI:** 19
USCS Classification: MH **AASHTO Classification:**
Testing Remarks:

Mechanical Analysis Data

	Initial
Dry sample and tare=	355.40
Tare =	0.00
Dry sample weight =	355.40

Sample split on number 10 **sieve**
Split sample data:
Sample and tare = 49.64 **Tare =** .00 **Sample weight =** 49.64
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
375 inch	0.00	100.0
4	11.33	96.8
# 10	23.74	93.3
# 20	1.51	90.5
# 40	2.90	87.8
# 60	4.22	85.4
# 140	8.04	78.2
# 200	9.72	75.0

Hydrometer Analysis Data

Separation sieve is #10
Percent -#10 based upon complete sample= 93.3
Weight of hydrometer sample: 51.13
Hygroscopic moisture correction:
Moist weight & tare = 47.81
Dry weight & tare = 46.73
Tare = 10.81
Hygroscopic moisture= 3.0 %
Calculated biased weight= 53.20
Table of composite correction values:

Temp, deg C:	10.7	23.1	40.2
Comp. corr:	-7.0	-4.0	0.0

Meniscus correction only= 1
ecific gravity of solids= 2.686
ific gravity correction factor= 0.992
ometer type: 152H

Effective depth L= 16.294964 - 0.164 x Rm

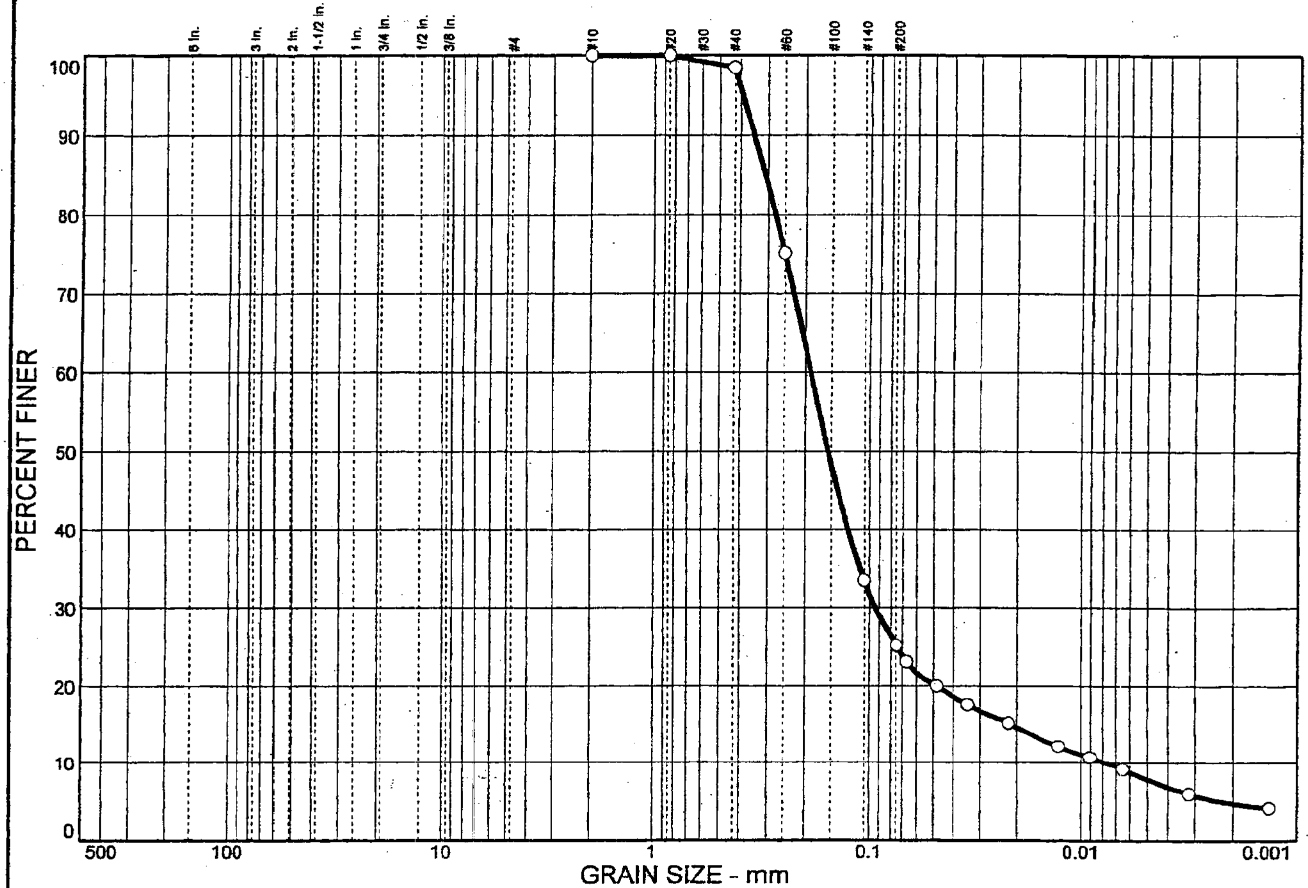
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
0.50	22.5	44.0	39.9	0.0131	45.0	8.9	0.0553	74.3
1.00	22.5	43.0	38.9	0.0131	44.0	9.1	0.0394	72.5
2.00	22.5	42.0	37.9	0.0131	43.0	9.2	0.0281	70.6
5.00	22.5	40.0	35.9	0.0131	41.0	9.6	0.0181	66.9
15.00	22.5	38.5	34.4	0.0131	39.5	9.8	0.0106	64.1
30.00	22.5	37.0	32.9	0.0131	38.0	10.1	0.0076	61.3
60.00	22.6	35.0	30.9	0.0131	36.0	10.4	0.0054	57.6
250.00	22.6	31.0	26.9	0.0131	32.0	11.0	0.0027	50.1
1440.00	22.2	29.0	24.8	0.0131	30.0	11.4	0.0012	46.2

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = **% GRAVEL =** 3.2 **% SAND =** 21.8
% SILT = 18.4 **% CLAY =** 56.6

D_{85}= 0.23 D_{60}= 0.01 D_{50}= 0.00

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	74.8	17.3	7.9

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	100.0		
#40	98.5		
#60	75.1		
#140	33.5		
#200	25.2		

* (no specification provided)

Material Description

Silty sand

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= 0.309 D_{60}= 0.188 D_{50}= 0.155
D_{30}= 0.0937 D_{15}= 0.0207 D_{10}= 0.0078
C_u= 24.11 C_c= 6.01

Classification

USCS= SM AASHTO=

Remarks

Sample No.: **Source of Sample:** **Date:** 1-20-06
Location: K-4 **Elev./Depth:** 12'-14'

MACTEC, INC.
Charlotte, North Carolina

Client: TVA
Project: TVA Kingston - Gypsum Disposal
Project No: 3043-05-1064 **Figure**

GRAIN SIZE DISTRIBUTION TEST DATA

Client: TVA
Project: TVA Kingston - Gypsum Disposal
roject Number: 3043-05-1064

Sample Data

Source:
Sample No.:
Elev. or Depth: 12'-14'
Sample Length(in./cm.):
Location: K-4
Description: Silty sand
Date: 1-20-06 **PL:** NP **LL:** NV **PI:** NP
USCS Classification: SM **AASHTO Classification:**
Testing Remarks:

Mechanical Analysis Data

	Initial
Dry sample and tare=	497.37
Tare =	0.00
Dry sample weight =	497.37

Sample split on number 10 **sieve**
Split sample data:
Sample and tare = 64.27 **Tare =** .00 **Sample weight =** 64.27
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
# 10	0.00	100.0
20	0.00	100.0
# 40	0.94	98.5
# 60	16.03	75.1
# 140	42.75	33.5
# 200	48.08	25.2

Hydrometer Analysis Data

Separation sieve is #10
Percent -#10 based upon complete sample= 100.0
Weight of hydrometer sample: 64.52
Hygroscopic moisture correction:
Moist weight & tare = 63.05
Dry weight & tare = 62.85
Tare = 11.56
Hygroscopic moisture= 0.4 %
Calculated biased weight= 64.27
Table of composite correction values:

Temp, deg C:	10.7	23.1	40.2
Comp. corr:	-7.0	-4.0	0.0

Meniscus correction only= 1
Specific gravity of solids= 2.669
Specific gravity correction factor= 0.996
drometer type: 152H
Effective depth L= 16.294964 - 0.164 x Rm

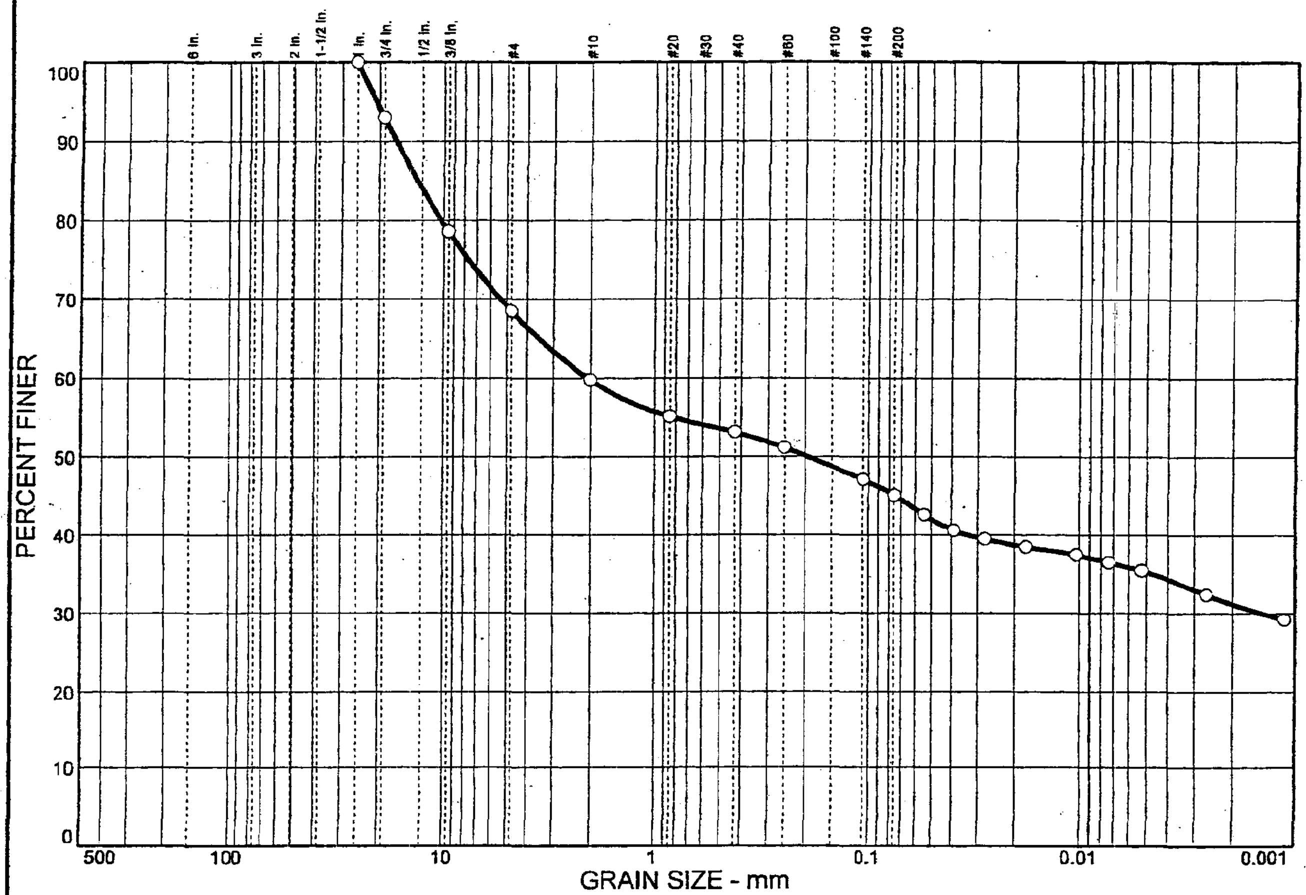
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
0.50	22.6	19.0	14.9	0.0131	20.0	13.0	0.0670	23.1
1.00	22.6	17.0	12.9	0.0131	18.0	13.3	0.0480	20.0
2.00	22.6	15.5	11.4	0.0131	16.5	13.6	0.0343	17.6
5.00	22.6	14.0	9.9	0.0131	15.0	13.8	0.0219	15.3
15.00	22.6	12.0	7.9	0.0131	13.0	14.2	0.0128	12.2
30.00	22.6	11.0	6.9	0.0131	12.0	14.3	0.0091	10.7
60.00	22.6	10.0	5.9	0.0131	11.0	14.5	0.0065	9.1
250.00	22.6	8.0	3.9	0.0131	9.0	14.8	0.0032	6.0
1440.00	21.9	7.0	2.7	0.0133	8.0	15.0	0.0014	4.2

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = **% GRAVEL =** **% SAND =** 74.8
% SILT = 17.3 **% CLAY =** 7.9

D_{85}= 0.31 D_{60}= 0.19 D_{50}= 0.16
D_{30}= 0.09 D_{15}= 0.02 D_{10}= 0.01
C_c= 6.0096 C_u= 24.1106

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	31.5	23.4	9.8	35.3

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1 in.	100.0		
.75 in.	93.0		
.375 in.	78.6		
#4	68.5		
#10	59.8		
#20	55.1		
#40	53.1		
#60	51.1		
#140	47.1		
#200	45.1		

* (no specification provided)

Material Description

Silty gravel with sand

Atterberg Limits

PL= 39 LL= 65 PI= 26

Coefficients

D_{85}= 13.3 D_{60}= 2.05 D_{50}= 0.194
D_{30}= 0.0014 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= GM AASHTO=

Remarks

Sample No.: **Source of Sample:** **Date:** 1-20-06
Location: K-5 **Elev./Depth:** 12'-14'

MACTEC, INC. Charlotte, North Carolina	Client: TVA Project: TVA Kingston - Gypsum Disposal Project No: 3043-05-1064 Figure

TVA-00020860

GRAIN SIZE DISTRIBUTION TEST DATA

Client: TVA
Project: TVA Kingston - Gypsum Disposal
roject Number: 3043-05-1064

Sample Data

Source:
Sample No.:
Elev. or Depth: 12'-14'
Sample Length(in./cm.):
Location: K-5
Description: Silty gravel with sand
Date: 1-20-06 **PL:** 39 **LL:** 65 **PI:** 26
USCS Classification: GM
AASHTO Classification:
Testing Remarks:

Mechanical Analysis Data

	Initial
Dry sample and tare=	464.13
Tare =	0.00
Dry sample weight =	464.13

Sample split on number 10 **sieve**
Split sample data:
Sample and tare = 58.08 **Tare** = .00 **Sample weight** = 58.08
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
¹ inch	0.00	100.0
75 inch	32.44	93.0
.375 inch	99.13	78.6
# 4	146.34	68.5
# 10	186.39	59.8
# 20	4.58	55.1
# 40	6.54	53.1
# 60	8.46	51.1
# 140	12.32	47.1
# 200	14.29	45.1

Hydrometer Analysis Data

Separation sieve is #10
Percent -#10 based upon complete sample= 59.8
Weight of hydrometer sample: 59.64
Hygroscopic moisture correction:
Moist weight & tare = 45.70
Dry weight & tare = 44.81
Tare = 11.65
Hygroscopic moisture= 2.7 %
Calculated biased weight= 97.13
Table of composite correction values:

Temp, deg C:	10.7	23.1	40.2
Comp. corr:	-7.0	-4.0	0.0

scus correction only= 1
ific gravity of solids= 2.706

Specific gravity correction factor= 0.988
Hydrometer type: 152H
Effective depth L= 16.294964 - 0.164 x Rm

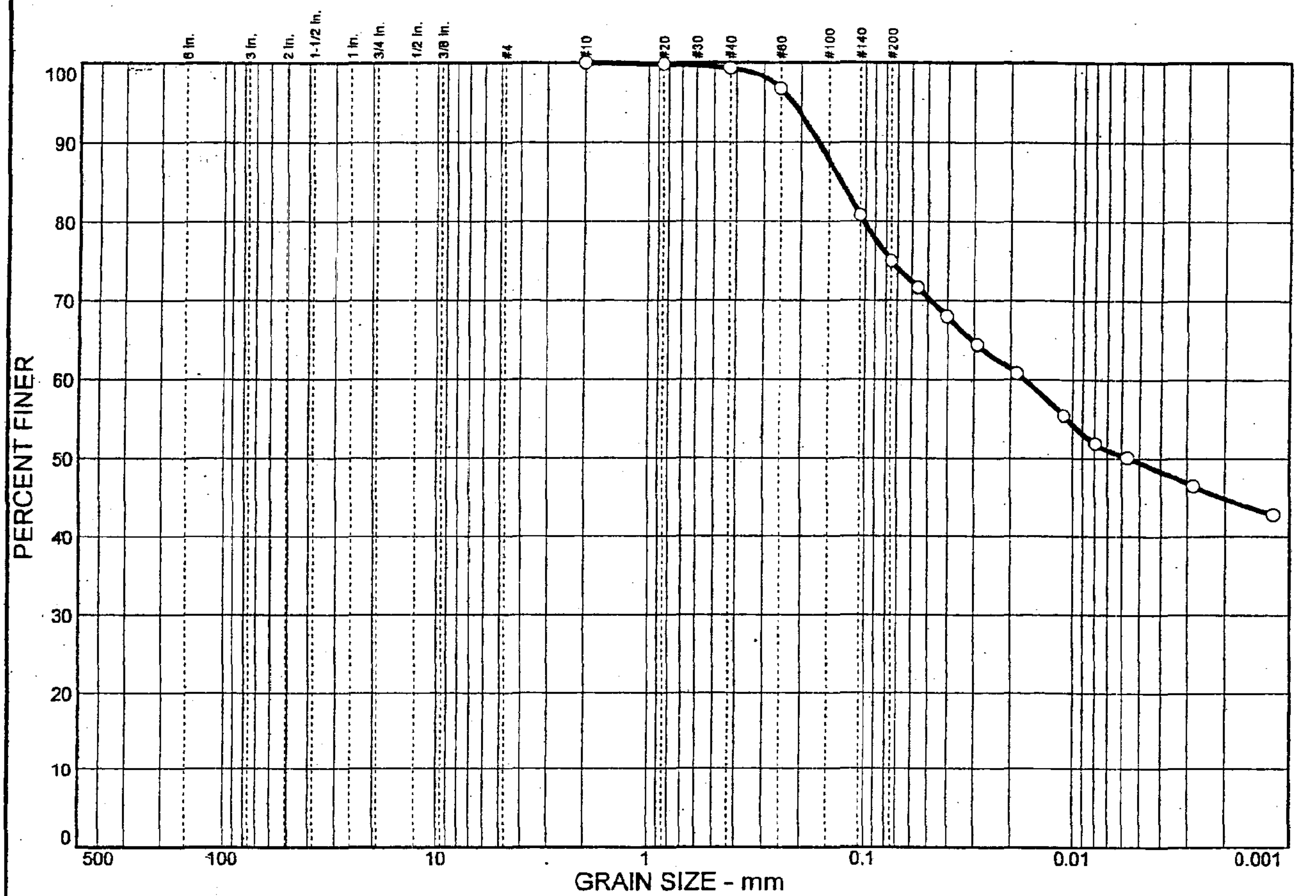
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
0.50	22.6	46.0	41.9	0.0130	47.0	8.6	0.0539	42.6
1.00	22.6	44.0	39.9	0.0130	45.0	8.9	0.0388	40.6
2.00	22.6	43.0	38.9	0.0130	44.0	9.1	0.0277	39.5
5.00	22.6	42.0	37.9	0.0130	43.0	9.2	0.0177	38.5
15.00	22.6	41.0	36.9	0.0130	42.0	9.4	0.0103	37.5
30.00	22.6	40.0	35.9	0.0130	41.0	9.6	0.0073	36.5
60.00	22.6	39.0	34.9	0.0130	40.0	9.7	0.0052	35.5
250.00	22.6	36.0	31.9	0.0130	37.0	10.2	0.0026	32.4
1440.00	22.0	33.0	28.7	0.0131	34.0	10.7	0.0011	29.2

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = **% GRAVEL =** 31.5 **% SAND =** 23.4
% SILT = 9.8 **% CLAY =** 35.3

D_{85}= 13.30 D_{60}= 2.05 D_{50}= 0.19
D_{30}= 0.00

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	25.0	25.5	49.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	99.8		
#40	99.3		
#60	96.7		
#140	80.8		
#200	75.0		

* (no specification provided)

Material Description

Silt with sand

Atterberg Limits

PL= 29 LL= 43 PI= 14

Coefficients

D_{85}= 0.130 D_{60}= 0.0170 D_{50}= 0.0055
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= ML AASHTO=

Remarks

Sample No.: **Source of Sample:** **Date:** 1-20-06
Location: K-6 **Elev./Depth:** 10'-15'

MACTEC, INC. Charlotte, North Carolina	**Client:** TVA **Project:** TVA Kingston - Gypsum Disposal **Project No:** 3043-05-1064 **Figure**

GRAIN SIZE DISTRIBUTION TEST DATA

Client: TVA
Project: TVA Kingston - Gypsum Disposal
roject Number: 3043-05-1064

Sample Data

Source:
Sample No.:
Elev. or Depth: 10'-15' **Sample Length(in./cm.):**
Location: K-6
Description: Silt with sand
Date: 1-20-06 **PL:** 29 **LL:** 43 **PI:** 14
USCS Classification: ML **AASHTO Classification:**
Testing Remarks:

Mechanical Analysis Data

	Initial
Dry sample and tare=	370.37
Tare =	0.00
Dry sample weight =	370.37

Sample split on number 10 **sieve**
Split sample data:
Sample and tare = 55.67 **Tare =** .00 **Sample weight =** 55.67
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
# 10	0.00	100.0
# 20	0.12	99.8
# 40	0.40	99.3
# 60	1.82	96.7
# 140	10.67	80.8
# 200	13.92	75.0

Hydrometer Analysis Data

Separation sieve is #10
Percent -#10 based upon complete sample= 100.0
Weight of hydrometer sample: 56.56
Hygroscopic moisture correction:
Moist weight & tare = 46.46
Dry weight & tare = 45.90
Tare = 11.57
Hygroscopic moisture= 1.6 %
Calculated biased weight= 55.65
Table of composite correction values:

Temp, deg C:	10.7	23.1	40.2
Comp. corr:	-7.0	-4.0	0.0

Meniscus correction only= 1
Specific gravity of solids= 2.648
Specific gravity correction factor= 1.000
ydrometer type: 152H
Effective depth L= 16.294964 - 0.164 x Rm

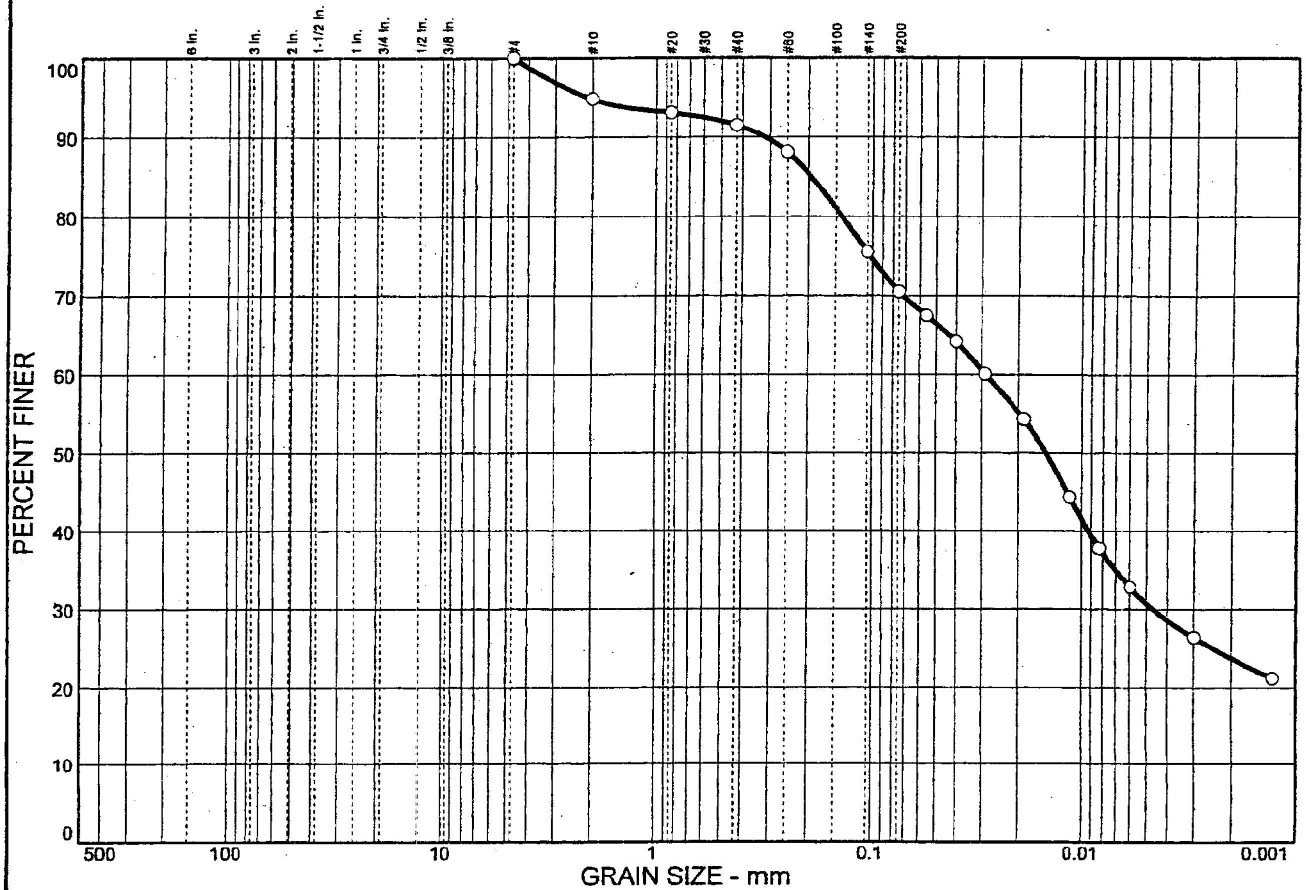
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
0.50	22.5	44.0	39.9	0.0132	45.0	8.9	0.0559	71.6
1.00	22.5	42.0	37.9	0.0132	43.0	9.2	0.0403	68.0
2.00	22.5	40.0	35.9	0.0132	41.0	9.6	0.0290	64.4
5.00	22.5	38.0	33.9	0.0132	39.0	9.9	0.0186	60.8
15.00	22.5	35.0	30.9	0.0132	36.0	10.4	0.0110	55.4
30.00	22.5	33.0	28.9	0.0132	34.0	10.7	0.0079	51.9
60.00	22.6	32.0	27.9	0.0132	33.0	10.9	0.0056	50.1
250.00	22.6	30.0	25.9	0.0132	31.0	11.2	0.0028	46.5
1440.00	22.3	28.0	23.8	0.0133	29.0	11.5	0.0012	42.8

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = **% GRAVEL =** **% SAND =** 25.0
% SILT = 25.5 **% CLAY =** 49.5

D_{85}= 0.13 D_{60}= 0.02 D_{50}= 0.01

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	29.5	39.8	30.7

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	94.8		
#20	93.1		
#40	91.5		
#60	88.1		
#140	75.5		
#200	70.5		

* (no specification provided)

Material Description

Lean clay with sand

Atterberg Limits

PL= 21 LL= 31 PI= 10

Coefficients

D_{85}= 0.194 D_{60}= 0.0287 D_{50}= 0.0149
D_{30}= 0.0046 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= CL AASHTO=

Remarks

Sample No.: **Source of Sample:** **Date:** 1-20-06
Location: K-7 **Elev./Depth:** 10'-15'

MACTEC, INC. Charlotte, North Carolina	**Client:** TVA **Project:** TVA Kingston - Gypsum Disposal **Project No:** 3043-05-1064 **Figure**

TVA-00020866

GRAIN SIZE DISTRIBUTION TEST DATA

Client: TVA
Project: TVA Kingston - Gypsum Disposal
roject Number: 3043-05-1064

Sample Data

Source:
Sample No.:
Elev. or Depth: 10'-15' **Sample Length(in./cm.):**
Location: K-7
Description: Lean clay with sand
Date: 1-20-06 **PL:** 21 **LL:** 31 **PI:** 10
USCS Classification: CL **AASHTO Classification:**
Testing Remarks:

Mechanical Analysis Data

Initial
Dry sample and tare= 337.15
Tare = 0.00
Dry sample weight = 337.15
Sample split on number 10 **sieve**
Split sample data:
Sample and tare = 56.79 **Tare =** .00 **Sample weight =** 56.79
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
" 4	0.00	100.0
10	17.66	94.8
# 20	0.99	93.1
# 40	1.96	91.5
# 60	4.04	88.1
# 140	11.56	75.5
# 200	14.56	70.5

Hydrometer Analysis Data

Separation sieve is #10
Percent -#10 based upon complete sample= 94.8
Weight of hydrometer sample: 58.15
Hygroscopic moisture correction:
Moist weight & tare = 48.03
Dry weight & tare = 47.61
Tare = 11.46
Hygroscopic moisture= 1.2 %
Calculated biased weight= 60.64
Table of composite correction values:

Temp, deg C:	10.7	23.1	40.2
Comp. corr:	-7.0	-4.0	0.0

Meniscus correction only= 1
Specific gravity of solids= 2.641
ecific gravity correction factor= 1.002
ometer type: 152H
ffective depth L= 16.294964 - 0.164 x Rm

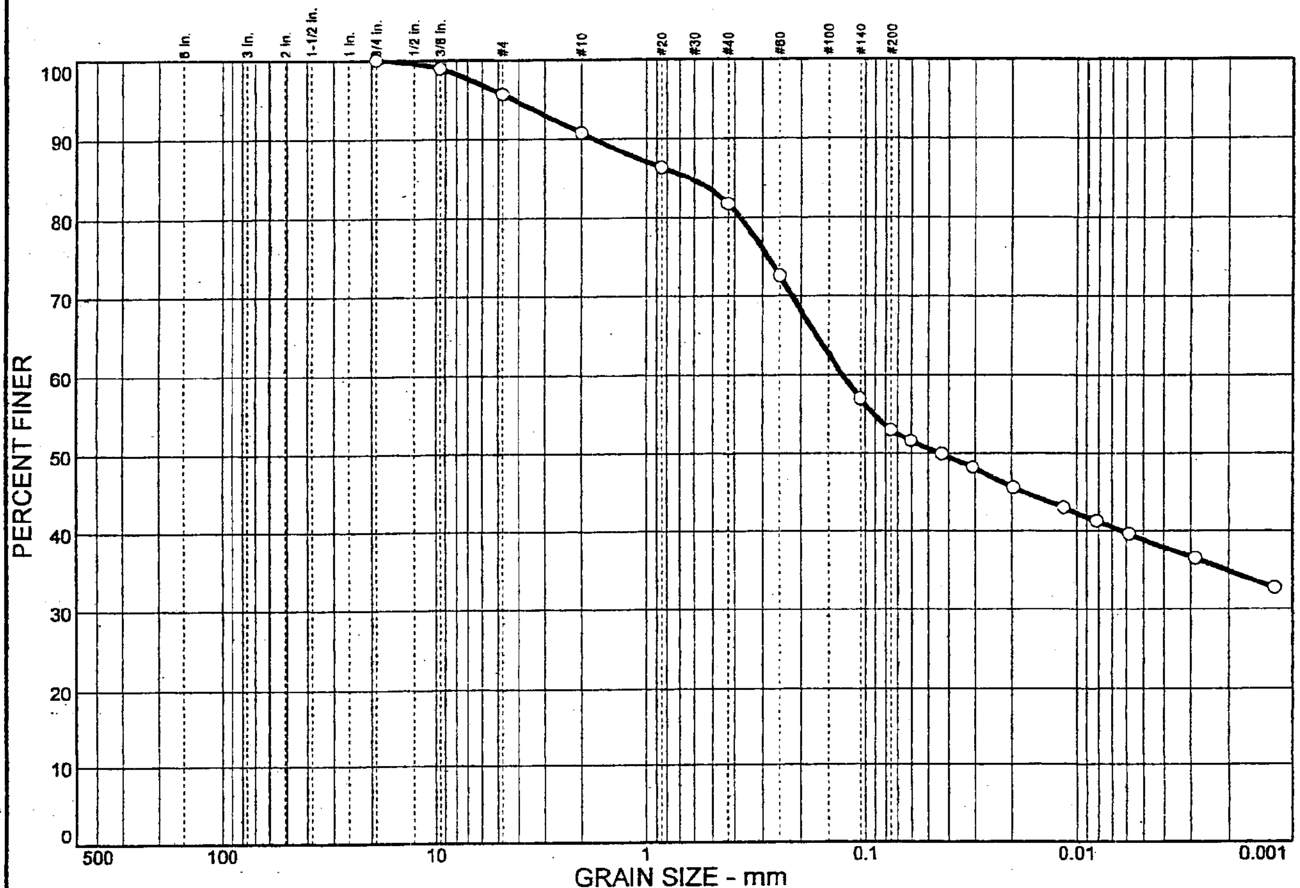
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
0.50	22.5	45.0	40.9	0.0133	46.0	8.8	0.0555	67.5
1.00	22.5	43.0	38.9	0.0133	44.0	9.1	0.0400	64.2
2.00	22.5	40.5	36.4	0.0133	41.5	9.5	0.0289	60.1
5.00	22.5	37.0	32.9	0.0133	38.0	10.1	0.0188	54.3
15.00	22.5	31.0	26.9	0.0133	32.0	11.0	0.0114	44.4
30.00	22.5	27.0	22.9	0.0133	28.0	11.7	0.0083	37.8
60.00	22.6	24.0	19.9	0.0133	25.0	12.2	0.0060	32.8
250.00	22.9	20.0	16.0	0.0132	21.0	12.9	0.0030	26.4
1440.00	22.5	17.0	12.9	0.0133	18.0	13.3	0.0013	21.2

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = **% GRAVEL =** **% SAND =** 29.5
% SILT = 39.8 **% CLAY =** 30.7

D_{85}= 0.19 D_{60}= 0.03 D_{50}= 0.01
D_{30}= 0.00

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	4.4	42.6	14.1	38.9

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75 in.	100.0		
.375 in.	98.9		
#4	95.6		
#10	90.7		
#20	86.3		
#40	81.7		
#60	72.6		
#140	57.0		
#200	53.0		

* (no specification provided)

Material Description

Sandy fat clay

Atterberg Limits

PL= 27 LL= 51 PI= 24

Coefficients

D_{85}= 0.635 D_{60}= 0.128 D_{50}= 0.0440
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= CH AASHTO=

Remarks

Sample No.: **Source of Sample:** **Date:** 1-20-06
Location: K-8 **Elev./Depth:** 10'-15'

MACTEC, INC. Charlotte, North Carolina	**Client:** TVA **Project:** TVA Kingston - Gypsum Disposal **Project No:** 3043-05-1064 **Figure**

GRAIN SIZE DISTRIBUTION TEST DATA

Client: TVA
Project: TVA Kingston - Gypsum Disposal
oject Number: 3043-05-1064

Sample Data

Source:
Sample No.:
Elev. or Depth: 10'-15' **Sample Length(in./cm.):**
Location: K-8
Description: Sandy fat clay
Date: 1-20-06 **PL:** 27 **LL:** 51 **PI:** 24
USCS Classification: CH **AASHTO Classification:**
Testing Remarks:

Mechanical Analysis Data

	Initial
Dry sample and tare=	355.84
Tare =	0.00
Dry sample weight =	355.84

Sample split on number 10 **sieve**
Split sample data:
Sample and tare = 52.23 **Tare =** .00 **Sample weight =** 52.23
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
75 inch	0.00	100.0
.375 inch	3.89	98.9
# 4	15.79	95.6
# 10	33.07	90.7
# 20	2.51	86.3
# 40	5.21	81.7
# 60	10.42	72.6
# 140	19.39	57.0
# 200	21.70	53.0

Hydrometer Analysis Data

Separation sieve is #10
Percent -#10 based upon complete sample= 90.7
Weight of hydrometer sample: 52.87
Hygroscopic moisture correction:
Moist weight & tare = 38.47
Dry weight & tare = 38.13
Tare = 10.71
Hygroscopic moisture= 1.2 %
Calculated biased weight= 57.58
Table of composite correction values:

Temp, deg C:	10.7	23.1	40.2
Comp. corr:	-7.0	-4.0	0.0

-iscus correction only= 1
:ific gravity of solids= 2.666
Specific gravity correction factor= 0.996

Hydrometer type: 152H
Effective depth L= 16.294964 - 0.164 x Rm

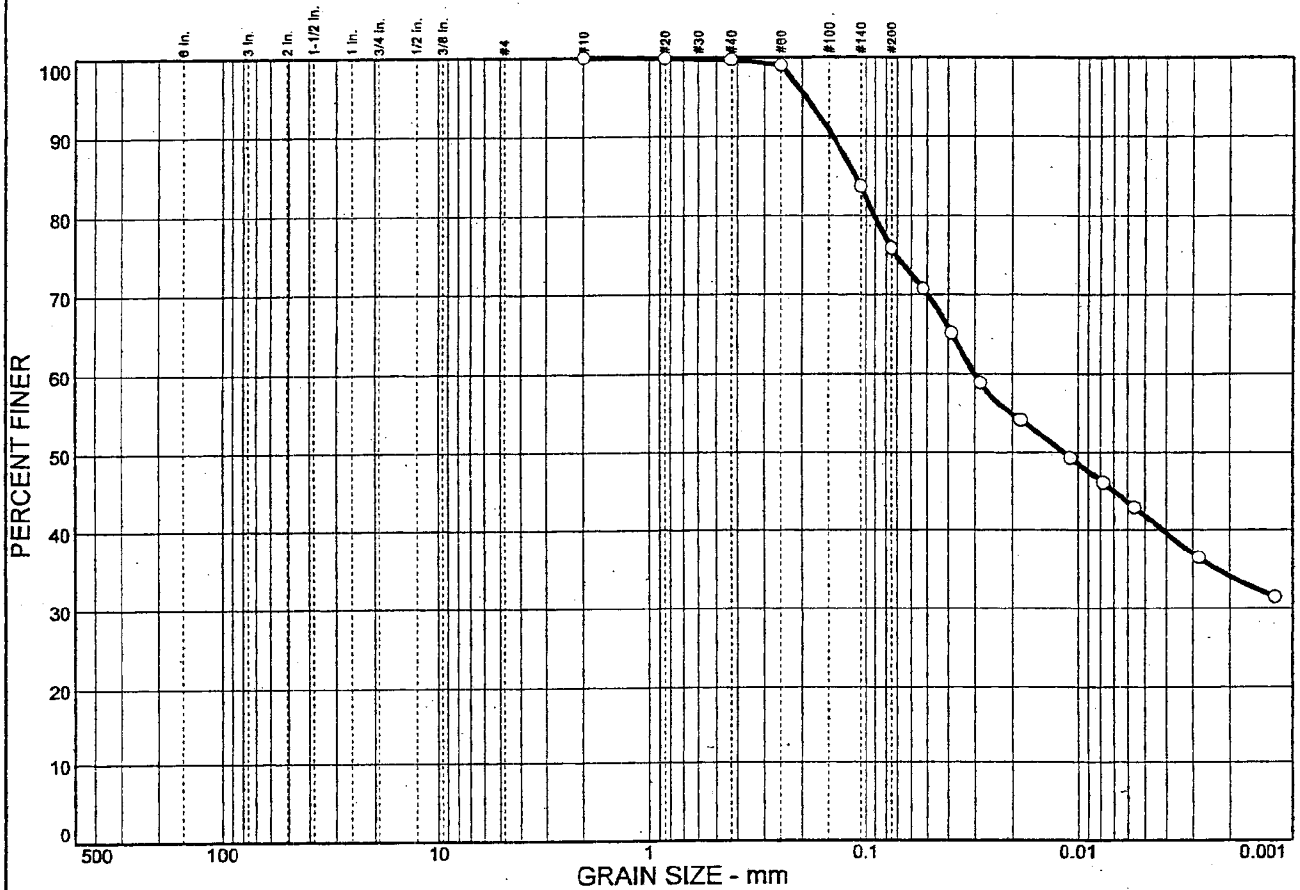
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
0.50	22.5	34.0	29.9	0.0132	35.0	10.6	0.0605	51.6
1.00	22.5	33.0	28.9	0.0132	34.0	10.7	0.0431	49.9
2.00	22.5	32.0	27.9	0.0132	33.0	10.9	0.0307	48.2
5.00	22.5	30.5	26.4	0.0132	31.5	11.1	0.0196	45.6
15.00	22.5	29.0	24.9	0.0132	30.0	11.4	0.0115	43.0
30.00	22.5	28.0	23.9	0.0132	29.0	11.5	0.0082	41.3
60.00	22.6	27.0	22.9	0.0132	28.0	11.7	0.0058	39.6
250.00	23.5	25.0	21.1	0.0130	26.0	12.0	0.0029	36.5
1440.00	22.8	23.0	18.9	0.0131	24.0	12.4	0.0012	32.7

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = **% GRAVEL =** 4.4 **% SAND =** 42.6
% SILT = 14.1 **% CLAY =** 38.9

D_{85}= 0.63 D_{60}= 0.13 D_{50}= 0.04

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	24.1	34.1	41.8

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	99.9		
#40	99.7		
#60	99.0		
#140	83.7		
#200	75.9		

* (no specification provided)

Material Description

Fat clay with sand

Atterberg Limits

PL= 28 LL= 50 PI= 22

Coefficients

D_{85}= 0.112 D_{60}= 0.0300 D_{50}= 0.0116
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= CH AASHTO=

Remarks

Sample No.: **Source of Sample:** **Date:** 1-20-06
Location: K-9 **Elev./Depth:** 12'-14'

MACTEC, INC.
Charlotte, North Carolina

Client: TVA
Project: TVA Kingston - Gypsum Disposal
Project No: 3043-05-1064 **Figure**

GRAIN SIZE DISTRIBUTION TEST DATA

Client: TVA
Project: TVA Kingston - Gypsum Disposal
oject Number: 3043-05-1064

Sample Data

Source:
Sample No.:
Elev. or Depth: 12'-14' **Sample Length(in./cm.):**
Location: K-9
Description: Fat clay with sand
Date: 1-20-06 **PL:** 28 **LL:** 50 **PI:** 22
USCS Classification: CH **AASHTO Classification:**
Testing Remarks:

Mechanical Analysis Data

	Initial
Dry sample and tare=	419.97
Tare =	0.00
Dry sample weight =	419.97

Sample split on number 10 **sieve**
Split sample data:
Sample and tare = 61.91 **Tare =** .00 **Sample weight =** 61.91
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
10	0.00	100.0
20	0.08	99.9
# 40	0.21	99.7
# 60	0.65	99.0
# 140	10.11	83.7
# 200	14.95	75.9

Hydrometer Analysis Data

Separation sieve is #10
Percent -#10 based upon complete sample= 100.0
Weight of hydrometer sample: 63.07
Hygroscopic moisture correction:
Moist weight & tare = 39.12
Dry weight & tare = 38.60
Tare = 10.80
Hygroscopic moisture= 1.9 %
Calculated biased weight= 61.91
Table of composite correction values:

Temp, deg C:	10.7	23.1	40.2
Comp. corr:	-7.0	-4.0	0.0

Meniscus correction only= 1
Specific gravity of solids= 2.706
Specific gravity correction factor= 0.988
drometer type: 152H
ffective depth L= 16.294964 - 0.164 x Rm

MACTEC, INC.

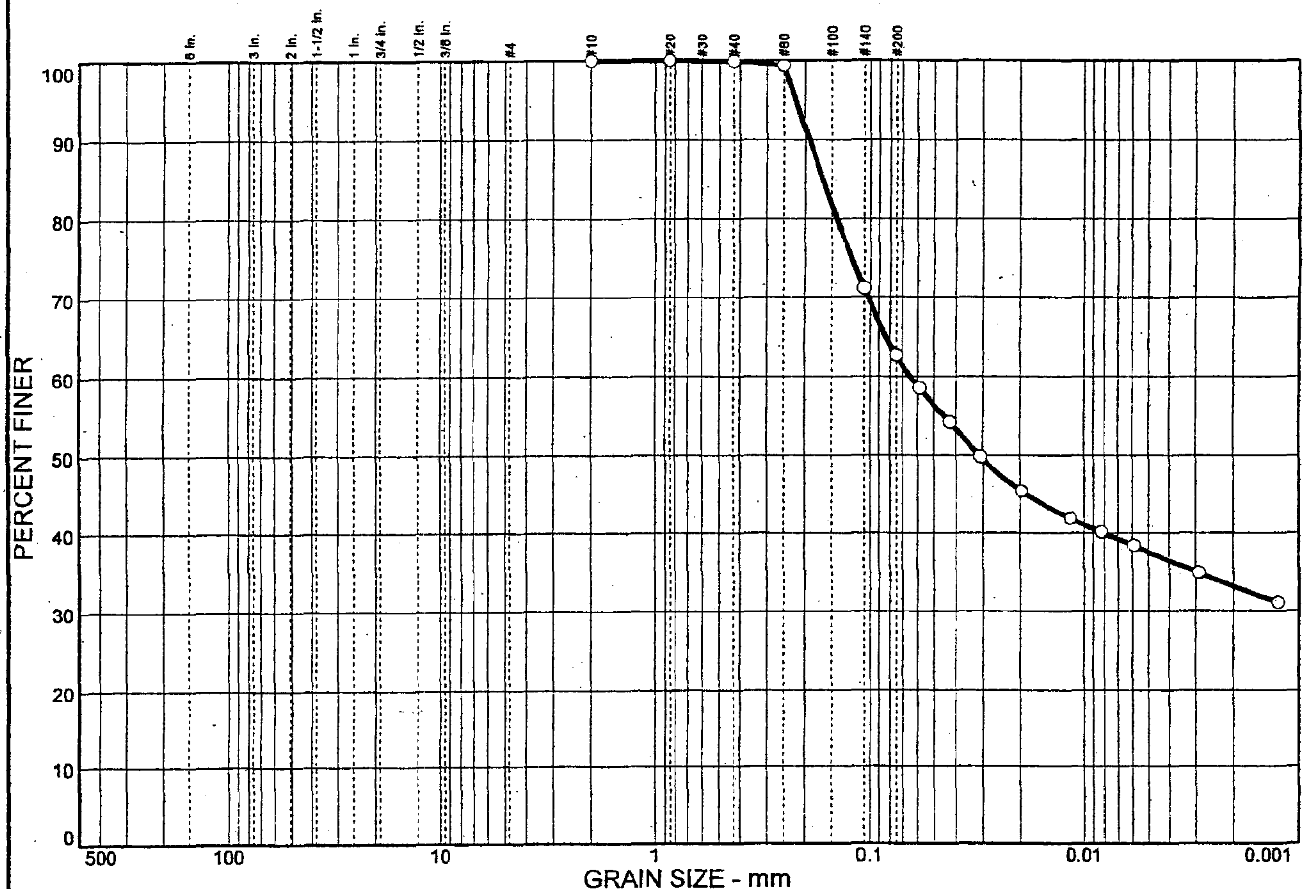
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
0.50	22.6	48.5	44.4	0.0130	49.5	8.2	0.0526	70.8
1.00	22.6	45.0	40.9	0.0130	46.0	8.8	0.0385	65.2
2.00	22.6	41.0	36.9	0.0130	42.0	9.4	0.0282	58.9
5.00	22.6	38.0	33.9	0.0130	39.0	9.9	0.0183	54.1
15.00	22.6	35.0	30.9	0.0130	36.0	10.4	0.0108	49.3
30.00	22.6	33.0	28.9	0.0130	34.0	10.7	0.0078	46.1
60.00	22.6	31.0	26.9	0.0130	32.0	11.0	0.0056	42.9
250.00	22.6	27.0	22.9	0.0130	28.0	11.7	0.0028	36.5
1440.00	21.9	24.0	19.7	0.0131	25.0	12.2	0.0012	31.5

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = **% GRAVEL =** **% SAND =** 24.1
% SILT = 34.1 **% CLAY =** 41.8

D_{85}= 0.11 D_{60}= 0.03 D_{50}= 0.01

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	37.3	25.1	37.6

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	100.0		
#40	99.9		
#60	99.3		
#140	71.2		
#200	62.7		

* (no specification provided)

Material Description

Sandy lean clay

Atterberg Limits

PL= 26 LL= 47 PI= 21

Coefficients

D_{85}= 0.165 D_{60}= 0.0647 D_{50}= 0.0311
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= CL AASHTO=

Remarks

Sample No.: Source of Sample: Date: 1-20-06
Location: K-10 Elev./Depth: 12'-14'

MACTEC, INC.
Charlotte, North Carolina

Client: TVA
Project: TVA Kingston - Gypsum Disposal
Project No: 3043-05-1064 Figure

GRAIN SIZE DISTRIBUTION TEST DATA

Client: TVA
oject: TVA Kingston - Gypsum Disposal
›ject Number: 3043-05-1064

Sample Data

Source:
Sample No.:
Elev. or Depth: 12'-14'
Sample Length(in./cm.):
Location: K-10
Description: Sandy lean clay
Date: 1-20-06 PL: 26 LL: 47 PI: 21
USCS Classification: CL
AASHTO Classification:
Testing Remarks:

Mechanical Analysis Data

	Initial
Dry sample and tare=	496.31
Tare =	0.00
Dry sample weight =	496.31

Sample split on number 10 sieve
Split sample data:
Sample and tare = 56.85 Tare = .00 Sample weight = 56.85
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
10	0.00	100.0
# 20	0.01	100.0
# 40	0.03	99.9
# 60	0.37	99.3
# 140	16.37	71.2
# 200	21.19	62.7

Hydrometer Analysis Data

Separation sieve is #10
Percent -#10 based upon complete sample= 100.0
Weight of hydrometer sample: 58.15
Hygroscopic moisture correction:
Moist weight & tare = 47.46
Dry weight & tare = 46.65
Tare = 11.18
Hygroscopic moisture= 2.3 %
Calculated biased weight= 56.85
Table of composite correction values:

Temp, deg C:	10.7	23.1	40.2
Comp. corr:	-7.0	-4.0	0.0

Meniscus correction only= 1
Specific gravity of solids= 2.664
ecific gravity correction factor= 0.997
ometer type: 152H
Effective depth L= 16.294964 - 0.164 x Rm

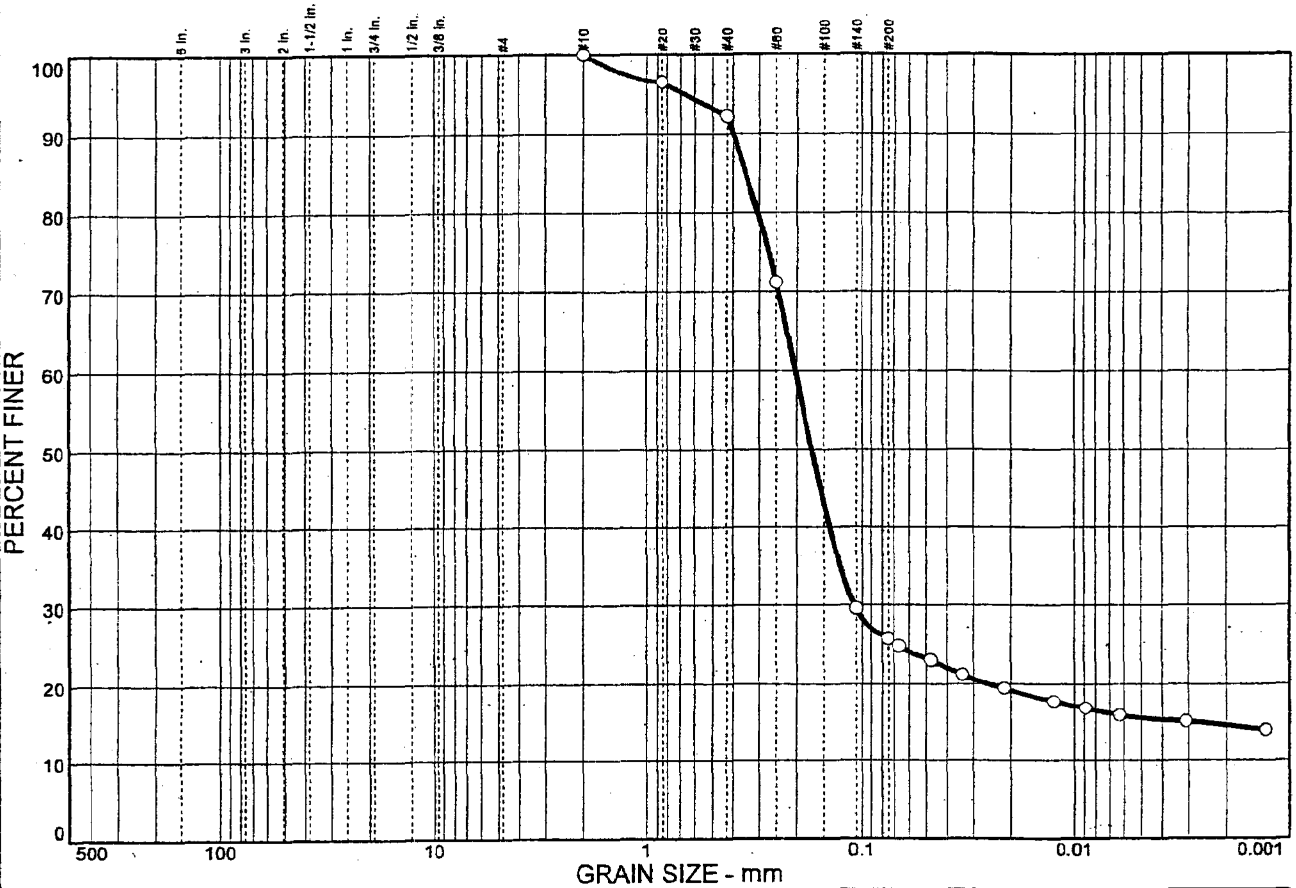
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
0.50	22.6	37.5	33.4	0.0132	38.5	10.0	0.0588	58.5
1.00	22.6	35.0	30.9	0.0132	36.0	10.4	0.0424	54.2
2.00	22.6	32.5	28.4	0.0132	33.5	10.8	0.0306	49.8
5.00	22.6	30.0	25.9	0.0132	31.0	11.2	0.0197	45.4
15.00	22.6	28.0	23.9	0.0132	29.0	11.5	0.0115	41.9
30.00	22.6	27.0	22.9	0.0132	28.0	11.7	0.0082	40.1
60.00	22.6	26.0	21.9	0.0132	27.0	11.9	0.0059	38.4
250.00	22.6	24.0	19.9	0.0132	25.0	12.2	0.0029	34.9
1440.00	21.9	22.0	17.7	0.0133	23.0	12.5	0.0012	31.1

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = **% GRAVEL =** **% SAND =** 37.3
% SILT = 25.1 **% CLAY =** 37.6

D_{85}= 0.16 D_{60}= 0.06 D_{50}= 0.03

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	74.3	10.3	15.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	96.5		
#40	92.2		
#60	71.2		
#140	29.6		
#200	25.7		

* (no specification provided)

Material Description

Silty sand

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= 0.347 D_{60}= 0.203 D_{50}= 0.170
D_{30}= 0.108 D_{15}= 0.0031 D_{10}=
C_u= C_c=

Classification

USCS= SM AASHTO=

Remarks

Sample No.: **Source of Sample:** **Date:** 1-20-06
Location: K-11 **Elev./Depth:** 12'-14'

MACTEC, INC.
Charlotte, North Carolina

Client: TVA
Project: TVA Kingston - Gypsum Disposal
Project No: 3043-05-1064 **Figure**

GRAIN SIZE DISTRIBUTION TEST DATA

Client: TVA
ject: TVA Kingston - Gypsum Disposal
oject Number: 3043-05-1064

Sample Data

Source:
Sample No.:
Elev. or Depth: 12'-14' **Sample Length(in./cm.):**
Location: K-11
Description: Silty sand
Date: 1-20-06 **PL:** NP **LL:** NV **PI:** NP
USCS Classification: SM **AASHTO Classification:**
Testing Remarks:

Mechanical Analysis Data

	Initial
Dry sample and tare=	546.12
Tare =	0.00
Dry sample weight =	546.12

Sample split on number 10 **sieve**
Split sample data:
Sample and tare = 55.24 **Tare =** .00 **Sample weight =** 55.24
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
# 10	0.00	100.0
# 20	1.93	96.5
# 40	4.30	92.2
# 60	15.92	71.2
# 140	38.88	29.6
# 200	41.03	25.7

Hydrometer Analysis Data

Separation sieve is #10
Percent -#10 based upon complete sample= 100.0
Weight of hydrometer sample: 57.31
Hygroscopic moisture correction:
Moist weight & tare = 52.91
Dry weight & tare = 51.39
Tare = 10.78
Hygroscopic moisture= 3.7 %
Calculated biased weight= 55.24
Table of composite correction values:

Temp, deg C:	10.7	23.1	40.2
Comp. corr:	-7.0	-4.0	0.0

Meniscus correction only= 1
Specific gravity of solids= 2.711
cific gravity correction factor= 0.987
rometer type: 152H
Effective depth L= 16.294964 - 0.164 x Rm

MACTEC, INC.

TVA-00020879

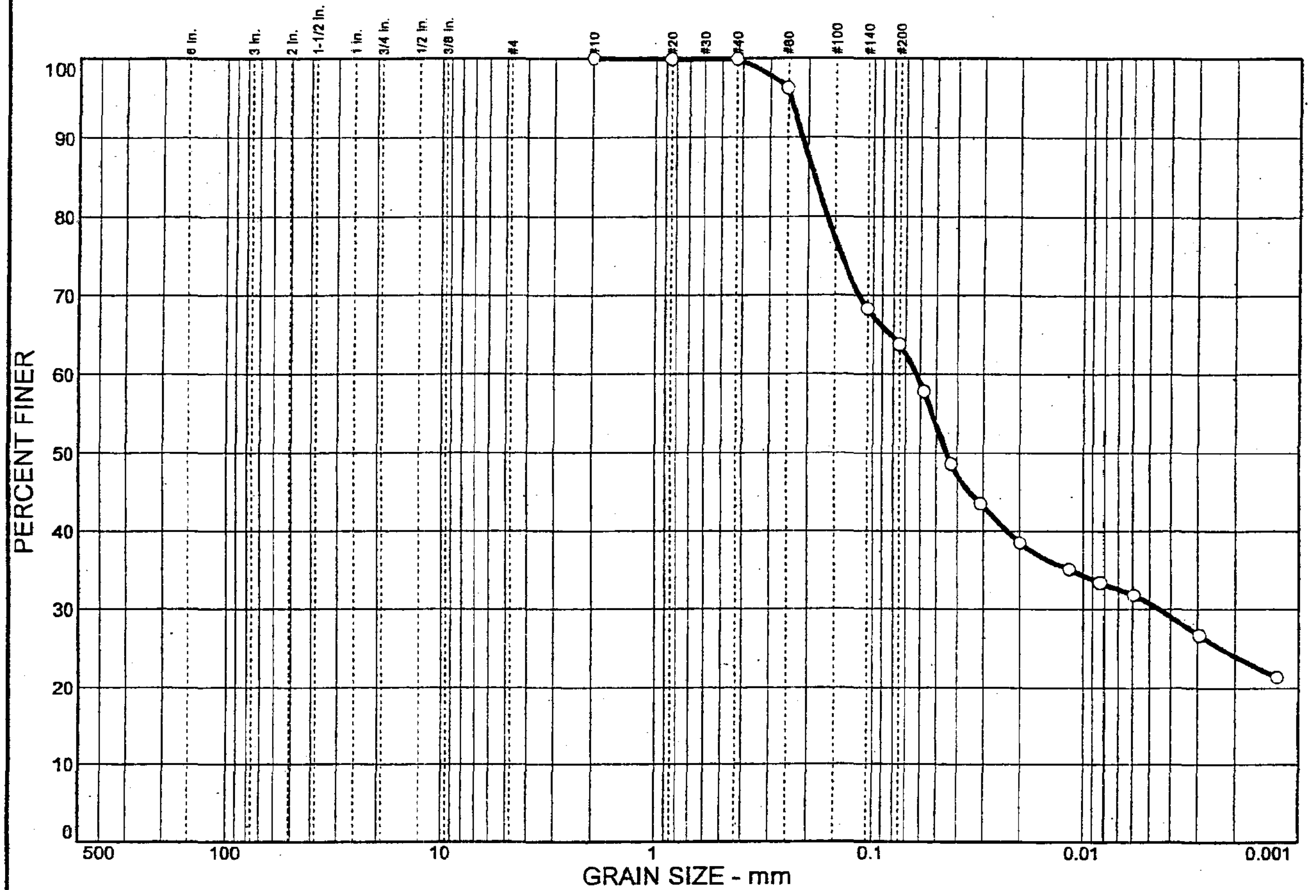
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
0.50	22.5	18.0	13.9	0.0130	19.0	13.2	0.0667	24.8
1.00	22.5	17.0	12.9	0.0130	18.0	13.3	0.0475	23.0
2.00	22.5	16.0	11.9	0.0130	17.0	13.5	0.0338	21.2
5.00	22.5	15.0	10.9	0.0130	16.0	13.7	0.0215	19.4
15.00	22.5	14.0	9.9	0.0130	15.0	13.8	0.0125	17.6
30.00	22.5	13.5	9.4	0.0130	14.5	13.9	0.0089	16.7
60.00	22.5	13.0	8.9	0.0130	14.0	14.0	0.0063	15.8
250.00	22.7	12.5	8.4	0.0130	13.5	14.1	0.0031	15.0
1440.00	22.2	12.0	7.8	0.0130	13.0	14.2	0.0013	13.9

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = **% GRAVEL =** **% SAND =** 74.3
% SILT = 10.3 **% CLAY =** 15.4

D_{85}= 0.35 D_{60}= 0.20 D_{50}= 0.17
D_{30}= 0.11 D_{15}= 0.00

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	36.2	33.0	30.8

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	99.9		
#40	99.9		
#60	96.2		
#140	68.3		
#200	63.8		

* (no specification provided)

Material Description

Sandy lean clay

Atterberg Limits

PL= 26 LL= 48 PI= 22

Coefficients

D_{85}= 0.187 D_{60}= 0.0624 D_{50}= 0.0448
D_{30}= 0.0045 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= CL AASHTO=

Remarks

Sample No.: **Source of Sample:** **Date:** 1-20-06
Location: K-12 **Elev./Depth:** 12'-14'

MACTEC, INC. Charlotte, North Carolina	Client: TVA Project: TVA Kingston - Gypsum Disposal Project No: 3043-05-1064 Figure

GRAIN SIZE DISTRIBUTION TEST DATA

Client: TVA
Project: TVA Kingston - Gypsum Disposal
Project Number: 3043-05-1064

Sample Data

Source:
Sample No.:
Elev. or Depth: 12'-14' **Sample Length(in./cm.):**
Location: K-12
Description: Sandy lean clay
Date: 1-20-06 **PL:** 26 **LL:** 48 **PI:** 22
USCS Classification: CL **AASHTO Classification:**
Testing Remarks:

Mechanical Analysis Data

	Initial
Dry sample and tare=	438.64
Tare =	0.00
Dry sample weight =	438.64

Sample split on number 10 **sieve**
Split sample data:
Sample and tare = 58.67 **Tare =** .00 **Sample weight =** 58.67
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
# 10	0.00	100.0
# 20	0.04	99.9
# 40	0.07	99.9
# 60	2.24	96.2
# 140	18.57	68.3
# 200	21.26	63.8

Hydrometer Analysis Data

Separation sieve is #10
Percent -#10 based upon complete sample= 100.0
Weight of hydrometer sample: 59.59
Hygroscopic moisture correction:
Moist weight & tare = 47.14
Dry weight & tare = 46.58
Tare = 11.00
Hygroscopic moisture= 1.6 %
Calculated biased weight= 58.67
Table of composite correction values:

Temp, deg C:	10.7	23.1	40.2
Comp. corr:	-7.0	-4.0	0.0

Meniscus correction only= 1
Specific gravity of solids= 2.708
Specific gravity correction factor= 0.987
Hydrometer type: 152H
Effective depth L= 16.294964 - 0.164 x Rm

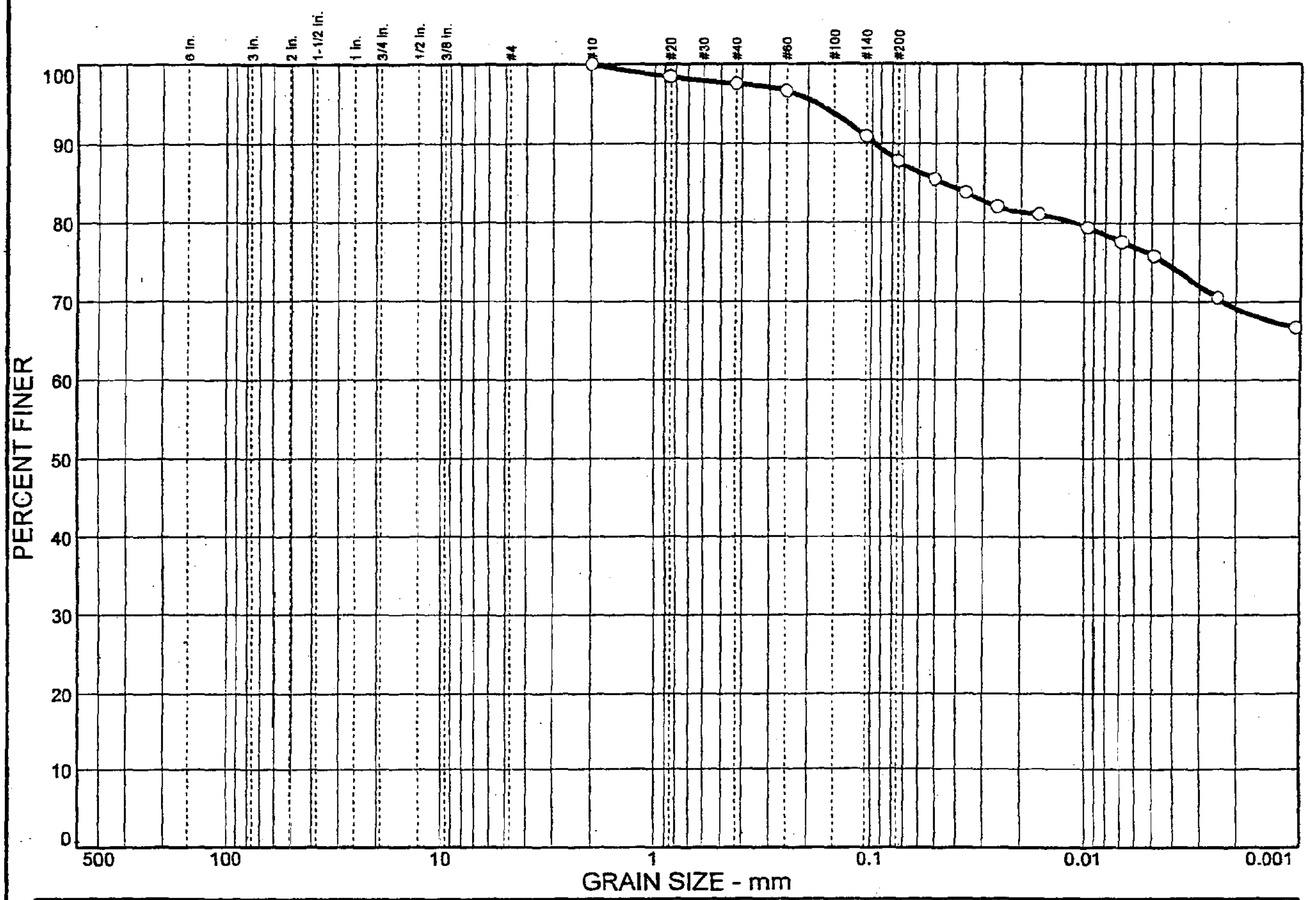
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
0.50	22.6	38.5	34.4	0.0130	39.5	9.8	0.0576	57.8
1.00	22.6	33.0	28.9	0.0130	34.0	10.7	0.0425	48.6
2.00	22.6	30.0	25.9	0.0130	31.0	11.2	0.0308	43.5
5.00	22.6	27.0	22.9	0.0130	28.0	11.7	0.0199	38.5
15.00	22.6	25.0	20.9	0.0130	26.0	12.0	0.0116	35.1
30.00	22.6	24.0	19.9	0.0130	25.0	12.2	0.0083	33.4
60.00	22.6	23.0	18.9	0.0130	24.0	12.4	0.0059	31.8
250.00	22.6	20.0	15.9	0.0130	21.0	12.9	0.0029	26.7
1440.00	21.9	17.0	12.7	0.0131	18.0	13.3	0.0013	21.4

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = **% GRAVEL =** **% SAND =** 36.2
% SILT = 33.0 **% CLAY =** 30.8

D_{85}= 0.19 D_{60}= 0.06 D_{50}= 0.04
D_{30}= 0.00

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	12.2	11.9	75.9

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	98.4		
#40	97.5		
#60	96.6		
#140	90.9		
#200	87.8		

* (no specification provided)

Material Description

Elastic silt

Atterberg Limits

PL= 37 LL= 69 PI= 32

Coefficients

D_{85}= 0.0457 D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= MH AASHTO=

Remarks

Sample No.: **Source of Sample:** **Date:** 1-20-06
Location: K-13 **Elev./Depth:** 12'-14'

MACTEC, INC.
Charlotte, North Carolina

Client: TVA
Project: TVA Kingston - Gypsum Disposal
Project No: 3043-05-1064 **Figure**

GRAIN SIZE DISTRIBUTION TEST DATA

Client: TVA
ject: TVA Kingston - Gypsum Disposal
ject Number: 3043-05-1064

Sample Data

Source:
Sample No.:
Elev. or Depth: 12'-14' **Sample Length(in./cm.):**
Location: K-13
Description: Elastic silt
Date: 1-20-06 **PL:** 37 **LL:** 69 **PI:** 32
USCS Classification: MH **AASHTO Classification:**
Testing Remarks:

Mechanical Analysis Data

	Initial
Dry sample and tare=	379.50
Tare =	0.00
Dry sample weight =	379.50

Sample split on number 10 **sieve**
Split sample data:
Sample and tare = 56.10 **Tare =** .00 **Sample weight =** 56.10
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
# 10	0.00	100.0
# 20	0.87	98.4
# 40	1.39	97.5
# 60	1.90	96.6
# 140	5.08	90.9
# 200	6.86	87.8

Hydrometer Analysis Data

Separation sieve is #10
Percent -#10 based upon complete sample= 100.0
Weight of hydrometer sample: 58.36
Hygroscopic moisture correction:
Moist weight & tare = 50.72
Dry weight & tare = 49.19
Tare = 11.20
Hygroscopic moisture= 4.0 %
Calculated biased weight= 56.10
Table of composite correction values:

Temp, deg C:	10.7	23.1	40.2
Comp. corr:	-7.0	-4.0	0.0

Meniscus correction only= 1
Specific gravity of solids= 2.687
cific gravity correction factor= 0.992
rometer type: 152H
Effective depth L= 16.294964 - 0.164 x Rm

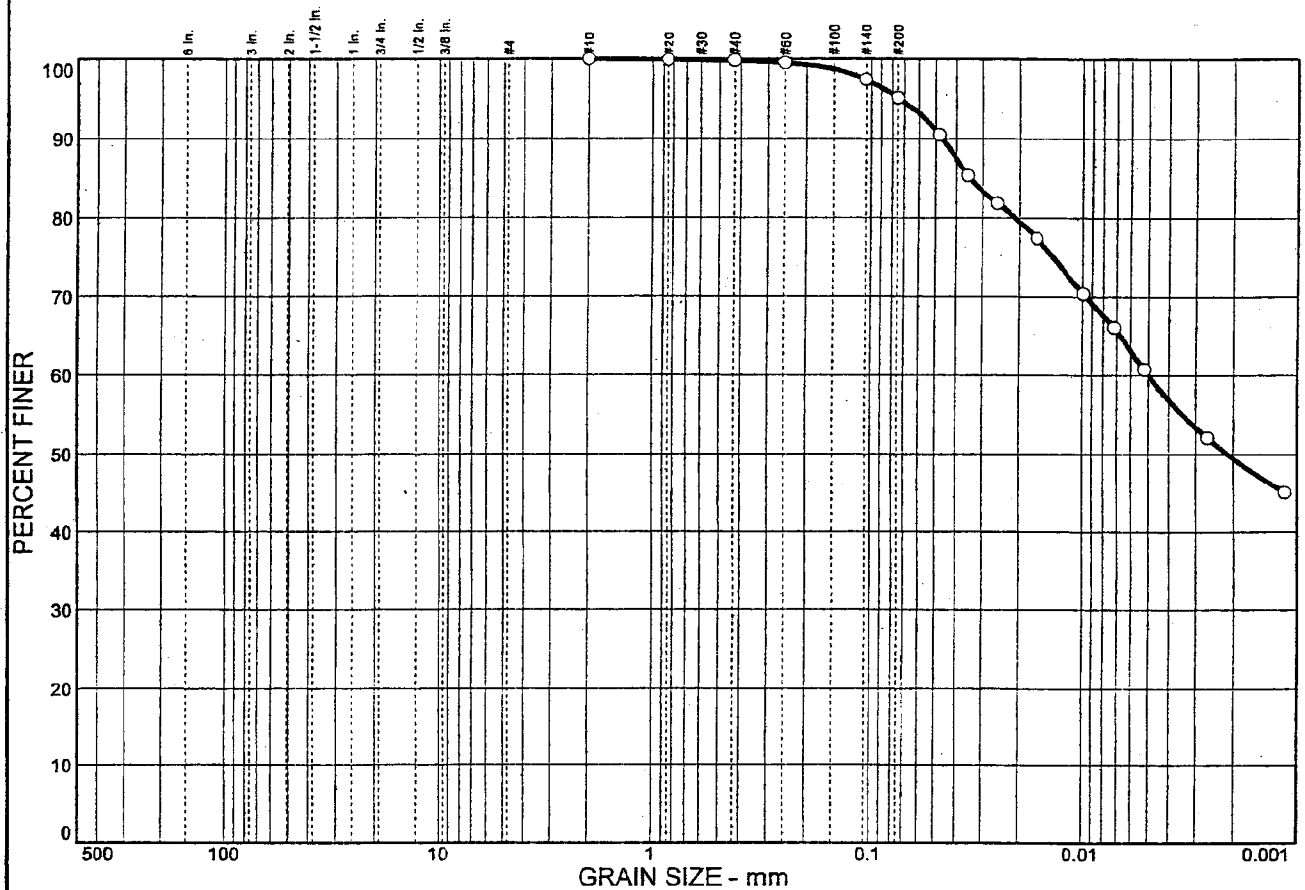
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
0.50	22.6	52.5	48.4	0.0131	53.5	7.5	0.0507	85.5
1.00	22.6	51.5	47.4	0.0131	52.5	7.7	0.0362	83.8
2.00	22.6	50.5	46.4	0.0131	51.5	7.8	0.0259	82.0
5.00	22.6	50.0	45.9	0.0131	51.0	7.9	0.0165	81.1
15.00	22.6	49.0	44.9	0.0131	50.0	8.1	0.0096	79.4
30.00	22.6	48.0	43.9	0.0131	49.0	8.3	0.0069	77.6
60.00	22.6	47.0	42.9	0.0131	48.0	8.4	0.0049	75.8
250.00	22.6	44.0	39.9	0.0131	45.0	8.9	0.0025	70.5
1440.00	22.0	42.0	37.7	0.0132	43.0	9.2	0.0011	66.7

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% **COBBLES** = % **GRAVEL** = % **SAND** = 12.2
% **SILT** = 11.9 % **CLAY** = 75.9

D_{85}= 0.05

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	4.9	34.9	60.2

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	99.9		
#40	99.8		
#60	99.5		
#140	97.4		
#200	95.1		

* (no specification provided)

Material Description

Elastic silt

Atterberg Limits

PL= 41 LL= 65 PI= 24

Coefficients

D_{85}= 0.0344 D_{60}= 0.0049 D_{50}= 0.0021
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= MH AASHTO=

Remarks

Sample No.: **Source of Sample:** **Date:** 1-20-06
Location: K-14 **Elev./Depth:** 12'-14'

MACTEC, INC.
Charlotte, North Carolina

Client: TVA
Project: TVA Kingston - Gypsum Disposal
Project No: 3043-05-1064 **Figure**

GRAIN SIZE DISTRIBUTION TEST DATA

‾lient: TVA
›ject: TVA Kingston - Gypsum Disposal
›oject Number: 3043-05-1064

Sample Data

Source:
Sample No.:
Elev. or Depth: 12'-14' **Sample Length(in./cm.):**
Location: K-14
Description: Elastic silt
Date: 1-20-06 **PL:** 41 **LL:** 65 **PI:** 24
USCS Classification: MH **AASHTO Classification:**
Testing Remarks:

Mechanical Analysis Data

	Initial
Dry sample and tare=	411.09
Tare =	0.00
Dry sample weight =	411.09

Sample split on number 10 **sieve**
Split sample data:
Sample and tare = 56.30 **Tare =** .00 **Sample weight =** 56.30
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
# 10	0.00	100.0
# 20	0.03	99.9
# 40	0.10	99.8
# 60	0.27	99.5
# 140	1.46	97.4
# 200	2.75	95.1

Hydrometer Analysis Data

Separation sieve is #10
Percent -#10 based upon complete sample= 100.0
Weight of hydrometer sample: 58.24
Hygroscopic moisture correction:
Moist weight & tare = 52.43
Dry weight & tare = 51.07
Tare = 11.53
Hygroscopic moisture= 3.4 %
Calculated biased weight= 56.30
Table of composite correction values:

Temp, deg C:	10.7	23.1	40.2
Comp. corr:	-7.0	-4.0	0.0

Meniscus correction only= 1
Specific gravity of solids= 2.733
›cific gravity correction factor= 0.982
rometer type: 152H
Effective depth L= 16.294964 - 0.164 x Rm

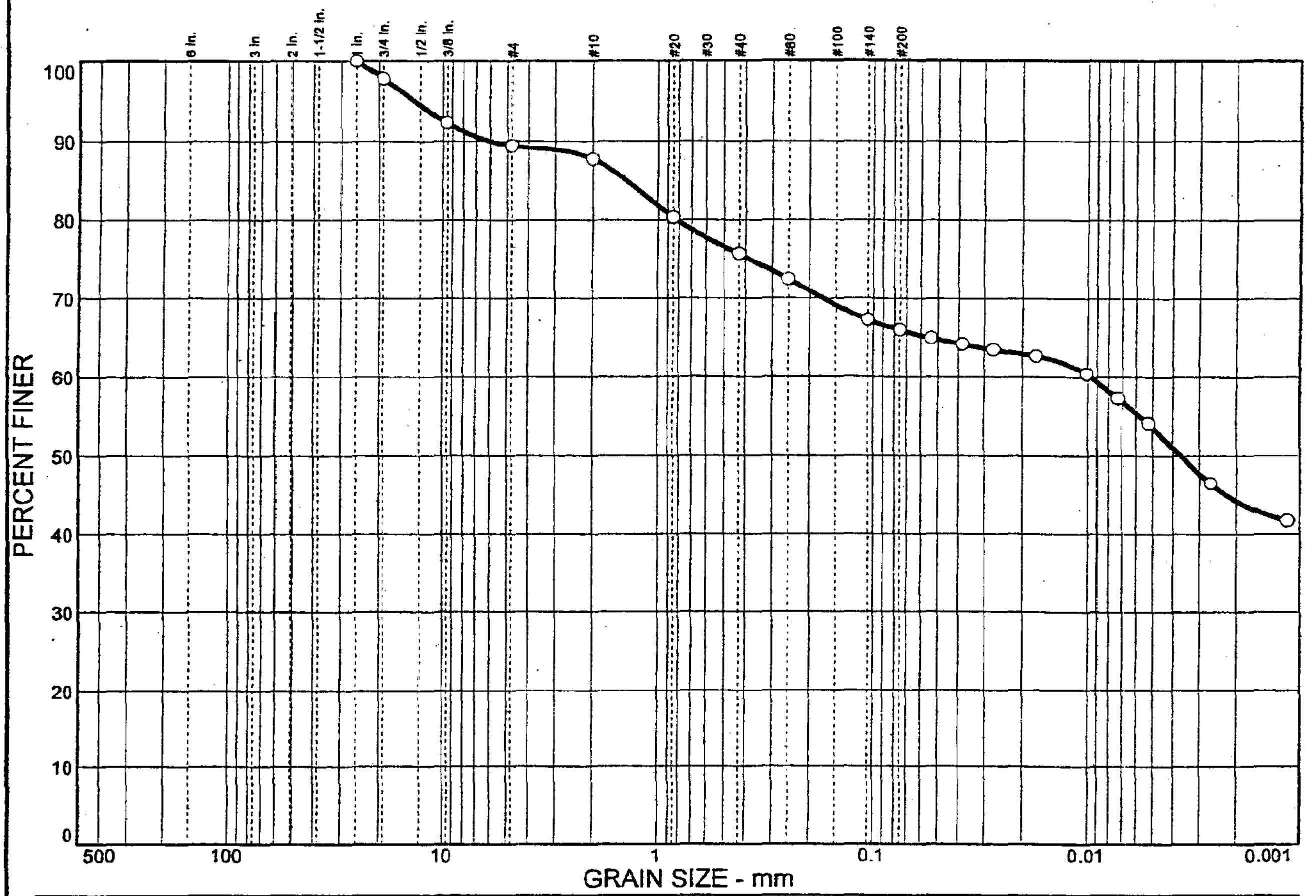
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
0.50	22.6	56.0	51.9	0.0129	57.0	6.9	0.0481	90.5
1.00	22.6	53.0	48.9	0.0129	54.0	7.4	0.0352	85.3
2.00	22.6	51.0	46.9	0.0129	52.0	7.8	0.0254	81.8
5.00	22.6	48.5	44.4	0.0129	49.5	8.2	0.0165	77.4
15.00	22.6	44.5	40.4	0.0129	45.5	8.8	0.0099	70.4
30.00	22.6	42.0	37.9	0.0129	43.0	9.2	0.0072	66.1
60.00	22.6	39.0	34.9	0.0129	40.0	9.7	0.0052	60.8
250.00	22.6	34.0	29.9	0.0129	35.0	10.6	0.0027	52.1
1440.00	22.4	30.0	25.8	0.0129	31.0	11.2	0.0011	45.1

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = **% GRAVEL =** **% SAND =** 4.9
% SILT = 34.9 **% CLAY =** 60.2

D_{85}= 0.03 D_{60}= 0.00 D_{50}= 0.00

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	10.6	23.4	12.4	53.6

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1 in.	100.0		
.75 in.	97.8		
.375 in.	92.3		
#4	89.4		
#10	87.7		
#20	80.3		
#40	75.6		
#60	72.4		
#140	67.3		
#200	66.0		

* (no specification provided)

Material Description

Sandy elastic silt

Atterberg Limits

PL= 42 LL= 60 PI= 18

Coefficients

D_{85}= 1.40 D_{60}= 0.0096 D_{50}= 0.0037
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= MH AASHTO=

Remarks

Sample No.: **Source of Sample:** **Date:** 1-20-06
Location: K-15A **Elev./Depth:** 12'-13'

MACTEC, INC.
Charlotte, North Carolina

Client: TVA
Project: TVA Kingston - Gypsum Disposal
Project No: 3043-05-1064 **Figure**

GRAIN SIZE DISTRIBUTION TEST DATA

Client: TVA
Project: TVA Kingston - Gypsum Disposal
Project Number: 3043-05-1064

Sample Data

Source:
Sample No.:
Elev. or Depth: 12'-13'
Sample Length(in./cm.):
Location: K-15A
Description: Sandy elastic silt
Date: 1-20-06 **PL:** 42 **LL:** 60 **PI:** 18
USCS Classification: MH **AASHTO Classification:**
Testing Remarks:

Mechanical Analysis Data

	Initial
Dry sample and tare=	397.13
Tare =	0.00
Dry sample weight =	397.13

Sample split on number 10 **sieve**
Split sample data:
Sample and tare = 55.76 **Tare =** .00 **Sample weight =** 55.76
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
1 inch	0.00	100.0
.75 inch	8.62	97.8
.375 inch	30.57	92.3
# 4	41.99	89.4
# 10	49.01	87.7
# 20	4.69	80.3
# 40	7.71	75.6
# 60	9.71	72.4
# 140	12.97	67.3
# 200	13.82	66.0

Hydrometer Analysis Data

Separation sieve is #10
Percent -#10 based upon complete sample= 87.7
Weight of hydrometer sample: 59.02
Hygroscopic moisture correction:
Moist weight & tare = 51.43
Dry weight & tare = 49.23
Tare = 11.65
Hygroscopic moisture= 5.9 %
Calculated biased weight= 63.58
Table of composite correction values:

Temp, deg C:	10.7	23.1	40.2
Comp. corr:	-7.0	-4.0	0.0

Meniscus correction only= 1
Specific gravity of solids= 2.711

Specific gravity correction factor= 0.987
Hydrometer type: 152H
Effective depth L= 16.294964 - 0.164 x Rm

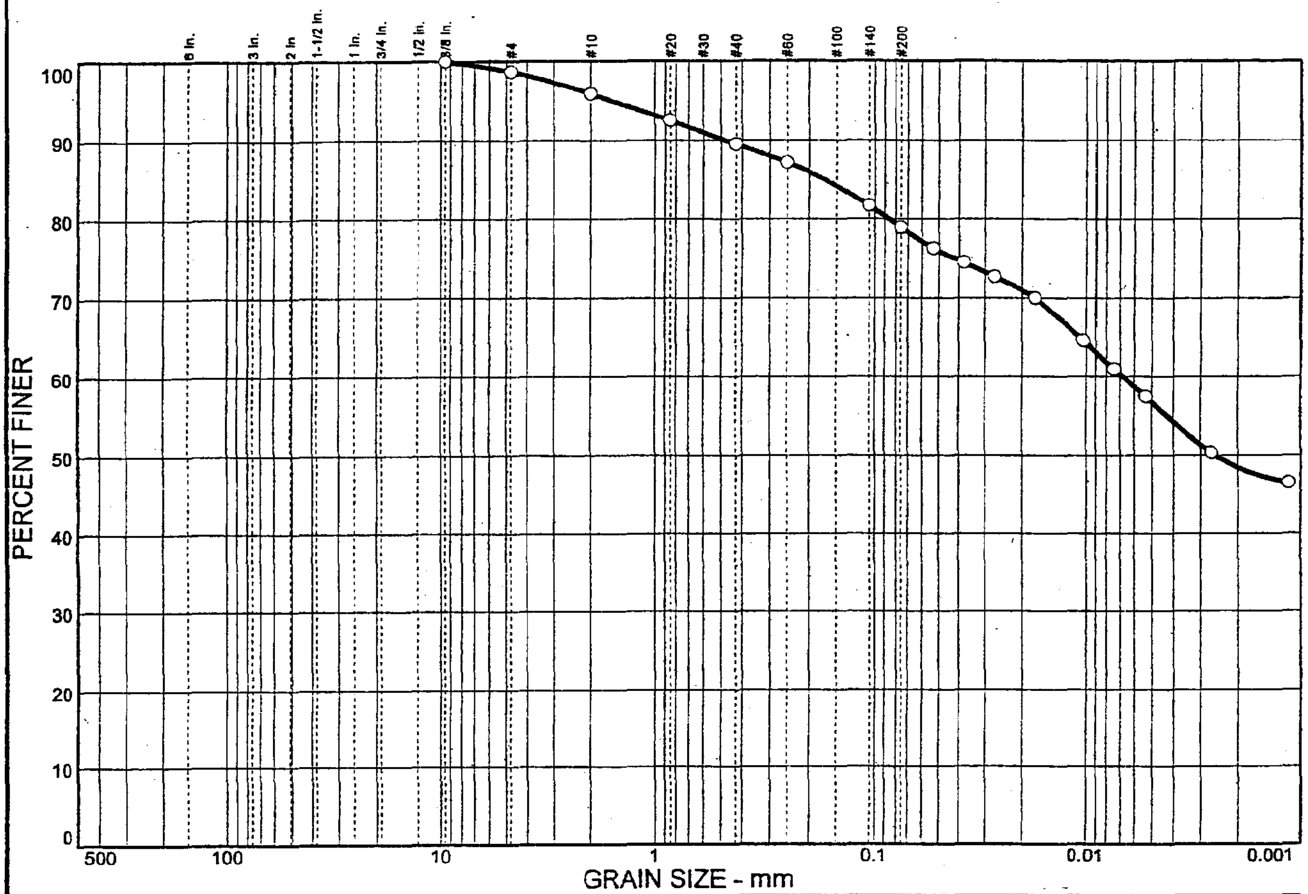
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
0.50	22.6	46.0	41.9	0.0130	47.0	8.6	0.0538	65.0
1.00	22.6	45.5	41.4	0.0130	46.5	8.7	0.0382	64.2
2.00	22.6	45.0	40.9	0.0130	46.0	8.8	0.0272	63.5
5.00	22.6	44.5	40.4	0.0130	45.5	8.8	0.0173	62.7
15.00	22.6	43.0	38.9	0.0130	44.0	9.1	0.0101	60.4
30.00	22.6	41.0	36.9	0.0130	42.0	9.4	0.0073	57.3
60.00	22.6	39.0	34.9	0.0130	40.0	9.7	0.0052	54.1
250.00	22.6	34.0	29.9	0.0130	35.0	10.6	0.0027	46.4
1440.00	22.6	31.0	26.9	0.0130	32.0	11.0	0.0011	41.7

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = **% GRAVEL =** 10.6 **% SAND =** 23.4
% SILT = 12.4 **% CLAY =** 53.6

D_{85}= 1.40 D_{60}= 0.01 D_{50}= 0.00

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	1.3	19.8	22.0	56.9

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.375 in.	100.0		
#4	98.7		
#10	95.9		
#20	92.5		
#40	89.5		
#60	87.2		
#140	81.7		
#200	78.9		

* (no specification provided)

Material Description

Elastic silt with sand

Atterberg Limits

PL= 29 LL= 52 PI= 23

Coefficients

D_{85}= 0.169 D_{60}= 0.0067 D_{50}= 0.0026
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= MH AASHTO=

Remarks

Sample No.: **Source of Sample:** **Date:** 1-20-06
Location: K-16 **Elev./Depth:** 10'-15'

MACTEC, INC.
Charlotte, North Carolina

Client: TVA
Project: TVA Kingston - Gypsum Disposal
Project No: 3043-05-1064 **Figure**

GRAIN SIZE DISTRIBUTION TEST DATA

C'ient: TVA
ject: TVA Kingston - Gypsum Disposal
ject Number: 3043-05-1064

Sample Data

Source:
Sample No.:
Elev. or Depth: 10'-15' **Sample Length(in./cm.):**
Location: K-16
Description: Elastic silt with sand
Date: 1-20-06 **PL:** 29 **LL:** 52 **PI:** 23
USCS Classification: MH **AASHTO Classification:**
Testing Remarks:

Mechanical Analysis Data

	Initial
Dry sample and tare=	265.46
Tare =	0.00
Dry sample weight =	265.46

Sample split on number 10 **sieve**
Split sample data:
Sample and tare = 52.09 **Tare =** .00 **Sample weight =** 52.09
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

'ieve	Cumul. Wt. retained	Percent finer
375 inch	0.00	100.0
# 4	3.36	98.7
# 10	10.82	95.9
# 20	1.86	92.5
# 40	3.45	89.5
# 60	4.74	87.2
# 140	7.73	81.7
# 200	9.25	78.9

Hydrometer Analysis Data

Separation sieve is #10
Percent -#10 based upon complete sample= 95.9
Weight of hydrometer sample: 52.72
Hygroscopic moisture correction:
Moist weight & tare = 46.63
Dry weight & tare = 46.20
Tare = 10.91
Hygroscopic moisture= 1.2 %
Calculated biased weight= 54.31
Table of composite correction values:

Temp, deg C:	10.7	23.1	40.2
Comp. corr:	-7.0	-4.0	0.0

scus correction only= 1
ific gravity of solids= 2.748
Specific gravity correction factor= 0.979
Hydrometer type: 152H

Effective depth L= 16.294964 - 0.164 x Rm

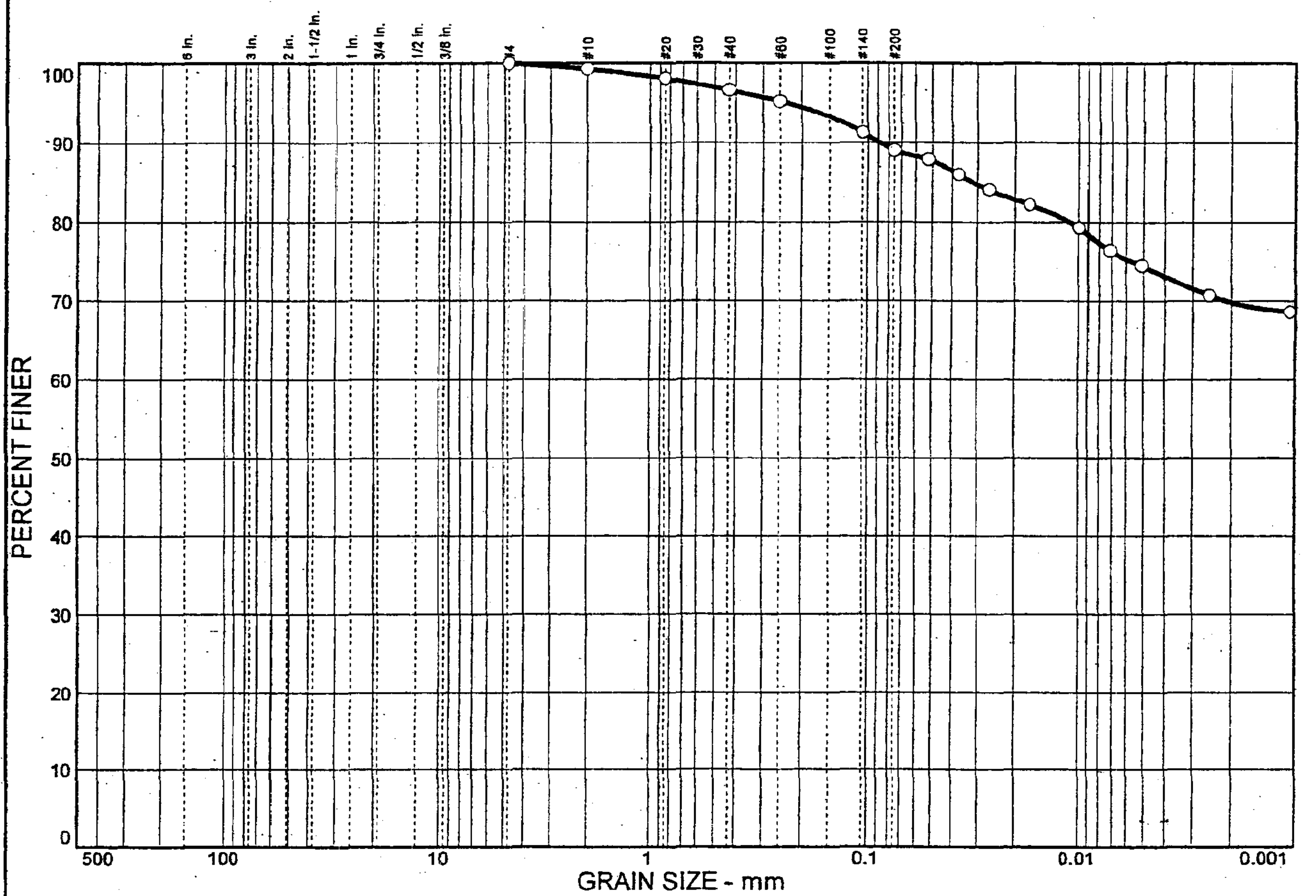
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
0.50	22.5	46.5	42.4	0.0129	47.5	8.5	0.0530	76.3
1.00	22.5	45.5	41.4	0.0129	46.5	8.7	0.0379	74.5
2.00	22.5	44.5	40.4	0.0129	45.5	8.8	0.0270	72.7
5.00	22.5	43.0	38.9	0.0129	44.0	9.1	0.0173	70.0
15.00	22.5	40.0	35.9	0.0129	41.0	9.6	0.0103	64.6
30.00	22.5	38.0	33.9	0.0129	39.0	9.9	0.0074	61.0
60.00	22.6	36.0	31.9	0.0128	37.0	10.2	0.0053	57.5
250.00	22.6	32.0	27.9	0.0128	33.0	10.9	0.0027	50.3
1440.00	22.3	30.0	25.8	0.0129	31.0	11.2	0.0011	46.5

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% **COBBLES** = % **GRAVEL** = 1.3 % **SAND** = 19.8
% **SILT** = 22.0 % **CLAY** = 56.9

D_{85}= 0.17 D_{60}= 0.01 D_{50}= 0.00

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	11.0	14.6	74.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	99.3		
#20	98.1		
#40	96.6		
#60	95.2		
#140	91.3		
#200	89.0		

* (no specification provided)

Material Description

Elastic silt

Atterberg Limits

PL= 40 LL= 75 PI= 35

Coefficients

D_{85}= 0.0314 D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= MH AASHTO=

Remarks

Sample No.: **Source of Sample:** **Date:** 1-20-06
Location: K-17 **Elev./Depth:** 10'-15'

MACTEC, INC. Charlotte, North Carolina	**Client:** TVA **Project:** TVA Kingston - Gypsum Disposal **Project No:** 3043-05-1064 **Figure**

GRAIN SIZE DISTRIBUTION TEST DATA

Client: TVA
oject: TVA Kingston - Gypsum Disposal
oject Number: 3043-05-1064

Sample Data

Source:
Sample No.:
Elev. or Depth: 10'-15' **Sample Length(in./cm.):**
Location: K-17
Description: Elastic silt
Date: 1-20-06 **PL:** 40 **LL:** 75 **PI:** 35
USCS Classification: MH **AASHTO Classification:**
Testing Remarks:

Mechanical Analysis Data

	Initial
Dry sample and tare=	285.36
Tare =	0.00
Dry sample weight =	285.36

Sample split on number 10 **sieve**
Split sample data:
Sample and tare = 51.22 **Tare =** .00 **Sample weight =** 51.22
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
# 4	0.00	100.0
# 10	1.90	99.3
# 20	0.64	98.1
# 40	1.37	96.6
# 60	2.10	95.2
# 140	4.12	91.3
# 200	5.29	89.0

Hydrometer Analysis Data

Separation sieve is #10
Percent -#10 based upon complete sample= 99.3
Weight of hydrometer sample: 52.33
Hygroscopic moisture correction:
Moist weight & tare = 47.75
Dry weight & tare = 46.97
Tare = 10.89
Hygroscopic moisture= 2.2 %
Calculated biased weight= 51.58
Table of composite correction values:

Temp, deg C:	10.7	23.1	40.2
Comp. corr:	-7.0	-4.0	0.0

eniscus correction only= 1
cific gravity of solids= 2.699
ific gravity correction factor= 0.989
ydrometer type: 152H
Effective depth L= 16.294964 - 0.164 x Rm

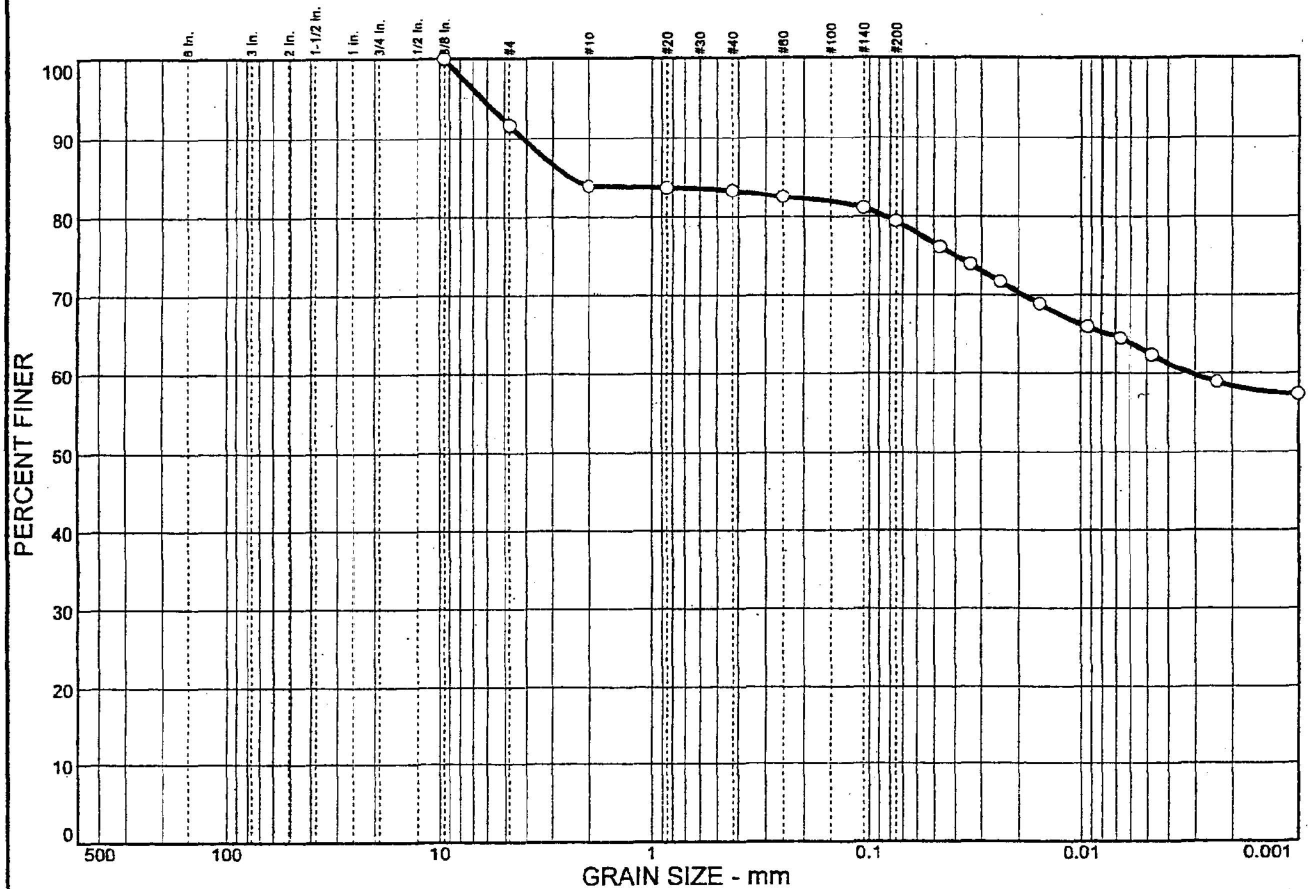
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
0.50	22.5	50.0	45.9	0.0130	51.0	7.9	0.0519	87.9
1.00	22.5	49.0	44.9	0.0130	50.0	8.1	0.0371	86.0
2.00	22.5	48.0	43.9	0.0130	49.0	8.3	0.0265	84.1
5.00	22.5	47.0	42.9	0.0130	48.0	8.4	0.0169	82.2
15.00	22.5	45.5	41.4	0.0130	46.5	8.7	0.0099	79.3
30.00	22.5	44.0	39.9	0.0130	45.0	8.9	0.0071	76.4
60.00	22.6	43.0	38.9	0.0130	44.0	9.1	0.0051	74.5
250.00	22.6	41.0	36.9	0.0130	42.0	9.4	0.0025	70.7
1440.00	22.2	40.0	35.8	0.0131	41.0	9.6	0.0011	68.6

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = **% GRAVEL =** **% SAND =** 11.0
% SILT = 14.6 **% CLAY =** 74.4

D_{85}= 0.03

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	8.4	12.2	16.7	62.7

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.375 in.	100.0		
#4	91.6		
#10	83.9		
#20	83.7		
#40	83.3		
#60	82.5		
#140	81.1		
#200	79.4		

* (no specification provided)

Material Description

Elastic silt with sand

Atterberg Limits

PL= 37 LL= 71 PI= 34

Coefficients

D_{85}= 2.44 D_{60}= 0.0031 D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= MH AASHTO=

Remarks

Sample No.: **Source of Sample:** **Date:** 1-20-06
Location: K-18 **Elev./Depth:** 10'-15'

MACTEC, INC.
Charlotte, North Carolina

Client: TVA
Project: TVA Kingston - Gypsum Disposal
Project No: 3043-05-1064 **Figure**

GRAIN SIZE DISTRIBUTION TEST DATA

‾ient: TVA
ject: TVA Kingston - Gypsum Disposal
ject Number: 3043-05-1064

Sample Data

Source:
Sample No.:
Elev. or Depth: 10'-15'
Sample Length(in./cm.):
Location: K-18
Description: Elastic silt with sand
Date: 1-20-06 **PL:** 37 **LL:** 71 **PI:** 34
USCS Classification: MH
AASHTO Classification:
Testing Remarks:

Mechanical Analysis Data

	Initial
Dry sample and tare=	304.28
Tare =	0.00
Dry sample weight =	304.28

Sample split on number 10 **sieve**
Split sample data:
Sample and tare = 56.68 **Tare =** .00 **Sample weight =** 56.68
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
.375 inch	0.00	100.0
# 4	25.63	91.6
# 10	49.03	83.9
# 20	0.14	83.7
# 40	0.43	83.3
# 60	0.92	82.5
# 140	1.87	81.1
# 200	3.06	79.4

Hydrometer Analysis Data

Separation sieve is #10
Percent -#10 based upon complete sample= 83.9
Weight of hydrometer sample: 57.16
Hygroscopic moisture correction:
Moist weight & tare = 43.17
Dry weight & tare = 42.90
Tare = 11.33
Hygroscopic moisture= 0.9 %
Calculated biased weight= 67.55
Table of composite correction values:

Temp, deg C:	10.7	23.1	40.2
Comp. corr:	-7.0	-4.0	0.0

iscus correction only= 1
cific gravity of solids= 2.781
Specific gravity correction factor= 0.972
Hydrometer type: 152H

Effective depth L= 16.294964 - 0.164 x Rm

Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
0.50	22.5	57.0	52.9	0.0127	58.0	6.8	0.0469	76.1
1.00	22.5	55.5	51.4	0.0127	56.5	7.0	0.0338	73.9
2.00	22.5	54.0	49.9	0.0127	55.0	7.3	0.0243	71.7
5.00	22.5	52.0	47.9	0.0127	53.0	7.6	0.0157	68.9
15.00	22.5	50.0	45.9	0.0127	51.0	7.9	0.0093	66.0
30.00	22.5	49.0	44.9	0.0127	50.0	8.1	0.0066	64.5
60.00	22.6	47.5	43.4	0.0127	48.5	8.3	0.0047	62.4
250.00	22.9	45.0	41.0	0.0127	46.0	8.8	0.0024	58.9
1440.00	22.4	44.0	39.8	0.0128	45.0	8.9	0.0010	57.3

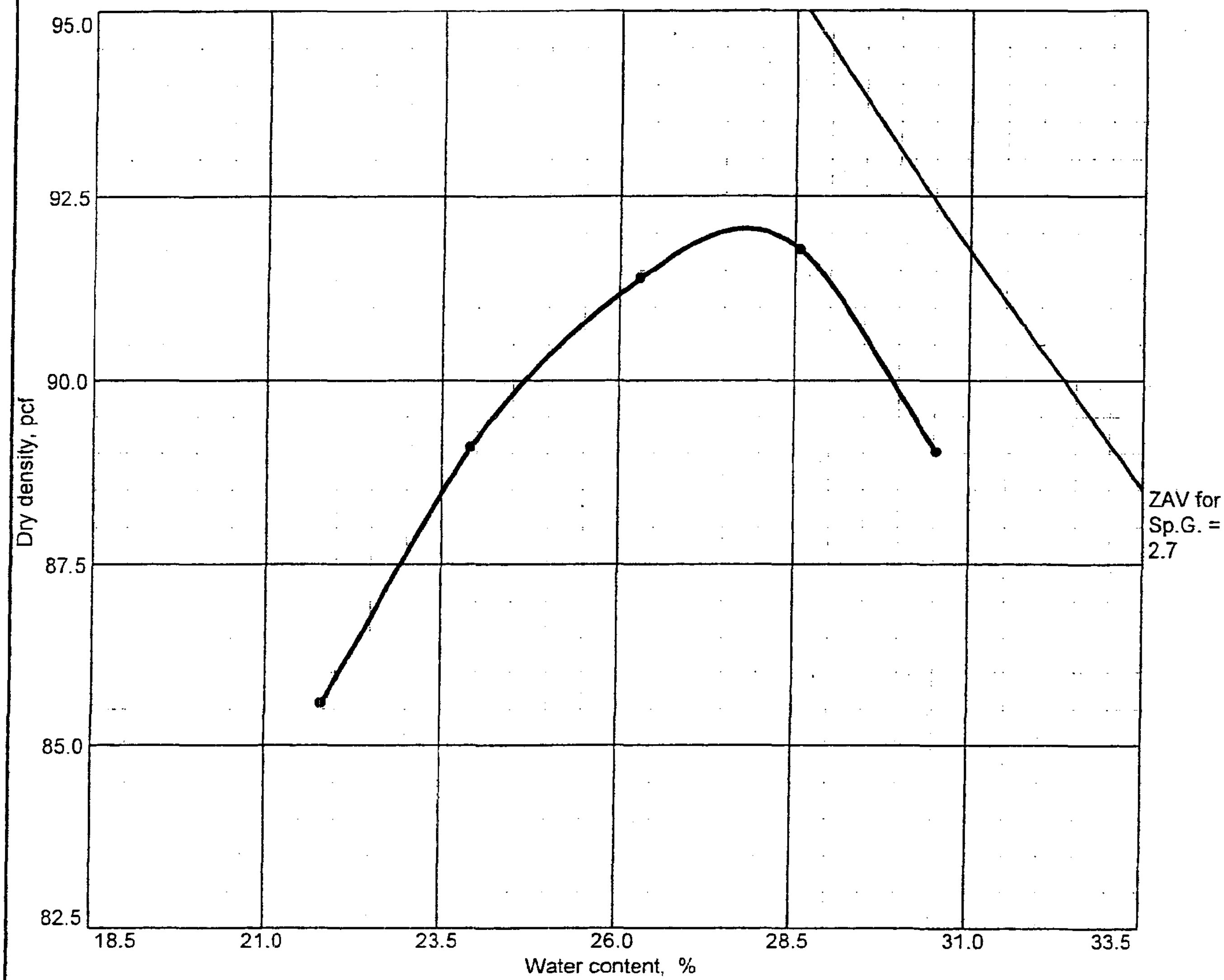
Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = **% GRAVEL =** 8.4 **% SAND =** 12.2
% SILT = 16.7 **% CLAY =** 62.7

D_{85}= 2.44 D_{60}= 0.00

MOISTURE-DENSITY RELATIONSHIP TEST RESULTS

COMPACTION TEST REPORT



Test specification: ASTM D 698-91 Procedure A Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
10'-15'	MH		34.7%	2.69	56	19	3.2	75.0

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 92.1 pcf Optimum moisture = 27.8 %	Red Brown Elastic Silt with SAND

Project No. 3043051064- **Client:**

Project: TVA Kingston Gypsum Disposal

• **Location:** K-3 10'-15'

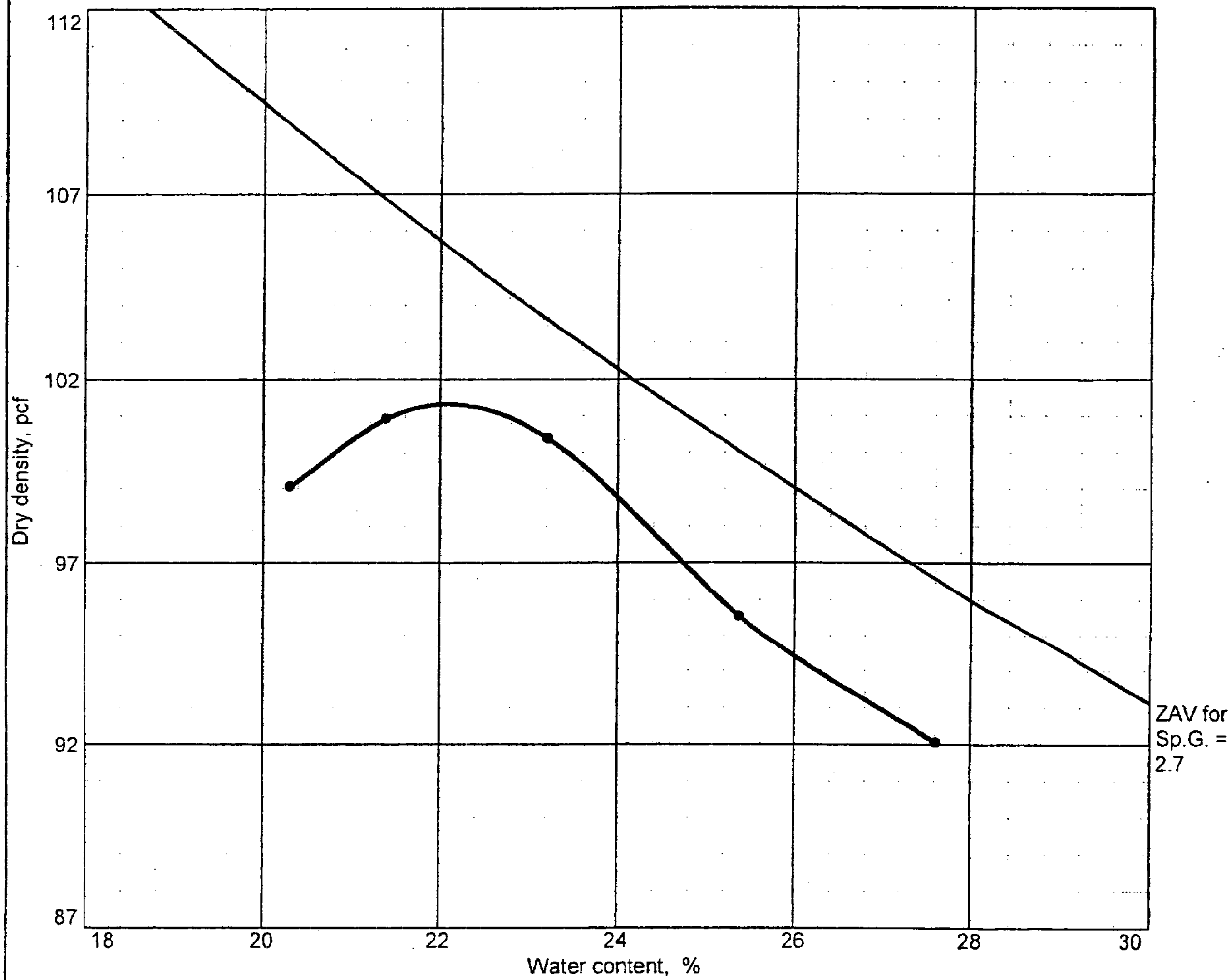
COMPACTION TEST REPORT

MACTEC, INC.

Remarks: CJ

Figure

COMPACTION TEST REPORT



Test specification: ASTM D 698-91 Procedure A Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
10'-15'	ML		25.6%	2.65	43	14	0.0	75.0

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 101.3 pcf Optimum moisture = 22.1 %	Red Brown Silt with SAND

Project No. 3043051064- **Client:**
Project: TVA Kingston Gypsum Disposal
-

● **Location:** K-6 10'-15'

COMPACTION TEST REPORT

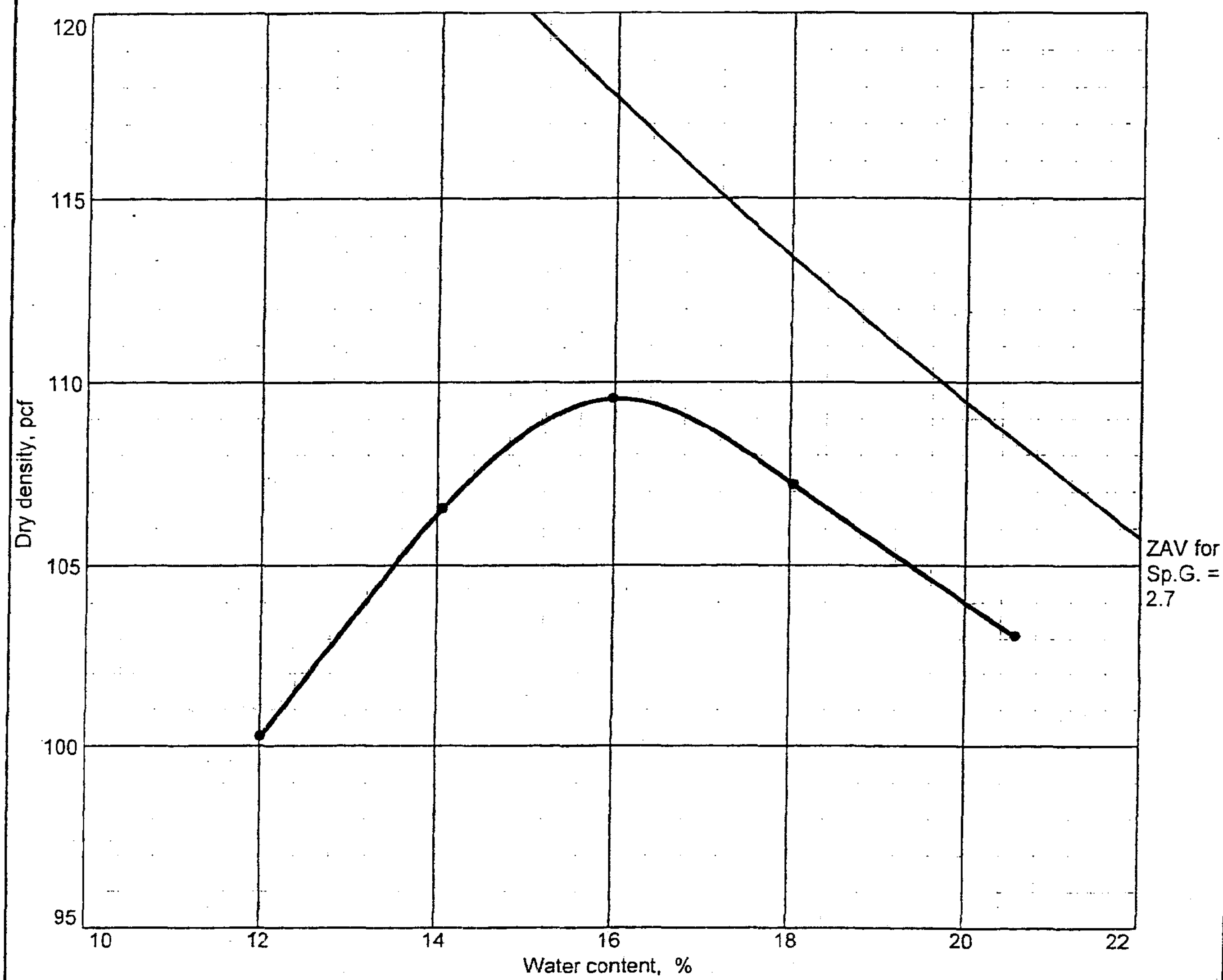
MACTEC, INC.

Remarks:
CTJ

Figure

TVA-00020904

COMPACTION TEST REPORT



Test specification: ASTM D 698-91 Procedure A Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
10'-15'	CL		22.3%	2.64	31	10	0.0	70.5

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 109.6 pcf Optimum moisture = 16.0 %	Dark Brown Lean Clay with SAND

Project No. 3043051064- **Client:**

Project: TVA Kingston Gypsum Disposal

● **Location:** K-7 10'-15'

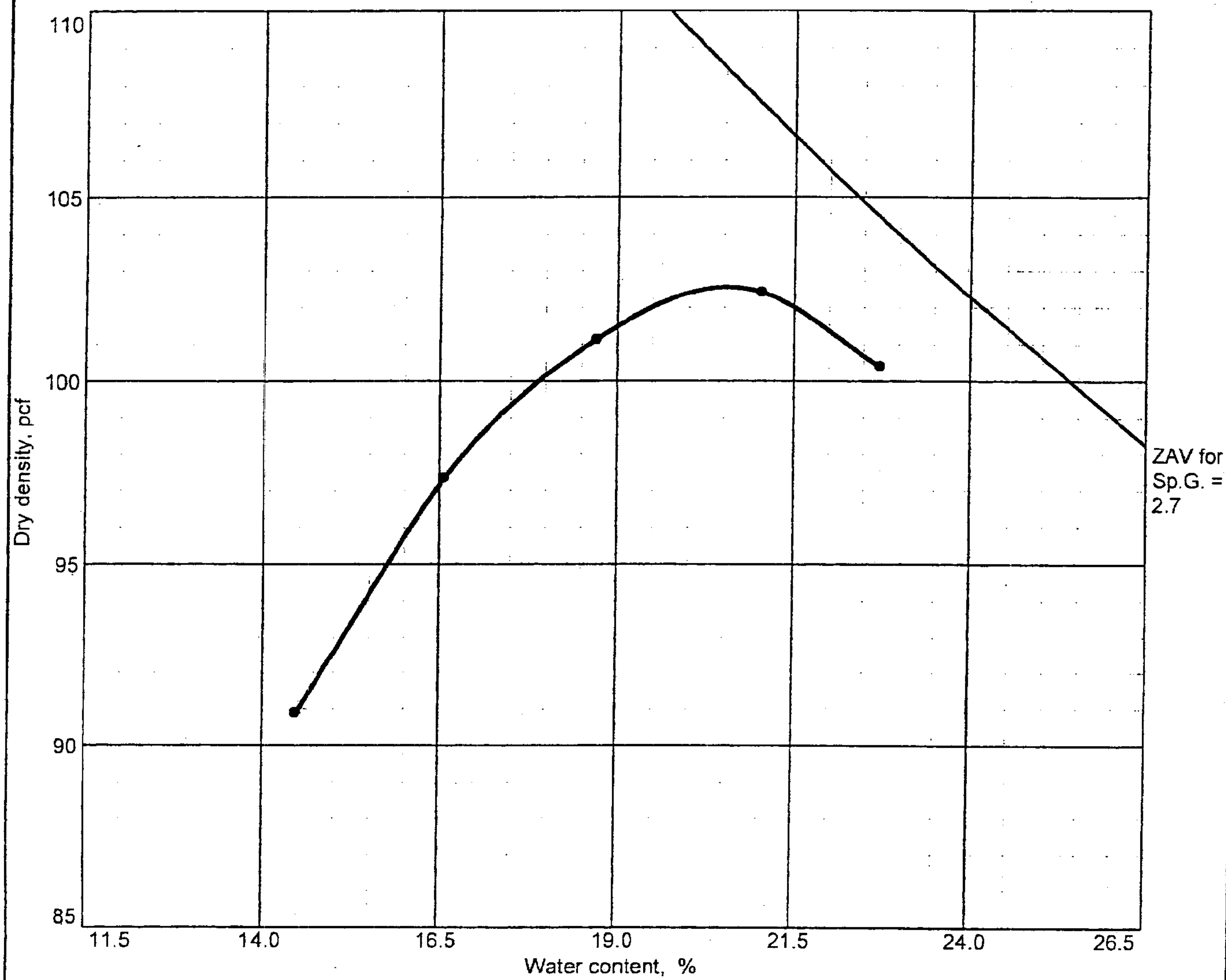
Remarks: CTX

COMPACTION TEST REPORT

MACTEC, INC.

Figure

COMPACTION TEST REPORT



Test specification: ASTM D 698-91 Procedure A Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
10'-15'	CH		22.4%	2.67	51	24	4.4	53.0

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 102.6 pcf Optimum moisture = 20.6 %	Red Brown Sandy Fat CLAY

Project No. 3043051064- **Client:**
Project: TVA Kingston Gypsum Disposal

● **Location:** K-8 10'-15'

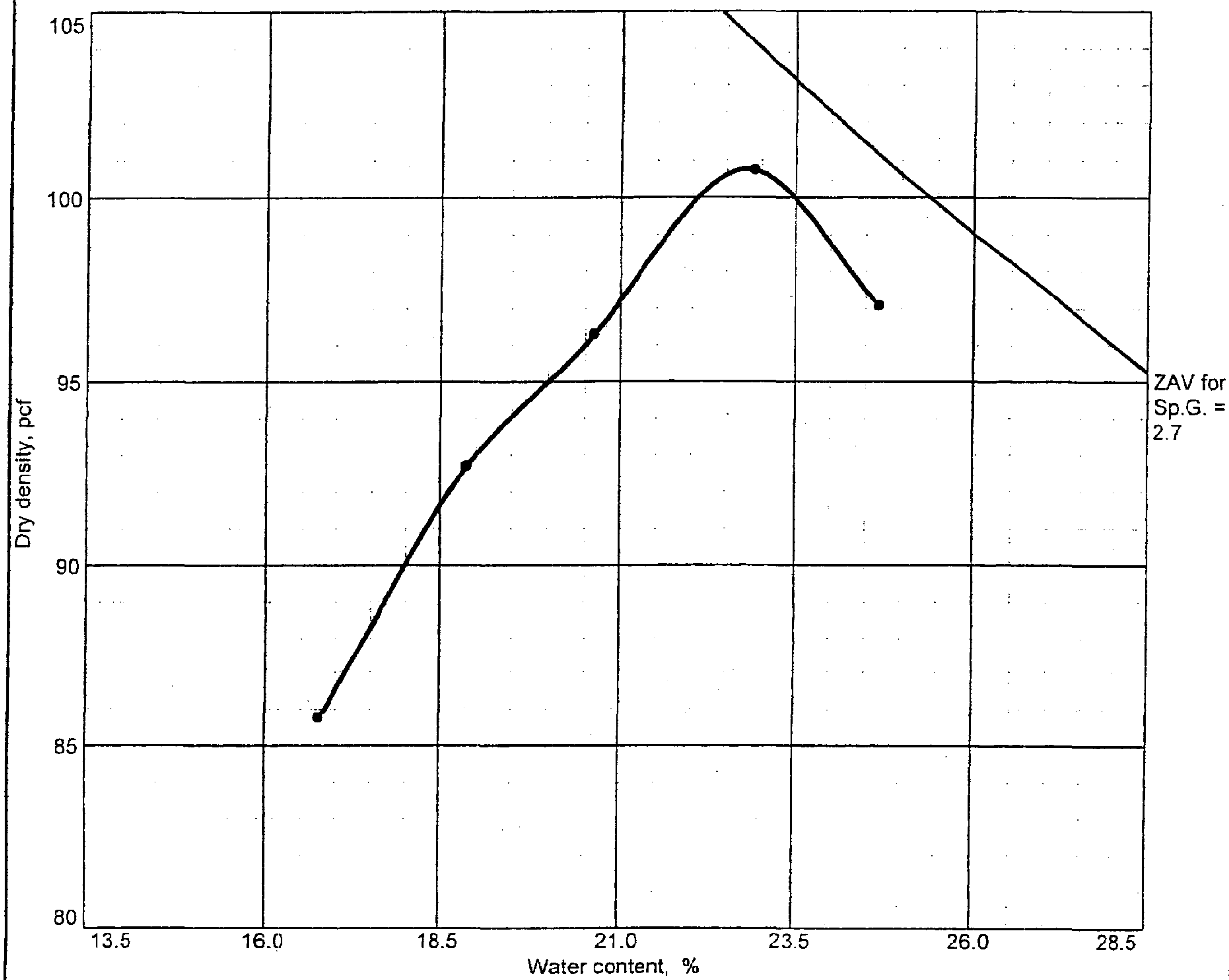
Remarks: CJK

COMPACTION TEST REPORT

MACTEC, INC.

Figure

COMPACTION TEST REPORT



Test specification: ASTM D 698-91 Procedure A Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
10'-15'	MH		28.3%	2.75	52	23	1.3	78.9

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 100.8 pcf Optimum moisture = 22.8 %	Dark Red Brown Elastic Silt with SAND

Project No. 3043051064- **Client:**
Project: TVA Kingston Gypsum Disposal

● **Location:** K-16 10'-15'

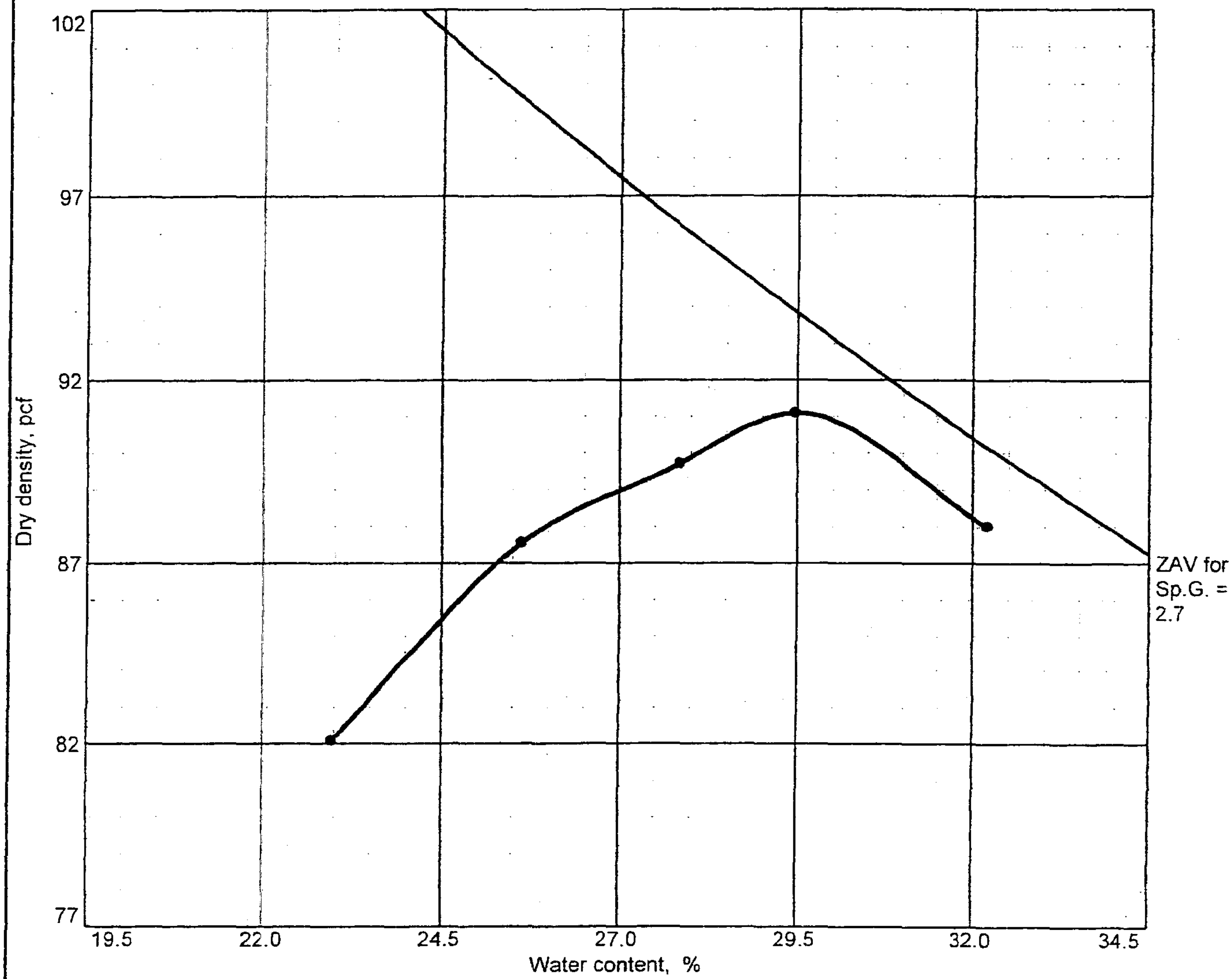
Remarks: CJf

COMPACTION TEST REPORT

MACTEC, INC.

Figure

COMPACTION TEST REPORT



Test specification: ASTM D 698-91 Procedure A Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
10'-15'	MH		30.6 %	2.70	75	35	0.0	89.0

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 91.1 pcf Optimum moisture = 29.5 %	Red Brown Elastic SILT

Project No. 3043051064- **Client:**
Project: TVA Kingston Gypsum Disposal

● **Location:** K-17 10'-15'

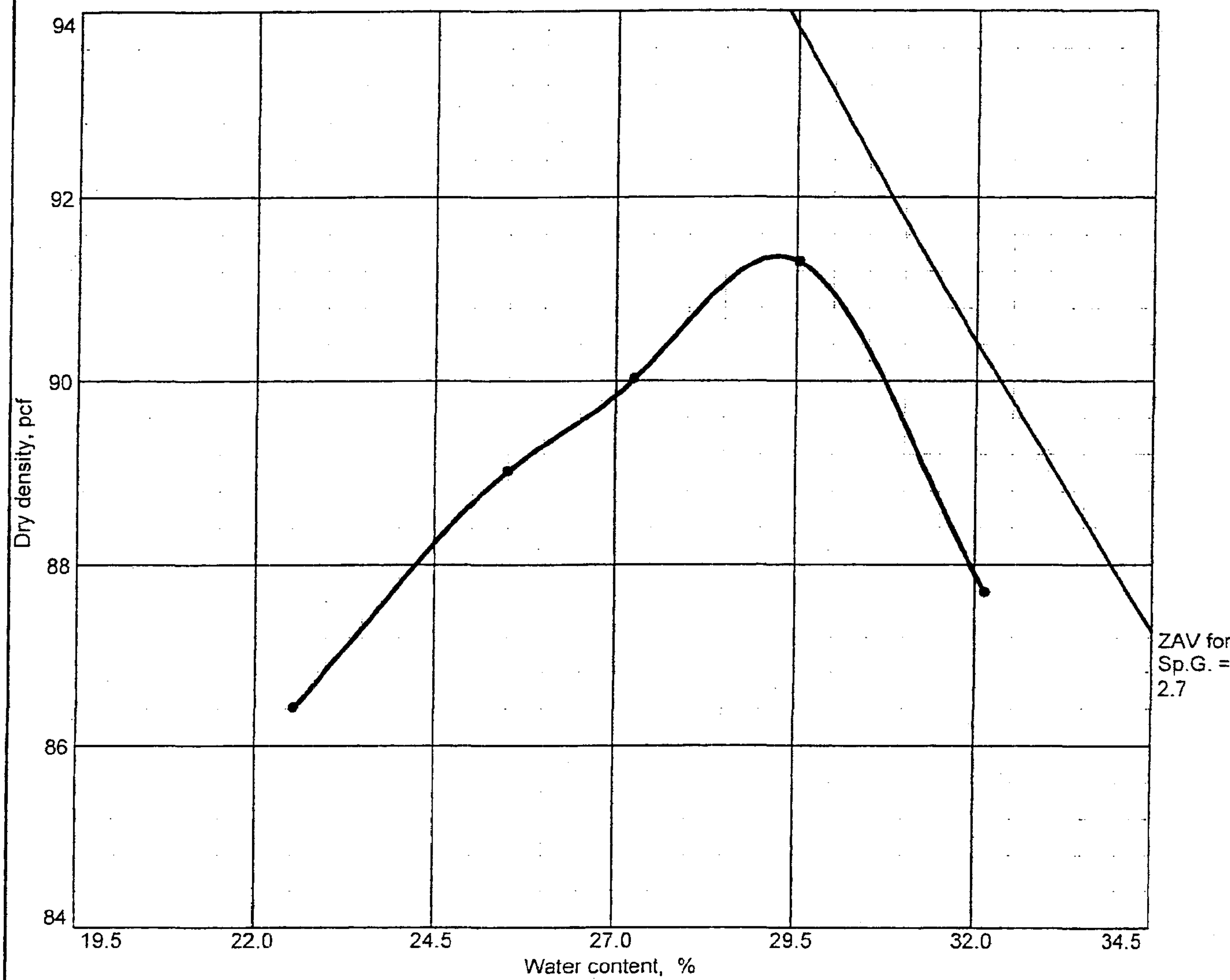
Remarks:

COMPACTION TEST REPORT

MACTEC, INC.

Figure

COMPACTION TEST REPORT



Test specification: ASTM D 698-91 Procedure A Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
10'-15'	MH		31.3%	2.78	71	34	8.4	79.4

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 91.4 pcf Optimum moisture = 29.2 %	Red Brown Elastic Silt with SAND

Project No. 3043051064- **Client:**
Project: TVA Kingston Gypsum Disposal

● **Location:** K-18 10'-15'

Remarks: CTJ

COMPACTION TEST REPORT

MACTEC, INC.

Figure

UNIT WEIGHT TEST RESULTS

GeoTesting Express

GTX TECHNICAL PROCEDURE T-03
UNIT WEIGHT OF SAMPLE

Project No.:	GTX G0959	Boring No.:	NB-21B
Lab No:	13775	Depth:	31-33 Ft.
Project Name:	Kingston Proposed Gypsum Stack	Sample ID:	Ud
Tested By:	HJ	Reviewed By:	JW
Date:	12/14/05	Date:	02/02/06

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	22.62			Tare No.	A-16	
2	22.6	Top	2.870	Tare Weight	16.41	*grams*
3	22.58	Bottom	2.870	Wet Weight + Tare	130.22	*grams*
Average	22.60	Average	2.870	Dry Weight + Tare	103.98	*grams*
				Moisture Content	30.0	%

Total Weight of Soil + Tube Section	6338.00	*grams*
Weight of Clean, Dry Tube Section	1713.80	*grams*
Wet Weight of Soil	10.19	*lbs*
Volume of Sample	0.085	ft^3

RESULT SUMMARY

Moisture Content	**30.0**	%
Wet Density	**120.5**	*pcf*
Dry Density	**92.7**	*pcf*

Remarks:

GeoTesting Express

GTX TECHNICAL PROCEDURE T-03
UNIT WEIGHT OF SAMPLE

Project No.: GTX G0959
Lab No: 13774
Project Name: Kingston Proposed Gypsum Stack
Tested By: HJ
Date: 12/22/05

Boring No.: NB-47BA
Depth: 20-22 Ft.
Sample ID: Ud
Reviewed By: JW
Date: 02/02/06

Total Sample Height, *inches*		**Inside Diameter of Cut Tube, *inches***		**Moisture Content**		
1	19.65			Tare No.	A-1	
2	19.65	Top	2.870	Tare Weight	16.96	*grams*
3	19.65	Bottom	2.870	Wet Weight + Tare	210.10	*grams*
Average	19.65	Average	2.870	Dry Weight + Tare	148.50	*grams*
				Moisture Content	46.8	%

Total Weight of Soil + Tube Section	5111.00	*grams*
Weight of Clean, Dry Tube Section	1490.10	*grams*
Wet Weight of Soil	7.98	*lbs*
Volume of Sample	0.074	*ft^3*

RESULT SUMMARY

Moisture Content	**46.8**	*%*
Wet Density	**108.5**	*pcf*
Dry Density	**73.9**	*pcf*

Remarks:

GeoTesting Express

GTX TECHNICAL PROCEDURE T-03
UNIT WEIGHT OF SAMPLE

Project No.:	GTX G0959	Boring No.:	NB-73WB
Lab No:	13767	Depth:	40-42 Ft.
Project Name:	Kingston Proposed Gypsum Stack	Sample ID:	Ud
Tested By:	HJ	Reviewed By:	JW
Date:	12/12/05	Date:	02/02/06

Total Sample Height, *inches*		**Inside Diameter of Cut Tube, *inches***		**Moisture Content**		
1	20.5			Tare No.	M-3	
2	20.5	Top	2.870	Tare Weight	77.96	*grams*
3	20.5	Bottom	2.870	Wet Weight + Tare	208.77	*grams*
Average	20.50	Average	2.870	Dry Weight + Tare	176.43	*grams*
				Moisture Content	32.8	%

Total Weight of Soil + Tube Section	5790.00	*grams*
Weight of Clean, Dry Tube Section	1611.40	*grams*
Wet Weight of Soil	9.21	*lbs*
Volume of Sample	0.077	ft^3

RESULT SUMMARY

Moisture Content	**32.8**	**%**
Wet Density	**120.0**	***pcf***
Dry Density	**90.4**	***pcf***

Remarks:

GeoTesting Express

GTX TECHNICAL PROCEDURE T-03
UNIT WEIGHT OF SAMPLE

Project No.:	GTX G0959	Boring No.:	NB-73WBA
Lab No:	13768	Depth:	40-42 Ft.
Project Name:	Kingston Proposed Gypsum Stack	Sample ID:	Ud
Tested By:	HJ	Reviewed By:	JW
Date:	12/14/05	Date:	02/02/06

Total Sample Height, *inches*		**Inside Diameter of Cut Tube, *inches***		**Moisture Content**		
1	5.57			Tare No.	B-29	
2	5.57	Top	2.848	Tare Weight	57.99	*grams*
3	5.57	Bottom	2.848	Wet Weight + Tare	1216.14	*grams*
Average	5.57	Average	2.848	Dry Weight + Tare	951.73	*grams*
				Moisture Content	29.6	%

Total Weight of Soil + Tube Section	1158.15	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	2.55	*lbs*
Volume of Sample	0.021	ft^3

RESULT SUMMARY

Moisture Content	**29.6**	%
Wet Density	**124.3**	*pcf*
Dry Density	**96.0**	*pcf*

Remarks:

GeoTesting Express

GTX TECHNICAL PROCEDURE T-03
UNIT WEIGHT OF SAMPLE

Project No.:	GTX G0959	Boring No.:	NB-77B
Lab No:	13765	Depth:	11-12.8 Ft.
Project Name:	Kingston Proposed Gypsum Stack	Sample ID:	Ud
Tested By:	HJ	Reviewed By:	JW
Date:	12/12/05	Date:	02/02/06

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	15.13			Tare No.	M-8	
2	15.09	Top	2.870	Tare Weight	75.28	*grams*
3	15.11	Bottom	2.870	Wet Weight + Tare	178.70	*grams*
Average	15.11	Average	2.870	Dry Weight + Tare	155.63	*grams*
				Moisture Content	28.7	*%*

Total Weight of Soil + Tube Section	4195.00	*grams*
Weight of Clean, Dry Tube Section	1145.80	*grams*
Wet Weight of Soil	6.72	*lbs*
Volume of Sample	0.057	*ft^3*

RESULT SUMMARY

Moisture Content	**28.7**	*%*
Wet Density	**118.8**	*pcf*
Dry Density	**92.3**	*pcf*

Remarks:

GeoTesting Express

GTX TECHNICAL PROCEDURE T-03
UNIT WEIGHT OF SAMPLE

Project No.:	GTX G0959	Boring No.:	NB-77B
Lab No:	13766	Depth:	13-15 Ft.
Project Name:	Kingston Proposed Gypsum Stack	Sample ID:	Ud
Tested By:	HJ	Reviewed By:	JW
Date:	12/12/05	Date:	02/02/06

Total Sample Height, *inches*		**Inside Diameter of Cut Tube, *inches***		**Moisture Content**		
1	15.1			Tare No.	M-5	
2	15.05	Top	2.870	Tare Weight	74.98	*grams*
3	15.15	Bottom	2.870	Wet Weight + Tare	155.41	*grams*
Average	15.10	Average	2.870	Dry Weight + Tare	136.50	*grams*
				Moisture Content	30.7	%

Total Weight of Soil + Tube Section	4194.00	*grams*
Weight of Clean, Dry Tube Section	1145.00	*grams*
Wet Weight of Soil	6.72	*lbs*
Volume of Sample	0.057	ft^3

RESULT SUMMARY

Moisture Content	**30.7**	*%*
Wet Density	**118.9**	*pcf*
Dry Density	**90.9**	*pcf*

Remarks:

GeoTesting Express

GTX TECHNICAL PROCEDURE T-03
UNIT WEIGHT OF SAMPLE

Project No.:	GTX G0959	Boring No.:	NB-85B
Lab No:	13771	Depth:	28-30 Ft.
Project Name:	Kingston Proposed Gypsum Stack	Sample ID:	Ud
Tested By:	HJ	Reviewed By:	JW
Date:	12/14/05	Date:	02/02/06

Total Sample Height, *inches*		**Inside Diameter of Cut Tube, *inches***		**Moisture Content**		
1	15.45			Tare No.	A-33	
2	15.45	Top	2.848	Tare Weight	17.16	*grams*
3	15.45	Bottom	2.848	Wet Weight + Tare	104.12	*grams*
Average	15.45	Average	2.848	Dry Weight + Tare	79.70	*grams*
				Moisture Content	39.0	%

Total Weight of Soil + Tube Section	4134.00	*grams*
Weight of Clean, Dry Tube Section	1205.70	*grams*
Wet Weight of Soil	6.46	*lbs*
Volume of Sample	0.057	ft^3

RESULT SUMMARY

Moisture Content	**39.0**	*%*
Wet Density	**113.3**	*pcf*
Dry Density	**81.5**	*pcf*

Remarks:

GeoTesting Express

GTX TECHNICAL PROCEDURE T-03
UNIT WEIGHT OF SAMPLE

Project No.:	GTX G0959	Boring No.:	NB-85B
Lab No:	13772	Depth:	30-32 Ft.
Project Name:	Kingston Proposed Gypsum Stack	Sample ID:	Ud
Tested By:	HJ	Reviewed By:	JW
Date:	12/14/05	Date:	02/02/06

Total Sample Height, *inches*		**Inside Diameter of Cut Tube, *inches***		**Moisture Content**		
1	9.03			Tare No.	A-46	
2	9.05	Top	2.870	Tare Weight	16.65	*grams*
3	9	Bottom	2.870	Wet Weight + Tare	123.74	*grams*
Average	9.03	Average	2.870	Dry Weight + Tare	99.01	*grams*
				Moisture Content	30.0	%

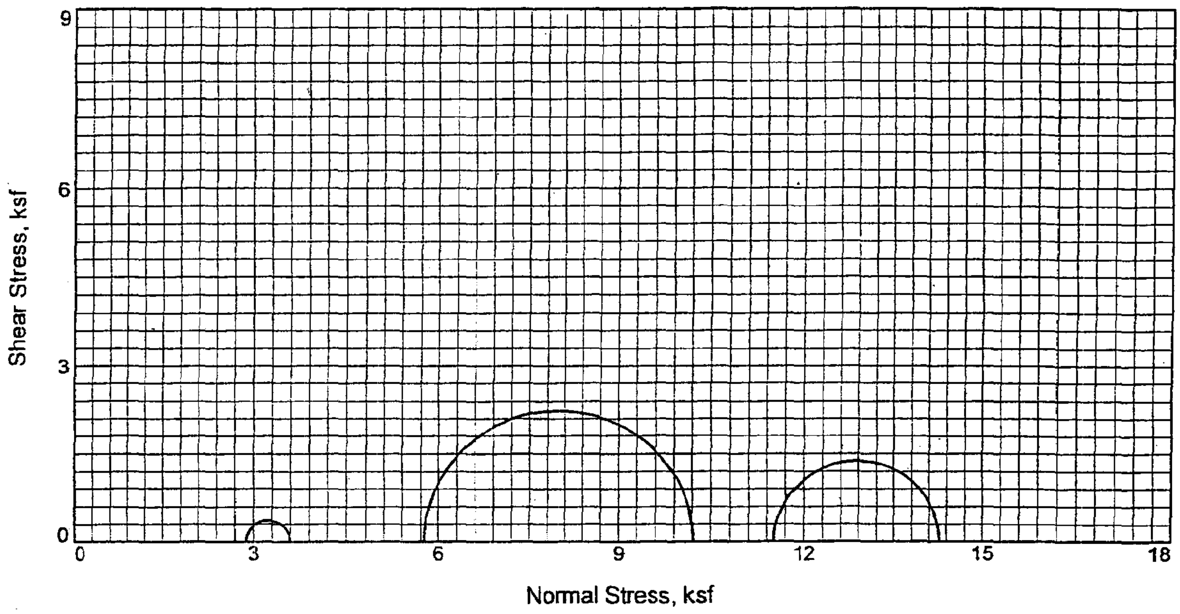
Total Weight of Soil + Tube Section	2530.00	*grams*
Weight of Clean, Dry Tube Section	687.00	*grams*
Wet Weight of Soil	4.06	*lbs*
Volume of Sample	0.034	ft^3

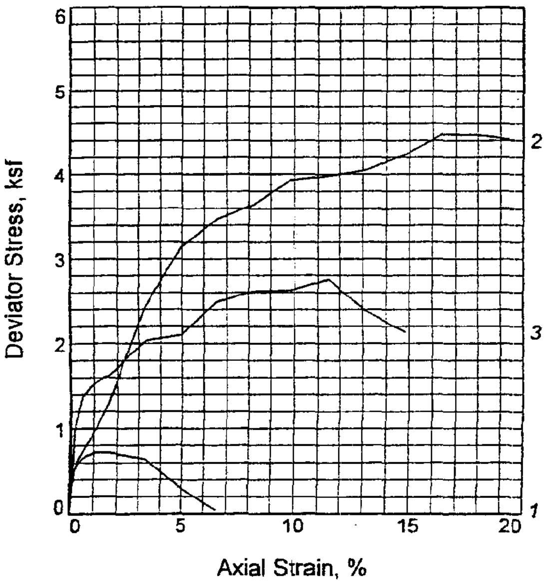
RESULT SUMMARY

Moisture Content	**30.0**	%
Wet Density	**120.2**	*pcf*
Dry Density	**92.5**	*pcf*

Remarks:

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST RESULTS





Sample No.		1	2	3
Initial	Water Content,	39.4	37.1	38.6
	Dry Density, pcf	79.9	82.3	77.4
	Saturation,	98.6	98.3	90.9
	Void Ratio	1.0459	0.9880	1.1127
	Diameter, in.	2.82	2.81	2.80
	Height, in.	6.11	6.09	6.08
At Test	Water Content,	39.9	37.7	42.5
	Dry Density, pcf	79.9	82.3	77.4
	Saturation,	100.0	100.0	100.0
	Void Ratio	1.0459	0.9880	1.1127
	Diameter, in.	2.82	2.81	2.80
	Height, in.	6.11	6.09	6.08
Strain rate, in./min.		0.02	0.02	0.02
Back Pressure, ksf		2.9	2.9	2.9
Cell Pressure, ksf		5.8	8.6	14.4
Fail. Stress, ksf		0.7	4.5	2.8
Ult. Stress, ksf				
σ_1 Failure, ksf		3.6	10.2	14.3
σ_3 Failure, ksf		2.9	5.8	11.5

Type of Test:
Unconsolidated Undrained

Sample Type: undisturbed sample

Description:

Assumed Specific Gravity= 2.62

Remarks:

Figure _______

Client: TVA

Project: TVA Kingston - Proposed Gypsum Stack

Location: NB-18

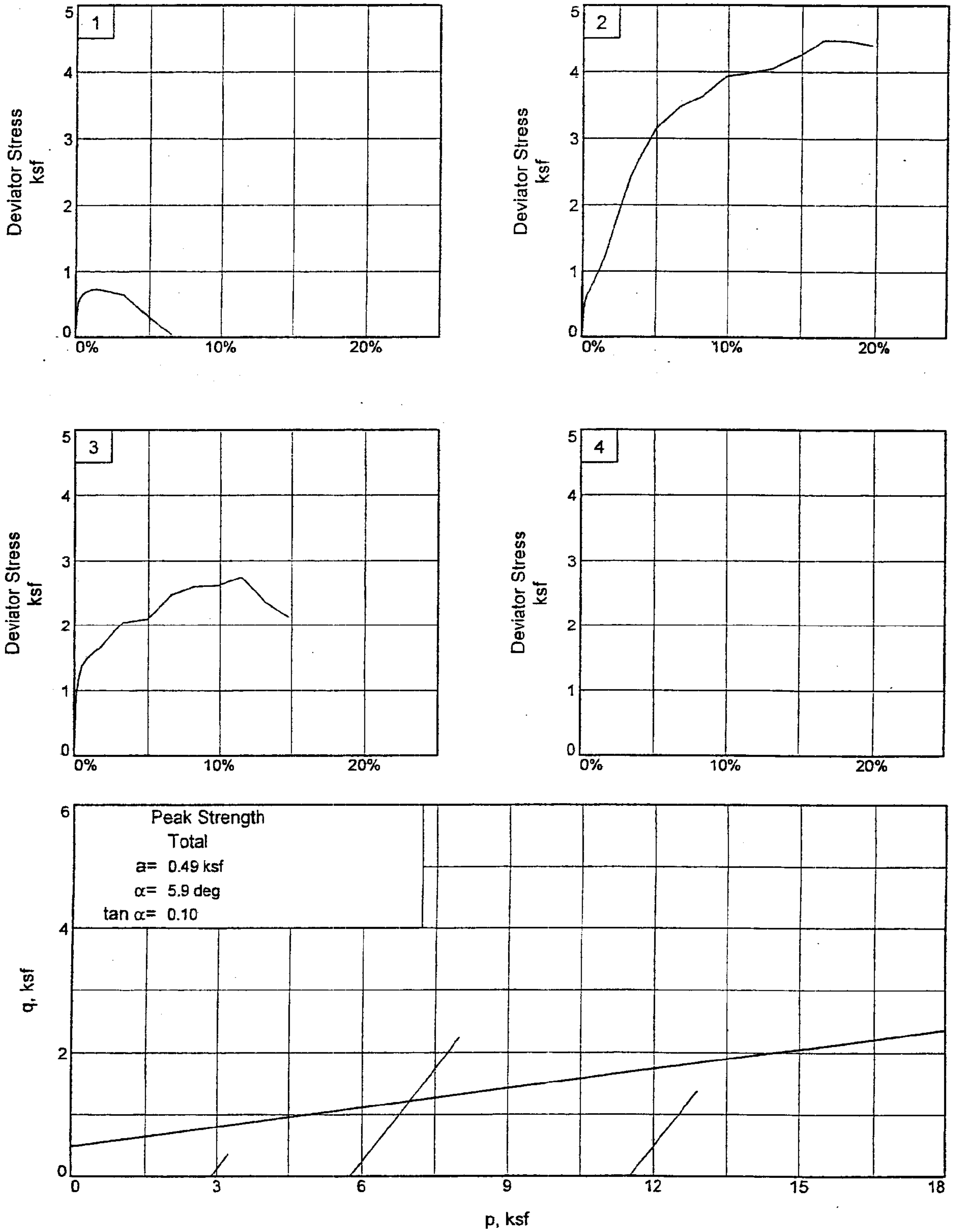
Sample Number: UD-2, 3 & 4 (UU) **Depth:** 9'-18.5'

Proj. No.: 3043051021 **Date:**

TRIAXIAL SHEAR TEST REPORT

MACTEC, INC.

Tested By: Alexander **Checked By:** Hamlett



Client: TVA
Project: TVA Kingston - Proposed Gypsum Stack
Location: NB-18 **Depth:** 9'-18.5' **Sample Number:** UD-2, 3 & 4 (UU)
Project No.: 3043051021 **Figure** ________ **MACTEC, INC.**

Tested By: Alexander **Checked By:** Hamlett

TRIAXIAL COMPRESSION TEST
Unconsolidated Undrained

9/13/2005
9:03 PM

Date:
Client: TVA
Project: TVA Kingston - Proposed Gypsum Stack
Project No.: 3043051021
Location: NB-18
Depth: 9'-18.5' **Sample Number:** UD-2, 3 & 4 (UU)
Description:
Remarks:
Type of Sample: undisturbed sample
Specific Gravity=2.62 **LL=** **PL=** **PI=**
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	1118.300		642.950
Moisture content: Dry soil+tare, gms.	802.500		447.100
Moisture content: Tare, gms.	0.000		14.010
Moisture, %	39.4	39.9	45.2
Moist specimen weight, gms.	1118.3		
Diameter, in.	2.82	2.82	
Area, in.^{2}	6.25	6.25	
Height, in.	6.11	6.11	
Net decrease in height, in.		0.00	
Wet Density, pcf	111.4	111.9	
Dry density, pcf	79.9	79.9	
Void ratio	1.0459	1.0459	
Saturation, %	98.6	100.0	

Test Readings for Specimen No. 1

Load ring constant = 0.72 lbs. per input unit
Cell pressure = 40.00 psi (5.76 ksf)
Back pressure = 20.00 psi (2.88 ksf)
Effective confining stress = 2.88 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 0.72 ksf **at reading no.** 7

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	2.88	2.88	1.00		2.88
1	0.0100	31.0	22.3	0.2	0.51	2.88	3.39	1.18		3.14
2	0.0200	36.0	25.9	0.3	0.59	2.88	3.47	1.21		3.18
3	0.0300	39.0	28.1	0.5	0.64	2.88	3.52	1.22		3.20
4	0.0400	41.0	29.5	0.7	0.68	2.88	3.56	1.23		3.22
5	0.0500	42.0	30.2	0.8	0.69	2.88	3.57	1.24		3.23
6	0.0600	43.0	31.0	1.0	0.71	2.88	3.59	1.25		3.23
7	0.0700	44.0	31.7	1.1	0.72	2.88	3.60	1.25		3.24
8	0.0800	44.0	31.7	1.3	0.72	2.88	3.60	1.25		3.24
9	0.0900	44.0	31.7	1.5	0.72	2.88	3.60	1.25		3.24
10	0.1000	44.0	31.7	1.6	0.72	2.88	3.60	1.25		3.24
11	0.2000	40.0	28.8	3.3	0.64	2.88	3.52	1.22		3.20
12	0.3000	20.0	14.4	4.9	0.32	2.88	3.20	1.11		3.04
13	0.4000	3.0	2.2	6.5	0.05	2.88	2.93	1.02		2.90

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	1119.600		646.220
Moisture content: Dry soil+tare, gms.	816.900		468.140
Moisture content: Tare, gms.	0.000		13.530
Moisture, %	37.1	37.7	39.2
Moist specimen weight, gms.	1119.6		
Diameter, in.	2.81	2.81	
Area, in.^{2}	6.21	6.21	
Height, in.	6.09	6.09	
Net decrease in height, in.		0.00	
Wet Density, pcf	112.8	113.3	
Dry density, pcf	82.3	82.3	
Void ratio	0.9880	0.9880	
Saturation, %	98.3	100.0	

Test Readings for Specimen No. 2

Load ring constant = 0.72 lbs. per input unit
Cell pressure = 60.00 psi (8.64 ksf)
Back pressure = 20.00 psi (2.88 ksf)
Effective confining stress = 5.76 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 4.47 ksf **at reading no.** 19

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	5.76	5.76	1.00		5.76
1	0.0100	31.0	22.3	0.2	0.52	5.76	6.28	1.09		6.02
2	0.0200	39.0	28.1	0.3	0.65	5.76	6.41	1.11		6.08
3	0.0300	43.0	31.0	0.5	0.71	5.76	6.47	1.12		6.12
4	0.0400	48.0	34.6	0.7	0.80	5.76	6.56	1.14		6.16
5	0.0500	52.0	37.4	0.8	0.86	5.76	6.62	1.15		6.19
6	0.0600	57.0	41.0	1.0	0.94	5.76	6.70	1.16		6.23
7	0.0700	61.0	43.9	1.1	1.01	5.76	6.77	1.17		6.26

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
8	0.0800	67.0	48.2	1.3	1.10	5.76	6.86	1.19		6.31
9	0.0900	73.0	52.6	1.5	1.20	5.76	6.96	1.21		6.36
10	0.1000	79.0	56.9	1.6	1.30	5.76	7.06	1.23		6.41
11	0.2000	150.0	108.0	3.3	2.42	5.76	8.18	1.42		6.97
12	0.3000	197.0	141.8	4.9	3.13	5.76	8.89	1.54		7.32
13	0.4000	222.0	159.8	6.6	3.47	5.76	9.23	1.60		7.49
14	0.5000	237.0	170.6	8.2	3.63	5.76	9.39	1.63		7.58
15	0.6000	261.0	187.9	9.8	3.93	5.76	9.69	1.68		7.73
16	0.7000	269.0	193.7	11.5	3.98	5.76	9.74	1.69		7.75
17	0.8000	279.0	200.9	13.1	4.05	5.76	9.81	1.70		7.78
18	0.9000	297.0	213.8	14.8	4.23	5.76	9.99	1.73		7.87
19	1.0000	320.0	230.4	16.4	4.47	5.76	10.23	1.78		7.99
20	1.1000	326.0	234.7	18.0	4.46	5.76	10.22	1.77		7.99
21	1.2000	328.0	236.2	19.7	4.40	5.76	10.16	1.76		7.96

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	1055.500		550.410
Moisture content: Dry soil+tare, gms.	761.600		388.030
Moisture content: Tare, gms.	0.000		14.010
Moisture, %	38.6	42.5	43.4
Moist specimen weight, gms.	1055.5		
Diameter, in.	2.80	2.80	
Area, in.²	6.16	6.16	
Height, in.	6.08	6.08	
Net decrease in height, in.		0.00	
Wet Density, pcf	107.3	110.3	
Dry density, pcf	77.4	77.4	
Void ratio	1.1127	1.1127	
Saturation, %	90.9	100.0	

Test Readings for Specimen No. 3

Load ring constant = 0.72 lbs. per input unit

Cell pressure = 100.00 psi (14.40 ksf)

Back pressure = 20.00 psi (2.88 ksf)

Effective confining stress = 11.52 ksf

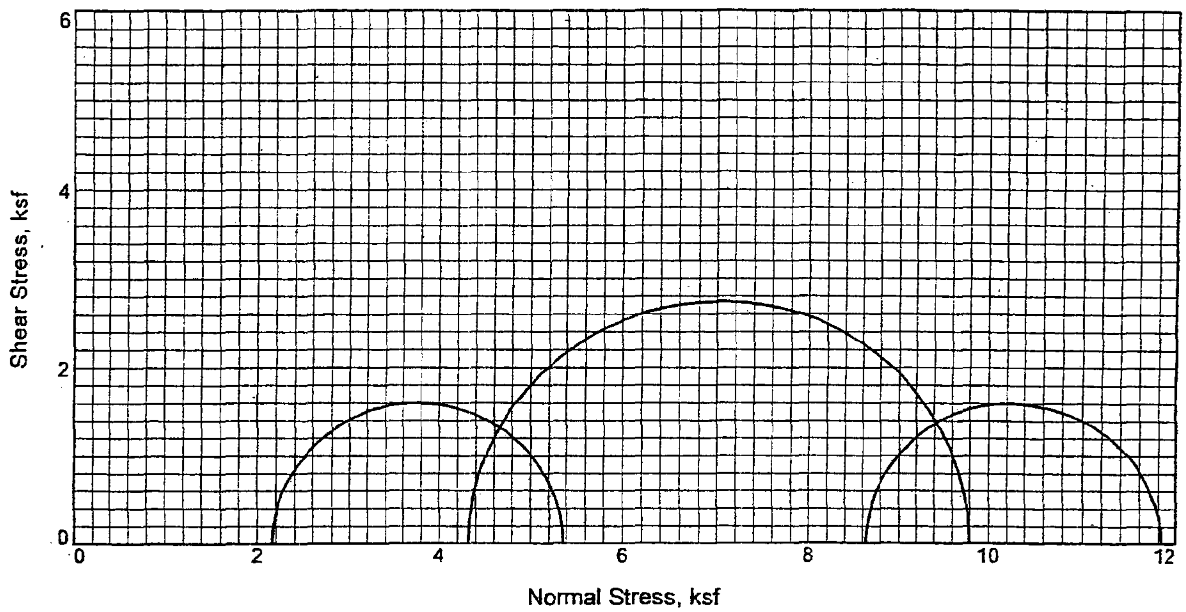
Strain rate, in./min. = 0.02

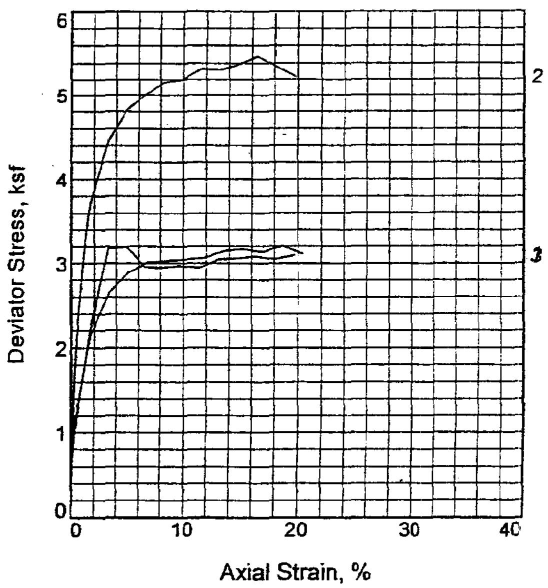
Fail. Stress = 2.75 ksf **at reading no.** 16

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	11.52	11.52	1.00		11.52
1	0.0100	57.0	41.0	0.2	0.96	11.52	12.48	1.08		12.00
2	0.0200	72.0	51.8	0.3	1.21	11.52	12.73	1.10		12.12
3	0.0300	82.0	59.0	0.5	1.37	11.52	12.89	1.12		12.21
4	0.0400	85.0	61.2	0.7	1.42	11.52	12.94	1.12		12.23
5	0.0500	89.0	64.1	0.8	1.49	11.52	13.01	1.13		12.26
6	0.0600	91.0	65.5	1.0	1.52	11.52	13.04	1.13		12.28
7	0.0700	93.0	67.0	1.2	1.55	11.52	13.07	1.13		12.29

Test Readings for Specimen No. [illegible]

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
8	0.0800	95.0	68.4	1.3	1.58	11.52	13.10	1.14		12.31
9	0.0900	97.0	69.8	1.5	1.61	11.52	13.13	1.14		12.32
10	0.1000	98.0	70.6	1.6	1.62	11.52	13.14	1.14		12.33
11	0.2000	125.0	90.0	3.3	2.03	11.52	13.55	1.18		12.54
12	0.3000	131.0	94.3	4.9	2.10	11.52	13.62	1.18		12.57
13	0.4000	158.0	113.8	6.6	2.48	11.52	14.00	1.22		12.76
14	0.5000	169.0	121.7	8.2	2.61	11.52	14.13	1.23		12.82
15	0.6000	173.0	124.6	9.9	2.62	11.52	14.14	1.23		12.83
16	0.7000	185.0	133.2	11.5	2.75	11.52	14.27	1.24		12.90
17	0.8000	163.0	117.4	13.2	2.38	11.52	13.90	1.21		12.71
18	0.9000	149.0	107.3	14.8	2.14	11.52	13.66	1.19		12.59





Sample No.		1	2	3
Initial	Water Content,	28.2	24.9	34.2
	Dry Density, pcf	94.4	93.5	86.8
	Saturation,	99.3	85.7	100.0
	Void Ratio	0.7519	0.7700	0.9067
	Diameter, in.	2.82	2.85	2.85
	Height, in.	5.88	6.05	6.09
At Test	Water Content,	28.4	29.1	34.2
	Dry Density, pcf	94.4	93.5	86.8
	Saturation,	100.0	100.0	100.0
	Void Ratio	0.7519	0.7700	0.9067
	Diameter, in.	2.82	2.85	2.85
	Height, in.	5.88	6.05	6.09
Strain rate, in./min.		0.02		0.02
Back Pressure, ksf		4.3	4.3	4.3
Cell Pressure, ksf		6.5	8.6	13.0
Fail. Stress, ksf		3.2	5.5	3.2
Ult. Stress, ksf				
σ_1 Failure, ksf		5.4	9.8	11.8
σ_3 Failure, ksf		2.2	4.3	8.6

Type of Test:
Unconsolidated Undrained
Sample Type: undisturbed
Description:

Assumed Specific Gravity= 2.65
Remarks:

Client: TVA

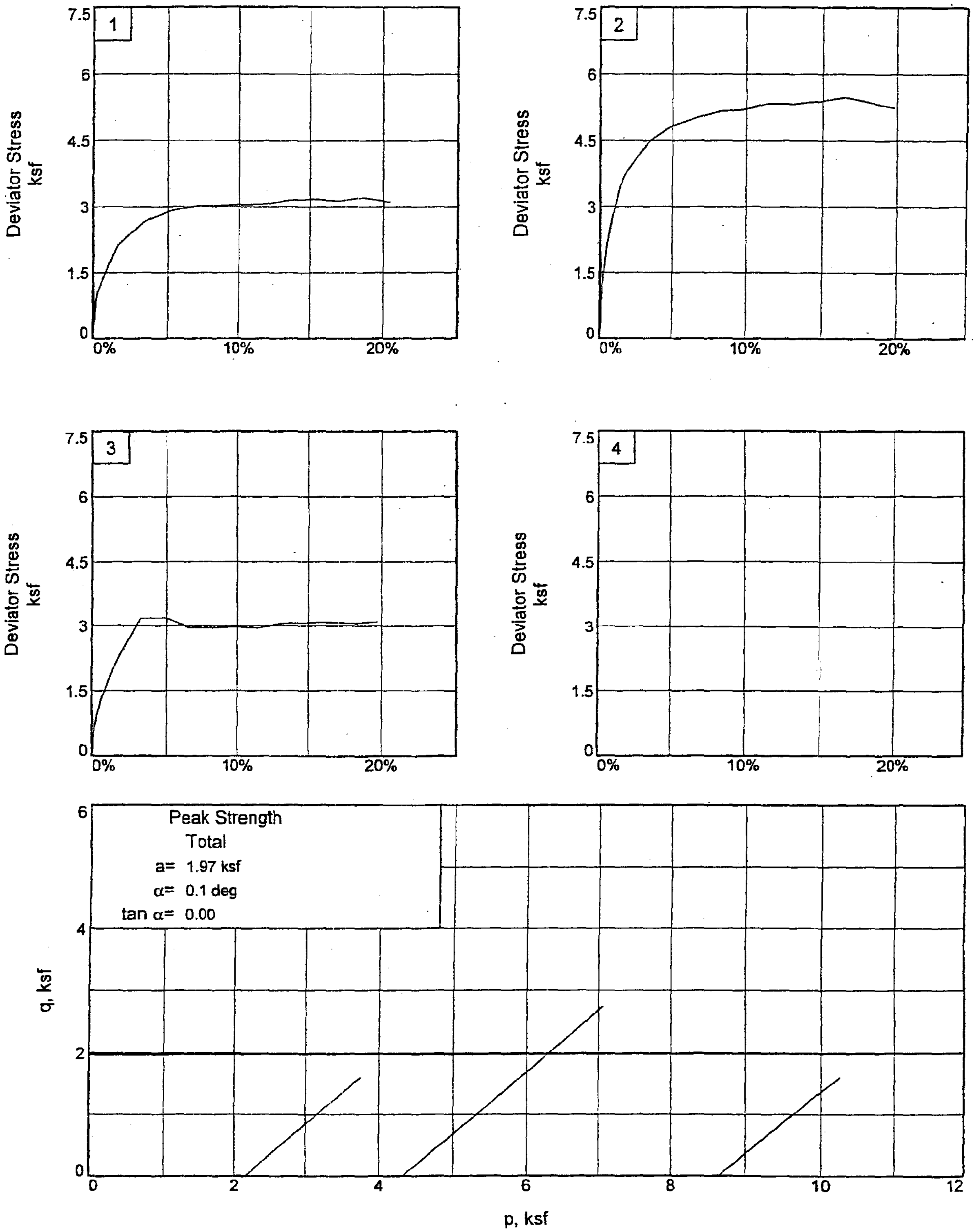
Project: TVA Kingston - Proposed Gypsum Stack

Location: NB-21A
Sample Number: UD-1, 2 & 3 (UU) **Depth:** 15'-23'
Proj. No.: 3043051021 **Date:**

TRIAXIAL SHEAR TEST REPORT
MACTEC, INC.

Figure ______

Tested By: Alexander **Checked By:** Hamlett



Client: TVA
Project: TVA Kingston - Proposed Gypsum Stack
Location: NB-21A **Depth:** 15'-23' **Sample Number:** UD-1, 2 & 3 (UU)
Project No.: 3043051021 **Figure** ______ **MACTEC, INC.**

Tested By: Alexander **Checked By:** Hamlett

TRIAXIAL COMPRESSION TEST
Unconsolidated Undrained

9/13/2005
9:15 PM

Date:
Client: TVA
Project: TVA Kingston - Proposed Gypsum Stack
Project No.: 3043051021
Location: NB-21A
Depth: 15'-23' **Sample Number:** UD-1, 2 & 3 (UU)
Description:
Remarks:
Type of Sample: undisturbed
Specific Gravity=2.65 **LL=** **PL=** **PI=**
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	1170.100		637.780
Moisture content: Dry soil+tare, gms.	912.940		492.750
Moisture content: Tare, gms.	0.000		14.200
Moisture, %	28.2	28.4	30.3
Moist specimen weight, gms.	1170.1		
Diameter, in.	2.82	2.82	
Area, in.²	6.26	6.26	
Height, in.	5.88	5.88	
Net decrease in height, in.		0.00	
Wet Density, pcf	121.0	121.2	
Dry density, pcf	94.4	94.4	
Void ratio	0.7519	0.7519	
Saturation, %	99.3	100.0	

Test Readings for Specimen No. 1

Load ring constant = 0.72 lbs. per input unit
Cell pressure = 45.00 psi (6.48 ksf)
Back pressure = 30.00 psi (4.32 ksf)
Effective confining stress = 2.16 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 3.20 ksf **at reading no.** 20

[illegible]

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	2.16	2.16	1.00		2.16
1	0.0100	49.0	35.3	0.2	0.81	2.16	2.97	1.37		2.56
2	0.0200	67.0	48.2	0.3	1.11	2.16	3.27	1.51		2.71
3	0.0300	75.0	54.0	0.5	1.24	2.16	3.40	1.57		2.78
4	0.0400	84.0	60.5	0.7	1.38	2.16	3.54	1.64		2.85
5	0.0500	92.0	66.2	0.9	1.51	2.16	3.67	1.70		2.91
6	0.0600	101.0	72.7	1.0	1.65	2.16	3.81	1.77		2.99
7	0.0700	109.0	78.5	1.2	1.78	2.16	3.94	1.83		3.05
8	0.0800	118.0	85.0	1.4	1.93	2.16	4.09	1.89		3.12
9	0.0900	125.0	90.0	1.5	2.04	2.16	4.20	1.94		3.18
10	0.1000	132.0	95.0	1.7	2.15	2.16	4.31	1.99		3.23
11	0.2000	166.0	119.5	3.4	2.65	2.16	4.81	2.23		3.49
12	0.3000	184.0	132.5	5.1	2.89	2.16	5.05	2.34		3.61
13	0.4000	195.0	140.4	6.8	3.01	2.16	5.17	2.39		3.66
14	0.5000	200.0	144.0	8.5	3.03	2.16	5.19	2.40		3.67
15	0.6000	205.0	147.6	10.2	3.05	2.16	5.21	2.41		3.68
16	0.7000	210.0	151.2	11.9	3.06	2.16	5.22	2.42		3.69
17	0.8000	220.0	158.4	13.6	3.15	2.16	5.31	2.46		3.73
18	0.9000	226.0	162.7	15.3	3.17	2.16	5.33	2.47		3.74
19	1.0000	228.0	164.2	17.0	3.13	2.16	5.29	2.45		3.73
20	1.1000	238.0	171.4	18.7	3.20	2.16	5.36	2.48		3.76
21	1.2000	236.0	169.9	20.4	3.11	2.16	5.27	2.44		3.71

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	1183.200		695.390
Moisture content: Dry soil+tare, gms.	947.400		564.140
Moisture content: Tare, gms.	0.000		110.760
Moisture, %	24.9	29.1	28.9
Moist specimen weight, gms.	1183.2		
Diameter, in.	2.85	2.85	
Area, in.²	6.38	6.38	
Height, in.	6.05	6.05	
Net decrease in height, in.		0.00	
Wet Density, pcf	116.7	120.6	
Dry density, pcf	93.5	93.5	
Void ratio	0.7700	0.7700	
Saturation, %	85.7	100.0	

Test Readings for Specimen No. 2

Load ring constant = 0.72 lbs. per input unit

Cell pressure = 60.00 psi (8.64 ksf)

Back pressure = 30.00 psi (4.32 ksf)

Effective confining stress = 4.32 ksf

Fail. Stress = 5.48 ksf **at reading no.** 19

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	4.32	4.32	1.00		4.32
1	0.0100	74.0	53.3	0.2	1.20	4.32	5.52	1.28		4.92
2	0.0200	107.0	77.0	0.3	1.73	4.32	6.05	1.40		5.19
3	0.0300	132.0	95.0	0.5	2.13	4.32	6.45	1.49		5.39
4	0.0400	151.0	108.7	0.7	2.44	4.32	6.76	1.56		5.54
5	0.0500	167.0	120.2	0.8	2.69	4.32	7.01	1.62		5.67
6	0.0600	184.0	132.5	1.0	2.96	4.32	7.28	1.69		5.80
7	0.0700	197.0	141.8	1.2	3.16	4.32	7.48	1.73		5.90
8	0.0800	211.0	151.9	1.3	3.38	4.32	7.70	1.78		6.01
9	0.0900	222.0	159.8	1.5	3.55	4.32	7.87	1.82		6.10
10	0.1000	232.0	167.0	1.7	3.71	4.32	8.03	1.86		6.17
11	0.2000	283.0	203.8	3.3	4.45	4.32	8.77	2.03		6.54
12	0.3000	312.0	224.6	5.0	4.82	4.32	9.14	2.12		6.73
13	0.4000	330.0	237.6	6.6	5.01	4.32	9.33	2.16		6.82
14	0.5000	346.0	249.1	8.3	5.16	4.32	9.48	2.19		6.90
15	0.6000	355.0	255.6	9.9	5.20	4.32	9.52	2.20		6.92
16	0.7000	371.0	267.1	11.6	5.33	4.32	9.65	2.23		6.99
17	0.8000	377.0	271.4	13.2	5.32	4.32	9.64	2.23		6.98
18	0.9000	389.0	280.1	14.9	5.38	4.32	9.70	2.25		7.01
19	1.0000	404.0	290.9	16.5	5.48	4.32	9.80	2.27		7.06
20	1.1000	403.0	290.2	18.2	5.36	4.32	9.68	2.24		7.00
21	1.2000	402.0	289.4	19.8	5.24	4.32	9.56	2.21		6.94

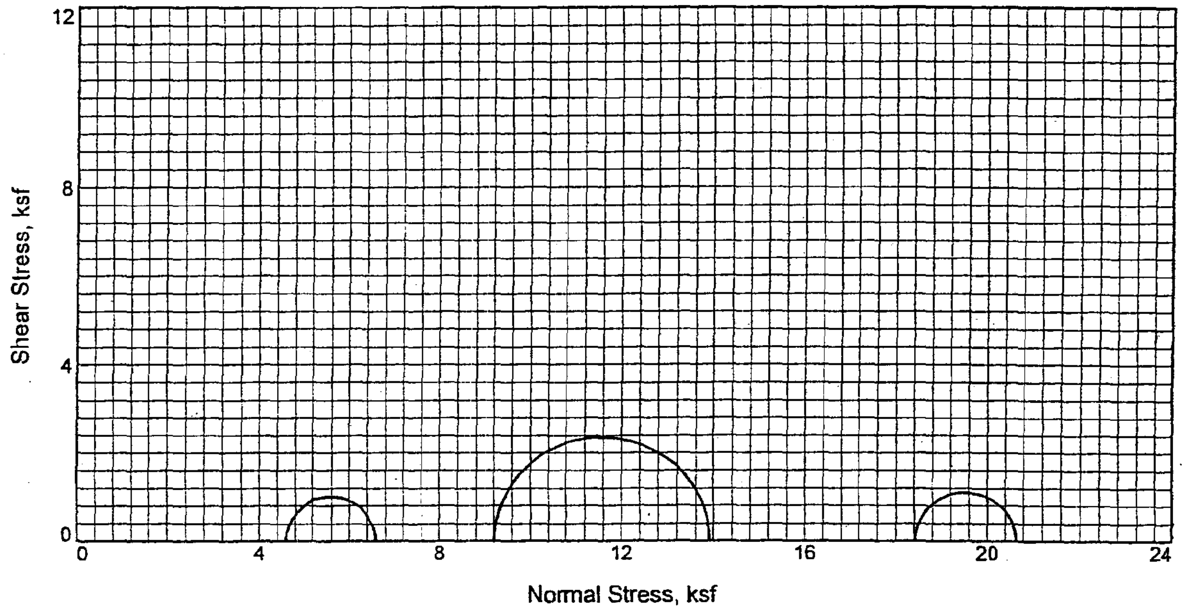
Parameters for Specimen No. 3

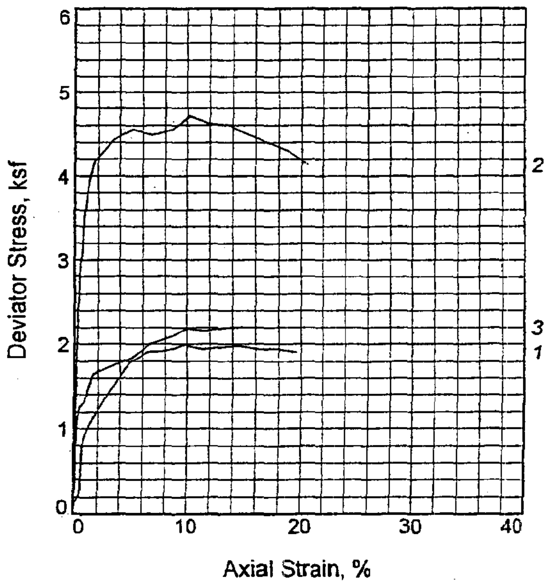
Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	1183.800		682.010
Moisture content: Dry soil+tare, gms.	882.000		507.430
Moisture content: Tare, gms.	0.000		13.630
Moisture, %	34.2	34.2	35.4
Moist specimen weight, gms.	1183.8		
Diameter, in.	2.85	2.85	
Area, in.^{2}	6.36	6.36	
Height, in.	6.09	6.09	
Net decrease in height, in.		0.00	
Wet Density, pcf	116.5	116.4	
Dry density, pcf	86.8	86.8	
Void ratio	0.9067	0.9067	
Saturation, %	100.0	100.0	

Test Readings for Specimen No. 3

Load ring constant = 0.72 lbs. per input unit
Cell pressure = 90.00 psi (12.96 ksf)
Back pressure = 30.00 psi (4.32 ksf)
Effective confining stress = 8.64 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 3.19 ksf **at reading no.** 12

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	8.64	8.64	1.00		8.64
1	0.0100	38.0	27.4	0.2	0.62	8.64	9.26	1.07		8.95
2	0.0200	59.0	42.5	0.3	0.96	8.64	9.60	1.11		9.12
3	0.0300	69.0	49.7	0.5	1.12	8.64	9.76	1.13		9.20
4	0.0400	82.0	59.0	0.7	1.33	8.64	9.97	1.15		9.30
5	0.0500	90.0	64.8	0.8	1.46	8.64	10.10	1.17		9.37
6	0.0600	100.0	72.0	1.0	1.61	8.64	10.25	1.19		9.45
7	0.0700	109.0	78.5	1.1	1.76	8.64	10.40	1.20		9.52
8	0.0800	118.0	85.0	1.3	1.90	8.64	10.54	1.22		9.59
9	0.0900	127.0	91.4	1.5	2.04	8.64	10.68	1.24		9.66
10	0.1000	136.0	97.9	1.6	2.18	8.64	10.82	1.25		9.73
11	0.2000	201.0	144.7	3.3	3.17	8.64	11.81	1.37		10.23
12	0.3000	206.0	148.3	4.9	3.19	8.64	11.83	1.37		10.24
13	0.4000	194.0	139.7	6.6	2.96	8.64	11.60	1.34		10.12
14	0.5000	197.0	141.8	8.2	2.95	8.64	11.59	1.34		10.11
15	0.6000	202.0	145.4	9.8	2.97	8.64	11.61	1.34		10.13
16	0.7000	204.0	146.9	11.5	2.94	8.64	11.58	1.34		10.11
17	0.8000	215.0	154.8	13.1	3.05	8.64	11.69	1.35		10.16
18	0.9000	220.0	158.4	14.8	3.06	8.64	11.70	1.35		10.17
19	1.0000	226.0	162.7	16.4	3.08	8.64	11.72	1.36		10.18
20	1.1000	228.0	164.2	18.1	3.05	8.64	11.69	1.35		10.16
21	1.2000	236.0	169.9	19.7	3.09	8.64	11.73	1.36		10.19





		1	2	3
Sample No.		1	2	3
Initial	Water Content,	42.2	23.4	39.4
	Dry Density, pcf	79.2	89.9	79.6
	Saturation,	100.0	71.5	94.4
	Void Ratio	1.1530	0.8947	1.1398
	Diameter, in.	2.84	2.98	2.82
	Height, in.	6.15	5.84	6.01
At Test	Water Content,	42.2	32.8	41.8
	Dry Density, pcf	79.2	89.9	79.6
	Saturation,	100.0	100.0	100.0
	Void Ratio	1.1530	0.8947	1.1398
	Diameter, in.	2.84	2.98	2.82
	Height, in.	6.15	5.84	6.01
Strain rate, in./min.		0.02	0.02	0.02
Back Pressure, ksf		2.9	2.9	2.9
Cell Pressure, ksf		7.5	12.1	21.3
Fail. Stress, ksf		2.0	4.7	2.2
Ult. Stress, ksf				
σ_1 Failure, ksf		6.6	13.9	20.6
σ_3 Failure, ksf		4.6	9.2	18.4

Type of Test:
Unconsolidated Undrained

Sample Type: undisturbed

Description:

Assumed Specific Gravity= 2.73

Remarks:

Figure ______

Client: TVA

Project: TVA Kingston - Proposed Gypsum Stack

Location: NB-44

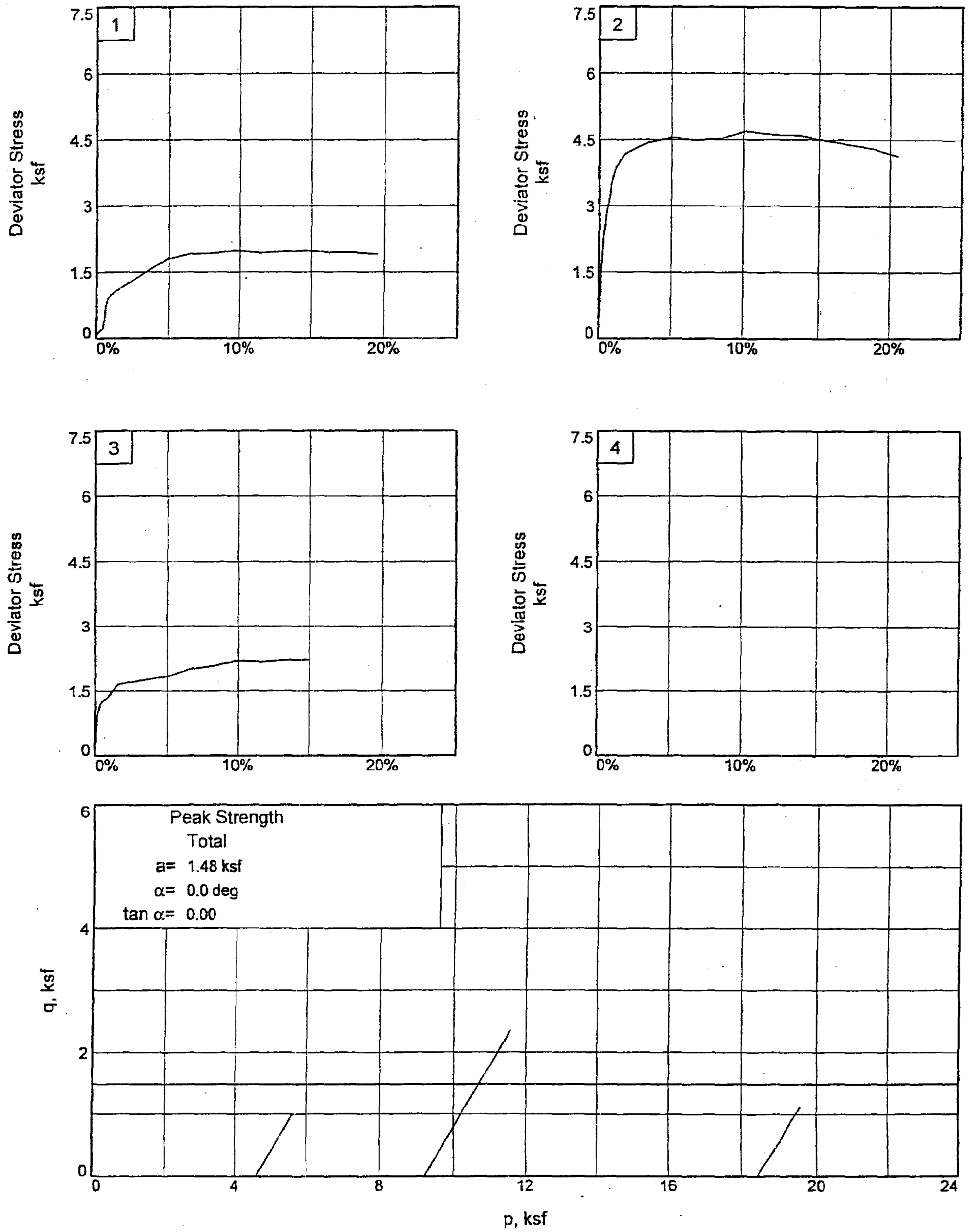
Sample Number: UD-3,4 & 5 (UU) **Depth:** 19'-28.5'

Proj. No.: 3043051021 **Date:**

TRIAXIAL SHEAR TEST REPORT

MACTEC, INC.

Tested By: Alexander **Checked By:** Hamlett



Client: TVA
Project: TVA Kingston - Proposed Gypsum Stack
Location: NB-44 **Depth:** 19'-28.5' **Sample Number:** UD-3,4 & 5 (UU)
Project No.: 3043051021 **Figure** ________

MACTEC, INC.

Tested By: Alexander **Checked By:** Hamlett

9/13/2005
6:44 PM

TRIAXIAL COMPRESSION TEST
Unconsolidated Undrained

Date:
Client: TVA
Project: TVA Kingston - Proposed Gypsum Stack
Project No.: 3043051021
Location: NB-44
Depth: 19'-28.5' **Sample Number:** UD-3,4 & 5 (UU)
Description:
Remarks:
Type of Sample: undisturbed
Specific Gravity=2.73 **LL**= **PL**= **PI**=
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	1142.890		556.460
Moisture content: Dry soil+tare, gms.	803.600		391.870
Moisture content: Tare, gms.	0.000		14.060
Moisture, %	42.2	42.2	43.6
Moist specimen weight, gms.	1154.0		
Diameter, in.	2.84	2.84	
Area, in.^{2}	6.35	6.35	
Height, in.	6.15	6.15	
Net decrease in height, in.		0.00	
Wet Density, pcf	112.6	112.6	
Dry density, pcf	79.2	79.2	
Void ratio	1.1530	1.1530	
Saturation, %	100.0	100.0	

Test Readings for Specimen No. 1

Load ring constant = 0.72 lbs. per input unit
Cell pressure = 52.00 psi (7.49 ksf)
Back pressure = 20.00 psi (2.88 ksf)
Effective confining stress = 4.61 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 1.99 ksf **at reading no.** 15

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	4.61	4.61	1.00		4.61
1	0.0100	9.0	6.5	0.2	0.15	4.61	4.75	1.03		4.68
2	0.0200	12.0	8.6	0.3	0.20	4.61	4.80	1.04		4.71
3	0.0300	14.0	10.1	0.5	0.23	4.61	4.84	1.05		4.72
4	0.0400	45.0	32.4	0.7	0.73	4.61	5.34	1.16		4.97
5	0.0500	56.0	40.3	0.8	0.91	4.61	5.51	1.20		5.06
6	0.0600	59.0	42.5	1.0	0.95	4.61	5.56	1.21		5.08
7	0.0700	62.0	44.6	1.1	1.00	4.61	5.61	1.22		5.11
8	0.0800	65.0	46.8	1.3	1.05	4.61	5.66	1.23		5.13
9	0.0900	68.0	49.0	1.5	1.09	4.61	5.70	1.24		5.15
10	0.1000	71.0	51.1	1.6	1.14	4.61	5.75	1.25		5.18
11	0.2000	93.0	67.0	3.3	1.47	4.61	6.08	1.32		5.34
12	0.3000	115.0	82.8	4.9	1.79	4.61	6.39	1.39		5.50
13	0.4000	125.0	90.0	6.5	1.91	4.61	6.52	1.41		5.56
14	0.5000	128.0	92.2	8.1	1.92	4.61	6.53	1.42		5.57
15	0.6000	135.0	97.2	9.8	1.99	4.61	6.60	1.43		5.60
16	0.7000	134.0	96.5	11.4	1.94	4.61	6.55	1.42		5.58
17	0.8000	138.0	99.4	13.0	1.96	4.61	6.57	1.43		5.59
18	0.9000	142.0	102.2	14.6	1.98	4.61	6.59	1.43		5.60
19	1.0000	142.0	102.2	16.3	1.94	4.61	6.55	1.42		5.58
20	1.1000	145.0	104.4	17.9	1.94	4.61	6.55	1.42		5.58
21	1.2000	145.0	104.4	19.5	1.90	4.61	6.51	1.41		5.56

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	1136.380		604.190
Moisture content: Dry soil+tare, gms.	920.700		472.980
Moisture content: Tare, gms.	0.000		14.100
Moisture, %	23.4	32.8	28.6
Moist specimen weight, gms.	1184.0		
Diameter, in.	2.98	2.98	
Area, in.²	6.96	6.96	
Height, in.	5.84	5.84	
Net decrease in height, in.		0.00	
Wet Density, pcf	111.0	119.4	
Dry density, pcf	89.9	89.9	
Void ratio	0.8947	0.8947	
Saturation, %	71.5	100.0	

Test Readings for Specimen No. 2

Load ring constant = 0.72 lbs. per input unit
Cell pressure = 84.00 psi (12.10 ksf)
Back pressure = 20.00 psi (2.88 ksf)
Effective confining stress = 9.22 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 4.71 ksf **at reading no.** 14

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	9.22	9.22	1.00		9.22
1	0.0100	109.0	78.5	0.2	1.62	9.22	10.84	1.18		10.03
2	0.0200	161.0	115.9	0.3	2.39	9.22	11.61	1.26		10.41
3	0.0300	193.0	139.0	0.5	2.86	9.22	12.08	1.31		10.65
4	0.0400	207.0	149.0	0.7	3.06	9.22	12.28	1.33		10.75
5	0.0500	236.0	169.9	0.9	3.49	9.22	12.70	1.38		10.96
6	0.0700	263.0	189.4	1.2	3.87	9.22	13.09	1.42		11.15
7	0.0800	271.0	195.1	1.4	3.98	9.22	13.20	1.43		11.21
8	0.0900	278.0	200.2	1.5	4.08	9.22	13.30	1.44		11.26
9	0.1000	285.0	205.2	1.7	4.18	9.22	13.39	1.45		11.30
10	0.2000	308.0	221.8	3.4	4.43	9.22	13.65	1.48		11.43
11	0.3000	322.0	231.8	5.1	4.55	9.22	13.77	1.49		11.49
12	0.4000	323.0	232.6	6.8	4.48	9.22	13.70	1.49		11.46
13	0.5000	333.0	239.8	8.6	4.54	9.22	13.75	1.49		11.49
14	0.6000	352.0	253.4	10.3	4.71	9.22	13.92	1.51		11.57
15	0.7000	352.0	253.4	12.0	4.62	9.22	13.83	1.50		11.52
16	0.8000	358.0	257.8	13.7	4.61	9.22	13.82	1.50		11.52
17	0.9000	356.0	256.3	15.4	4.49	9.22	13.70	1.49		11.46
18	1.0000	356.0	256.3	17.1	4.40	9.22	13.61	1.48		11.41
19	1.1000	355.0	255.6	18.8	4.29	9.22	13.51	1.47		11.36
20	1.2000	349.0	251.3	20.5	4.13	9.22	13.35	1.45		11.28

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	1096.380		503.560
Moisture content: Dry soil+tare, gms.	786.500		365.160
Moisture content: Tare, gms.	0.000		8.120
Moisture, %	39.4	41.8	38.8
Moist specimen weight, gms.	1091.7		
Diameter, in.	2.82	2.82	
Area, in.²	6.24	6.24	
Height, in.	6.01	6.01	
Net decrease in height, in.		0.00	
Wet Density, pcf	111.0	112.9	
Dry density, pcf	79.6	79.6	
Void ratio	1.1398	1.1398	
Saturation, %	94.4	100.0	

Test Readings for Specimen No. 3

Load ring constant = 0.72 lbs. per input unit

Cell pressure = 148.00 psi (21.31 ksf)

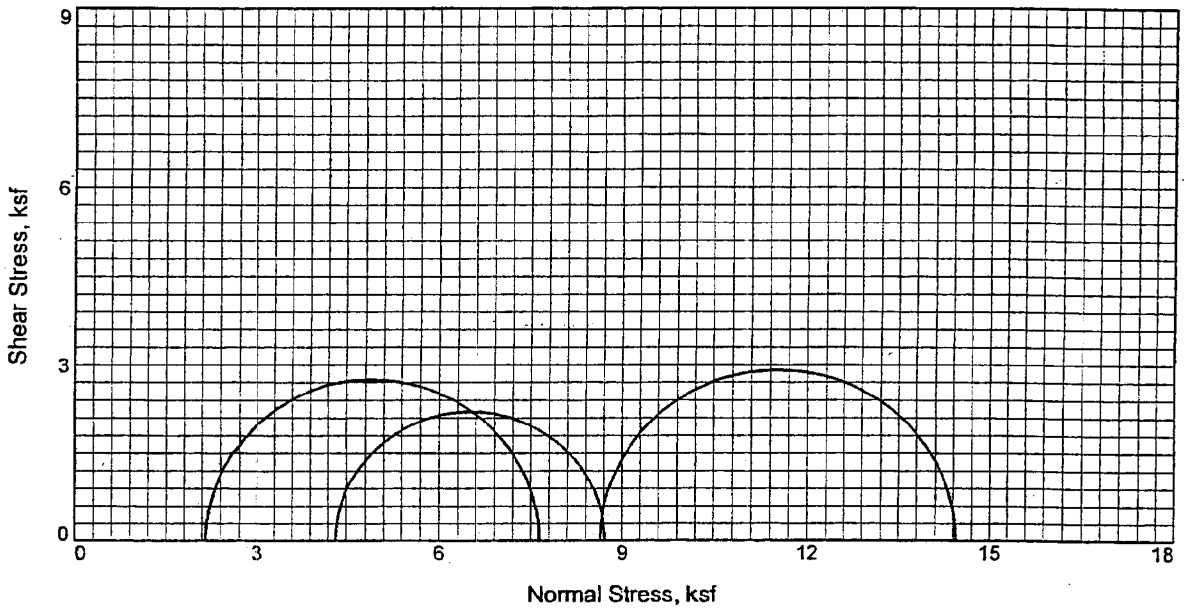
Back pressure = 20.00 psi (2.88 ksf)

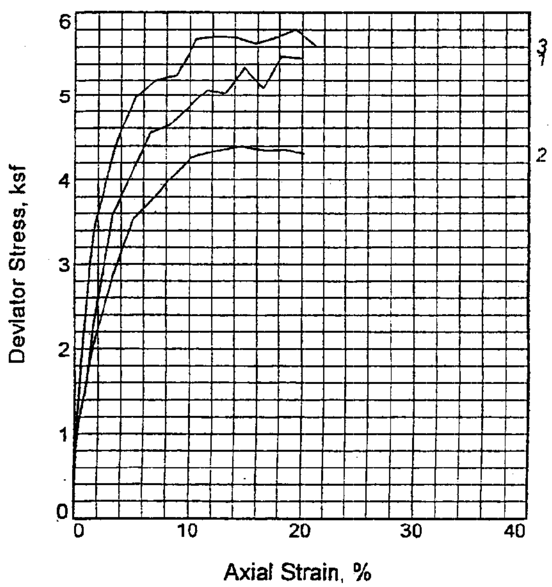
Effective confining stress = 18.43 ksf

Strain rate, in./min. = 0.02

Fail. Stress = 2.20 ksf **at reading no.** 17

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	18.43	18.43	1.00		18.43
1	0.0100	56.0	40.3	0.2	0.93	18.43	19.36	1.05		18.90
2	0.0200	71.0	51.1	0.3	1.18	18.43	19.61	1.06		19.02
3	0.0300	76.0	54.7	0.5	1.26	18.43	19.69	1.07		19.06
4	0.0400	78.0	56.2	0.7	1.29	18.43	19.72	1.07		19.08
5	0.0500	79.0	56.9	0.8	1.30	18.43	19.73	1.07		19.08
6	0.0600	84.0	60.5	1.0	1.38	18.43	19.81	1.08		19.12
7	0.0700	90.0	64.8	1.2	1.48	18.43	19.91	1.08		19.17
8	0.0800	94.0	67.7	1.3	1.54	18.43	19.97	1.08		19.20
9	0.0900	99.0	71.3	1.5	1.62	18.43	20.05	1.09		19.24
10	0.1000	101.0	72.7	1.7	1.65	18.43	20.08	1.09		19.26
11	0.3000	116.0	83.5	5.0	1.83	18.43	20.26	1.10		19.35
12	0.4000	129.0	92.9	6.7	2.00	18.43	20.43	1.11		19.43
13	0.5000	136.0	97.9	8.3	2.07	18.43	20.50	1.11		19.47
14	0.6000	146.0	105.1	10.0	2.18	18.43	20.62	1.12		19.52
15	0.7000	147.0	105.8	11.7	2.16	18.43	20.59	1.12		19.51
16	0.8000	152.0	109.4	13.3	2.19	18.43	20.62	1.12		19.53
17	0.9000	156.0	112.3	15.0	2.20	18.43	20.64	1.12		19.53





Sample No.		1	2	3
Initial	Water Content,	25.4	25.6	20.5
	Dry Density, pcf	97.3	99.4	100.9
	Saturation,	92.8	98.3	81.8
	Void Ratio	0.7445	0.7080	0.6830
	Diameter, in.	2.88	2.83	2.79
	Height, in.	6.05	5.93	5.67
At Test	Water Content,	27.4	26.0	25.1
	Dry Density, pcf	97.3	99.4	100.9
	Saturation,	100.0	100.0	100.0
	Void Ratio	0.7445	0.7080	0.6830
	Diameter, in.	2.88	2.83	2.79
	Height, in.	6.05	5.93	5.67
Strain rate, in./min.		0.02	0.02	0.02
Back Pressure, ksf		5.8	5.8	5.8
Cell Pressure, ksf		7.9	10.1	14.4
Fail. Stress, ksf		5.5	4.4	5.8
Ult. Stress, ksf				
σ_1 Failure, ksf		7.6	8.7	14.4
σ_3 Failure, ksf		2.2	4.3	8.6

Type of Test:
Unconsolidated Undrained
Sample Type: undisturbed
Description:

Assumed Specific Gravity= 2.72
Remarks:

Figure ________

Client: TVA

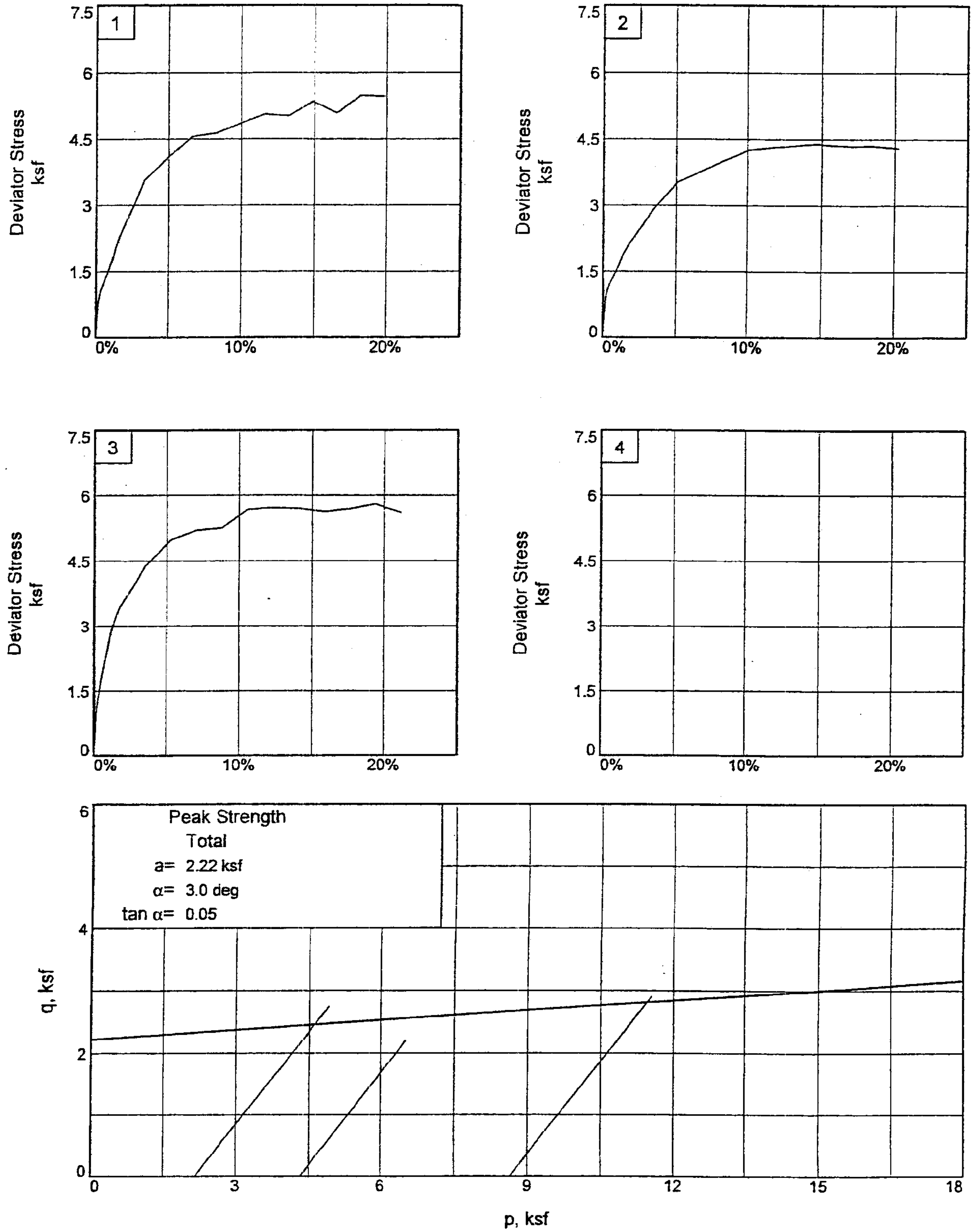
Project: TVA Kingston - Proposed Gypsum Stack

Location: NB-47A
Sample Number: UD-1, 2 & 3 (UU) **Depth:** 9'-17'
Proj. No.: 3043051021 **Date:**

TRIAXIAL SHEAR TEST REPORT

MACTEC, INC.

Tested By: Alexander **Checked By:** Hamlett



Client: TVA
Project: TVA Kingston - Proposed Gypsum Stack
Location: NB-47A **Depth:** 9'-17' **Sample Number:** UD-1, 2 & 3 (UU)
Project No.: 3043051021 **Figure** ________ **MACTEC, INC.**

Tested By: Alexander **Checked By:** Hamlett

TRIAXIAL COMPRESSION TEST

Unconsolidated Undrained

9/13/2005
6:55 PM

Date:
Client: TVA
Project: TVA Kingston - Proposed Gypsum Stack
Project No.: 3043051021
Location: NB-47A
Depth: 9'-17' **Sample Number:** UD-1, 2 & 3 (UU)
Description:
Remarks:
Type of Sample: undisturbed
Specific Gravity=2.72 **LL=** **PL=** **PI=**
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	1235.900		649.520
Moisture content: Dry soil+tare, gms.	985.650		511.890
Moisture content: Tare, gms.	0.000		14.190
Moisture, %	25.4	27.4	27.7
Moist specimen weight, gms.	1258.7		
Diameter, in.	2.88	2.88	
Area, in.^{2}	6.49	6.49	
Height, in.	6.05	6.05	
Net decrease in height, in.		0.00	
Wet Density, pcf	122.0	124.0	
Dry density, pcf	97.3	97.3	
Void ratio	0.7445	0.7445	
Saturation, %	92.8	100.0	

Test Readings for Specimen No. 1

Load ring constant = 0.72 lbs. per input unit
Cell pressure = 55.00 psi (7.92 ksf)
Back pressure = 40.00 psi (5.76 ksf)
Effective confining stress = 2.16 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 5.49 ksf **at reading no.** 20

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	2.16	2.16	1.00		2.16
1	0.0100	48.0	34.6	0.2	0.77	2.16	2.93	1.35		2.54
2	0.0200	65.0	46.8	0.3	1.03	2.16	3.19	1.48		2.68
3	0.0300	75.0	54.0	0.5	1.19	2.16	3.35	1.55		2.76
4	0.0400	85.0	61.2	0.7	1.35	2.16	3.51	1.62		2.83
5	0.0500	92.0	66.2	0.8	1.46	2.16	3.62	1.67		2.89
6	0.0600	103.0	74.2	1.0	1.63	2.16	3.79	1.75		2.97
7	0.0700	114.0	82.1	1.2	1.80	2.16	3.96	1.83		3.06
8	0.0800	126.0	90.7	1.3	1.99	2.16	4.15	1.92		3.15
9	0.0900	137.0	98.6	1.5	2.16	2.16	4.32	2.00		3.24
10	0.1000	147.0	105.8	1.7	2.31	2.16	4.47	2.07		3.31
11	0.2000	232.0	167.0	3.3	3.58	2.16	5.74	2.66		3.95
12	0.3000	269.0	193.7	5.0	4.08	2.16	6.24	2.89		4.20
13	0.4000	305.0	219.6	6.6	4.55	2.16	6.71	3.11		4.43
14	0.5000	316.0	227.5	8.3	4.63	2.16	6.79	3.14		4.47
15	0.6000	337.0	242.6	9.9	4.85	2.16	7.01	3.24		4.58
16	0.7000	359.0	258.5	11.6	5.07	2.16	7.23	3.35		4.70
17	0.8000	363.0	261.4	13.2	5.03	2.16	7.19	3.33		4.68
18	0.9000	394.0	283.7	14.9	5.36	2.16	7.52	3.48		4.84
19	1.0000	382.0	275.0	16.5	5.09	2.16	7.25	3.36		4.71
20	1.1000	420.0	302.4	18.2	5.49	2.16	7.65	3.54		4.90
21	1.2000	427.0	307.4	19.8	5.47	2.16	7.63	3.53		4.89

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	1182.300		674.310
Moisture content: Dry soil+tare, gms.	941.500		523.170
Moisture content: Tare, gms.	0.000		14.380
Moisture, %	25.6	26.0	29.7
Moist specimen weight, gms.	1221.1		
Diameter, in.	2.83	2.83	
Area, in.^{2}	6.29	6.29	
Height, in.	5.93	5.93	
Net decrease in height, in.		0.00	
Wet Density, pcf	124.8	125.3	
Dry density, pcf	99.4	99.4	
Void ratio	0.7080	0.7080	
Saturation, %	98.3	100.0	

Test Readings for Specimen No. 2

Load ring constant = 0.72 lbs. per input unit

Cell pressure = 70.00 psi (10.08 ksf)

Back pressure = 40.00 psi (5.76 ksf)

Effective confining stress = 4.32 ksf

Strain rate, in./min. = 0.02

Fail. Stress = 4.40 ksf **at reading no.** 17

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	4.32	4.32	1.00		4.32
1	0.0100	53.0	38.2	0.2	0.87	4.32	5.19	1.20		4.76
2	0.0200	66.0	47.5	0.3	1.08	4.32	5.40	1.25		4.86
3	0.0300	76.0	54.7	0.5	1.25	4.32	5.57	1.29		4.94
4	0.0400	83.0	59.8	0.7	1.36	4.32	5.68	1.31		5.00
5	0.0500	90.0	64.8	0.8	1.47	4.32	5.79	1.34		5.06
6	0.0600	98.0	70.6	1.0	1.60	4.32	5.92	1.37		5.12
7	0.0700	107.0	77.0	1.2	1.74	4.32	6.06	1.40		5.19
8	0.0800	115.0	82.8	1.3	1.87	4.32	6.19	1.43		5.26
9	0.0900	121.0	87.1	1.5	1.97	4.32	6.29	1.45		5.30
10	0.1000	128.0	92.2	1.7	2.08	4.32	6.40	1.48		5.36
11	0.2000	181.0	130.3	3.4	2.88	4.32	7.20	1.67		5.76
12	0.3000	225.0	162.0	5.1	3.52	4.32	7.84	1.82		6.08
13	0.4000	245.0	176.4	6.7	3.77	4.32	8.09	1.87		6.20
14	0.5000	266.0	191.5	8.4	4.02	4.32	8.34	1.93		6.33
15	0.6000	287.0	206.6	10.1	4.25	4.32	8.57	1.98		6.45
16	0.7000	297.0	213.8	11.8	4.32	4.32	8.64	2.00		6.48
17	0.8760	313.0	225.4	14.8	4.40	4.32	8.72	2.02		6.52
18	0.9000	313.0	225.4	15.2	4.38	4.32	8.70	2.01		6.51
19	1.0000	317.0	228.2	16.9	4.35	4.32	8.67	2.01		6.49
20	1.1000	324.0	233.3	18.6	4.35	4.32	8.67	2.01		6.50
21	1.2000	327.0	235.4	20.2	4.30	4.32	8.62	2.00		6.47

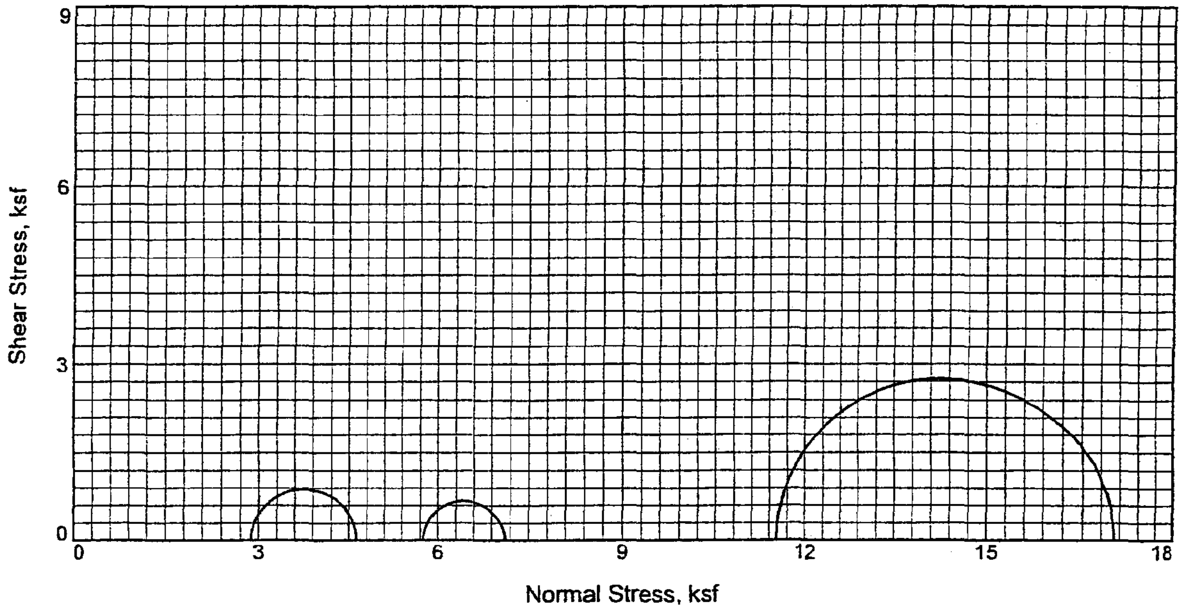
Parameters for Specimen No. [illegible]

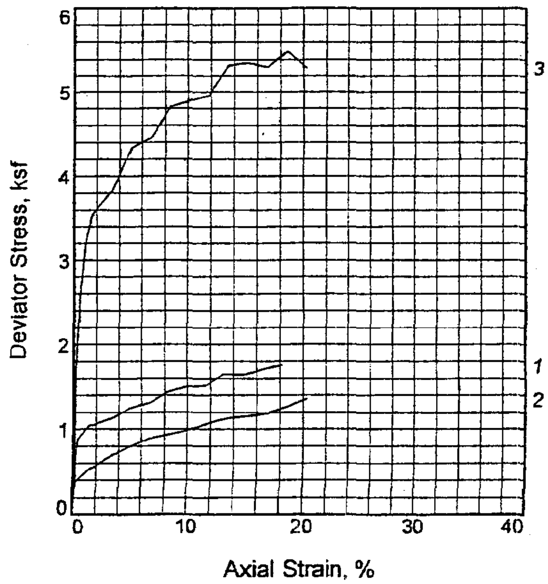
Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	1054.000		558.820
Moisture content: Dry soil+tare, gms.	874.400		444.260
Moisture content: Tare, gms.	0.000		14.300
Moisture, %	20.5	25.1	26.6
Moist specimen weight, gms.	1107.0		
Diameter, in.	2.79	2.79	
Area, in.²	6.11	6.11	
Height, in.	5.67	5.67	
Net decrease in height, in.		0.00	
Wet Density, pcf	121.6	126.2	
Dry density, pcf	100.9	100.9	
Void ratio	0.6830	0.6830	
Saturation, %	81.8	100.0	

Test Readings for Specimen No. [illegible]

Load ring constant = 0.72 lbs. per input unit
Cell pressure = 100.00 psi (14.40 ksf)
Back pressure = 40.00 psi (5.76 ksf)
Effective confining stress = 8.64 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 5.81 ksf **at reading no.** 20

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	8.64	8.64	1.00		8.64
1	0.0100	63.0	45.4	0.2	1.07	8.64	9.71	1.12		9.17
2	0.0200	85.0	61.2	0.4	1.44	8.64	10.08	1.17		9.36
3	0.0300	107.0	77.0	0.5	1.81	8.64	10.45	1.21		9.54
4	0.0400	126.0	90.7	0.7	2.12	8.64	10.76	1.25		9.70
5	0.0500	140.0	100.8	0.9	2.35	8.64	10.99	1.27		9.82
6	0.0600	158.0	113.8	1.1	2.65	8.64	11.29	1.31		9.97
7	0.0700	175.0	126.0	1.2	2.93	8.64	11.57	1.34		10.11
8	0.0800	188.0	135.4	1.4	3.14	8.64	11.78	1.36		10.21
9	0.0900	198.0	142.6	1.6	3.30	8.64	11.94	1.38		10.29
10	0.1000	208.0	149.8	1.8	3.47	8.64	12.11	1.40		10.37
11	0.2000	269.0	193.7	3.5	4.40	8.64	13.04	1.51		10.84
12	0.3000	310.0	223.2	5.3	4.98	8.64	13.62	1.58		11.13
13	0.4000	330.0	237.6	7.1	5.20	8.64	13.84	1.60		11.24
14	0.5000	340.0	244.8	8.8	5.26	8.64	13.90	1.61		11.27
15	0.6000	375.0	270.0	10.6	5.69	8.64	14.33	1.66		11.48
16	0.7000	385.0	277.2	12.3	5.72	8.64	14.36	1.66		11.50
17	0.8000	392.0	282.2	14.1	5.71	8.64	14.35	1.66		11.50
18	0.9000	395.0	284.4	15.9	5.64	8.64	14.28	1.65		11.46
19	1.0000	408.0	293.8	17.6	5.70	8.64	14.34	1.66		11.49
20	1.1000	425.0	306.0	19.4	5.81	8.64	14.45	1.67		11.54
21	1.2000	420.0	302.4	21.2	5.62	8.64	14.26	1.65		11.45





	Sample No.	1	2	3
Initial	Water Content,	25.8	31.3	27.5
	Dry Density, pcf	94.4	87.2	91.7
	Saturation,	87.7	90.0	87.8
	Void Ratio	0.7995	0.9468	0.8508
	Diameter, in.	2.82	2.86	2.83
	Height, in.	6.05	5.90	5.92
At Test	Water Content,	29.4	34.8	31.3
	Dry Density, pcf	94.4	87.2	91.7
	Saturation,	100.0	100.0	100.0
	Void Ratio	0.7995	0.9468	0.8508
	Diameter, in.	2.82	2.86	2.83
	Height, in.	6.05	5.90	5.92
	Strain rate, in./min.	0.02	0.02	0.02
	Back Pressure, ksf	2.9	2.9	2.9
	Cell Pressure, ksf	5.8	8.6	14.4
	Fail. Stress, ksf	1.8	1.4	5.5
	Ult. Stress, ksf			
	σ_1 Failure, ksf	4.6	7.1	17.0
	σ_3 Failure, ksf	2.9	5.8	11.5

Type of Test:
Unconsolidated Undrained
Sample Type: undisturbed
Description:

Assumed Specific Gravity= 2.72
Remarks:

Client: TVA

Project: TVA Kingston - Proposed Gypsum Stack

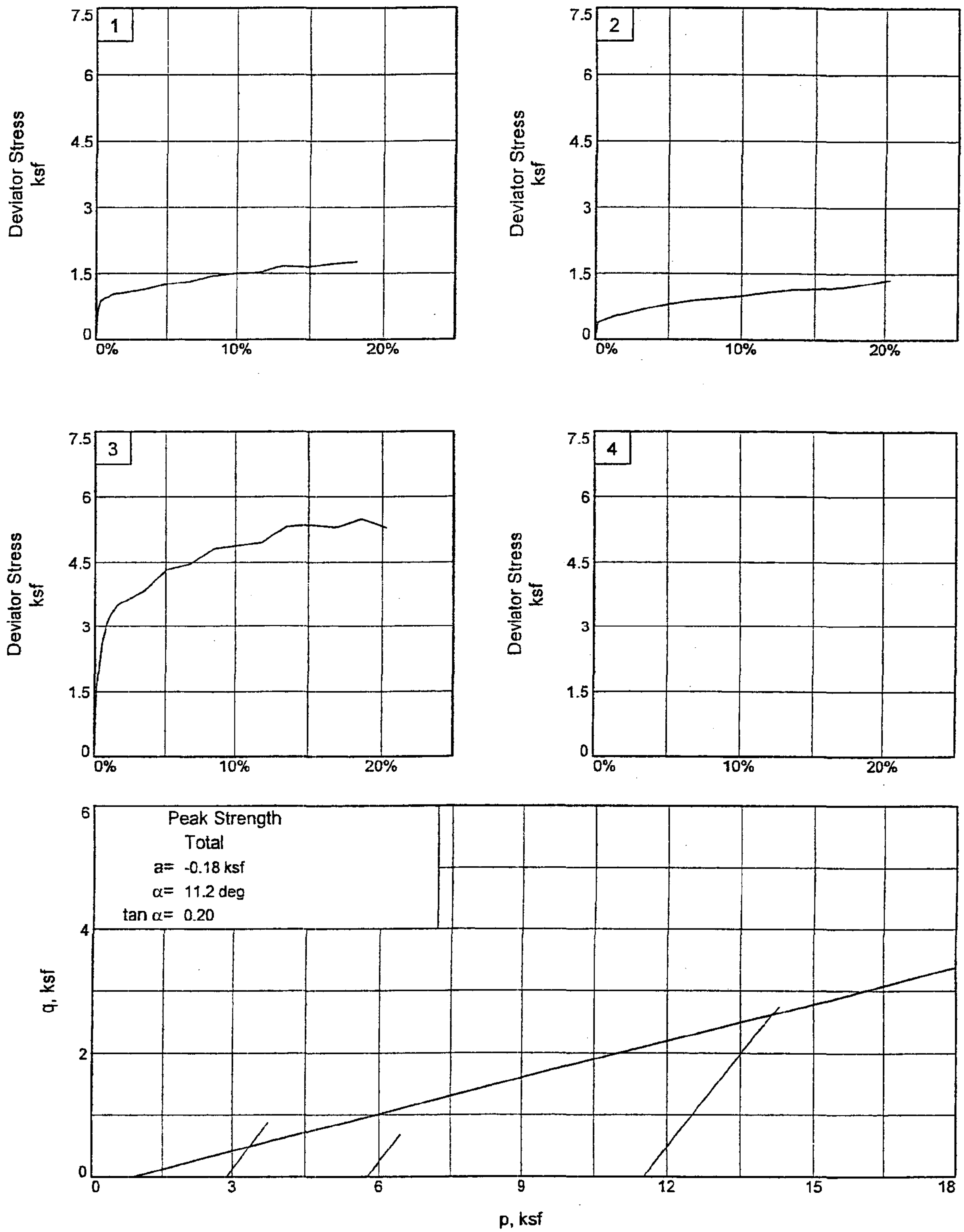
Location: NB-47A
Sample Number: UD-4, 5 & 6 (UU) **Depth:** 18'-27'
Proj. No.: 3043051021 **Date:**

TRIAXIAL SHEAR TEST REPORT

MACTEC, INC.

Figure ________

Tested By: Alexander **Checked By:** Hamlett



Client: TVA
Project: TVA Kingston - Proposed Gypsum Stack
Location: NB-47A **Depth:** 18'-27' **Sample Number:** UD-4, 5 & 6 (UU)
Project No.: 3043051021 **Figure** ______

MACTEC, INC.

Tested By: Alexander **Checked By:** Hamlett

TRIAXIAL COMPRESSION TEST
Unconsolidated Undrained

9/13/2005
7:46 PM

Date:
Client: TVA
Project: TVA Kingston - Proposed Gypsum Stack
Project No.: 3043051021
Location: NB-47A
Depth: 18'-27' **Sample Number:** UD-4, 5 & 6 (UU)
Description:
Remarks:
Type of Sample: undisturbed
Specific Gravity=2.72 **LL**=58 **PL**=34 **PI**=24
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	1194.000		623.320
Moisture content: Dry soil+tare, gms.	949.200		502.460
Moisture content: Tare, gms.	0.000		14.190
Moisture, %	25.8	29.4	24.8
Moist specimen weight, gms.	1177.9		
Diameter, in.	2.82	2.82	
Area, in.²	6.25	6.25	
Height, in.	6.05	6.05	
Net decrease in height, in.		0.00	
Wet Density, pcf	118.7	122.1	
Dry density, pcf	94.4	94.4	
Void ratio	0.7995	0.7995	
Saturation, %	87.7	100.0	

Test Readings for Specimen No. 1

Load ring constant = 0.72 lbs. per input unit
Cell pressure = 40.00 psi (5.76 ksf)
Back pressure = 20.00 psi (2.88 ksf)
Effective confining stress = 2.88 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 1.75 ksf **at reading no.** 20

MACTEC, INC.

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	2.88	2.88	1.00		2.88
1	0.0100	40.0	28.8	0.2	0.66	2.88	3.54	1.23		3.21
2	0.0200	53.0	38.2	0.3	0.88	2.88	3.76	1.30		3.32
3	0.0300	55.0	39.6	0.5	0.91	2.88	3.79	1.32		3.33
4	0.0400	57.0	41.0	0.7	0.94	2.88	3.82	1.33		3.35
5	0.0500	58.0	41.8	0.8	0.95	2.88	3.83	1.33		3.36
6	0.0600	60.0	43.2	1.0	0.99	2.88	3.87	1.34		3.37
7	0.0700	62.0	44.6	1.2	1.02	2.88	3.90	1.35		3.39
8	0.0800	63.0	45.4	1.3	1.03	2.88	3.91	1.36		3.40
9	0.0900	64.0	46.1	1.5	1.05	2.88	3.93	1.36		3.40
10	0.1000	64.0	46.1	1.7	1.04	2.88	3.92	1.36		3.40
11	0.2000	70.0	50.4	3.3	1.12	2.88	4.00	1.39		3.44
12	0.3000	79.0	56.9	5.0	1.25	2.88	4.13	1.43		3.50
13	0.4000	84.0	60.5	6.6	1.30	2.88	4.18	1.45		3.53
14	0.5000	94.0	67.7	8.3	1.43	2.88	4.31	1.50		3.60
15	0.6000	100.0	72.0	9.9	1.50	2.88	4.38	1.52		3.63
16	0.7000	103.0	74.2	11.6	1.51	2.88	4.39	1.53		3.64
17	0.8000	115.0	82.8	13.2	1.66	2.88	4.54	1.58		3.71
18	0.9000	116.0	83.5	14.9	1.64	2.88	4.52	1.57		3.70
19	1.0000	123.0	88.6	16.5	1.70	2.88	4.58	1.59		3.73
20	1.1000	129.0	92.9	18.2	1.75	2.88	4.63	1.61		3.76

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	1166.800		1151.350
Moisture content: Dry soil+tare, gms.	888.400		897.910
Moisture content: Tare, gms.	0.000		13.610
Moisture, %	31.3	34.8	28.7
Moist specimen weight, gms.	1138.9		
Diameter, in.	2.86	2.86	
Area, in.²	6.42	6.42	
Height, in.	5.90	5.90	
Net decrease in height, in.		0.00	
Wet Density, pcf	114.6	117.6	
Dry density, pcf	87.2	87.2	
Void ratio	0.9468	0.9468	
Saturation, %	90.0	100.0	

Test Readings for Specimen No. 2

Load ring constant = 0.72 lbs. per input unit
Cell pressure = 60.00 psi (8.64 ksf)
Back pressure = 20.00 psi (2.88 ksf)
Effective confining stress = 5.76 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 1.35 ksf **at reading no.** 21

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	5.76	5.76	1.00		5.76
1	0.0100	24.0	17.3	0.2	0.39	5.76	6.15	1.07		5.95
2	0.0200	25.0	18.0	0.3	0.40	5.76	6.16	1.07		5.96
3	0.0300	27.0	19.4	0.5	0.43	5.76	6.19	1.08		5.98
4	0.0400	28.0	20.2	0.7	0.45	5.76	6.21	1.08		5.98
5	0.0500	29.0	20.9	0.8	0.46	5.76	6.22	1.08		5.99
6	0.0600	30.0	21.6	1.0	0.48	5.76	6.24	1.08		6.00
7	0.0700	32.0	23.0	1.2	0.51	5.76	6.27	1.09		6.02
8	0.0800	33.0	23.8	1.4	0.53	5.76	6.29	1.09		6.02
9	0.0900	34.0	24.5	1.5	0.54	5.76	6.30	1.09		6.03
10	0.1000	34.0	24.5	1.7	0.54	5.76	6.30	1.09		6.03
11	0.2000	44.0	31.7	3.4	0.69	5.76	6.45	1.12		6.10
12	0.3000	52.0	37.4	5.1	0.80	5.76	6.56	1.14		6.16
13	0.4000	59.0	42.5	6.8	0.89	5.76	6.65	1.15		6.20
14	0.5000	63.0	45.4	8.5	0.93	5.76	6.69	1.16		6.23
15	0.6000	68.0	49.0	10.2	0.99	5.76	6.75	1.17		6.25
16	0.7000	75.0	54.0	11.9	1.07	5.76	6.83	1.19		6.29
17	0.8000	81.0	58.3	13.6	1.13	5.76	6.89	1.20		6.33
18	0.9000	84.0	60.5	15.2	1.15	5.76	6.91	1.20		6.34
19	1.0000	88.0	63.4	16.9	1.18	5.76	6.94	1.21		6.35
20	1.1000	96.0	69.1	18.6	1.26	5.76	7.02	1.22		6.39
21	1.2000	105.0	75.6	20.3	1.35	5.76	7.11	1.23		6.44

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	1110.000		629.880
Moisture content: Dry soil+tare, gms.	870.900		478.800
Moisture content: Tare, gms.	0.000		13.550
Moisture, %	27.5	31.3	32.5
Moist specimen weight, gms.	1146.1		
Diameter, in.	2.83	2.83	
Area, in.²	6.31	6.31	
Height, in.	5.92	5.92	
Net decrease in height, in.		0.00	
Wet Density, pcf	116.9	120.4	
Dry density, pcf	91.7	91.7	
Void ratio	0.8508	0.8508	
Saturation, %	87.8	100.0	

Test Readings for Specimen No. 3

Load ring constant = 0.72 lbs. per input unit

Cell pressure = 100.00 psi (14.40 ksf)

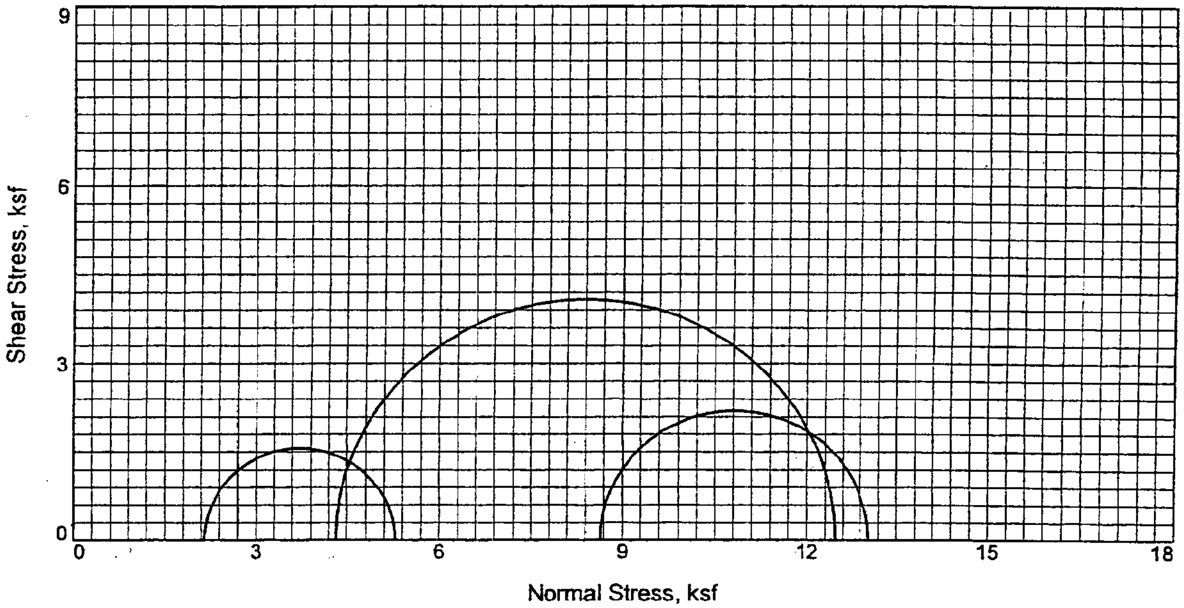
Back pressure = 20.00 psi (2.88 ksf)

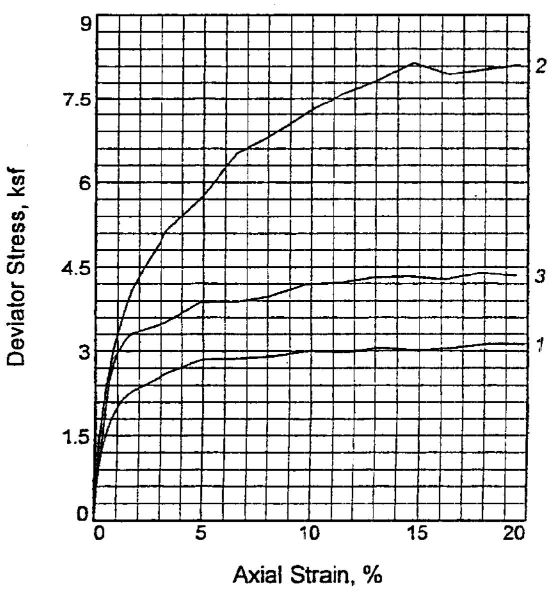
Effective confining stress = 11.52 ksf

Strain rate, in./min. = 0.02

Fail. Stress = 5.50 ksf **at reading no.** 20

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	11.52	11.52	1.00		11.52
1	0.0100	98.0	70.6	0.2	1.61	11.52	13.13	1.14		12.32
2	0.0200	128.0	92.2	0.3	2.10	11.52	13.62	1.18		12.57
3	0.0300	158.0	113.8	0.5	2.58	11.52	14.10	1.22		12.81
4	0.0400	172.0	123.8	0.7	2.81	11.52	14.33	1.24		12.92
5	0.0500	186.0	133.9	0.8	3.03	11.52	14.55	1.26		13.03
6	0.0600	197.0	141.8	1.0	3.20	11.52	14.72	1.28		13.12
7	0.0700	204.0	146.9	1.2	3.31	11.52	14.83	1.29		13.18
8	0.0800	210.0	151.2	1.4	3.40	11.52	14.92	1.30		13.22
9	0.0900	216.0	155.5	1.5	3.49	11.52	15.01	1.30		13.27
10	0.1000	220.0	158.4	1.7	3.55	11.52	15.07	1.31		13.30
11	0.2000	241.0	173.5	3.4	3.82	11.52	15.34	1.33		13.43
12	0.3000	278.0	200.2	5.1	4.33	11.52	15.85	1.38		13.69
13	0.4000	291.0	209.5	6.8	4.46	11.52	15.98	1.39		13.75
14	0.5000	320.0	230.4	8.5	4.81	11.52	16.33	1.42		13.93
15	0.6000	331.0	238.3	10.1	4.89	11.52	16.41	1.42		13.96
16	0.7000	342.0	246.2	11.8	4.95	11.52	16.47	1.43		14.00
17	0.8000	375.0	270.0	13.5	5.33	11.52	16.85	1.46		14.18
18	0.9000	385.0	277.2	15.2	5.36	11.52	16.88	1.47		14.20
19	1.0000	389.0	280.1	16.9	5.31	11.52	16.83	1.46		14.17
20	1.1000	411.0	295.9	18.6	5.50	11.52	17.02	1.48		14.27
21	1.2000	405.0	291.6	20.3	5.30	11.52	16.82	1.46		14.17





	Sample No.	1	2	3
Initial	Water Content,	26.0	19.5	31.2
	Dry Density, pcf	92.7	105.1	87.3
	Saturation,	87.6	89.6	92.1
	Void Ratio	0.7905	0.5805	0.9011
	Diameter, in.	2.85	2.86	2.83
	Height, in.	6.03	6.12	6.17
At Test	Water Content,	29.7	21.8	33.9
	Dry Density, pcf	92.7	105.1	87.3
	Saturation,	100.0	100.0	100.0
	Void Ratio	0.7905	0.5805	0.9011
	Diameter, in.	2.85	2.86	2.83
	Height, in.	6.03	6.12	6.17
	Strain rate, in./min.	0.02	0.02	0.02
	Back Pressure, ksf	5.8	5.8	5.8
	Cell Pressure, ksf	7.9	10.1	14.4
	Fail. Stress, ksf	3.1	8.2	4.4
	Ult. Stress, ksf			
	σ_1 Failure, ksf	5.3	12.5	13.0
	σ_3 Failure, ksf	2.2	4.3	8.6

Type of Test:
Unconsolidated Undrained
Sample Type: undisturbed
Description:

Assumed Specific Gravity= 2.66
Remarks:

Client: TVA

Project: TVA Kingston - Proposed Gypsum Stack

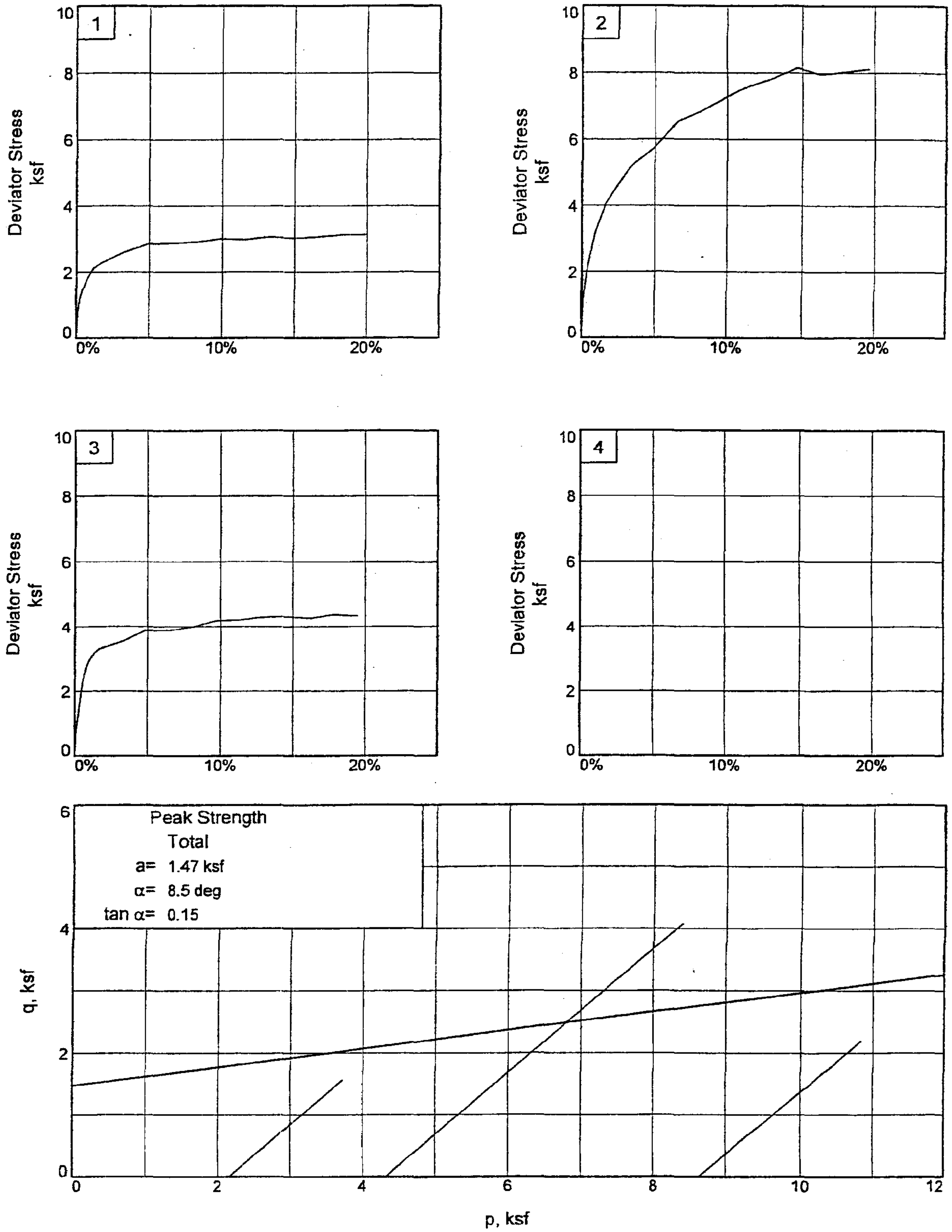
Location: NB-77A
Sample Number: UD-1, 2 & 3 (UU) **Depth:** 4'-14'
Proj. No.: 3043051021 **Date:**

TRIAXIAL SHEAR TEST REPORT

MACTEC, INC.

igure _______

Tested By: Alexander **Checked By:** Hamlett



Client: TVA
Project: TVA Kingston - Proposed Gypsum Stack
Location: NB-77 **Depth:** 4'-14' **Sample Number:** UD-1, 2 & 3 (UU)
Project No.: 3043051021 **Figure** ______ **MACTEC, INC.**

Tested By: Alexander **Checked By:** Hamlett

TRIAXIAL COMPRESSION TEST
Unconsolidated Undrained

9/13/2005
8:23 PM

Date:
Client: TVA
Project: TVA Kingston - Proposed Gypsum Stack
Project No.: 3043051021
Location: NB-77
Depth: 4'-14' **Sample Number:** UD-1, 2 & 3 (UU)
Description:
Remarks:
Type of Sample: undisturbed
Specific Gravity=2.66 **LL**=41 **PL**=25 **PI**=16
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	1158.400		557.770
Moisture content: Dry soil+tare, gms.	919.200		435.970
Moisture content: Tare, gms.	0.000		13.420
Moisture, %	26.0	29.7	28.8
Moist specimen weight, gms.	1184.0		
Diameter, in.	2.85	2.85	
Area, in.²	6.40	6.40	
Height, in.	6.03	6.03	
Net decrease in height, in.		0.00	
Wet Density, pcf	116.9	120.3	
Dry density, pcf	92.7	92.7	
Void ratio	0.7905	0.7905	
Saturation, %	87.6	100.0	

Test Readings for Specimen No. 1

Load ring constant = 0.72 lbs. per input unit
Cell pressure = 55.00 psi (7.92 ksf)
Back pressure = 40.00 psi (5.76 ksf)
Effective confining stress = 2.16 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 3.13 ksf **at reading no.** 21

Test Readings for Specimen No. [illegible]

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	2.16	2.16	1.00		2.16
1	0.0100	56.0	40.3	0.2	0.91	2.16	3.07	1.42		2.61
2	0.0200	80.0	57.6	0.3	1.29	2.16	3.45	1.60		2.81
3	0.0300	94.0	67.7	0.5	1.51	2.16	3.67	1.70		2.92
4	0.0400	107.0	77.0	0.7	1.72	2.16	3.88	1.80		3.02
5	0.0500	117.0	84.2	0.8	1.88	2.16	4.04	1.87		3.10
6	0.0600	125.0	90.0	1.0	2.00	2.16	4.16	1.93		3.16
7	0.0700	132.0	95.0	1.2	2.11	2.16	4.27	1.98		3.22
8	0.0800	136.0	97.9	1.3	2.17	2.16	4.33	2.01		3.25
9	0.0900	140.0	100.8	1.5	2.23	2.16	4.39	2.03		3.28
10	0.1000	143.0	103.0	1.7	2.28	2.16	4.44	2.05		3.30
11	0.2000	167.0	120.2	3.3	2.61	2.16	4.77	2.21		3.47
12	0.3000	185.0	133.2	5.0	2.85	2.16	5.01	2.32		3.58
13	0.4000	190.0	136.8	6.6	2.87	2.16	5.03	2.33		3.60
14	0.5000	196.0	141.1	8.3	2.91	2.16	5.07	2.35		3.62
15	0.6000	206.0	148.3	10.0	3.00	2.16	5.16	2.39		3.66
16	0.7000	208.0	149.8	11.6	2.98	2.16	5.14	2.38		3.65
17	0.8000	218.0	157.0	13.3	3.06	2.16	5.22	2.42		3.69
18	0.9000	219.0	157.7	14.9	3.02	2.16	5.18	2.40		3.67
19	1.0000	226.0	162.7	16.6	3.05	2.16	5.21	2.41		3.69
20	1.1000	236.0	169.9	18.2	3.12	2.16	5.28	2.45		3.72
21	1.2000	241.0	173.5	19.9	3.13	2.16	5.29	2.45		3.72

[illegible]

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	1282.400		670.280
Moisture content: Dry soil+tare, gms.	1072.700		555.710
Moisture content: Tare, gms.	0.000		13.530
Moisture, %	19.5	21.8	21.1
Moist specimen weight, gms.	1299.0		
Diameter, in.	2.86	2.86	
Area, in.^{2}	6.44	6.44	
Height, in.	6.12	6.12	
Net decrease in height, in.		0.00	
Wet Density, pcf	125.6	128.0	
Dry density, pcf	105.1	105.1	
Void ratio	0.5805	0.5805	
Saturation, %	89.6	100.0	

Test Readings for Specimen No. 2

Load ring constant = 0.72 lbs. per input unit

Cell pressure = 70.00 psi (10.08 ksf)

Back pressure = 40.00 psi (5.76 ksf)

Effective confining stress = 4.32 ksf

Strain rate, in./min. = 0.02

Fail. Stress = 8.16 ksf **at reading no.** 18

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	4.32	4.32	1.00		4.32
1	0.0100	88.0	63.4	0.2	1.41	4.32	5.73	1.33		5.03
2	0.0200	121.0	87.1	0.3	1.94	4.32	6.26	1.45		5.29
3	0.0300	148.0	106.6	0.5	2.37	4.32	6.69	1.55		5.51
4	0.0400	168.0	121.0	0.7	2.69	4.32	7.01	1.62		5.66
5	0.0500	189.0	136.1	0.8	3.02	4.32	7.34	1.70		5.83
6	0.0600	204.0	146.9	1.0	3.25	4.32	7.57	1.75		5.95
7	0.0700	218.0	157.0	1.1	3.47	4.32	7.79	1.80		6.06
8	0.0800	232.0	167.0	1.3	3.69	4.32	8.01	1.85		6.16
9	0.0900	244.0	175.7	1.5	3.87	4.32	8.19	1.90		6.26
10	0.1000	257.0	185.0	1.6	4.07	4.32	8.39	1.94		6.36
11	0.2000	331.0	238.3	3.3	5.16	4.32	9.48	2.19		6.90
12	0.3000	374.0	269.3	4.9	5.73	4.32	10.05	2.33		7.18
13	0.4000	433.0	311.8	6.5	6.52	4.32	10.84	2.51		7.58
14	0.5000	462.0	332.6	8.2	6.83	4.32	11.15	2.58		7.74
15	0.6000	498.0	358.6	9.8	7.23	4.32	11.55	2.67		7.94
16	0.7000	532.0	383.0	11.4	7.59	4.32	11.91	2.76		8.11
17	0.8000	560.0	403.2	13.1	7.84	4.32	12.16	2.81		8.24
18	0.9000	594.0	427.7	14.7	8.16	4.32	12.48	2.89		8.40
19	1.0000	590.0	424.8	16.3	7.95	4.32	12.27	2.84		8.29
20	1.1000	608.0	437.8	18.0	8.03	4.32	12.35	2.86		8.34
21	1.2000	627.0	451.4	19.6	8.12	4.32	12.44	2.88		8.38

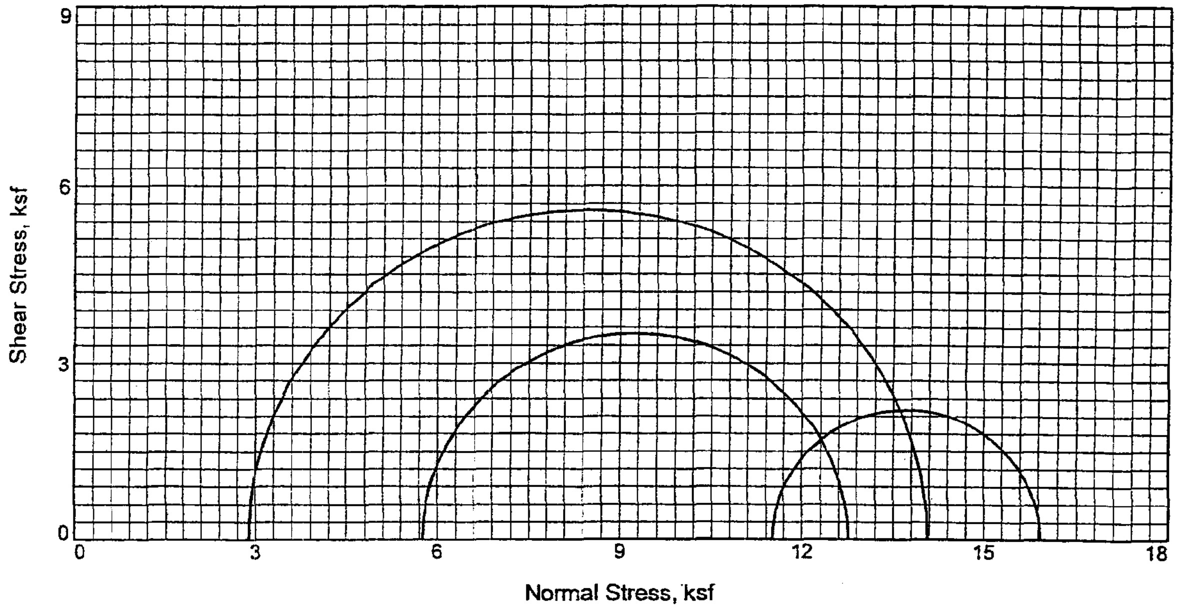
[illegible]

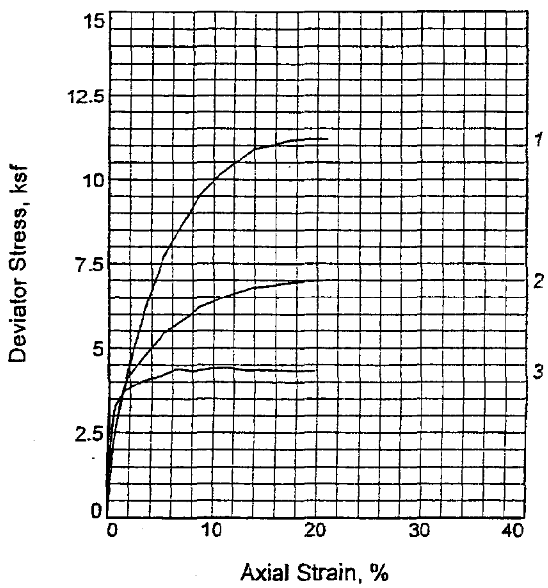
Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	1142.300		567.310
Moisture content: Dry soil+tare, gms.	870.700		427.450
Moisture content: Tare, gms.	0.000		13.570
Moisture, %	31.2	33.9	33.8
Moist specimen weight, gms.	1165.0		
Diameter, in.	2.83	2.83	
Area, in.^{2}	6.28	6.28	
Height, in.	6.17	6.17	
Net decrease in height, in.		0.00	
Wet Density, pcf	114.6	116.9	
Dry density, pcf	87.3	87.3	
Void ratio	0.9011	0.9011	
Saturation, %	92.1	100.0	

Test Readings for Specimen No. [illegible]

Load ring constant = 0.72 lbs. per input unit
Cell pressure = 100.00 psi (14.40 ksf)
Back pressure = 40.00 psi (5.76 ksf)
Effective confining stress = 8.64 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 4.39 ksf **at reading no.** 20

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	8.64	8.64	1.00		8.64
1	0.0100	54.0	38.9	0.2	0.89	8.64	9.53	1.10		9.08
2	0.0200	90.0	64.8	0.3	1.48	8.64	10.12	1.17		9.38
3	0.0300	125.0	90.0	0.5	2.05	8.64	10.69	1.24		9.67
4	0.0400	151.0	108.7	0.6	2.48	8.64	11.12	1.29		9.88
5	0.0500	168.0	121.0	0.8	2.75	8.64	11.39	1.32		10.02
6	0.0600	180.0	129.6	1.0	2.94	8.64	11.58	1.34		10.11
7	0.0700	187.0	134.6	1.1	3.05	8.64	11.69	1.35		10.17
8	0.0800	194.0	139.7	1.3	3.16	8.64	11.80	1.37		10.22
9	0.0900	199.0	143.3	1.5	3.24	8.64	11.88	1.37		10.26
10	0.1000	203.0	146.2	1.6	3.30	8.64	11.94	1.38		10.29
11	0.2000	220.0	158.4	3.2	3.51	8.64	12.15	1.41		10.40
12	0.3000	246.0	177.1	4.9	3.86	8.64	12.50	1.45		10.57
13	0.4000	251.0	180.7	6.5	3.87	8.64	12.51	1.45		10.58
14	0.5000	262.0	188.6	8.1	3.97	8.64	12.61	1.46		10.63
15	0.6000	281.0	202.3	9.7	4.19	8.64	12.83	1.48		10.73
16	0.7000	288.0	207.4	11.4	4.21	8.64	12.85	1.49		10.75
17	0.8000	300.0	216.0	13.0	4.31	8.64	12.95	1.50		10.79
18	0.9000	307.0	221.0	14.6	4.33	8.64	12.97	1.50		10.80
19	1.0000	309.0	222.5	16.2	4.27	8.64	12.91	1.49		10.78
20	1.1000	324.0	233.3	17.8	4.39	8.64	13.03	1.51		10.84
21	1.2000	327.0	235.4	19.5	4.35	8.64	12.99	1.50		10.81





Sample No.		1	2	3
Initial	Water Content,	21.2	21.1	39.8
	Dry Density, pcf	92.4	96.8	79.9
	Saturation,	71.5	79.3	98.8
	Void Ratio	0.7838	0.7029	1.0625
	Diameter, in.	2.87	2.87	2.83
	Height, in.	5.73	5.82	6.09
At Test	Water Content,	29.7	26.6	40.2
	Dry Density, pcf	92.4	96.8	79.9
	Saturation,	100.0	100.0	100.0
	Void Ratio	0.7838	0.7029	1.0625
	Diameter, in.	2.87	2.87	2.83
	Height, in.	5.73	5.82	6.09
Strain rate, in./min.		0.02	0.02	0.02
Back Pressure, ksf		2.9	2.9	2.9
Cell Pressure, ksf		5.8	8.6	14.4
Fail. Stress, ksf		11.2	7.0	4.4
Ult. Stress, ksf				
σ_1 Failure, ksf		14.1	12.8	15.9
σ_3 Failure, ksf		2.9	5.8	11.5

Type of Test:
Unconsolidated Undrained
Sample Type: undisturbed
Description:

Assumed Specific Gravity= 2.64
Remarks:

Figure ________

Client: TVA

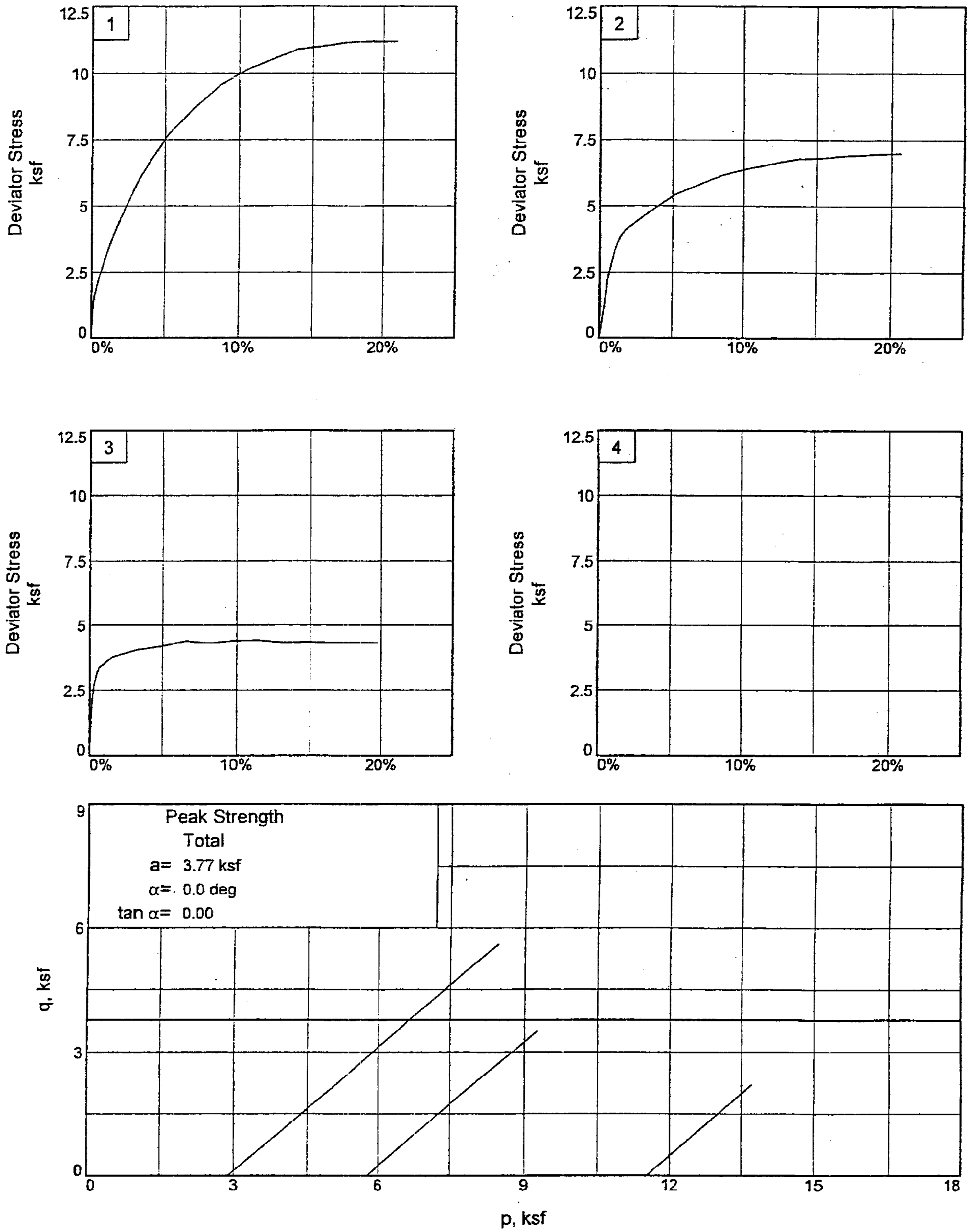
Project: TVA Kingston - Proposed Gypsum Stack

Location: NB-77A
Sample Number: UD-4, 6 & 7 (UU) **Depth:** 15'-26'
Proj. No.: 3043051021 **Date:**

TRIAXIAL SHEAR TEST REPORT

MACTEC, INC.

Tested By: Alexander **Checked By:** Hamlett



Client: TVA

Project: TVA Kingston - Proposed Gypsum Stack

Location: NB-77A **Depth:** 15'-26' **Sample Number:** UD-4, 6 & 7 (UU)

Project No.: 3043051021 **Figure** ________

MACTEC, INC.

Tested By: Alexander **Checked By:** Hamlett

TRIAXIAL COMPRESSION TEST
Unconsolidated Undrained

9/19/2005
1:38 PM

Date:
Client: TVA
Project: TVA Kingston - Proposed Gypsum Stack
Project No.: 3043051021
Location: NB-77A
Depth: 15'-26' **Sample Number:** UD-4, 6 & 7 (UU)
Description:
Remarks:
Type of Sample: undisturbed
Assumed Specific Gravity=2.64 **LL=** **PL=** **PI=**
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	1078.860		460.990
Moisture content: Dry soil+tare, gms.	890.040		376.420
Moisture content: Tare, gms.	0.000		14.130
Moisture, %	21.2	29.7	23.3
Moist specimen weight, gms.	1090.3		
Diameter, in.	2.87	2.87	
Area, in.²	6.47	6.47	
Height, in.	5.73	5.73	
Net decrease in height, in.		0.00	
Wet Density, pcf	112.0	119.8	
Dry density, pcf	92.4	92.4	
Void ratio	0.7838	0.7838	
Saturation, %	71.5	100.0	

Test Readings for Specimen No. 1

Load ring constant = 0.72 lbs. per input unit
Cell pressure = 40.00 psi (5.76 ksf)
Back pressure = 20.00 psi (2.88 ksf)
Effective confining stress = 2.88 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 11.19 ksf **at reading no.** 20

Test Readings for Specimen No.

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	2.88	2.88	1.00		2.88
1	0.0100	90.0	64.8	0.2	1.44	2.88	4.32	1.50		3.60
2	0.0200	118.0	85.0	0.3	1.88	2.88	4.76	1.65		3.82
3	0.0300	143.0	103.0	0.5	2.28	2.88	5.16	1.79		4.02
4	0.0400	163.0	117.4	0.7	2.59	2.88	5.47	1.90		4.18
5	0.0500	184.0	132.5	0.9	2.92	2.88	5.80	2.01		4.34
6	0.0600	203.0	146.2	1.0	3.22	2.88	6.10	2.12		4.49
7	0.0700	219.0	157.7	1.2	3.47	2.88	6.35	2.20		4.61
8	0.0800	236.0	169.9	1.4	3.73	2.88	6.61	2.29		4.74
9	0.0900	252.0	181.4	1.6	3.98	2.88	6.86	2.38		4.87
10	0.1000	267.0	192.2	1.7	4.20	2.88	7.08	2.46		4.98
11	0.2000	403.0	290.2	3.5	6.23	2.88	9.11	3.16		6.00
12	0.3000	508.0	365.8	5.2	7.72	2.88	10.60	3.68		6.74
13	0.4000	582.0	419.0	7.0	8.68	2.88	11.56	4.01		7.22
14	0.5000	652.0	469.4	8.7	9.54	2.88	12.42	4.31		7.65
15	0.6000	706.0	508.3	10.5	10.13	2.88	13.01	4.52		7.95
16	0.7000	747.0	537.8	12.2	10.51	2.88	13.39	4.65		8.14
17	0.8000	789.0	568.1	14.0	10.88	2.88	13.76	4.78		8.32
18	0.9000	814.0	586.1	15.7	11.00	2.88	13.88	4.82		8.38
19	1.0000	843.0	607.0	17.4	11.15	2.88	14.03	4.87		8.46
20	1.1000	864.0	622.1	19.2	11.19	2.88	14.07	4.89		8.48
21	1.2000	883.0	635.8	20.9	11.19	2.88	14.07	4.89		8.47

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	1154.900		634.320
Moisture content: Dry soil+tare, gms.	953.580		520.590
Moisture content: Tare, gms.	0.000		11.220
Moisture, %	21.1	26.6	22.3
Moist specimen weight, gms.	1161.5		
Diameter, in.	2.87	2.87	
Area, in.²	6.48	6.48	
Height, in.	5.82	5.82	
Net decrease in height, in.		0.00	
Wet Density, pcf	117.2	122.5	
Dry density, pcf	96.8	96.8	
Void ratio	0.7029	0.7029	
Saturation, %	79.3	100.0	

Test Readings for Specimen No. 2

Load ring constant = 0.72 lbs. per input unit
Cell pressure = 60.00 psi (8.64 ksf)
Back pressure = 20.00 psi (2.88 ksf)
Effective confining stress = 5.76 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 7.00 ksf **at reading no.** 21

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	5.76	5.76	1.00		5.76
1	0.0100	42.0	30.2	0.2	0.67	5.76	6.43	1.12		6.10
2	0.0200	84.0	60.5	0.3	1.34	5.76	7.10	1.23		6.43
3	0.0300	137.0	98.6	0.5	2.18	5.76	7.94	1.38		6.85
4	0.0400	167.0	120.2	0.7	2.65	5.76	8.41	1.46		7.09
5	0.0500	189.0	136.1	0.9	3.00	5.76	8.76	1.52		7.26
6	0.0600	212.0	152.6	1.0	3.36	5.76	9.12	1.58		7.44
7	0.0700	227.0	163.4	1.2	3.59	5.76	9.35	1.62		7.55
8	0.0800	241.0	173.5	1.4	3.80	5.76	9.56	1.66		7.66
9	0.0900	251.0	180.7	1.5	3.95	5.76	9.71	1.69		7.74
10	0.1000	260.0	187.2	1.7	4.09	5.76	9.85	1.71		7.80
11	0.2000	310.0	223.2	3.4	4.79	5.76	10.55	1.83		8.15
12	0.3000	358.0	257.8	5.2	5.43	5.76	11.19	1.94		8.48
13	0.4000	390.0	280.8	6.9	5.81	5.76	11.57	2.01		8.66
14	0.5000	423.0	304.6	8.6	6.18	5.76	11.94	2.07		8.85
15	0.6000	447.0	321.8	10.3	6.41	5.76	12.17	2.11		8.97
16	0.7000	469.0	337.7	12.0	6.60	5.76	12.36	2.15		9.06
17	0.8000	491.0	353.5	13.7	6.77	5.76	12.53	2.18		9.15
18	0.9000	505.0	363.6	15.5	6.83	5.76	12.59	2.19		9.17
19	1.0000	522.0	375.8	17.2	6.91	5.76	12.67	2.20		9.22
20	1.1000	537.0	386.6	18.9	6.97	5.76	12.73	2.21		9.24
21	1.2000	551.0	396.7	20.6	7.00	5.76	12.76	2.21		9.26

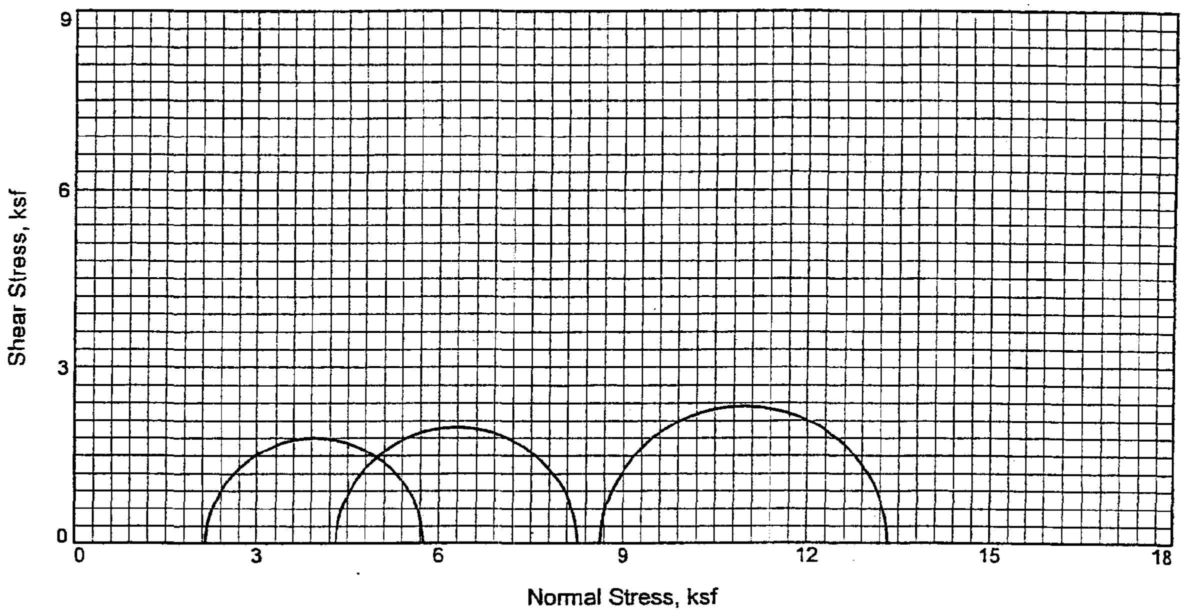
Parameters for Specimen No. 2

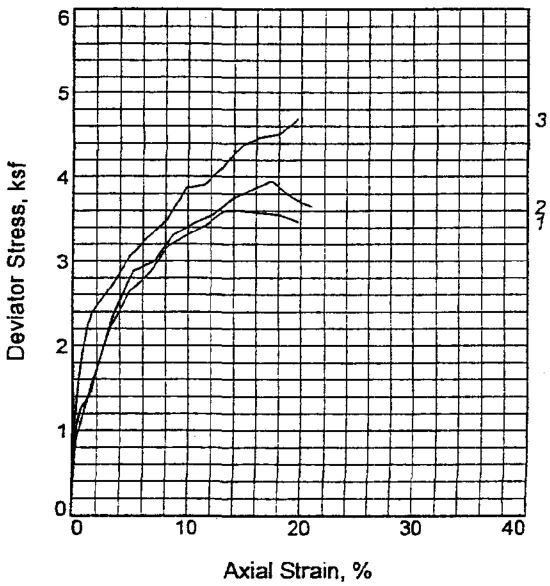
Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	1114.200		526.400
Moisture content: Dry soil+tare, gms.	797.260		373.280
Moisture content: Tare, gms.	0.000		8.080
Moisture, %	39.8	40.2	41.9
Moist specimen weight, gms.	1124.1		
Diameter, in.	2.83	2.83	
Area, in.²	6.30	6.30	
Height, in.	6.09	6.09	
Net decrease in height, in.		0.00	
Wet Density, pcf	111.7	112.1	
Dry density, pcf	79.9	79.9	
Void ratio	1.0625	1.0625	
Saturation, %	98.8	100.0	

Test Readings for Specimen No. 2

Load ring constant = 0.72 lbs. per input unit
Cell pressure = 100.00 psi (14.40 ksf)
Back pressure = 20.00 psi (2.88 ksf)
Effective confining stress = 11.52 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 4.41 ksf **at reading no.** 16

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	11.52	11.52	1.00		11.52
1	0.0100	117.0	84.2	0.2	1.92	11.52	13.44	1.17		12.48
2	0.0200	166.0	119.5	0.3	2.72	11.52	14.24	1.24		12.88
3	0.0300	190.0	136.8	0.5	3.11	11.52	14.63	1.27		13.08
4	0.0400	205.0	147.6	0.7	3.35	11.52	14.87	1.29		13.20
5	0.0500	210.0	151.2	0.8	3.43	11.52	14.95	1.30		13.23
6	0.0600	215.0	154.8	1.0	3.50	11.52	15.02	1.30		13.27
7	0.0700	221.0	159.1	1.1	3.60	11.52	15.12	1.31		13.32
8	0.0800	225.0	162.0	1.3	3.65	11.52	15.17	1.32		13.35
9	0.0900	230.0	165.6	1.5	3.73	11.52	15.25	1.32		13.38
10	0.1000	233.0	167.8	1.6	3.77	11.52	15.29	1.33		13.41
11	0.2000	254.0	182.9	3.3	4.04	11.52	15.56	1.35		13.54
12	0.3000	267.0	192.2	4.9	4.18	11.52	15.70	1.36		13.61
13	0.4000	285.0	205.2	6.6	4.38	11.52	15.90	1.38		13.71
14	0.5000	285.0	205.2	8.2	4.31	11.52	15.83	1.37		13.67
15	0.6000	296.0	213.1	9.9	4.39	11.52	15.91	1.38		13.72
16	0.7000	303.0	218.2	11.5	4.41	11.52	15.93	1.38		13.73
17	0.8000	303.0	218.2	13.1	4.33	11.52	15.85	1.38		13.69
18	0.9000	310.0	223.2	14.8	4.35	11.52	15.87	1.38		13.69
19	1.0000	315.0	226.8	16.4	4.33	11.52	15.85	1.38		13.69
20	1.1000	321.0	231.1	18.1	4.33	11.52	15.85	1.38		13.68
21	1.2000	327.0	235.4	19.7	4.32	11.52	15.84	1.38		13.68





Sample No.		1	2	3
Initial	Water Content,	25.0	25.0	25.0
	Dry Density, pcf	96.5	98.5	99.8
	Saturation,	92.2	96.8	100.0
	Void Ratio	0.7215	0.6855	0.6647
	Diameter, in.	2.84	2.86	2.91
	Height, in.	6.09	5.75	6.11
At Test	Water Content,	27.1	25.8	25.0
	Dry Density, pcf	96.5	98.5	99.8
	Saturation,	100.0	100.0	100.0
	Void Ratio	0.7215	0.6855	0.6647
	Diameter, in.	2.84	2.86	2.91
	Height, in.	6.09	5.75	6.11
Strain rate, in./min.		0.02	0.02	0.02
Back Pressure, ksf		5.8	5.8	5.8
Cell Pressure, ksf		7.9	10.1	14.4
Fail. Stress, ksf		3.6	4.0	4.7
Ult. Stress, ksf				
σ_1 Failure, ksf		5.8	8.3	13.3
σ_3 Failure, ksf		2.2	4.3	8.6

Type of Test:
Unconsolidated Undrained
Sample Type: undisturbed
Description:

Assumed Specific Gravity= 2.66
Remarks:

Client: TVA

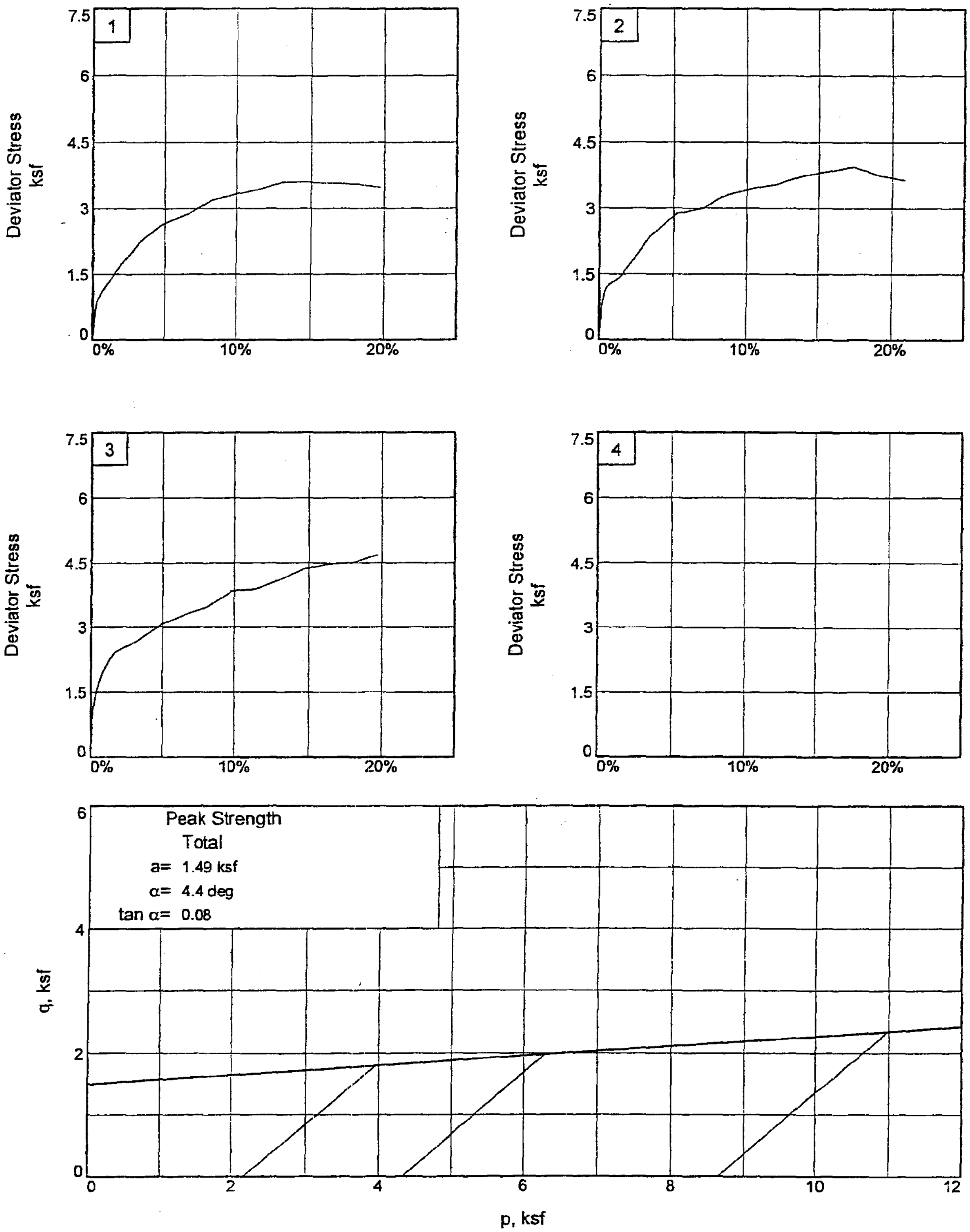
Project: TVA Kingston - Proposed Gypsum Stack

Location: NB-85A and NB-85B
Sample Number: UD-1, 2 & 3 (UU) **Depth:** 13'-19'
Proj. No.: 3043051021 **Date:**

TRIAXIAL SHEAR TEST REPORT
MACTEC, INC.

Figure ________

Tested By: Alexander **Checked By:** Hamlett



Client: TVA
Project: TVA Kingston - Proposed Gypsum Stack
Location: NB-85A and NB-85B **Depth:** 13'-19' **Sample Number:** UD-1, 2 & 3 (UU)
Project No.: 3043051021 **Figure** _______ **MACTEC, INC.**

Tested By: Alexander **Checked By:** Hamlett

TRIAXIAL COMPRESSION TEST

Unconsolidated Undrained

9/13/2005
9:41 PM

Date:
Client: TVA
Project: TVA Kingston - Proposed Gypsum Stack
Project No.: 3043051021
Location: NB-85A and NB-85B
Depth: 13'-19' **Sample Number:** UD-1, 2 & 3 (UU)
Description:
Remarks:
Type of Sample: undisturbed
Specific Gravity=2.66 **LL=** **PL=** **PI=**
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	1220.400		1336.600
Moisture content: Dry soil+tare, gms.	976.200		1068.970
Moisture content: Tare, gms.	0.000		93.350
Moisture, %	25.0	27.1	27.4
Moist specimen weight, gms.	1220.4		
Diameter, in.	2.84	2.84	
Area, in.²	6.33	6.33	
Height, in.	6.09	6.09	
Net decrease in height, in.		0.00	
Wet Density, pcf	120.6	122.6	
Dry density, pcf	96.5	96.5	
Void ratio	0.7215	0.7215	
Saturation, %	92.2	100.0	

Test Readings for Specimen No. 1

Load ring constant = 0.72 lbs. per input unit
Cell pressure = 55.00 psi (7.92 ksf)
Back pressure = 40.00 psi (5.76 ksf)
Effective confining stress = 2.16 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 3.60 ksf **at reading no.** 18

MACTEC, INC.

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	2.16	2.16	1.00		2.16
1	0.0100	40.0	28.8	0.2	0.65	2.16	2.81	1.30		2.49
2	0.0200	55.0	39.6	0.3	0.90	2.16	3.06	1.42		2.61
3	0.0300	62.0	44.6	0.5	1.01	2.16	3.17	1.47		2.66
4	0.0400	68.0	49.0	0.7	1.11	2.16	3.27	1.51		2.71
5	0.0500	73.0	52.6	0.8	1.18	2.16	3.34	1.55		2.75
6	0.0600	78.0	56.2	1.0	1.26	2.16	3.42	1.59		2.79
7	0.0700	82.0	59.0	1.2	1.33	2.16	3.49	1.61		2.82
8	0.0800	87.0	62.6	1.3	1.41	2.16	3.57	1.65		2.86
9	0.0900	92.0	66.2	1.5	1.48	2.16	3.64	1.69		2.90
10	0.1000	97.0	69.8	1.6	1.56	2.16	3.72	1.72		2.94
11	0.2000	141.0	101.5	3.3	2.23	2.16	4.39	2.03		3.28
12	0.3000	170.0	122.4	4.9	2.65	2.16	4.81	2.22		3.48
13	0.4000	187.0	134.6	6.6	2.86	2.16	5.02	2.32		3.59
14	0.5000	211.0	151.9	8.2	3.17	2.16	5.33	2.47		3.74
15	0.6000	224.0	161.3	9.9	3.30	2.16	5.46	2.53		3.81
16	0.7000	236.0	169.9	11.5	3.42	2.16	5.58	2.58		3.87
17	0.8000	253.0	182.2	13.1	3.60	2.16	5.76	2.67		3.96
18	0.9000	258.0	185.8	14.8	3.60	2.16	5.76	2.67		3.96
19	1.0000	261.0	187.9	16.4	3.57	2.16	5.73	2.65		3.94
20	1.1000	265.0	190.8	18.1	3.55	2.16	5.71	2.65		3.94
21	1.2000	264.0	190.1	19.7	3.47	2.16	5.63	2.61		3.89

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	1192.400		1305.860
Moisture content: Dry soil+tare, gms.	954.290		1061.280
Moisture content: Tare, gms.	0.000		91.170
Moisture, %	25.0	25.8	25.2
Moist specimen weight, gms.	1192.4		
Diameter, in.	2.86	2.86	
Area, in.²	6.42	6.42	
Height, in.	5.75	5.75	
Net decrease in height, in.		0.00	
Wet Density, pcf	123.1	123.9	
Dry density, pcf	98.5	98.5	
Void ratio	0.6855	0.6855	
Saturation, %	96.8	100.0	

Test Readings for Specimen No. 2

Load ring constant = 0.72 lbs. per input unit
Cell pressure = 70.00 psi (10.08 ksf)
Back pressure = 40.00 psi (5.76 ksf)
Effective confining stress = 4.32 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 3.95 ksf **at reading no.** 19

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	4.32	4.32	1.00		4.32
1	0.0100	48.0	34.6	0.2	0.77	4.32	5.09	1.18		4.71
2	0.0200	67.0	48.2	0.3	1.08	4.32	5.40	1.25		4.86
3	0.0300	75.0	54.0	0.5	1.21	4.32	5.53	1.28		4.92
4	0.0400	79.0	56.9	0.7	1.27	4.32	5.59	1.29		4.95
5	0.0500	82.0	59.0	0.9	1.31	4.32	5.63	1.30		4.98
6	0.0600	84.0	60.5	1.0	1.34	4.32	5.66	1.31		4.99
7	0.0700	87.0	62.6	1.2	1.39	4.32	5.71	1.32		5.01
8	0.0800	89.0	64.1	1.4	1.42	4.32	5.74	1.33		5.03
9	0.0900	92.0	66.2	1.6	1.46	4.32	5.78	1.34		5.05
10	0.1000	99.0	71.3	1.7	1.57	4.32	5.89	1.36		5.11
11	0.2000	152.0	109.4	3.5	2.37	4.32	6.69	1.55		5.51
12	0.3000	188.0	135.4	5.2	2.88	4.32	7.20	1.67		5.76
13	0.4000	199.0	143.3	7.0	2.99	4.32	7.31	1.69		5.82
14	0.5000	224.0	161.3	8.7	3.31	4.32	7.63	1.77		5.97
15	0.6000	238.0	171.4	10.4	3.45	4.32	7.77	1.80		6.04
16	0.7000	250.0	180.0	12.2	3.55	4.32	7.87	1.82		6.09
17	0.8000	269.0	193.7	13.9	3.74	4.32	8.06	1.87		6.19
18	0.9000	282.0	203.0	15.6	3.84	4.32	8.16	1.89		6.24
19	1.0000	296.0	213.1	17.4	3.95	4.32	8.27	1.91		6.30
20	1.1000	288.0	207.4	19.1	3.76	4.32	8.08	1.87		6.20
21	1.2000	285.0	205.2	20.9	3.65	4.32	7.97	1.84		6.14

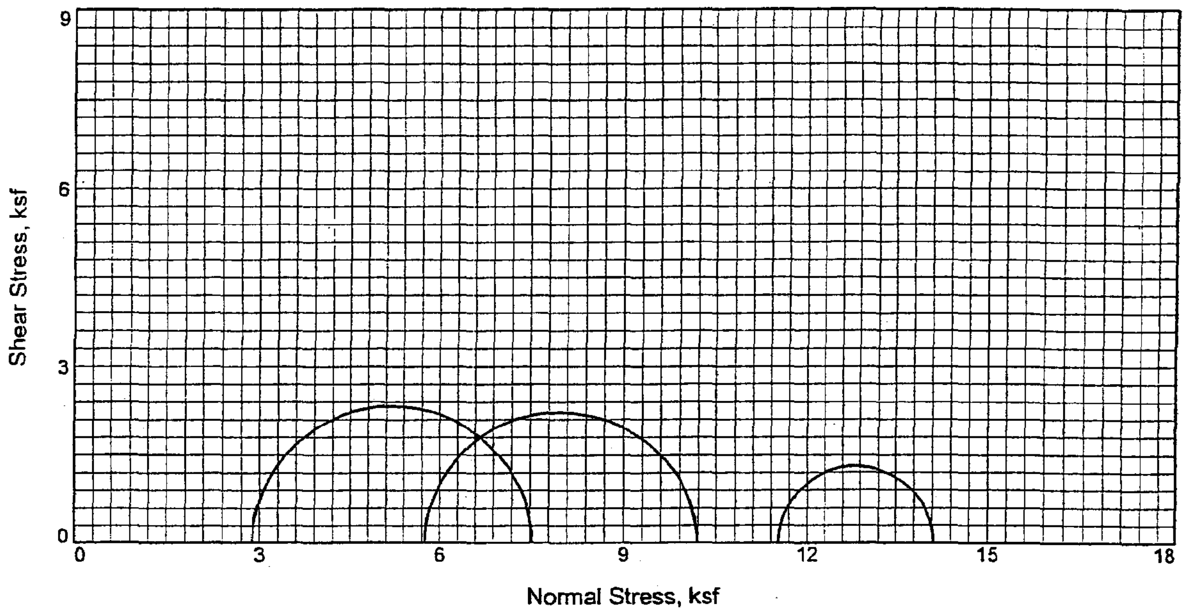
Parameters for Specimen No. 3

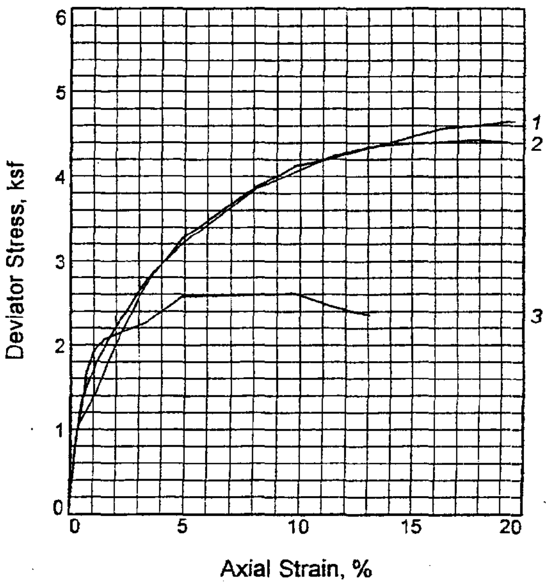
Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	1326.900		1440.860
Moisture content: Dry soil+tare, gms.	1061.520		1221.470
Moisture content: Tare, gms.	0.000		87.240
Moisture, %	25.0	25.0	19.3
Moist specimen weight, gms.	1326.9		
Diameter, in.	2.91	2.91	
Area, in.²	6.64	6.64	
Height, in.	6.11	6.11	
Net decrease in height, in.		0.00	
Wet Density, pcf	124.7	124.7	
Dry density, pcf	99.8	99.8	
Void ratio	0.6647	0.6647	
Saturation, %	100.0	100.0	

Test Readings for Specimen No. 3

Load ring constant = 0.72 lbs. per input unit
Cell pressure = 100.00 psi (14.40 ksf)
Back pressure = 40.00 psi (5.76 ksf)
Effective confining stress = 8.64 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 4.68 ksf **at reading no.** 21

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	8.64	8.64	1.00		8.64
1	0.0100	72.0	51.8	0.2	1.12	8.64	9.76	1.13		9.20
2	0.0200	89.0	64.1	0.3	1.39	8.64	10.03	1.16		9.33
3	0.0300	102.0	73.4	0.5	1.59	8.64	10.23	1.18		9.43
4	0.0400	114.0	82.1	0.7	1.77	8.64	10.41	1.20		9.52
5	0.0500	124.0	89.3	0.8	1.92	8.64	10.56	1.22		9.60
6	0.0600	133.0	95.8	1.0	2.06	8.64	10.70	1.24		9.67
7	0.0700	140.0	100.8	1.1	2.16	8.64	10.80	1.25		9.72
8	0.0800	147.0	105.8	1.3	2.27	8.64	10.91	1.26		9.77
9	0.0900	150.0	108.0	1.5	2.31	8.64	10.95	1.27		9.79
10	0.1000	156.0	112.3	1.6	2.40	8.64	11.04	1.28		9.84
11	0.2000	178.0	128.2	3.3	2.69	8.64	11.33	1.31		9.98
12	0.3000	206.0	148.3	4.9	3.06	8.64	11.70	1.35		10.17
13	0.4000	226.0	162.7	6.5	3.30	8.64	11.94	1.38		10.29
14	0.5000	244.0	175.7	8.2	3.50	8.64	12.14	1.41		10.39
15	0.6000	274.0	197.3	9.8	3.86	8.64	12.50	1.45		10.57
16	0.7000	282.0	203.0	11.5	3.90	8.64	12.54	1.45		10.59
17	0.8000	304.0	218.9	13.1	4.13	8.64	12.77	1.48		10.70
18	0.9000	328.0	236.2	14.7	4.37	8.64	13.01	1.51		10.82
19	1.0000	342.0	246.2	16.4	4.47	8.64	13.11	1.52		10.87
20	1.1000	352.0	253.4	18.0	4.51	8.64	13.15	1.52		10.89
21	1.2000	373.0	268.6	19.6	4.68	8.64	13.32	1.54		10.98





Sample No.		1	2	3
Initial	Water Content,	23.9	29.4	32.8
	Dry Density, pcf	99.7	92.8	88.4
	Saturation,	96.7	100.0	100.0
	Void Ratio	0.6526	0.7754	0.8651
	Diameter, in.	2.83	2.83	2.84
	Height, in.	6.13	6.14	6.13
At Test	Water Content,	24.7	29.4	32.8
	Dry Density, pcf	99.7	92.8	88.4
	Saturation,	100.0	100.0	100.0
	Void Ratio	0.6526	0.7754	0.8651
	Diameter, in.	2.83	2.83	2.84
	Height, in.	6.13	6.14	6.13
Strain rate, in./min.		0.02	0.02	0.02
Back Pressure, ksf		2.9	2.9	2.9
Cell Pressure, ksf		5.8	8.6	14.4
Fail. Stress, ksf		4.7	4.4	2.6
Ult. Stress, ksf				
σ_1 Failure, ksf		7.5	10.2	14.1
σ_3 Failure, ksf		2.9	5.8	11.5

Type of Test:
Unconsolidated Undrained
Sample Type: undisturbed
Description:

Assumed Specific Gravity= 2.64
Remarks:

Client: TVA

Project: TVA Kingston - Proposed Gypsum Stack

Location: NB-85B

Sample Number: UD-6, 7 & 8 (UU) **Depth:** 23'-29'

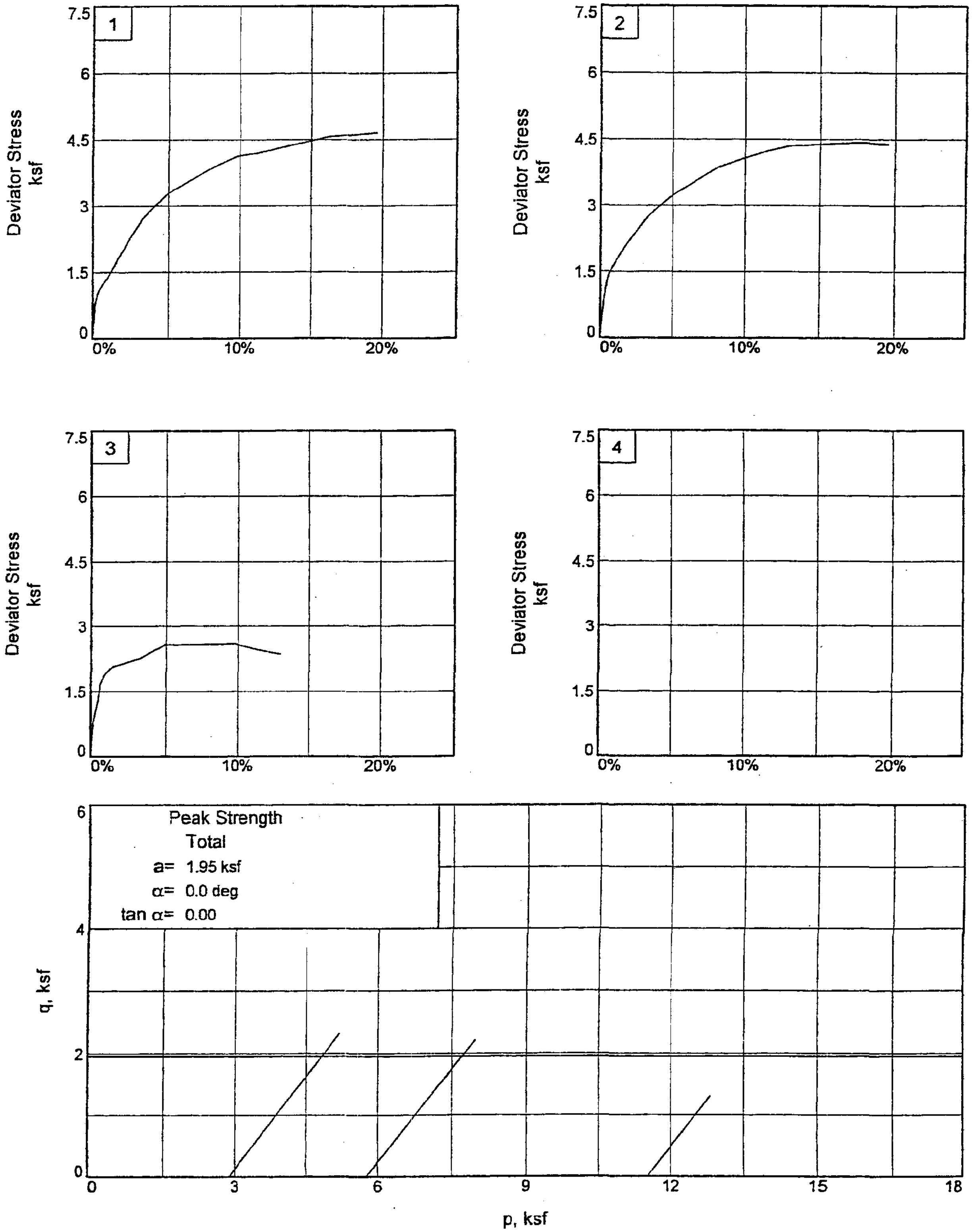
Proj. No.: 3043051021 **Date:**

TRIAXIAL SHEAR TEST REPORT

MACTEC, INC.

Figure ________

Tested By: Alexander **Checked By:** Hamlett



Client: TVA
Project: TVA Kingston - Proposed Gypsum Stack
Location: NB-85B **Depth:** 23'-29' **Sample Number:** UD-6, 7 & 8 (UU)
Project No.: 3043051021 **Figure** ______ **MACTEC, INC.**

Tested By: Alexander **Checked By:** Hamlett

TRIAXIAL COMPRESSION TEST
Unconsolidated Undrained

9/13/2005
10:00 PM

Date:
Client: TVA
Project: TVA Kingston - Proposed Gypsum Stack
Project No.: 3043051021
Location: NB-85B
Depth: 23'-29' **Sample Number:** UD-6, 7 & 8 (UU)
Description:
Remarks:
Type of Sample: undisturbed
Specific Gravity=2.64 **LL=** **PL=** **PI=**
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	1254.700		1366.730
Moisture content: Dry soil+tare, gms.	1012.600		1105.290
Moisture content: Tare, gms.	0.000		93.360
Moisture, %	23.9	24.7	25.8
Moist specimen weight, gms.	1254.7		
Diameter, in.	2.83	2.83	
Area, in.²	6.31	6.31	
Height, in.	6.13	6.13	
Net decrease in height, in.		0.00	
Wet Density, pcf	123.6	124.4	
Dry density, pcf	99.7	99.7	
Void ratio	0.6526	0.6526	
Saturation, %	96.7	100.0	

Test Readings for Specimen No. 1

Load ring constant = 0.72 lbs. per input unit
Cell pressure = 40.00 psi (5.76 ksf)
Back pressure = 20.00 psi (2.88 ksf)
Effective confining stress = 2.88 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 4.65 ksf **at reading no.** 21

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	2.88	2.88	1.00		2.88
1	0.0100	46.0	33.1	0.2	0.75	2.88	3.63	1.26		3.26
2	0.0200	62.0	44.6	0.3	1.02	2.88	3.90	1.35		3.39
3	0.0300	69.0	49.7	0.5	1.13	2.88	4.01	1.39		3.44
4	0.0400	74.0	53.3	0.7	1.21	2.88	4.09	1.42		3.48
5	0.0500	79.0	56.9	0.8	1.29	2.88	4.17	1.45		3.52
6	0.0600	84.0	60.5	1.0	1.37	2.88	4.25	1.47		3.56
7	0.0700	89.0	64.1	1.1	1.45	2.88	4.33	1.50		3.60
8	0.0800	96.0	69.1	1.3	1.56	2.88	4.44	1.54		3.66
9	0.0900	103.0	74.2	1.5	1.67	2.88	4.55	1.58		3.71
10	0.1000	111.0	79.9	1.6	1.79	2.88	4.67	1.62		3.78
11	0.2000	170.0	122.4	3.3	2.70	2.88	5.58	1.94		4.23
12	0.3000	209.0	150.5	4.9	3.27	2.88	6.15	2.13		4.51
13	0.4000	233.0	167.8	6.5	3.58	2.88	6.46	2.24		4.67
14	0.5000	257.0	185.0	8.2	3.88	2.88	6.76	2.35		4.82
15	0.6000	278.0	200.2	9.8	4.12	2.88	7.00	2.43		4.94
16	0.7000	289.0	208.1	11.4	4.21	2.88	7.09	2.46		4.98
17	0.8000	303.0	218.2	13.0	4.33	2.88	7.21	2.50		5.05
18	0.9000	317.0	228.2	14.7	4.45	2.88	7.33	2.54		5.10
19	1.0000	332.0	239.0	16.3	4.57	2.88	7.45	2.59		5.16
20	1.1000	341.0	245.5	17.9	4.60	2.88	7.48	2.60		5.18
21	1.2000	352.0	253.4	19.6	4.65	2.88	7.53	2.62		5.21

Test Data for Specimen No. 2

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	1216.300		650.000
Moisture content: Dry soil+tare, gms.	940.100		500.550
Moisture content: Tare, gms.	0.000		13.930
Moisture, %	29.4	29.4	30.7
Moist specimen weight, gms.	1216.3		
Diameter, in.	2.83	2.83	
Area, in.²	6.28	6.28	
Height, in.	6.14	6.14	
Net decrease in height, in.		0.00	
Wet Density, pcf	120.1	120.1	
Dry density, pcf	92.8	92.8	
Void ratio	0.7754	0.7754	
Saturation, %	100.0	100.0	

Test Readings for Specimen No. 2

Load ring constant = 0.72 lbs. per input unit
Cell pressure = 60.00 psi (8.64 ksf)
Back pressure = 20.00 psi (2.88 ksf)
Effective confining stress = 5.76 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 4.43 ksf **at reading no.** 20

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	5.76	5.76	1.00		5.76
1	0.0100	39.0	28.1	0.2	0.64	5.76	6.40	1.11		6.08
2	0.0200	65.0	46.8	0.3	1.07	5.76	6.83	1.19		6.29
3	0.0300	82.0	59.0	0.5	1.35	5.76	7.11	1.23		6.43
4	0.0400	91.0	65.5	0.7	1.49	5.76	7.25	1.26		6.51
5	0.0500	98.0	70.6	0.8	1.60	5.76	7.36	1.28		6.56
6	0.0600	103.0	74.2	1.0	1.68	5.76	7.44	1.29		6.60
7	0.0700	110.0	79.2	1.1	1.79	5.76	7.55	1.31		6.66
8	0.0800	115.0	82.8	1.3	1.87	5.76	7.63	1.33		6.70
9	0.0900	120.0	86.4	1.5	1.95	5.76	7.71	1.34		6.74
10	0.1000	126.0	90.7	1.6	2.05	5.76	7.81	1.36		6.78
11	0.2000	172.0	123.8	3.3	2.75	5.76	8.51	1.48		7.13
12	0.3000	204.0	146.9	4.9	3.20	5.76	8.96	1.56		7.36
13	0.4000	229.0	164.9	6.5	3.53	5.76	9.29	1.61		7.53
14	0.5000	254.0	182.9	8.1	3.85	5.76	9.61	1.67		7.69
15	0.6000	272.0	195.8	9.8	4.05	5.76	9.81	1.70		7.79
16	0.7000	289.0	208.1	11.4	4.23	5.76	9.99	1.73		7.87
17	0.8000	303.0	218.2	13.0	4.35	5.76	10.11	1.76		7.93
18	0.9000	311.0	223,9	14.7	4.38	5.76	10.14	1.76		7.95
19	1.0000	319.0	229.7	16.3	4.41	5.76	10.17	1.77		7.96
20	1.1000	327.0	235.4	17.9	4.43	5.76	10.19	1.77		7.98
21	1.2000	331.0	238.3	19.5	4.40	5.76	10.16	1.76		7.96

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	1192.600		565.110
Moisture content: Dry soil+tare, gms.	898.200		423.480
Moisture content: Tare, gms.	0.000		13.360
Moisture, %	32.8	32.8	34.5
Moist specimen weight, gms.	1192.6		
Diameter, in.	2.84	2.84	
Area, in.^{2}	6.32	6.32	
Height, in.	6.13	6.13	
Net decrease in height, in.		0.00	
Wet Density, pcf	117.3	117.3	
Dry density, pcf	88.4	88.4	
Void ratio	0.8651	0.8651	
Saturation, %	100.0	100.0	

Test Readings for Specimen No. 3

Load ring constant = 0.72 lbs. per input unit

Cell pressure = 100.00 psi (14.40 ksf)

Back pressure = 20.00 psi (2.88 ksf)

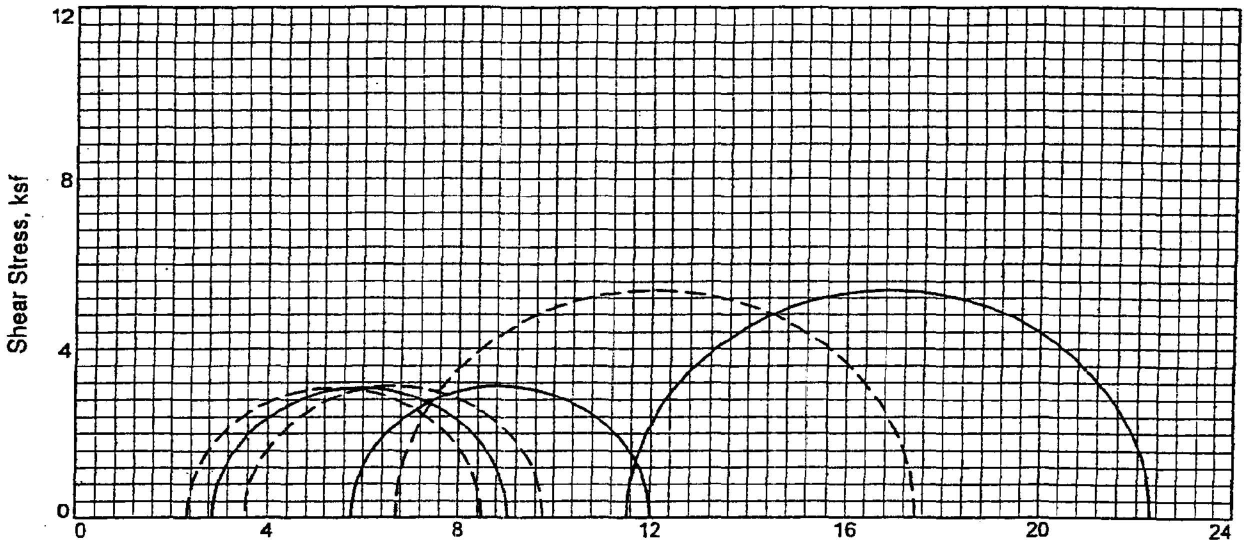
Effective confining stress = 11.52 ksf

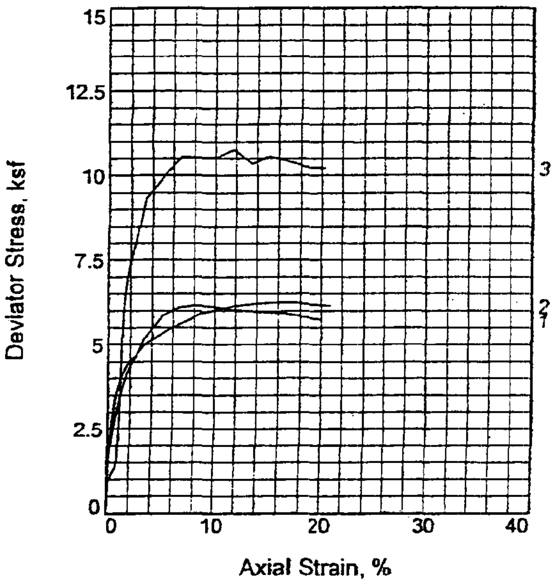
Strain rate, in./min. = 0.02

Fail. Stress = 2.61 ksf **at reading no.** 15

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	11.52	11.52	1.00		11.52
1	0.0100	48.0	34.6	0.2	0.79	11.52	12.31	1.07		11.91
2	0.0200	65.0	46.8	0.3	1.06	11.52	12.58	1.09		12.05
3	0.0300	78.0	56.2	0.5	1.27	11.52	12.79	1.11		12.16
4	0.0400	103.0	74.2	0.7	1.68	11.52	13.20	1.15		12.36
5	0.0500	110.0	79.2	0.8	1.79	11.52	13.31	1.16		12.42
6	0.0600	117.0	84.2	1.0	1.90	11.52	13.42	1.17		12.47
7	0.0700	121.0	87.1	1.1	1.96	11.52	13.48	1.17		12.50
8	0.0800	124.0	89.3	1.3	2.01	11.52	13.53	1.17		12.52
9	0.0900	128.0	92.2	1.5	2.07	11.52	13.59	1.18		12.56
10	0.1000	129.0	92.9	1.6	2.08	11.52	13.60	1.18		12.56
11	0.2000	142.0	102.2	3.3	2.25	11.52	13.77	1.20		12.65
12	0.3000	165.0	118.8	4.9	2.58	11.52	14.10	1.22		12.81
13	0.4000	168.0	121.0	6.5	2.58	11.52	14.10	1.22		12.81
14	0.5000	172.0	123.8	8.2	2.59	11.52	14.11	1.23		12.82
15	0.6000	176.0	126.7	9.8	2.61	11.52	14.13	1.23		12.82
16	0.7000	169.0	121.7	11.4	2.46	11.52	13.98	1.21		12.75
17	0.8000	165.0	118.8	13.1	2.35	11.52	13.87	1.20		12.70

CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST RESULTS





Sample No.		1	2	3
Initial	Water Content,	29.2	26.7	32.3
	Dry Density, pcf	89.0	90.1	83.7
	Saturation,	91.2	85.8	88.8
	Void Ratio	0.8376	0.8153	0.9535
	Diameter, in.	2.84	2.84	2.81
	Height, in.	6.02	5.85	6.07
At Test	Water Content,	31.4	28.0	30.7
	Dry Density, pcf	89.8	94.4	90.7
	Saturation,	100.0	100.0	100.0
	Void Ratio	0.8221	0.7325	0.8037
	Diameter, in.	2.84	2.80	2.74
	Height, in.	6.00	5.76	5.91
Strain rate, in./min.		0.02	0.02	0.02
Back Pressure, ksf		2.9	2.9	2.9
Cell Pressure, ksf		5.8	8.6	14.4
Fail. Stress, ksf		6.2	6.2	10.8
Total Pore Pr., ksf		3.4	5.1	7.7
Ult. Stress, ksf				
Total Pore Pr., ksf				
$\bar{\sigma}_1$ Failure, ksf		8.5	9.8	17.4
$\bar{\sigma}_3$ Failure, ksf		2.3	3.5	6.7

Type of Test:
CU with Pore Pressures

Sample Type: undisturbed

Description: Brown to red brown elastic silt

LL= 81 **PL=** 42 **PI=** 39

Specific Gravity= 2.62

Remarks: MH

Figure ______

Client: TVA

Project: TVA Kingston - Proposed Gypsum Stack

Location: NB-18

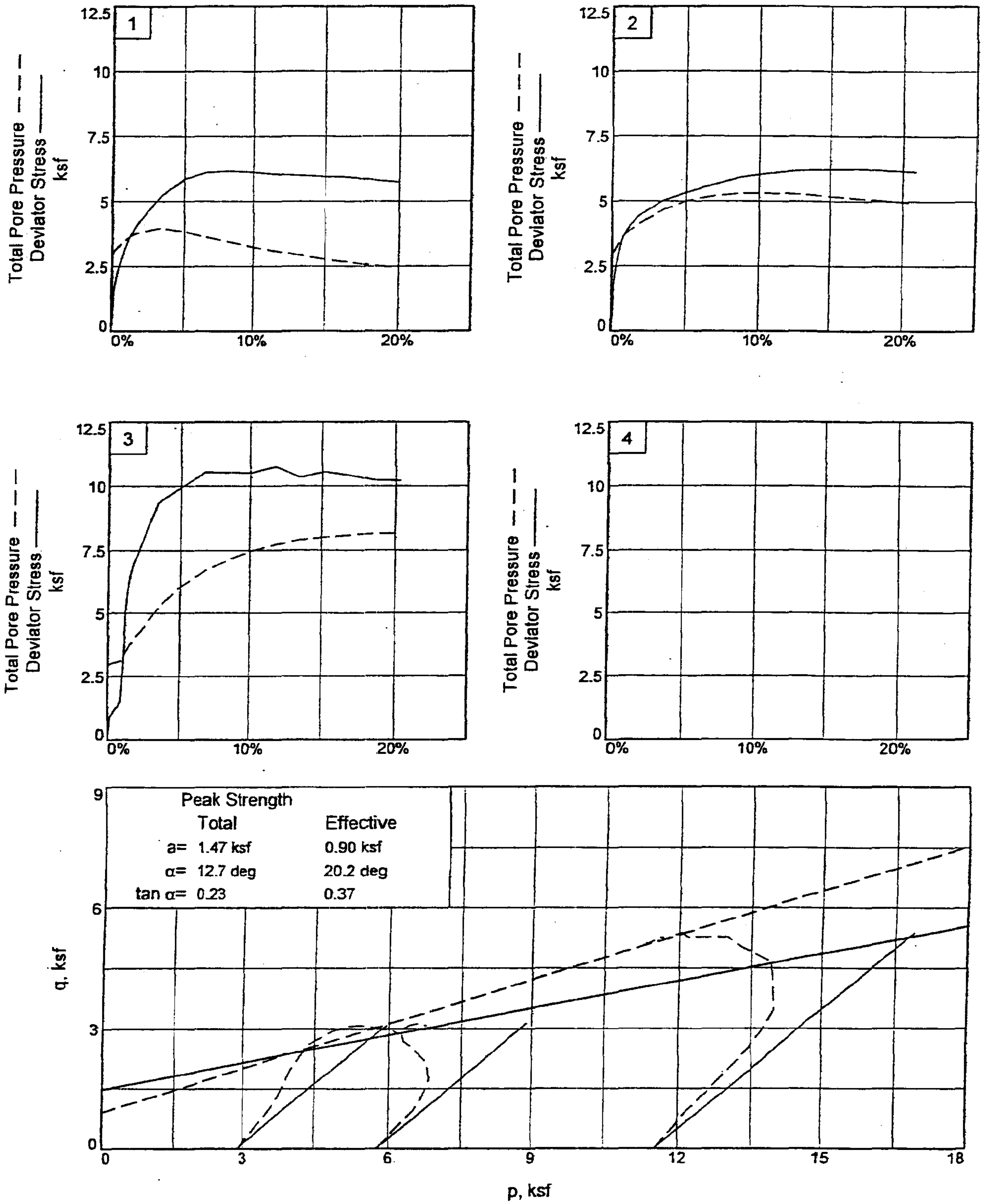
Sample Number: UD-1, 3 & 4 (CU) **Depth:** 6.5'-18.5'

Proj. No.: 3043051021 **Date:**

TRIAXIAL SHEAR TEST REPORT

MACTEC, INC.

Tested By: Alexander **Checked By:** Hamlett



Stress Paths: Total ——— Effective — — —

Client: TVA

Project: TVA Kingston - Proposed Gypsum Stack

Location: NB-18 **Depth:** 6.5'-18.5' **Sample Number:** UD-1, 3 & 4 (CU)

Project No.: 3043051021 **Figure** ________ **MACTEC, INC.**

Tested By: Alexander **Checked By:** Hamlett

TRIAXIAL COMPRESSION TEST

CU with Pore Pressures

9/13/2005
9:04 PM

Date:
Client: TVA
Project: TVA Kingston - Proposed Gypsum Stack
Project No.: 3043051021
Location: NB-18
Depth: 6.5'-18.5' **Sample Number:** UD-1, 3 & 4 (CU)
Description:
Remarks:
Type of Sample: undisturbed
Specific Gravity=2.62 LL=81 **PL**=42 **PI**=39
Test Method: COE uniform strain

[illegible]

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1153.600			1184.710
Moisture content: Dry soil+tare, gms.	893.200			907.100
Moisture content: Tare, gms.	0.000			14.150
Moisture, %	29.2	32.0	31.4	31.1
Moist specimen weight, gms.	1153.6			
Diameter, in.	2.84	2.84	2.84	
Area, in.^{2}	6.35	6.35	6.32	
Height, in.	6.02	6.02	6.00	
Net decrease in height, in.		0.00	0.02	
Wet Density, pcf	115.0	117.5	117.9	
Dry density, pcf	89.0	89.0	89.8	
Void ratio	0.8376	0.8376	0.8221	
Saturation, %	91.2	100.0	100.0	

[illegible]

Load ring constant = 0.72 lbs. per input unit
Consolidation cell pressure = 40.00 psi (5.76 ksf)
Consolidation back pressure = 20.00 psi (2.88 ksf)
Consolidation effective confining stress = 2.88 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 6.15 ksf **at reading no.** 14

Test Readings for Specimen No. [illegible]

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	2.88	2.88	1.00	20.00	2.88	0.00
1	0.0100	97.0	69.8	0.2	1.59	2.65	4.24	1.60	21.60	3.44	0.79
2	0.0200	132.0	95.0	0.3	2.16	2.55	4.71	1.85	22.30	3.63	1.08
3	0.0300	156.0	112.3	0.5	2.55	2.45	5.00	2.04	23.00	3.72	1.27
4	0.0400	174.0	125.3	0.7	2.84	2.38	5.21	2.19	23.50	3.79	1.42
5	0.0500	192.0	138.2	0.8	3.13	2.29	5.41	2.36	24.10	3.85	1.56
6	0.0600	206.0	148.3	1.0	3.35	2.22	5.57	2.51	24.60	3.89	1.67
7	0.0700	219.0	157.7	1.2	3.55	2.15	5.70	2.66	25.10	3.92	1.78
8	0.0800	232.0	167.0	1.3	3.76	2.09	5.85	2.80	25.50	3.97	1.88
9	0.0900	243.0	175.0	1.5	3.93	2.03	5.96	2.93	25.90	3.99	1.96
10	0.1000	255.0	183.6	1.7	4.12	1.99	6.10	3.07	26.20	4.05	2.06
11	0.2000	327.0	235.4	3.3	5.19	1.79	6.97	3.91	27.60	4.38	2.59
12	0.3000	375.0	270.0	5.0	5.85	1.92	7.76	4.05	26.70	4.84	2.92
13	0.4000	398.0	286.6	6.7	6.10	2.13	8.23	3.86	25.20	5.18	3.05
14	0.5000	409.0	294.5	8.3	6.15	2.33	8.49	3.64	23.80	5.41	3.08
15	0.6000	414.0	298.1	10.0	6.12	2.53	8.65	3.41	22.40	5.59	3.06
16	0.7000	416.0	299.5	11.7	6.03	2.69	8.72	3.24	21.30	5.71	3.02
17	0.8000	421.0	303.1	13.3	5.99	2.85	8.84	3.10	20.20	5.85	2.99
18	0.9070	426.0	306.7	15.1	5.94	3.01	8.95	2.97	19.10	5.98	2.97
19	1.0000	433.0	311.8	16.7	5.92	3.11	9.03	2.90	18.40	6.07	2.96
20	1.1460	435.0	313.2	19.1	5.78	3.27	9.05	2.77	17.30	6.16	2.89
21	1.2017	437.0	314.6	20.0	5.74	3.34	9.08	2.72	16.80	6.21	2.87

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1113.500			1136.000
Moisture content: Dry soil+tare, gms.	878.900			892.950
Moisture content: Tare, gms.	0.000			13.930
Moisture, %	26.7	31.1	28.0	27.7
Moist specimen weight, gms.	1113.5			
Diameter, in.	2.84	2.84	2.80	
Area, in.²	6.35	6.35	6.15	
Height, in.	5.85	5.85	5.76	
Net decrease in height, in.		0.00	0.09	
Wet Density, pcf	114.1	118.1	120.8	
Dry density, pcf	90.1	90.1	94.4	
Void ratio	0.8153	0.8153	0.7325	
Saturation, %	85.8	100.0	100.0	

Test Readings for Specimen No. 2

Load ring constant = 0.72 lbs. per input unit
Consolidation cell pressure = 60.00 psi (8.64 ksf)
Consolidation back pressure = 20.00 psi (2.88 ksf)
Consolidation effective confining stress = 5.76 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 6.24 ksf **at reading no.** 19

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	5.76	5.76	1.00	20.00	5.76	0.00
1	0.0100	115.0	82.8	0.2	1.93	5.54	7.48	1.35	21.50	6.51	0.97
2	0.0200	155.0	111.6	0.3	2.60	5.39	7.99	1.48	22.60	6.69	1.30
3	0.0300	186.0	133.9	0.5	3.12	5.23	8.35	1.60	23.70	6.79	1.56
4	0.0400	209.0	150.5	0.7	3.50	5.08	8.58	1.69	24.70	6.83	1.75
5	0.0500	222.0	159.8	0.9	3.71	4.95	8.66	1.75	25.60	6.81	1.85
6	0.0600	235.0	169.2	1.0	3.92	4.84	8.76	1.81	26.40	6.80	1.96
7	0.0700	245.0	176.4	1.2	4.08	4.75	8.83	1.86	27.00	6.79	2.04
8	0.0800	252.0	181.4	1.4	4.19	4.68	8.87	1.89	27.50	6.77	2.09
9	0.0900	259.0	186.5	1.6	4.30	4.61	8.90	1.93	28.00	6.76	2.15
10	0.1000	266.0	191.5	1.7	4.40	4.54	8.94	1.97	28.50	6.74	2.20
11	0.2000	309.0	222.5	3.5	5.03	3.97	9.00	2.26	32.40	6.49	2.51
12	0.3000	336.0	241.9	5.2	5.37	3.61	8.98	2.48	34.90	6.30	2.68
13	0.4000	360.0	259.2	6.9	5.65	3.44	9.09	2.64	36.10	6.26	2.82
14	0.5000	384.0	276.5	8.7	5.91	3.34	9.25	2.77	36.80	6.30	2.95
15	0.6000	400.0	288.0	10.4	6.04	3.33	9.37	2.82	36.90	6.35	3.02
16	0.7000	415.0	298.8	12.1	6.14	3.34	9.48	2.84	36.80	6.41	3.07
17	0.8000	427.0	307.4	13.9	6.20	3.40	9.59	2.82	36.40	6.50	3.10
18	0.9000	438.0	315.4	15.6	6.23	3.47	9.70	2.79	35.90	6.58	3.11
19	1.0000	448.0	322.6	17.3	6.24	3.54	9.78	2.76	35.40	6.66	3.12
20	1.1000	453.0	326.2	19.1	6.18	3.61	9.79	2.71	34.90	6.70	3.09
21	1.2000	460.0	331.2	20.8	6.14	3.72	9.85	2.65	34.20	6.78	3.07

Parameters for Specimen No. [illegible]

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1095.000			1095.900
Moisture content: Dry soil+tare, gms.	827.600			841.350
Moisture content: Tare, gms.	0.000			13.570
Moisture, %	32.3	36.4	30.7	30.8
Moist specimen weight, gms.	1095.0			
Diameter, in.	2.81	2.81	2.74	
Area, in.²	6.20	6.20	5.88	
Height, in.	6.07	6.07	5.91	
Net decrease in height, in.		0.00	0.16	
Wet Density, pcf	110.8	114.2	118.5	
Dry density, pcf	83.7	83.7	90.7	
Void ratio	0.9535	0.9535	0.8037	
Saturation, %	88.8	100.0	100.0	

Test Readings for Specimen No. [illegible]

Load ring constant = 0.72 lbs. per input unit

Consolidation cell pressure = 100.00 psi (14.40 ksf)

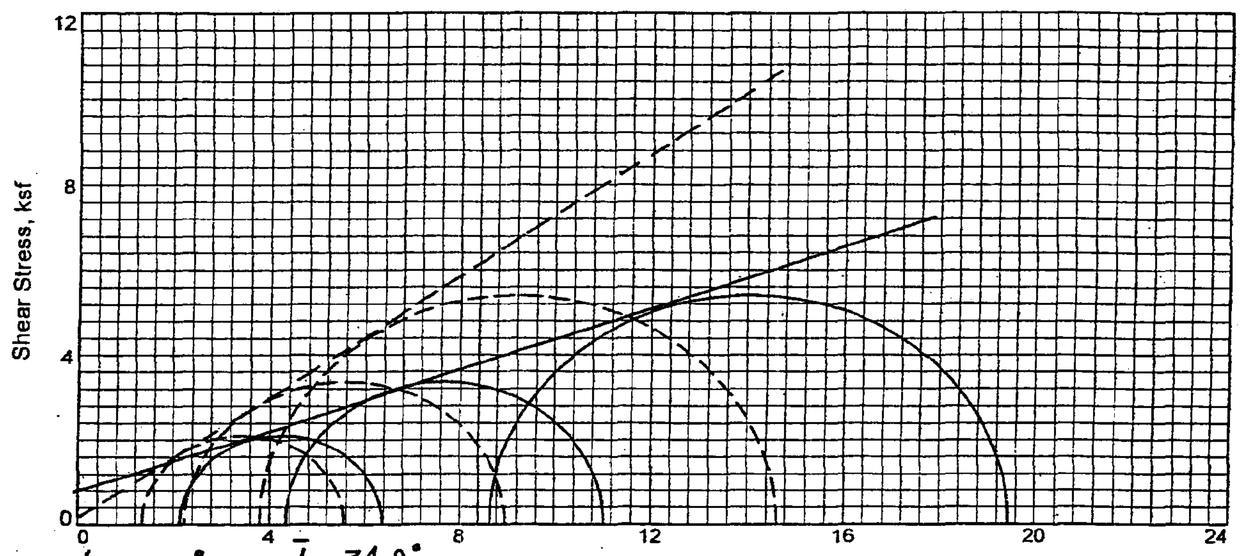
Consolidation back pressure = 20.00 psi (2.88 ksf)

Consolidation effective confining stress = 11.52 ksf

Strain rate, in./min. = 0.02

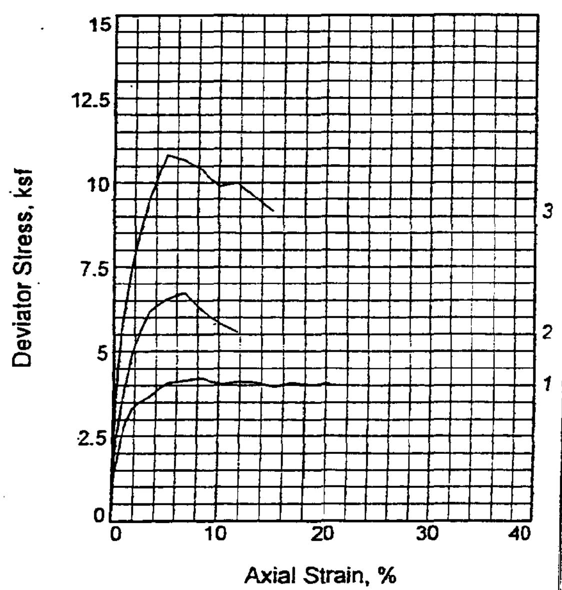
Fail. Stress = 10.76 ksf at reading no. 16

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	11.52	11.52	1.00	20.00	11.52	0.00
1	0.0100	52.0	37.4	0.2	0.92	11.40	12.32	1.08	20.80	11.86	0.46
2	0.0200	59.0	42.5	0.3	1.04	11.39	12.43	1.09	20.90	11.91	0.52
3	0.0300	69.0	49.7	0.5	1.21	11.36	12.57	1.11	21.10	11.97	0.61
4	0.0400	75.0	54.0	0.7	1.31	11.33	12.65	1.12	21.30	11.99	0.66
5	0.0500	86.0	61.9	0.8	1.50	11.29	12.79	1.13	21.60	12.04	0.75
6	0.0600	168.0	121.0	1.0	2.93	11.16	14.09	1.26	22.50	12.63	1.47
7	0.0700	289.0	208.1	1.2	5.04	10.93	15.97	1.46	24.10	13.45	2.52
8	0.0800	342.0	246.2	1.4	5.95	10.77	16.72	1.55	25.20	13.75	2.97
9	0.0900	376.0	270.7	1.5	6.53	10.63	17.16	1.61	26.20	13.89	3.27
10	0.1000	401.0	288.7	1.7	6.95	10.51	17.46	1.66	27.00	13.99	3.48
11	0.2000	548.0	394.6	3.4	9.34	9.26	18.60	2.01	35.70	13.93	4.67
12	0.3000	596.0	429.1	5.1	9.98	8.35	18.33	2.19	42.00	13.34	4.99
13	0.4000	641.0	461.5	6.8	10.54	7.72	18.26	2.37	46.40	12.99	5.27
14	0.5000	652.0	469.4	8.5	10.53	7.27	17.80	2.45	49.50	12.54	5.26
15	0.6000	664.0	478.1	10.1	10.52	6.93	17.45	2.52	51.90	12.19	5.26
16	0.7000	692.0	498.2	11.8	10.76	6.68	17.44	2.61	53.60	12.06	5.38
17	0.8000	678.0	488.2	13.5	10.34	6.49	16.83	2.59	54.90	11.66	5.17
18	0.9000	706.0	508.3	15.2	10.56	6.39	16.95	2.65	55.60	11.67	5.28
19	1.0000	711.0	511.9	16.9	10.42	6.32	16.74	2.65	56.10	11.53	5.21
20	1.1000	713.0	513.4	18.6	10.24	6.26	16.50	2.63	56.50	11.38	5.12
21	1.2000	727.0	523.4	20.3	10.22	6.24	16.46	2.64	56.70	11.35	5.11



$\phi = 19.9°$ $\bar{\phi} = 34.8°$ Total Normal Stress, ksf ———

$C = 0.76$ ksf $\bar{C} = 0.16$ ksf Effective Normal Stress, ksf — — —



	Sample No.	1	2	3
Initial	Water Content,	27.5	29.6	29.4
	Dry Density, pcf	93.0	89.8	92.7
	Saturation,	93.8	93.1	99.6
	Void Ratio	0.7787	0.8428	0.7837
	Diameter, in.	2.85	2.84	2.83
	Height, in.	5.98	6.08	6.11
At Test	Water Content,	26.5	27.5	25.0
	Dry Density, pcf	97.2	95.6	99.5
	Saturation,	100.0	100.0	100.0
	Void Ratio	0.7027	0.7299	0.6629
	Diameter, in.	2.81	2.78	2.76
	Height, in.	5.89	5.96	5.97
	Strain rate, in./min.	0.02	0.02	0.02
	Back Pressure, ksf	4.3	4.3	4.3
	Cell Pressure, ksf	6.5	8.6	13.0
	Fail. Stress, ksf	4.2	6.7	10.8
	Total Pore Pr., ksf	5.1	6.4	9.2
	Ult. Stress, ksf			
	Total Pore Pr., ksf			
	$\bar{\sigma}_1$ Failure, ksf	5.6	9.0	14.6
	$\bar{\sigma}_3$ Failure, ksf	1.4	2.2	3.8

Type of Test:
CU with Pore Pressures

Sample Type: undisturbed

Description: Brown fat clay with sand

LL= 53 **PL=** 28 **PI=** 25

Specific Gravity= 2.65

Remarks: CH

Figure ______

Client: TVA

Project: TVA Kingston - Proposed Gypsum Stack

Location: NB-21A

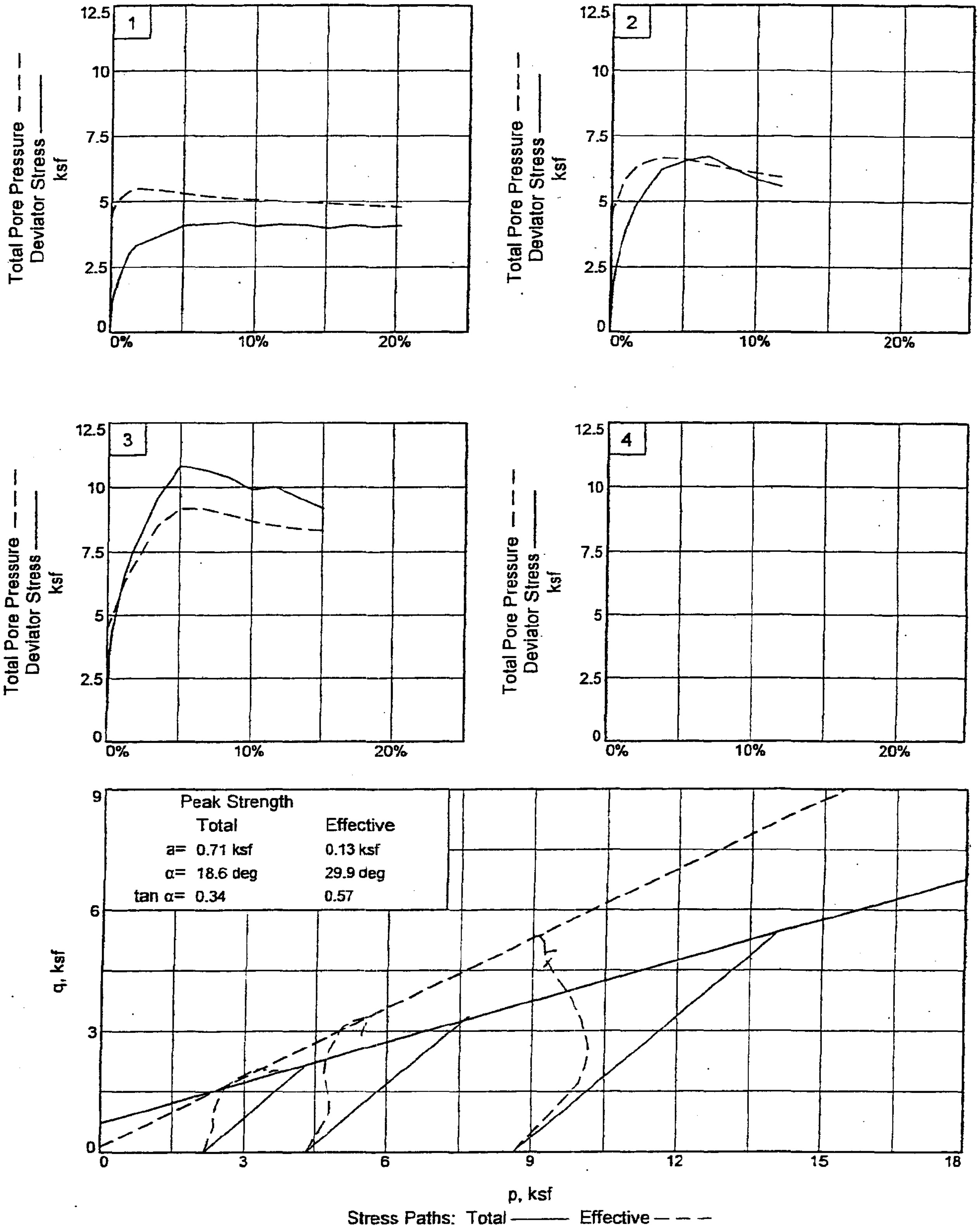
Sample Number: UD-1, 2 & 3 (CU) **Depth:** 15'-23'

Proj. No.: 3043051021 **Date:**

TRIAXIAL SHEAR TEST REPORT

MACTEC, INC.

Tested By: Alexander **Checked By:** Hamlett



Client: TVA

Project: TVA Kingston - Proposed Gypsum Stack

Location: NB-21A **Depth:** 15'-23' **Sample Number:** UD-1, 2 & 3 (CU)

Project No.: 3043051021 **Figure** ______ **MACTEC, INC.**

Tested By: Alexander **Checked By:** Hamlett

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

9/13/2005
9:21 PM

Date:
Client: TVA
Project: TVA Kingston - Proposed Gypsum Stack
Project No.: 3043051021
Location: NB-21A
Depth: 15'-23' **Sample Number:** UD-1, 2 & 3 (CU)
Description:
Remarks:
Type of Sample: undisturbed
Specific Gravity=2.65 **LL**=53 **PL**=28 **PI**=25
Test Method: COE uniform strain

[illegible]

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1190.700			1289.490
Moisture content: Dry soil+tare, gms.	933.520			1021.630
Moisture content: Tare, gms.	0.000			88.110
Moisture, %	27.5	29.4	26.5	28.7
Moist specimen weight, gms.	1190.7			
Diameter, in.	2.85	2.85	2.81	
Area, in.²	6.39	6.39	6.21	
Height, in.	5.98	5.98	5.89	
Net decrease in height, in.		0.00	0.09	
Wet Density, pcf	118.6	120.3	122.9	
Dry density, pcf	93.0	93.0	97.2	
Void ratio	0.7787	0.7787	0.7027	
Saturation, %	93.8	100.0	100.0	

[illegible]

Load ring constant = 0.72 lbs. per input unit
Consolidation cell pressure = 45.00 psi (6.48 ksf)
Consolidation back pressure = 30.00 psi (4.32 ksf)
Consolidation effective confining stress = 2.16 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 4.20 ksf **at reading no.** 14

[illegible] Readings for Specimen No. [illegible]

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	2.16	2.16	1.00	30.00	2.16	0.00
1	0.0100	74.0	53.3	0.2	1.23	1.74	2.98	1.71	32.90	2.36	0.62
2	0.0200	98.0	70.6	0.3	1.63	1.54	3.17	2.06	34.30	2.36	0.82
3	0.0300	120.0	86.4	0.5	1.99	1.37	3.36	2.46	35.50	2.36	1.00
4	0.0400	138.0	99.4	0.7	2.29	1.27	3.56	2.81	36.20	2.41	1.14
5	0.0500	153.0	110.2	0.8	2.53	1.20	3.73	3.12	36.70	2.46	1.27
6	0.0600	166.0	119.5	1.0	2.74	1.14	3.88	3.41	37.10	2.51	1.37
7	0.0700	179.0	128.9	1.2	2.95	1.08	4.03	3.73	37.50	2.56	1.48
8	0.0800	187.0	134.6	1.4	3.08	1.05	4.13	3.93	37.70	2.59	1.54
9	0.0900	194.0	139.7	1.5	3.19	1.01	4.20	4.16	38.00	2.60	1.60
10	0.1000	201.0	144.7	1.7	3.30	0.98	4.28	4.37	38.20	2.63	1.65
11	0.2000	229.0	164.9	3.4	3.69	1.05	4.75	4.51	37.70	2.90	1.85
12	0.3000	256.0	184.3	5.1	4.06	1.18	5.24	4.44	36.80	3.21	2.03
13	0.4000	265.0	190.8	6.8	4.12	1.28	5.41	4.22	36.10	3.34	2.06
14	0.5000	275.0	198.0	8.5	4.20	1.35	5.56	4.10	35.60	3.45	2.10
15	0.6000	269.0	193.7	10.2	4.03	1.41	5.45	3.86	35.20	3.43	2.02
16	0.7000	279.0	200.9	11.9	4.11	1.47	5.57	3.80	34.80	3.52	2.05
17	0.8000	283.0	203.8	13.6	4.08	1.53	5.61	3.68	34.40	3.57	2.04
18	0.9000	279.0	200.9	15.3	3.95	1.57	5.52	3.52	34.10	3.54	1.97
19	1.0000	294.0	211.7	17.0	4.08	1.63	5.70	3.51	33.70	3.67	2.04
20	1.1000	295.0	212.4	18.7	4.01	1.66	5.66	3.42	33.50	3.66	2.00
21	1.2000	305.0	219.6	20.4	4.06	1.70	5.76	3.39	33.20	3.73	2.03

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1178.700			1201.320
Moisture content: Dry soil+tare, gms.	909.500			923.300
Moisture content: Tare, gms.	0.000			13.570
Moisture, %	29.6	31.8	27.5	30.6
Moist specimen weight, gms.	1178.7			
Diameter, in.	2.84	2.84	2.78	
Area, in.^{2}	6.34	6.34	6.08	
Height, in.	6.08	6.08	5.96	
Net decrease in height, in.		0.00	0.13	
Wet Density, pcf	116.3	118.3	122.0	
Dry density, pcf	89.8	89.8	95.6	
Void ratio	0.8428	0.8428	0.7299	
Saturation, %	93.1	100.0	100.0	

Readings for Specimen No. 2

Load ring constant = 0.72 lbs. per input unit

Consolidation cell pressure = 60.00 psi (8.64 ksf)

Consolidation back pressure = 30.00 psi (4.32 ksf)

Consolidation effective confining stress = 4.32 ksf

Strain rate, in./min. = 0.02

Fail. Stress = 6.73 ksf **at reading no.** 13

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	4.32	4.32	1.00	30.00	4.32	0.00
1	0.0100	114.0	82.1	0.2	1.94	3.83	5.77	1.51	33.40	4.80	0.97
2	0.0200	149.0	107.3	0.3	2.53	3.54	6.07	1.71	35.40	4.81	1.27
3	0.0300	173.0	124.6	0.5	2.93	3.30	6.23	1.89	37.10	4.77	1.47
4	0.0400	194.0	139.7	0.7	3.29	3.10	6.38	2.06	38.50	4.74	1.64
5	0.0500	211.0	151.9	0.8	3.57	2.92	6.49	2.22	39.70	4.71	1.78
6	0.0600	229.0	164.9	1.0	3.87	2.75	6.62	2.41	40.90	4.68	1.93
7	0.0700	246.0	177.1	1.2	4.15	2.62	6.77	2.58	41.80	4.69	2.07
8	0.0800	261.0	187.9	1.3	4.39	2.51	6.90	2.75	42.60	4.70	2.20
9	0.0900	277.0	199.4	1.5	4.65	2.40	7.06	2.93	43.30	4.73	2.33
10	0.1000	292.0	210.2	1.7	4.90	2.30	7.20	3.12	44.00	4.75	2.45
11	0.2000	376.0	270.7	3.4	6.20	1.97	8.17	4.14	46.30	5.07	3.10
12	0.3000	403.0	290.2	5.0	6.53	2.03	8.56	4.21	45.90	5.29	3.26
13	0.4000	423.0	304.6	6.7	6.73	2.25	8.97	4.00	44.40	5.61	3.36
14	0.5000	399.0	287.3	8.4	6.23	2.42	8.65	3.58	43.20	5.54	3.12
15	0.6000	380.0	273.6	10.1	5.83	2.56	8.39	3.27	42.20	5.48	2.91
16	0.7000	370.0	266.4	11.7	5.57	2.71	8.27	3.06	41.20	5.49	2.78

Parameters for Specimen No. [illegible]

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1208.200			1209.110
Moisture content: Dry soil+tare, gms.	933.400			946.980
Moisture content: Tare, gms.	0.000			13.380
Moisture, %	29.4	29.6	25.0	28.1
Moist specimen weight, gms.	1208.2			
Diameter, in.	2.83	2.83	2.76	
Area, in.^{2}	6.28	6.28	5.99	
Height, in.	6.11	6.11	5.97	
Net decrease in height, in.		0.00	0.14	
Wet Density, pcf	120.1	120.2	124.4	
Dry density, pcf	92.7	92.7	99.5	
Void ratio	0.7837	0.7837	0.6629	
Saturation, %	99.6	100.0	100.0	

Test Readings for Specimen No. [illegible]

Load ring constant = 0.72 lbs. per input unit

Consolidation cell pressure = 90.00 psi (12.96 ksf)

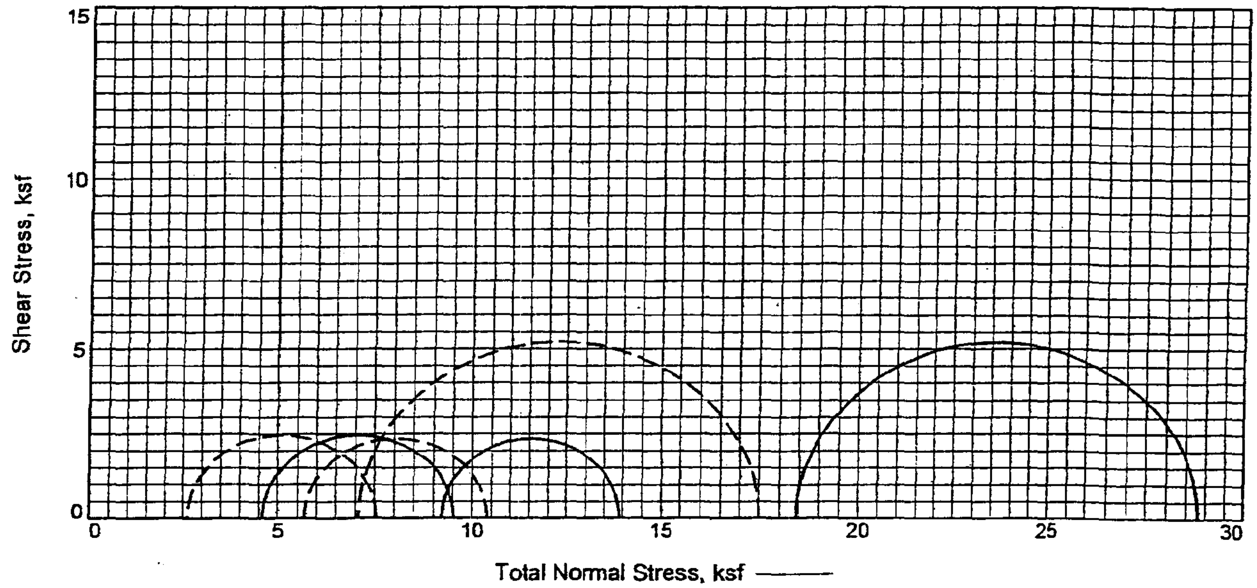
Consolidation back pressure = 30.00 psi (4.32 ksf)

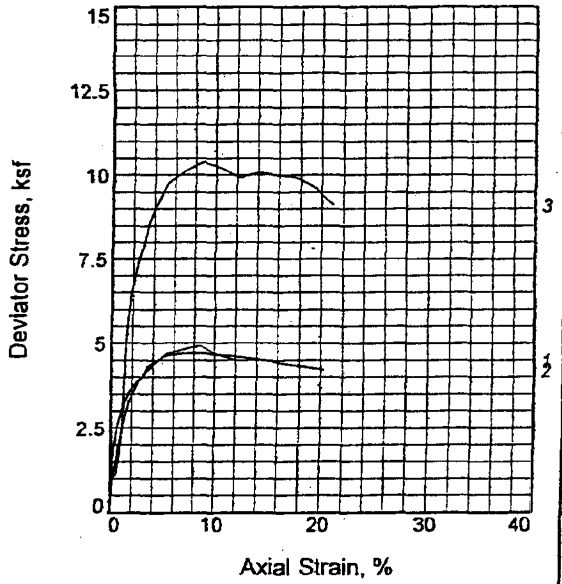
Consolidation effective confining stress = 8.64 ksf

Strain rate, in./min. = 0.02

Fail. Stress = 10.82 ksf **at reading no.** 12

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	8.64	8.64	1.00	30.00	8.64	0.00
1	0.0100	197.0	141.8	0.2	3.40	8.27	11.67	1.41	32.60	9.97	1.70
2	0.0200	249.0	179.3	0.3	4.30	7.96	12.26	1.54	34.70	10.11	2.15
3	0.0300	285.0	205.2	0.5	4.91	7.70	12.61	1.64	36.50	10.16	2.45
4	0.0400	312.0	224.6	0.7	5.36	7.46	12.82	1.72	38.20	10.14	2.68
5	0.0500	336.0	241.9	0.8	5.77	7.21	12.98	1.80	39.90	10.10	2.88
6	0.0600	359.0	258.5	1.0	6.15	6.97	13.12	1.88	41.60	10.05	3.08
7	0.0700	383.0	275.8	1.2	6.55	6.74	13.29	1.97	43.20	10.02	3.28
8	0.0800	402.0	289.4	1.3	6.87	6.51	13.37	2.05	44.80	9.94	3.43
9	0.0900	421.0	303.1	1.5	7.18	6.28	13.46	2.14	46.40	9.87	3.59
10	0.1000	439.0	316.1	1.7	7.47	6.11	13.58	2.22	47.60	9.84	3.74
11	0.2000	570.0	410.4	3.4	9.54	4.48	14.02	3.13	58.90	9.25	4.77
12	0.3000	658.0	473.8	5.0	10.82	3.80	14.62	3.85	63.60	9.21	5.41
13	0.4000	660.0	475.2	6.7	10.66	3.80	14.46	3.80	63.60	9.13	5.33
14	0.5000	655.0	471.6	8.4	10.39	4.03	14.42	3.58	62.00	9.23	5.19
15	0.6000	635.0	457.2	10.1	9.89	4.29	14.18	3.30	60.20	9.23	4.94
16	0.7000	655.0	471.6	11.7	10.01	4.46	14.47	3.24	59.00	9.47	5.00
17	0.8000	638.0	459.4	13.4	9.56	4.58	14.14	3.09	58.20	9.36	4.78
18	0.9000	623.0	448.6	15.1	9.16	4.64	13.80	2.98	57.80	9.22	4.58





Sample No.		1	2	3
Initial	Water Content,	24.5	29.9	26.5
	Dry Density, pcf	97.3	90.8	90.0
	Saturation,	92.4	95.8	83.5
	Void Ratio	0.7062	0.8288	0.8444
	Diameter, in.	2.85	2.84	2.89
	Height, in.	5.98	6.09	5.88
At Test	Water Content,	21.5	24.4	24.8
	Dry Density, pcf	105.7	100.6	100.1
	Saturation,	100.0	100.0	100.0
	Void Ratio	0.5717	0.6499	0.6587
	Diameter, in.	2.78	2.75	2.79
	Height, in.	5.82	5.88	5.68
Strain rate, in./min.		0.02	0.02	0.02
Back Pressure, ksf		2.9	2.9	2.9
Cell Pressure, ksf		7.5	12.1	21.3
Fail. Stress, ksf		4.9	4.7	10.4
Total Pore Pr., ksf		4.9	6.4	14.2
Ult. Stress, ksf				
Total Pore Pr., ksf				
$\bar{\sigma}_1$ Failure, ksf		7.6	10.4	17.5
$\bar{\sigma}_3$ Failure, ksf		2.6	5.7	7.1

Type of Test:
CU with Pore Pressures

Sample Type: undisturbed

Description: Dark gray lean clay with sand

LL= 36 **PL=** 21 **PI=** 15

Specific Gravity= 2.66

Remarks: CL

Figure ________

Client: TVA

Project: TVA Kingston - Proposed Gypsum Stack

Location: NB-21A

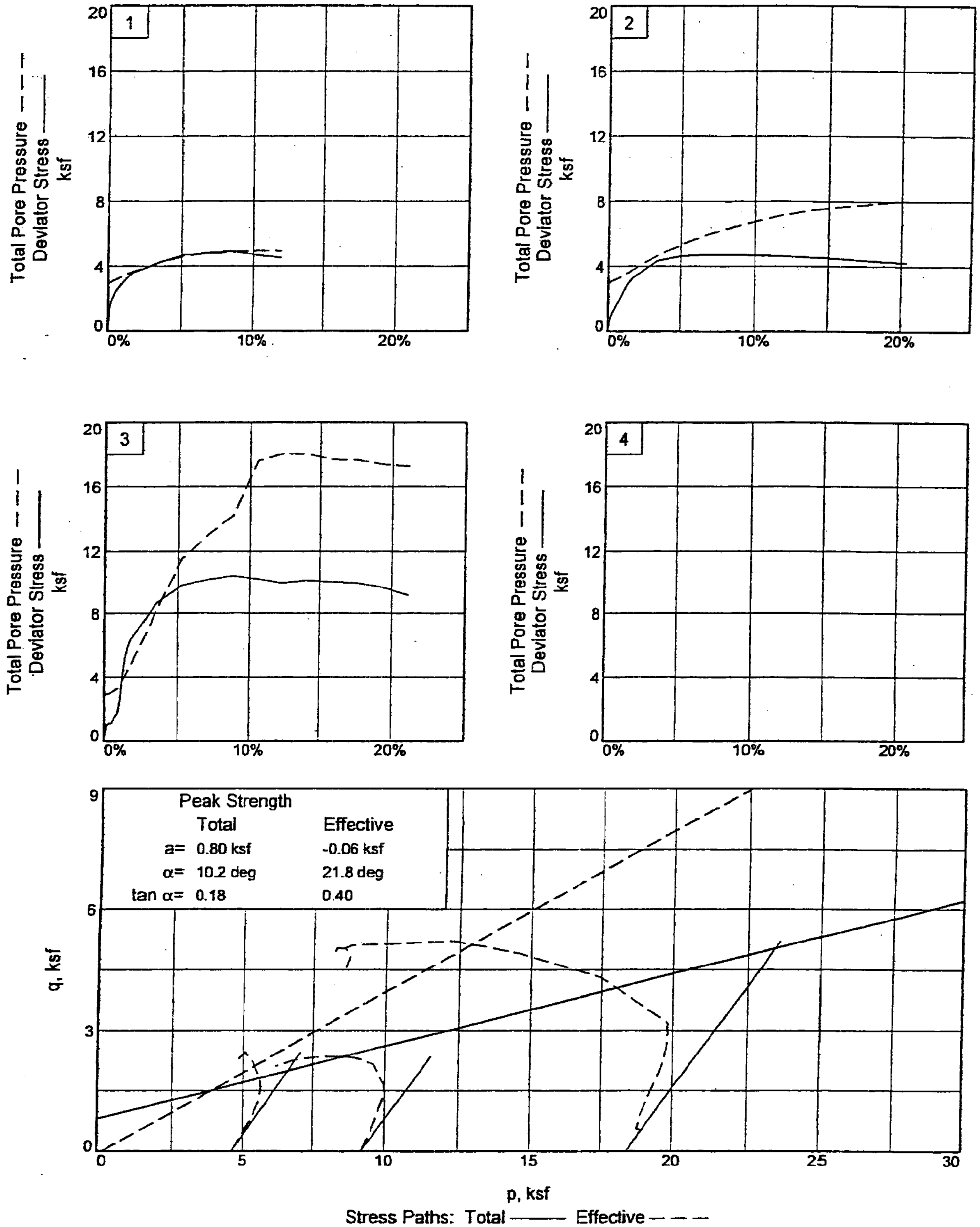
Sample Number: UD-4, 5 & 6 (CU) **Depth:** 30'-38'

Proj. No.: 3043051021 **Date:**

TRIAXIAL SHEAR TEST REPORT

MACTEC, INC.

Tested By: Alexander **Checked By:** Hamlett



Client: TVA
Project: TVA Kingston - Proposed Gypsum Stack
Location: NB-21A **Depth:** 30'-38' **Sample Number:** UD-4, 5 & 6 (CU)
Project No.: 3043051021 **Figure** ______

MACTEC, INC.

Tested By: Alexander **Checked By:** Hamlett

TRIAXIAL COMPRESSION TEST

CU with Pore Pressures

9/13/2005
9:27 PM

Date:
Client: TVA
Project: TVA Kingston - Proposed Gypsum Stack
Project No.: 3043051021
Location: NB-21A
Depth: 30'-38' **Sample Number:** UD-4, 5 & 6 (CU)
Description:
Remarks:
Type of Sample: undisturbed
Specific Gravity=2.66 **LL**=36 **PL**=21 **PI**=15
Test Method: COE uniform strain

Parameters for Specimen No.

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1220.600			649.530
Moisture content: Dry soil+tare, gms.	980.100			526.180
Moisture content: Tare, gms.	0.000			13.780
Moisture, %	24.5	26.5	21.5	24.1
Moist specimen weight, gms.	1216.3			
Diameter, in.	2.85	2.85	2.78	
Area, in.^{2}	6.39	6.39	6.05	
Height, in.	5.98	5.98	5.82	
Net decrease in height, in.		0.00	0.16	
Wet Density, pcf	121.2	123.2	128.4	
Dry density, pcf	97.3	97.3	105.7	
Void ratio	0.7062	0.7062	0.5717	
Saturation, %	92.4	100.0	100.0	

Test Readings for Specimen No.

Load ring constant = 0.72 lbs. per input unit
Consolidation cell pressure = 52.00 psi (7.49 ksf)
Consolidation back pressure = 20.00 psi (2.88 ksf)
Consolidation effective confining stress = 4.61 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 4.92 ksf **at reading no.** 14

Test Readings for Specimen No. [illegible]

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	4.61	4.61	1.00	20.00	4.61	0.00
1	0.0100	96.0	69.1	0.2	1.64	4.49	6.13	1.37	20.80	5.31	0.82
2	0.0200	121.0	87.1	0.3	2.07	4.39	6.46	1.47	21.50	5.43	1.03
3	0.0300	142.0	102.2	0.5	2.42	4.33	6.76	1.56	21.90	5.54	1.21
4	0.0400	156.0	112.3	0.7	2.65	4.25	6.90	1.62	22.50	5.58	1.33
5	0.0500	168.0	121.0	0.9	2.85	4.18	7.03	1.68	23.00	5.60	1.43
6	0.0600	180.0	129.6	1.0	3.05	4.10	7.16	1.74	23.50	5.63	1.53
7	0.0700	189.0	136.1	1.2	3.20	4.03	7.23	1.79	24.00	5.63	1.60
8	0.0800	198.0	142.6	1.4	3.35	3.96	7.31	1.84	24.50	5.63	1.67
9	0.0900	204.0	146.9	1.5	3.44	3.90	7.34	1.88	24.90	5.62	1.72
10	0.1000	211.0	151.9	1.7	3.55	3.84	7.40	1.92	25.30	5.62	1.78
11	0.2000	254.0	182.9	3.4	4.20	3.31	7.51	2.27	29.00	5.41	2.10
12	0.3000	287.0	206.6	5.2	4.66	2.92	7.59	2.60	31.70	5.26	2.33
13	0.4000	301.0	216.7	6.9	4.80	2.72	7.52	2.76	33.10	5.12	2.40
14	0.5000	314.0	226.1	8.6	4.92	2.64	7.55	2.87	33.70	5.09	2.46
15	0.6000	303.0	218.2	10.3	4.66	2.55	7.21	2.83	34.30	4.88	2.33
16	0.7000	298.0	214.6	12.0	4.49	2.56	7.06	2.75	34.20	4.81	2.25

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1228.800			600.630
Moisture content: Dry soil+tare, gms.	946.300			478.110
Moisture content: Tare, gms.	0.000			14.160
Moisture, %	29.9	31.2	24.4	26.4
Moist specimen weight, gms.	1196.2			
Diameter, in.	2.84	2.84	2.75	
Area, in.²	6.35	6.35	5.92	
Height, in.	6.09	6.09	5.88	
Net decrease in height, in.		0.00	0.20	
Wet Density, pcf	117.9	119.1	125.2	
Dry density, pcf	90.8	90.8	100.6	
Void ratio	0.8288	0.8288	0.6499	
Saturation, %	95.8	100.0	100.0	

Test Readings for Specimen No. 2

Load ring constant = 0.72 lbs. per input unit
Consolidation cell pressure = 84.00 psi (12.10 ksf)
Consolidation back pressure = 20.00 psi (2.88 ksf)
Consolidation effective confining stress = 9.22 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 4.71 ksf **at reading no.** 14

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	9.22	9.22	1.00	20.00	9.22	0.00
1	0.0100	51.0	36.7	0.2	0.89	9.04	9.93	1.10	21.20	9.49	0.45
2	0.0200	70.0	50.4	0.3	1.22	8.97	10.19	1.14	21.70	9.58	0.61
3	0.0300	87.0	62.6	0.5	1.51	8.91	10.43	1.17	22.10	9.67	0.76
4	0.0400	105.0	75.6	0.7	1.82	8.84	10.67	1.21	22.60	9.75	0.91
5	0.0500	122.0	87.8	0.8	2.12	8.76	10.87	1.24	23.20	9.81	1.06
6	0.0600	139.0	100.1	1.0	2.41	8.68	11.09	1.28	23.70	9.89	1.20
7	0.0700	154.0	110.9	1.2	2.66	8.61	11.27	1.31	24.20	9.94	1.33
8	0.0800	167.0	120.2	1.4	2.88	8.52	11.41	1.34	24.80	9.97	1.44
9	0.0900	179.0	128.9	1.5	3.08	8.44	11.52	1.37	25.40	9.98	1.54
10	0.1000	190.0	136.8	1.7	3.27	8.34	11.61	1.39	26.10	9.97	1.63
11	0.2000	255.0	183.6	3.4	4.31	7.46	11.77	1.58	32.20	9.61	2.16
12	0.3000	278.0	200.2	5.1	4.62	6.75	11.37	1.68	37.10	9.06	2.31
13	0.4000	288.0	207.4	6.8	4.70	6.16	10.86	1.76	41.20	8.51	2.35
14	0.5000	294.0	211.7	8.5	4.71	5.69	10.40	1.83	44.50	8.04	2.35
15	0.6000	297.0	213.8	10.2	4.67	5.30	9.97	1.88	47.20	7.63	2.33
16	0.7000	299.0	215.3	11.9	4.61	4.97	9.58	1.93	49.50	7.27	2.30
17	0.8000	301.0	216.7	13.6	4.55	4.71	9.26	1.97	51.30	6.98	2.28
18	0.9000	302.0	217.4	15.3	4.48	4.49	8.97	2.00	52.80	6.73	2.24
19	1.0000	301.0	216.7	17.0	4.37	4.33	8.71	2.01	53.90	6.52	2.19
20	1.1000	302.0	217.4	18.7	4.30	4.19	8.49	2.03	54.90	6.34	2.15
21	1.2000	303.0	218.2	20.4	4.22	4.08	8.30	2.04	55.70	6.19	2.11

Parameters for Specimen No. [illegible]

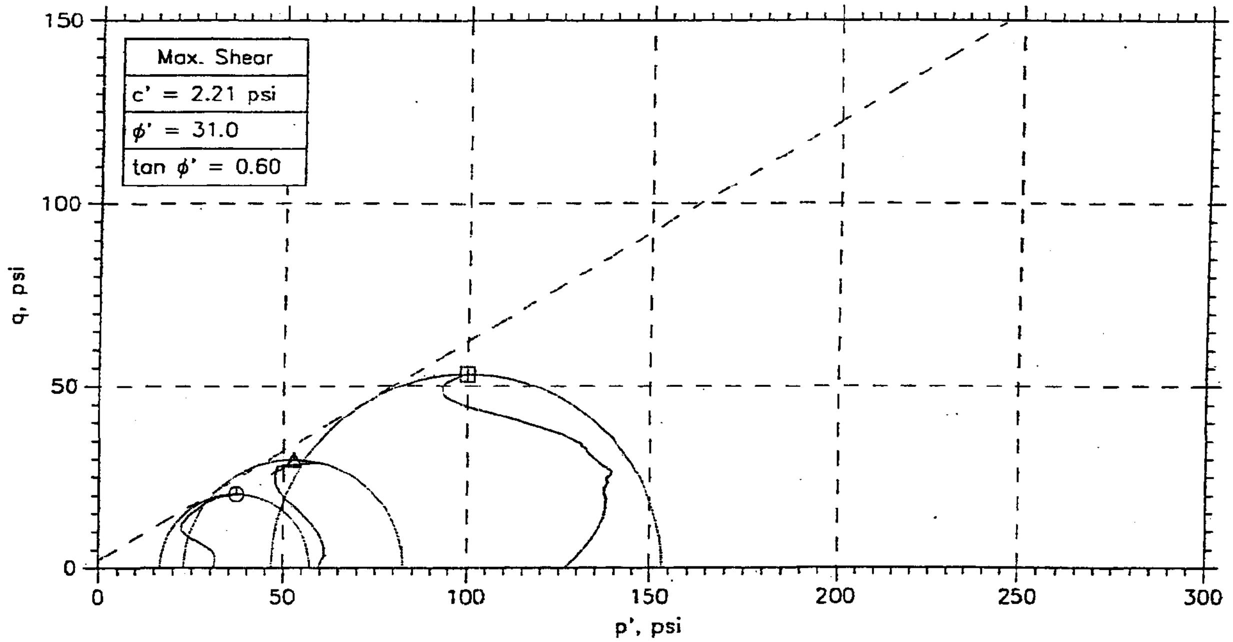
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1196.100			534.570
Moisture content: Dry soil+tare, gms.	945.400			438.140
Moisture content: Tare, gms.	0.000			8.080
Moisture, %	26.5	31.7	24.8	22.4
Moist specimen weight, gms.	1157.1			
Diameter, in.	2.89	2.89	2.79	
Area, in.²	6.58	6.58	6.13	
Height, in.	5.88	5.88	5.68	
Net decrease in height, in.		0.00	0.20	
Wet Density, pcf	113.9	118.6	124.9	
Dry density, pcf	90.0	90.0	100.1	
Void ratio	0.8444	0.8444	0.6587	
Saturation, %	83.5	100.0	100.0	

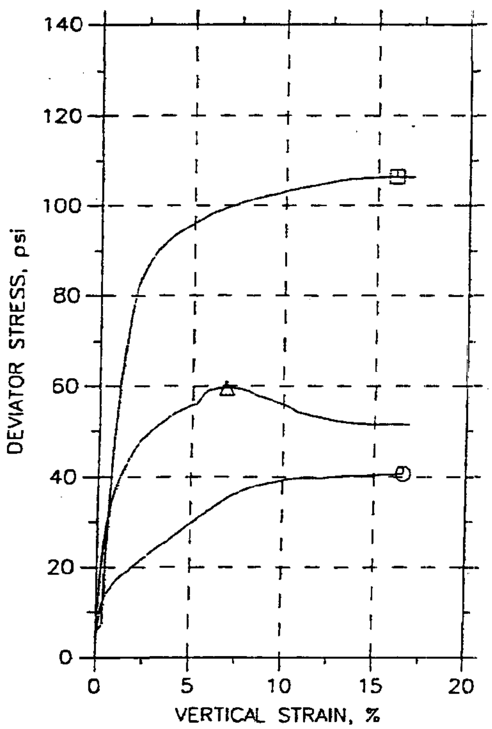
Test Readings for Specimen No. [illegible]

Load ring constant = 0.72 lbs. per input unit
Consolidation cell pressure = 148.00 psi (21.31 ksf)
Consolidation back pressure = 20.00 psi (2.88 ksf)
Consolidation effective confining stress = 18.43 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 10.40 ksf at reading no. 14

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	18.43	18.43	1.00	20.00	18.43	0.00
1	0.0100	59.0	42.5	0.2	1.00	18.40	19.40	1.05	20.20	18.90	0.50
2	0.0200	65.0	46.8	0.4	1.10	18.32	19.41	1.06	20.80	18.86	0.55
3	0.0300	65.0	46.8	0.5	1.09	18.23	19.32	1.06	21.40	18.78	0.55
4	0.0400	88.0	63.4	0.7	1.48	18.13	19.61	1.08	22.10	18.87	0.74
5	0.0500	104.0	74.9	0.9	1.74	18.01	19.76	1.10	22.90	18.89	0.87
6	0.0600	151.0	108.7	1.1	2.53	17.86	20.38	1.14	24.00	19.12	1.26
7	0.0700	252.0	181.4	1.2	4.21	17.52	21.74	1.24	26.30	19.63	2.11
8	0.0800	313.0	225.4	1.4	5.22	17.19	22.42	1.30	28.60	19.80	2.61
9	0.0900	351.0	252.7	1.6	5.85	16.91	22.75	1.35	30.60	19.83	2.92
10	0.1000	383.0	275.8	1.8	6.37	16.63	23.00	1.38	32.50	19.82	3.18
11	0.2000	528.0	380.2	3.5	8.62	13.18	21.80	1.65	56.50	17.49	4.31
12	0.3000	610.0	439.2	5.3	9.78	9.73	19.51	2.00	80.40	14.62	4.89
13	0.4000	645.0	464.4	7.0	10.15	8.31	18.46	2.22	90.30	13.38	5.07
14	0.5000	674.0	485.3	8.8	10.40	7.10	17.50	2.47	98.70	12.30	5.20
15	0.6000	674.0	485.3	10.6	10.20	3.72	13.92	3.75	122.20	8.82	5.10
16	0.7000	668.0	481.0	12.3	9.91	3.28	13.20	4.02	125.20	8.24	4.96
17	0.8000	694.0	499.7	14.1	10.09	3.28	13.37	4.07	125.20	8.33	5.05
18	0.9000	702.0	505.4	15.8	10.00	3.63	13.63	3.76	122.80	8.63	5.00
19	1.0000	712.0	512.6	17.6	9.93	3.66	13.59	3.71	122.60	8.62	4.96
20	1.1000	706.0	508.3	19.4	9.63	3.93	13.57	3.45	120.70	8.75	4.82
21	1.2000	682.0	491.0	21.1	9.10	4.05	13.15	3.25	119.90	8.60	4.55

CONSOLIDATED UNDRAINED TRIAXIAL TEST





Symbol		○	△	□	
Sample No.		UD-4	UD-4	UD-4	
Test No.		13775.1	13775.2	13775.3	
Depth		31-33 Ft.	31-33 ft	31-33 ft	
Initial	Diameter, in	2.85	2.828	2.87	
	Height, in	5.57	5.57	5.57	
	Water Content, %	27.4	26.7	26.4	
	Dry Density, pcf	95.63	96.16	97.38	
	Saturation, %	97.6	96.1	98.0	
	Void Ratio	0.756	0.746	0.724	
Before Shear	Water Content, %	24.7	24.3	21.0	
	Dry Density, pcf	100.9	101.4	107.4	
	Saturation*, %	100.0	99.7	100.0	
	Void Ratio	0.665	0.656	0.564	
	Back Press., psi	59.99	72.03	20	
Ver. Eff. Cons. Stress, psi		32	63.97	128	
Shear Strength, psi		20.33	29.8	53.19	
Strain at Failure, %		16.5	6.83	16	
Strain Rate, %/min		0.022	0.022	0.022	
B-Value		0.95	0.95	0.95	
Measured Specific Gravity		2.69	2.69	2.69	
Liquid Limit		34	34	34	
Plastic Limit		22	22	22	

GeoTesting express the groundwork for success

Project: TVA Kingston Gypsym Stock
Location: NB-21B
Project No.: GTX G0959
Boring No.: NB-21B
Sample Type: Shelby Tube
Description:
Remarks:

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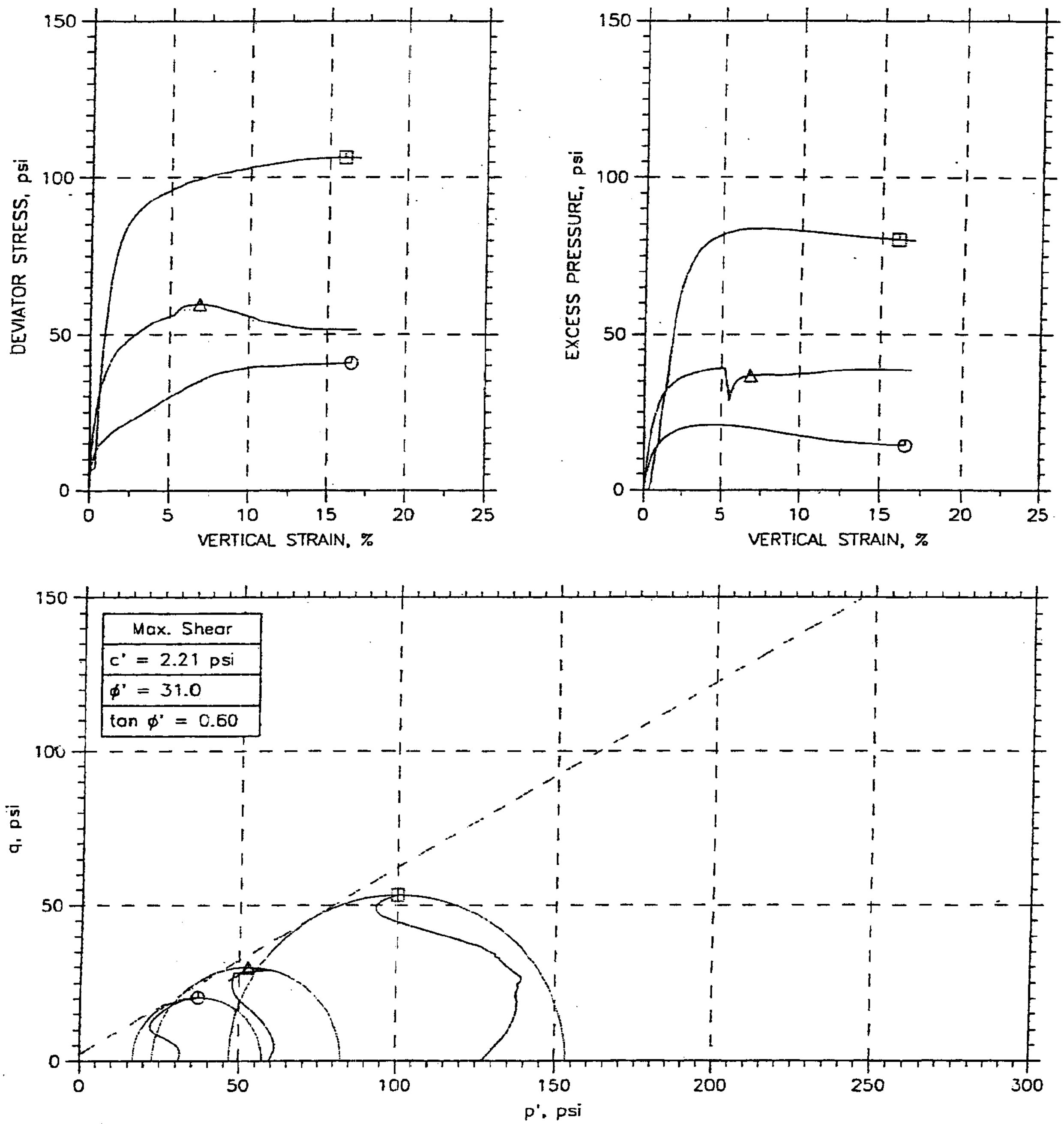
Phase calculations based on start and end of test.
* Saturation is set to 100% for phase calculations.

CONSOLIDATED UNDRAINED TRIAXIAL TEST



	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
O	UD-4	13775.1	31-33 Ft.	JW	12/12/05	HJ		13775.1_2054.dat
Δ	UD-5	13775.2	31-33 ft	JW	12/12/05	HJ		13775.2_1057.dat
□	UD-4	13775.3	31-33 ft	JW	12/12/05	HJ		13775.3o_1062.dat

GeoTesting express the groundwork for success

Project: TVA Kingston Gypsym Stdd	Location: NB-21B	Project No.: GTX G0959
Boring No.: NB-21B	Sample Type: Shelby Tube	
Description:		
Remarks:		

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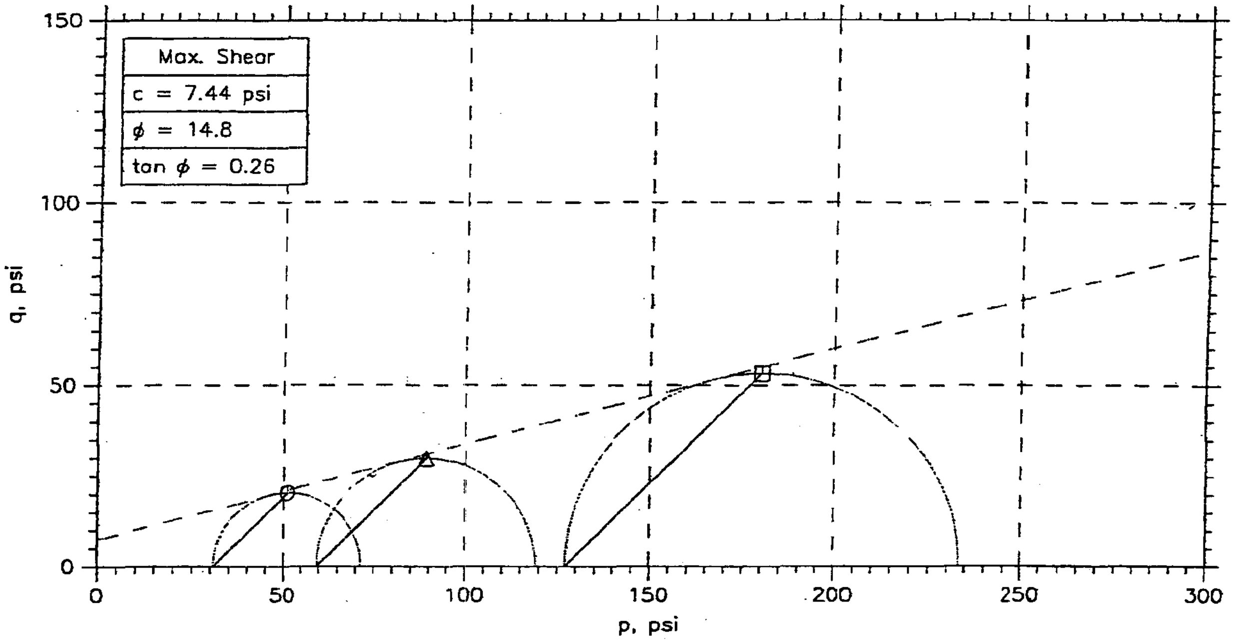
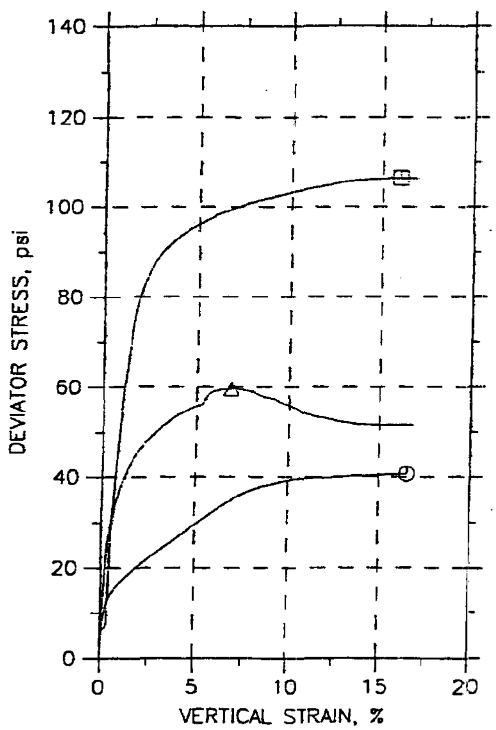
CONSOLIDATED UNDRAINED TRIAXIAL TEST





Symbol		O	Δ	□	
Sample No.		UD-4	UD-4	UD-4	
Test No.		13775.1	13775.2	13775.3	
Depth		31-33 Ft.	31-33 ft	31-33 ft	
Initial	Diameter, in	2.85	2.828	2.87	
	Height, in	5.57	5.57	5.57	
	Water Content, %	27.4	26.7	26.4	
	Dry Density, pcf	95.63	96.16	97.38	
	Saturation, %	97.6	96.1	98.0	
	Void Ratio	0.756	0.746	0.724	
Before Shear	Water Content, %	24.7	24.3	21.0	
	Dry Density, pcf	100.9	101.4	107.4	
	Saturation*, %	100.0	99.7	100.0	
	Void Ratio	0.665	0.656	0.564	
	Back Press., psi	59.99	72.03	20	
Ver. Eff. Cons. Stress, psi		32	63.97	128	
Shear Strength, psi		20.33	29.8	53.19	
Strain at Failure, %		16.5	6.83	16	
Strain Rate, %/min		0.022	0.022	0.022	
B-Value		0.95	0.95	0.95	
Measured Specific Gravity		2.69	2.69	2.69	
Liquid Limit		34	34	34	
Plastic Limit		22	22	22	

GeoTesting express the groundwork for success

Project: TVA Kingston Gypsym Stack	
Location: NB-21B	
Project No.: GTX G0959	
Boring No.: NB-21B	
Sample Type: Shelby Tube	
Description:	
Remarks:	

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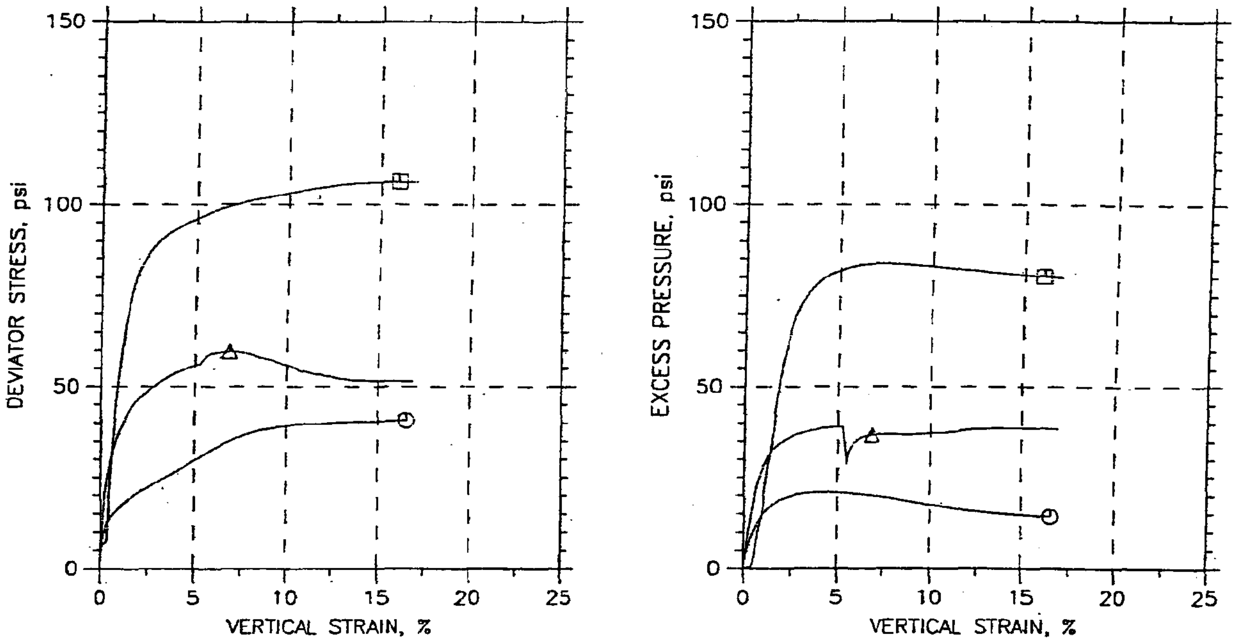
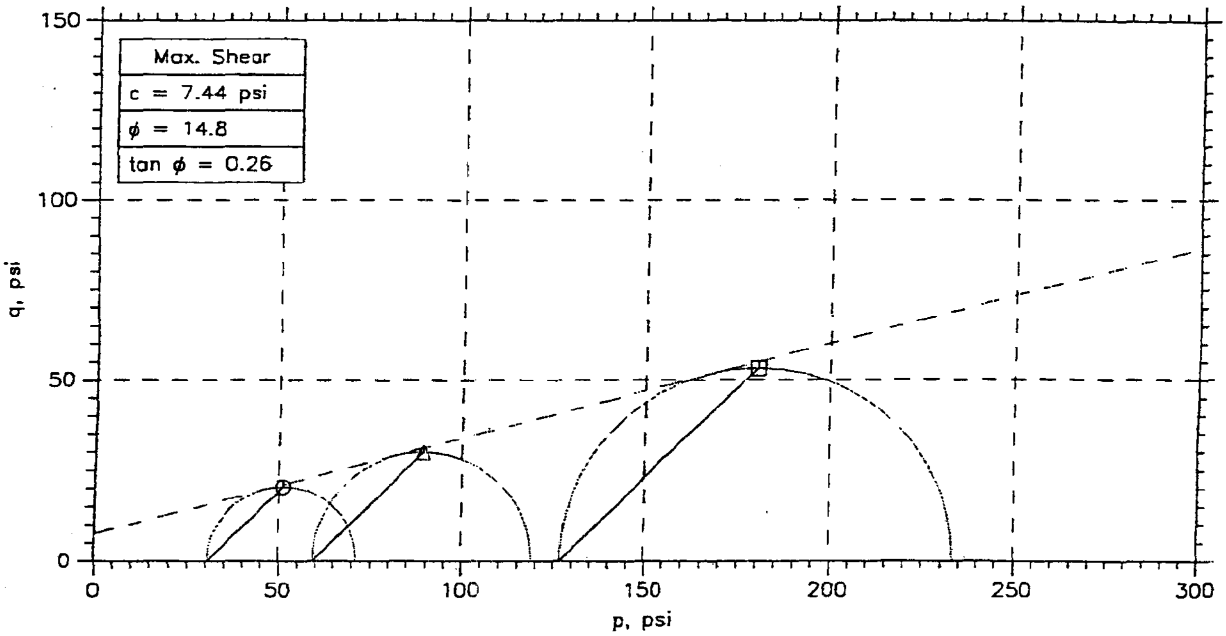
Phase calculations based on start and end of test.

* Saturation is set to 100% for phase calculations.

CONSOLIDATED UNDRAINED TRIAXIAL TEST





	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	UD-4	13775.1	31-33 Ft.	JW	12/12/05	HJ		13775.1_2054.dat
△	UD-5	13775.2	31-33 ft	JW	12/12/05	HJ		13775.2_1057.dat
□	UD-4	13775.3	31-33 ft.	JW	12/12/05	HJ		13775.3a_1062.dat

GeoTesting express
the groundwork for success

Project: TVA Kingston Gypsym Std	Location: NB-21B	Project No.: GTX G0959
Boring No.: NB-21B	Sample Type: Shelby Tube	
Description:		
Remarks:		

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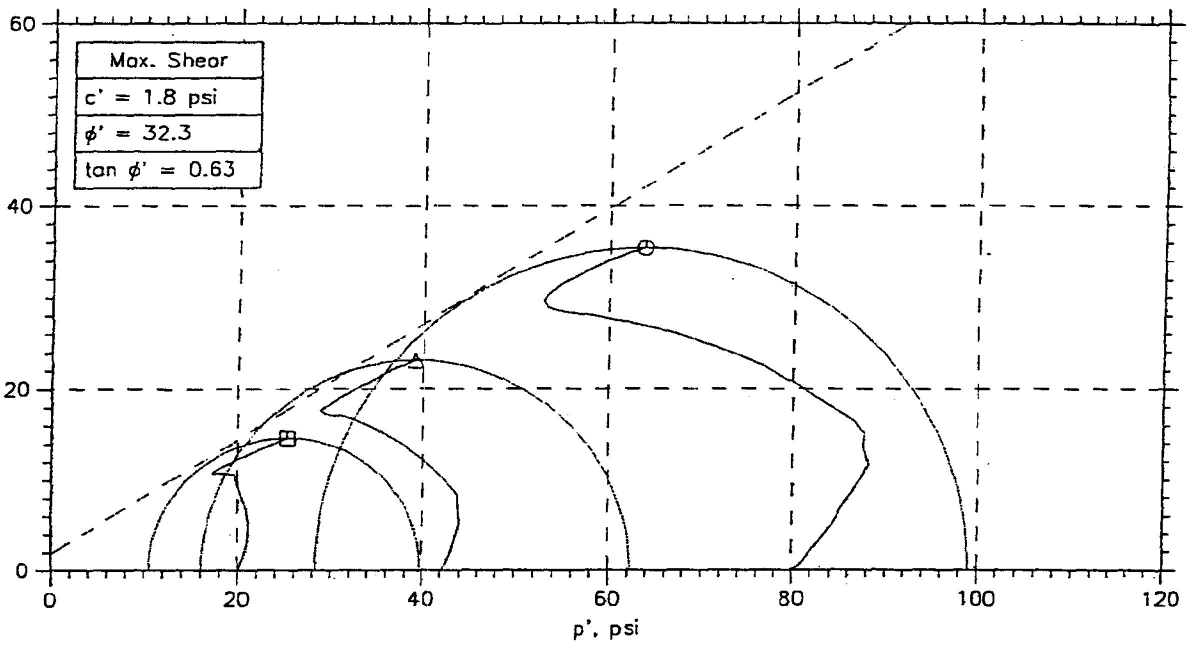
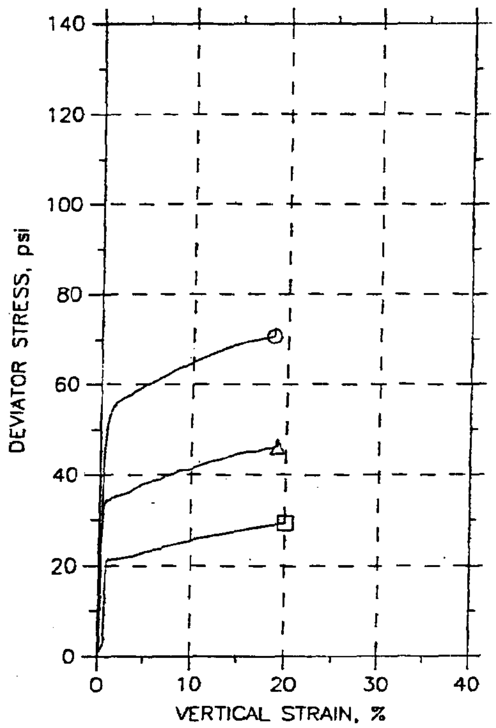
CONSOLIDATED UNDRAINED TRIAXIAL TEST





		○	△	□	
Symbol		○	△	□	
Sample No.		Bag	Bag	Bag	
Test No.		13923.3	13923.2	13923.1	
Depth		2-10 ft	2-10 ft	2-10 ft	
Initial	Diameter, in	2.87	2.87	2.87	
	Height, in	6	6	6	
	Water Content, %	19.7	19.6	19.7	
	Dry Density, pcf	101.9	101.9	102.	
	Saturation, %	84.5	84.4	85.0	
	Void Ratio	0.612	0.612	0.609	
Before Shear	Water Content, %	20.1	21.8	22.9	
	Dry Density, pcf	107.5	104.3	102.5	
	Saturation*, %	100.0	100.0	100.0	
	Void Ratio	0.527	0.574	0.601	
	Back Press., psi	59.99	89.99	89.99	
Ver. Eff. Cons. Stress, psi		80.01	40.32	20	
Shear Strength, psi		35.34	23.1	14.61	
Strain at Failure, %		18.5	19	19.9	
Strain Rate, %/min		0.022	0.022	0.022	
B-Value		0.95	0.95	0.95	
Measured Specific Gravity		2.63	2.63	2.63	
Liquid Limit		40	40	40	
Plastic Limit		22	22	22	

GeoTesting express a groundwork for success

Project: TVA Kingston Gypsym Stock	
Location: NB-22	
Project No.: GTX-G0959	
Boring No.: NB-22	
Sample Type: Remolded	
Description: Reddish Orange Lean Clay with Sand	
Remarks: Remolded to 95% of Standard Proctor max. dry density and +2% over opt.	

Phase calculations based on start and end of test.

* Saturation is set to 100% for phase calculations.

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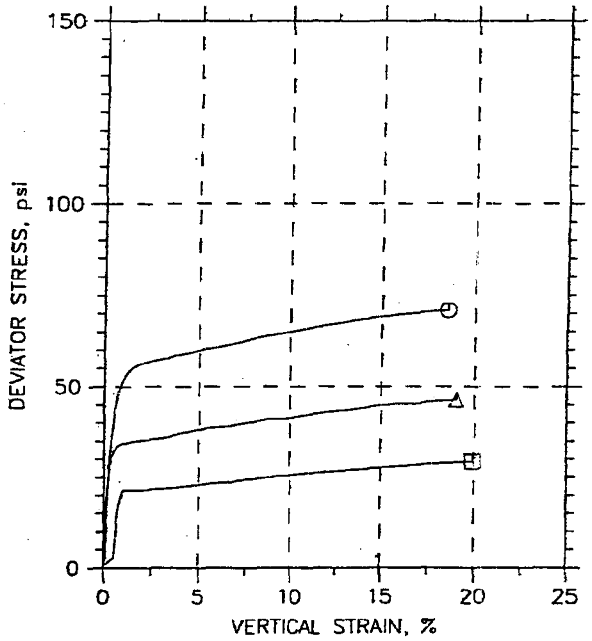
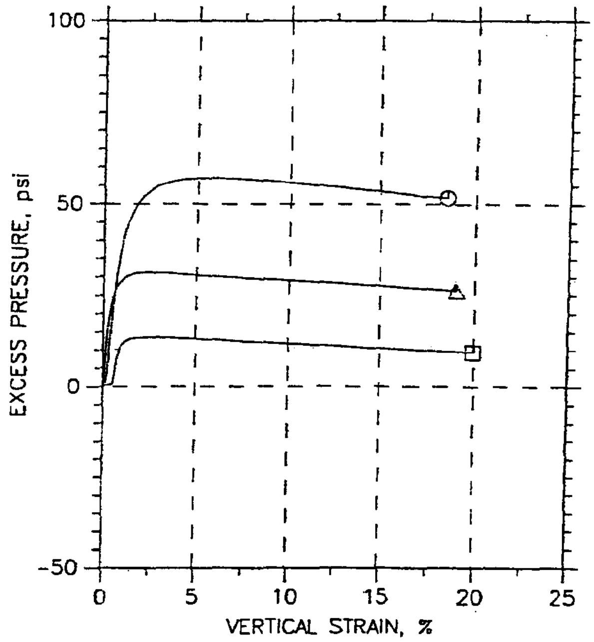
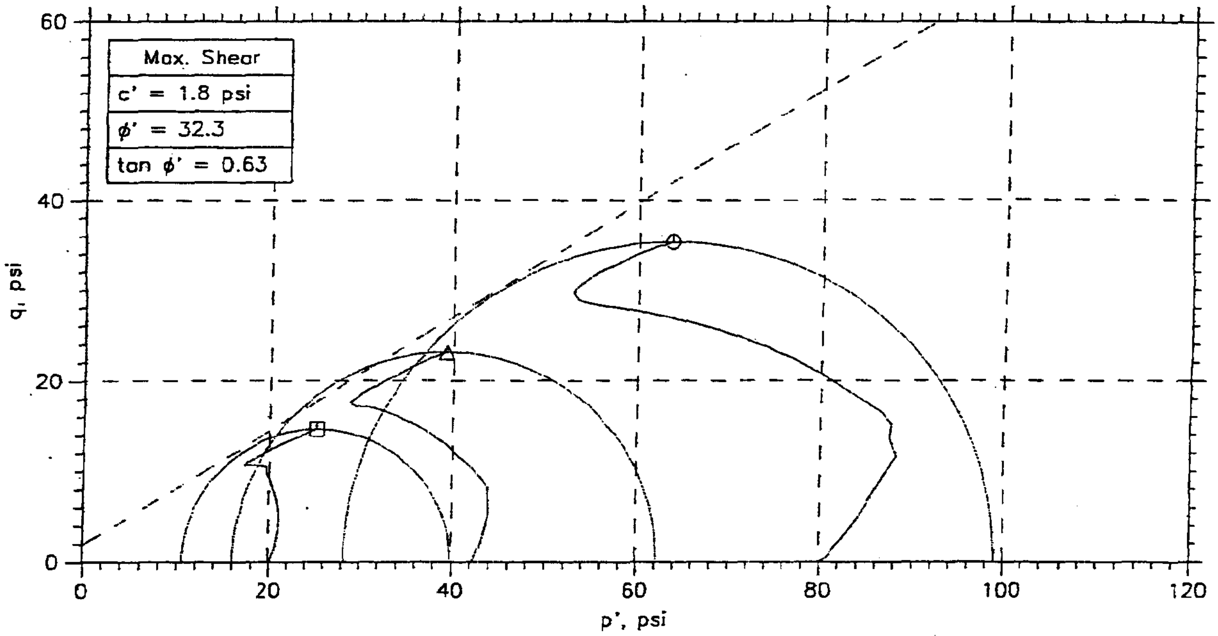
CONSOLIDATED UNDRAINED TRIAXIAL TEST







	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
⊙	Bag	13923.3	2-10 ft	JW	1/13/06	HJ		13923.3a_1062.dat
Δ	Bag	13923.2	2-10 ft	JW	1/13/05	HJ		13923.2a_1057.dat
⊡	Bag	13923.1	2-10 ft	HJ	1/13/06	JW		13923.1_2054.dat

GeoTesting express
the groundwork for success

Project: TVA Kingston Gypsym Std	Location: NB-22	Project No.: GTX-G0959
Boring No.: NB-22	Sample Type: Remolded	
Description: Reddish Orange Lean Clay with Sand		
Remarks: Remolded to 95% of Standard Proctor max. dry density and +2% over opt.		

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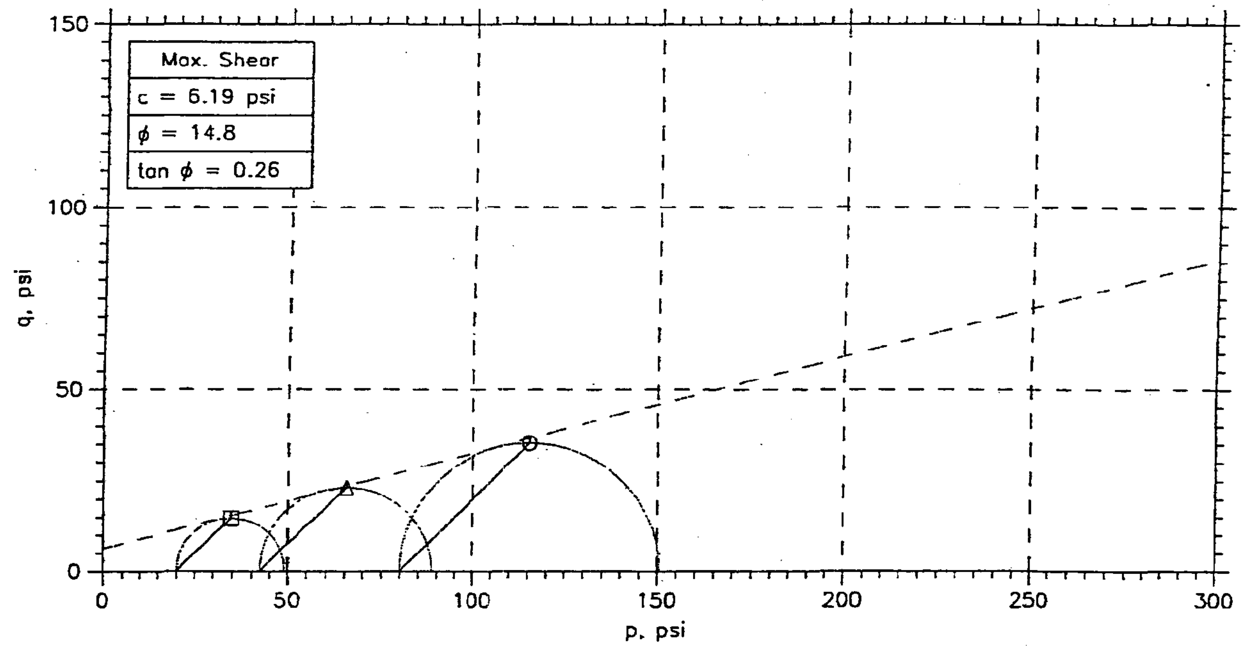
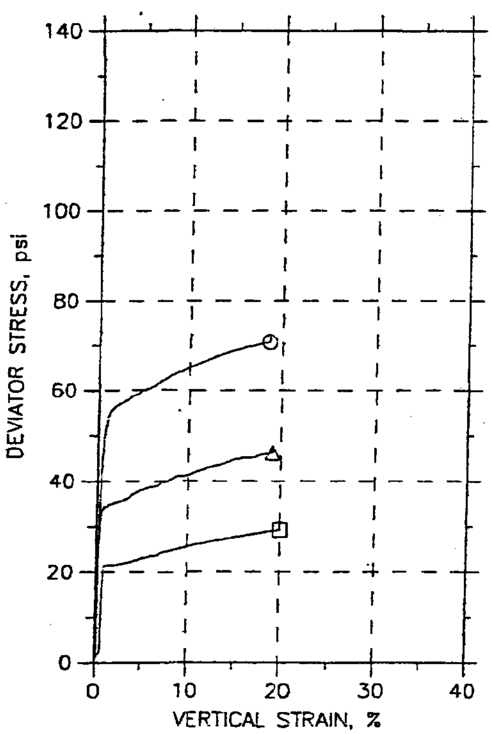
CONSOLIDATED UNDRAINED TRIAXIAL TEST





Symbol		○	△	□	
Sample No.		Bag	Bag	Bag	
Test No.		13923.3	13923.2	13923.1	
Depth		2-10 ft	2-10 ft	2-10 ft	
Initial	Diameter, in	2.87	2.87	2.87	
	Height, in	6	6	6	
	Water Content, %	19.7	19.6	19.7	
	Dry Density, pcf	101.9	101.9	102.	
	Saturation, %	84.5	84.4	85.0	
	Void Ratio	0.612	0.612	0.609	
Before Shear	Water Content, %	20.1	21.8	22.9	
	Dry Density, pcf	107.5	104.3	102.5	
	Saturation*, %	100.0	100.0	100.0	
	Void Ratio	0.527	0.574	0.601	
	Back Press., psi	59.99	89.99	89.99	
Ver. Eff. Cons. Stress, psi		80.01	40.32	20	
Shear Strength, psi		35.34	23.1	14.61	
Strain at Failure, %		18.5	19	19.9	
Strain Rate, %/min		0.022	0.022	0.022	
B-Value		0.95	0.95	0.95	
Measured Specific Gravity		2.63	2.63	2.63	
Liquid Limit		40	40	40	
Plastic Limit		22	22	22	

GeoTesting express — the groundwork for success

Project: TVA Kingston Gypsym Stack	
Location: NB-22	
Project No.: GTX-G0959	
Boring No.: NB-22	
Sample Type: Remolded	
Description: Reddish Orange Lean Clay with Sand	
Remarks: Remolded to 95% of Standard Proctor max. dry density and +2% over opt.	

Phase calculations based on start and end of test.

* Saturation is set to 100% for phase calculations.

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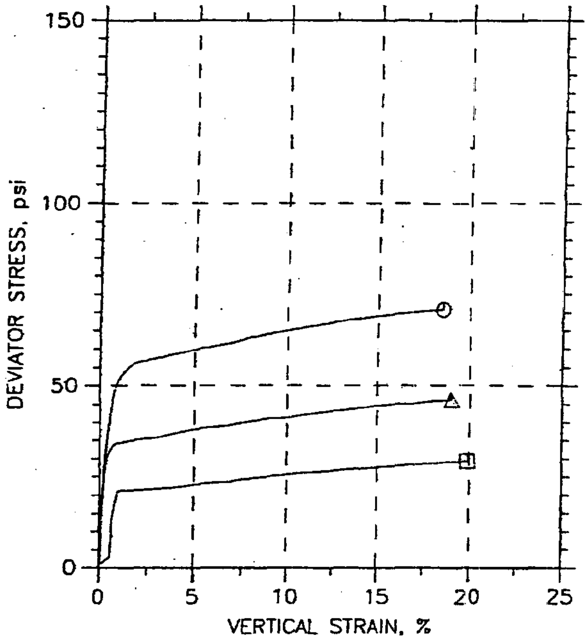
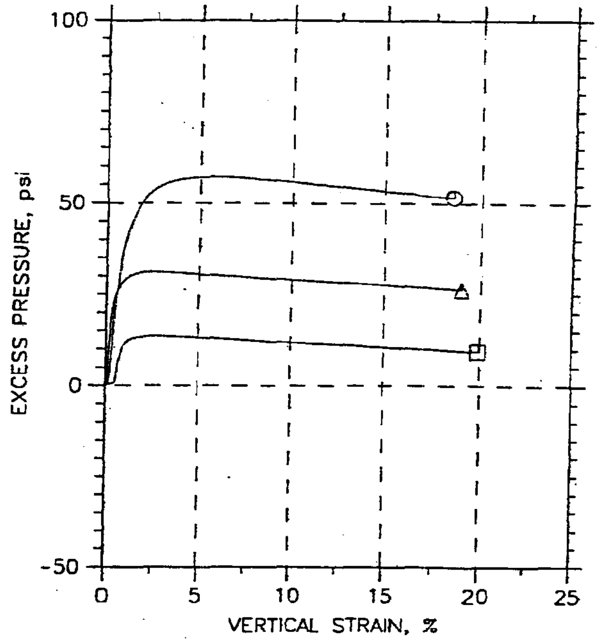
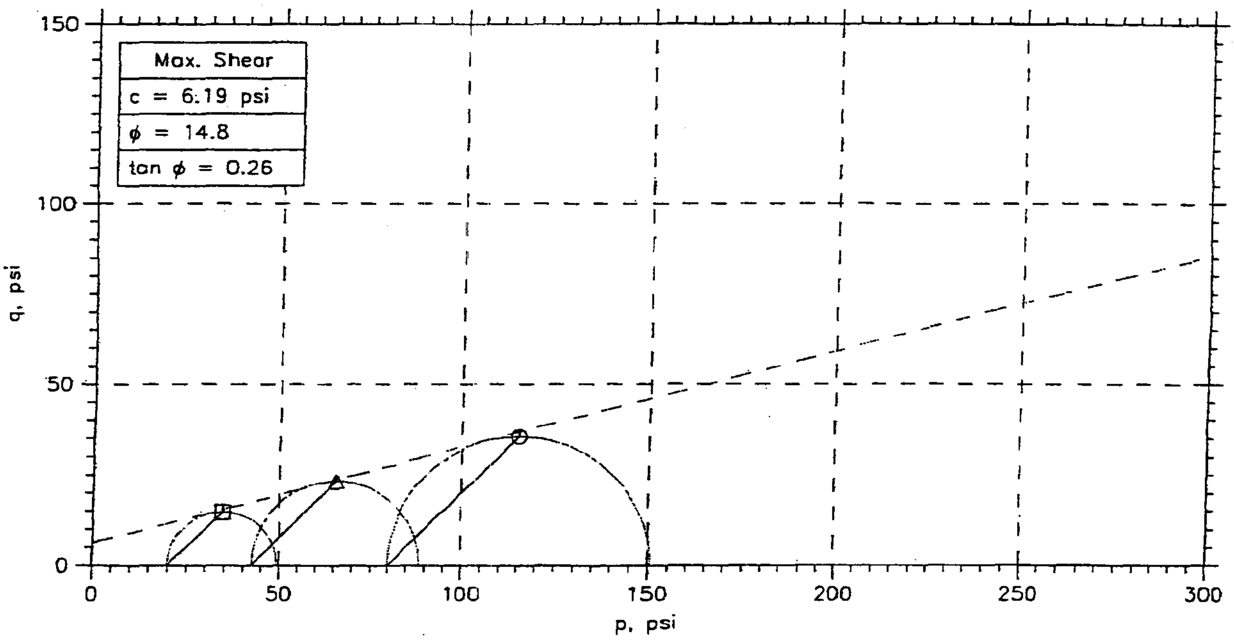
CONSOLIDATED UNDRAINED TRIAXIAL TEST







	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	Bag	13923.3	2-10 ft	JW	1/13/06	HJ		13923.3a_1062.dat
△	Bag	13923.2	2-10 ft	JW	1/13/05	HJ		13923.2a_1057.dat
□	Bag	13923.1	2-10 ft	HJ	1/13/06	JW		13923.1_2054.dat

GeoTesting express
the groundwork for success

Project: TVA Kingston Gypsym Std	Location: NB-22	Project No.: GTX-G0959
Boring No.: NB-22	Sample Type: Remolded	
Description: Reddish Orange Lean Clay with Sand		
Remarks: Remolded to 95% of Standard Proctor max. dry density and +2% over opt.		

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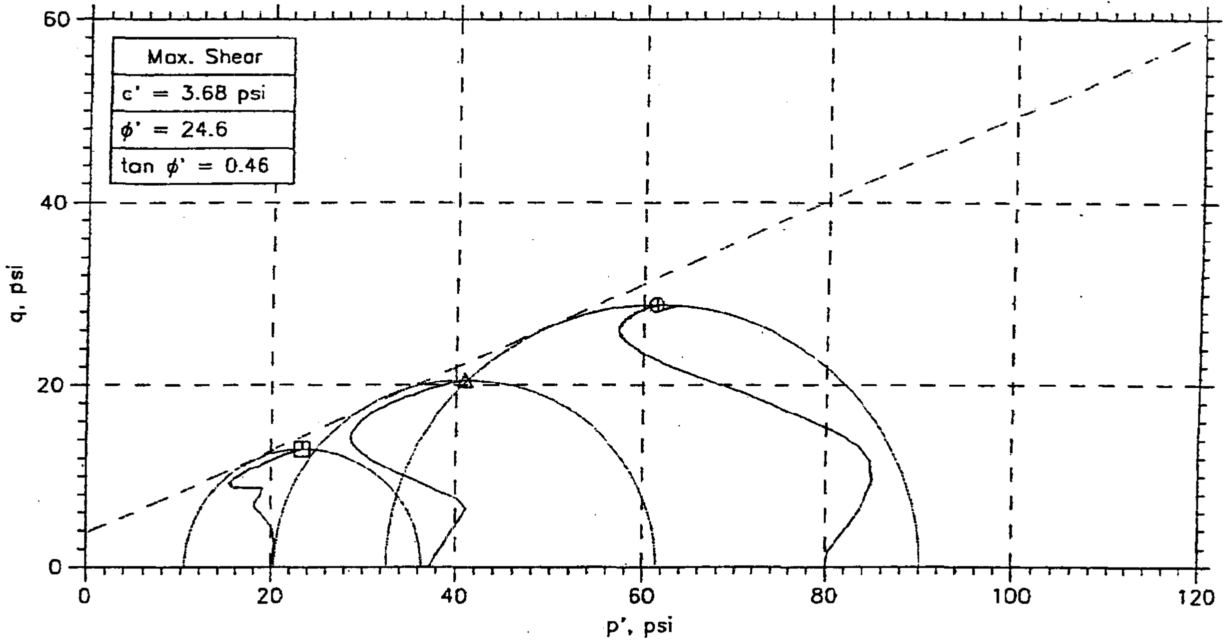
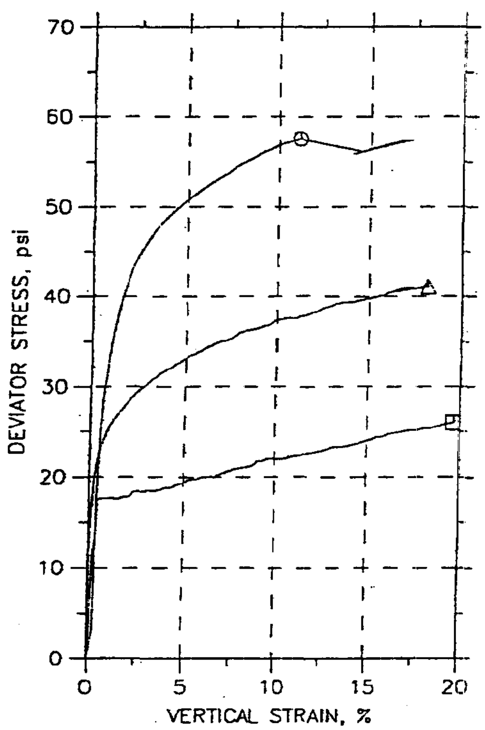
CONSOLIDATED UNDRAINED TRIAXIAL TEST





		○	△	□	
Symbol		○	△	□	
Sample No.		Bag	Bag	Bag	
Test No.		13924.3	13924.2	13924.1	
Depth		2-10 ft	2-10 ft	2-10 ft	
Initial	Diameter, in	2.87	2.87	2.87	
	Height, in	6	6	6	
	Water Content, %	27.5	27.6	27.3	
	Dry Density, pcf	90.23	90.2	90.68	
	Saturation, %	84.1	84.3	84.3	
	Void Ratio	0.896	0.896	0.886	
Before Shear	Water Content, %	29.4	30.4	30.8	
	Dry Density, pcf	94.76	93.33	92.76	
	Saturation*, %	100.1	100.0	100.0	
	Void Ratio	0.805	0.833	0.844	
	Back Press., psi	60	90	80.01	
Ver. Eff. Cons. Stress, psi		80	40	19.99	
Shear Strength, psi		28.76	20.54	12.97	
Strain at Failure, %		11.2	18.2	19.7	
Strain Rate, %/min		0.022	0.022	0.022	
B-Value		0.95	0.95	0.95	
Measured Specific Gravity		2.74	2.74	2.74	
Liquid Limit		72	72	72	
Plastic Limit		25	25	25	

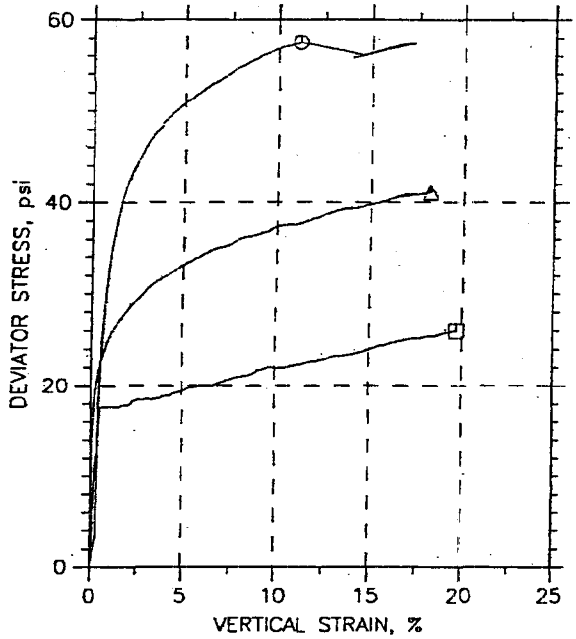
GeoTesting express
the groundwork for success

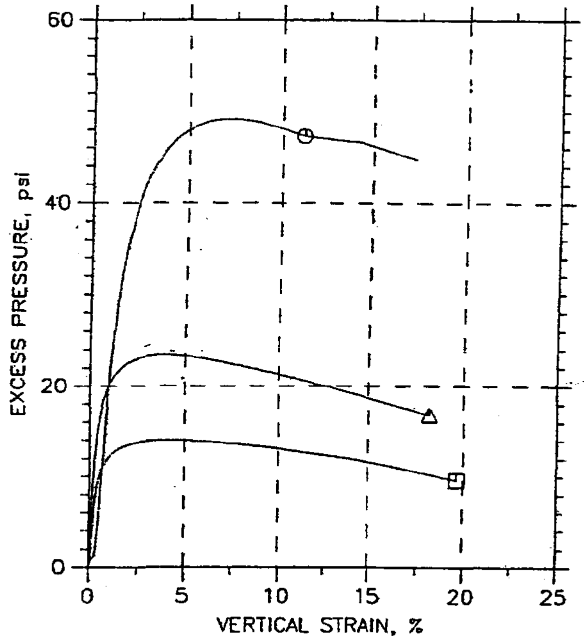
Project: TVA Kingston Gypsym Stack
Location: NB-25
Project No.: GTX-G0959
Boring No.: NB-25
Sample Type: Remolded
Description: Orange Brown Fat Clay
Remarks: Remolded to 95% of Standard Proctor max. dry density and +2% opt. moisture content.

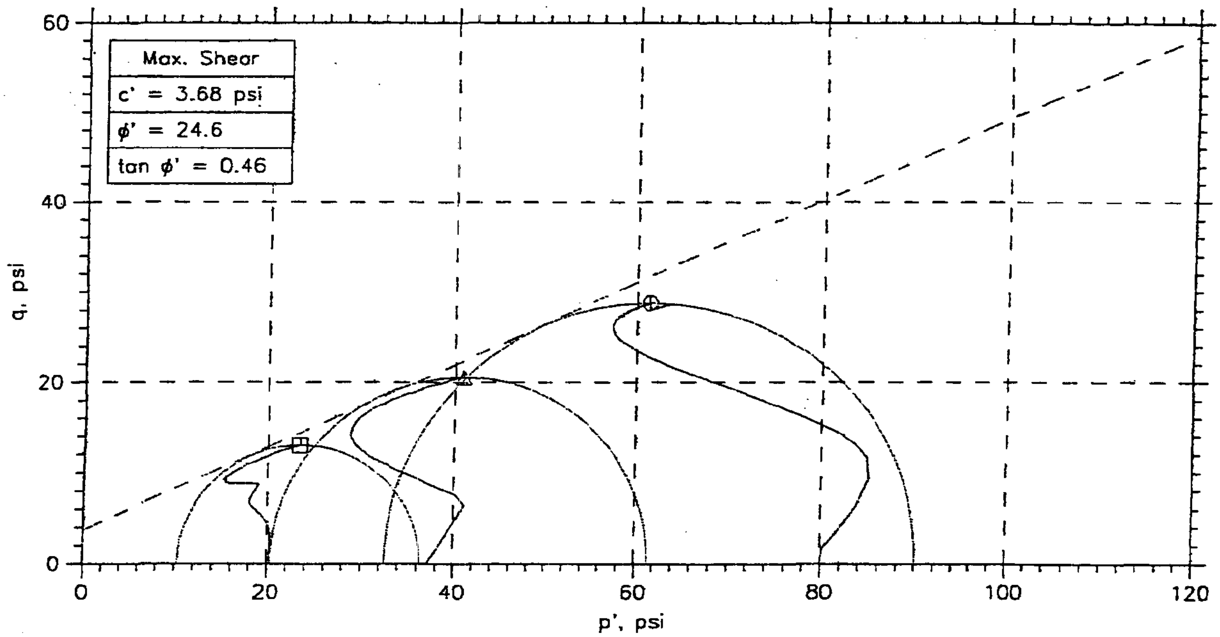
Tue, 24-JAN-2006 14:55:53

Phase calculations based on start and end of test.
* Saturation is set to 100% for phase calculations.

CONSOLIDATED UNDRAINED TRIAXIAL TEST







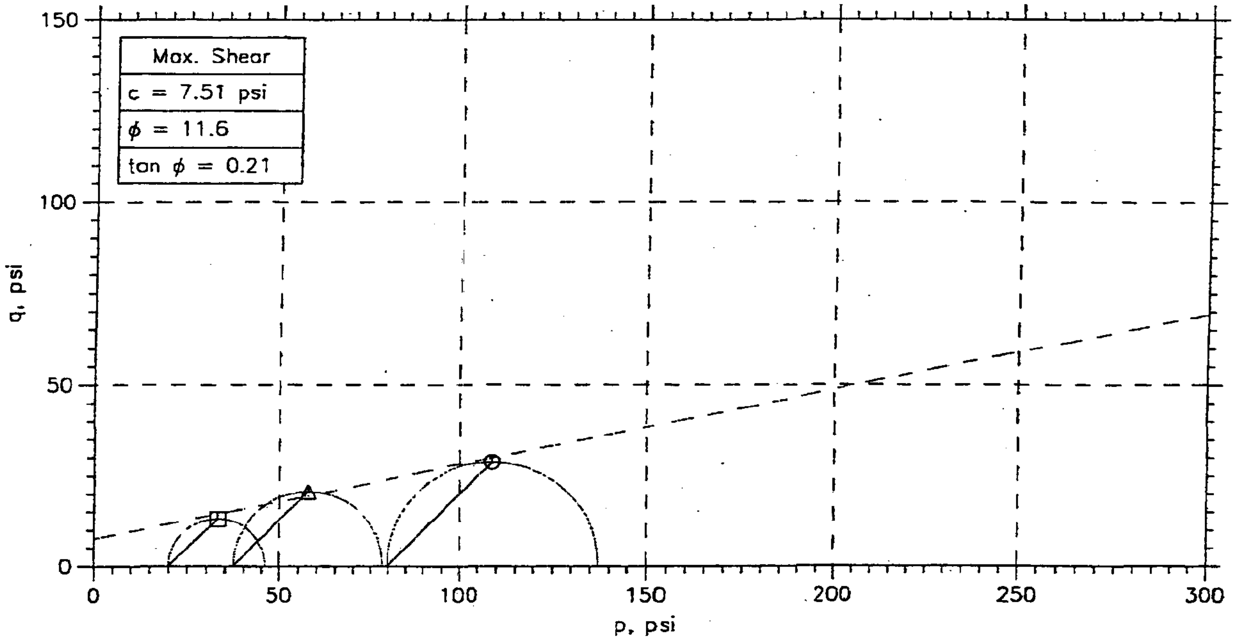
	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	Bag	13924.3	2-10 ft	JW	1/19/06	HJ		13924.3b_1062.dat
△	Bag	13924.2	2-10 ft	JW	1/19/05	HJ		13924.2_1057.dat
□	Bag	13924.1	2-10 ft	HJ	1/19/06	JW		13924.1a_2054.dat

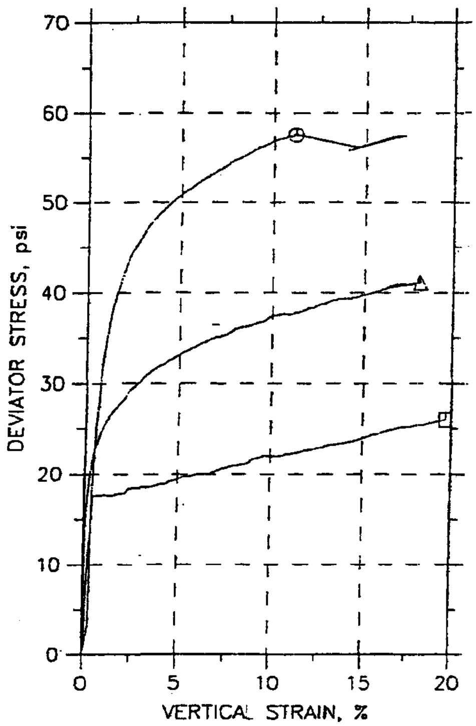
GeoTesting express the groundwork for success

Project: TVA Kingston Gypsym Std	Location: NB-25	Project No.: GTX-G0959
Boring No.: NB-25	Sample Type: Remoided	
Description: Orange Brown Fat Clay		
Remarks: Remolded to 95% of Standard Proctor max. dry density and +2% opt. moisture content.		

Tue, 24-JAN-2006 14:55:53

CONSOLIDATED UNDRAINED TRIAXIAL TEST





Symbol		○	△	□	
Sample No.		Bag	Bag	Bag	
Test No.		13924.3	13924.2	13924.1	
Depth		2-10 ft	2-10 ft	2-10 ft	
Initial	Diameter, in	2.87	2.87	2.87	
	Height, in	6	6	6	
	Water Content, %	27.5	27.6	27.3	
	Dry Density, pcf	90.23	90.2	90.68	
	Saturation, %	84.1	84.3	84.3	
	Void Ratio	0.896	0.896	0.886	
Before Shear	Water Content, %	29.4	30.4	30.8	
	Dry Density, pcf	94.76	93.33	92.76	
	Saturation*, %	100.1	100.0	100.0	
	Void Ratio	0.805	0.833	0.844	
	Back Press., psi	60	90	80.01	
Ver. Eff. Cons. Stress, psi		80	40	19.99	
Shear Strength, psi		28.76	20.54	12.97	
Strain at Failure, %		11.2	18.2	19.7	
Strain Rate, %/min		0.022	0.022	0.022	
B-Value		0.95	0.95	0.95	
Measured Specific Gravity		2.74	2.74	2.74	
Liquid Limit		72	72	72	
Plastic Limit		25	25	25	

GeoTesting express the groundwork for success

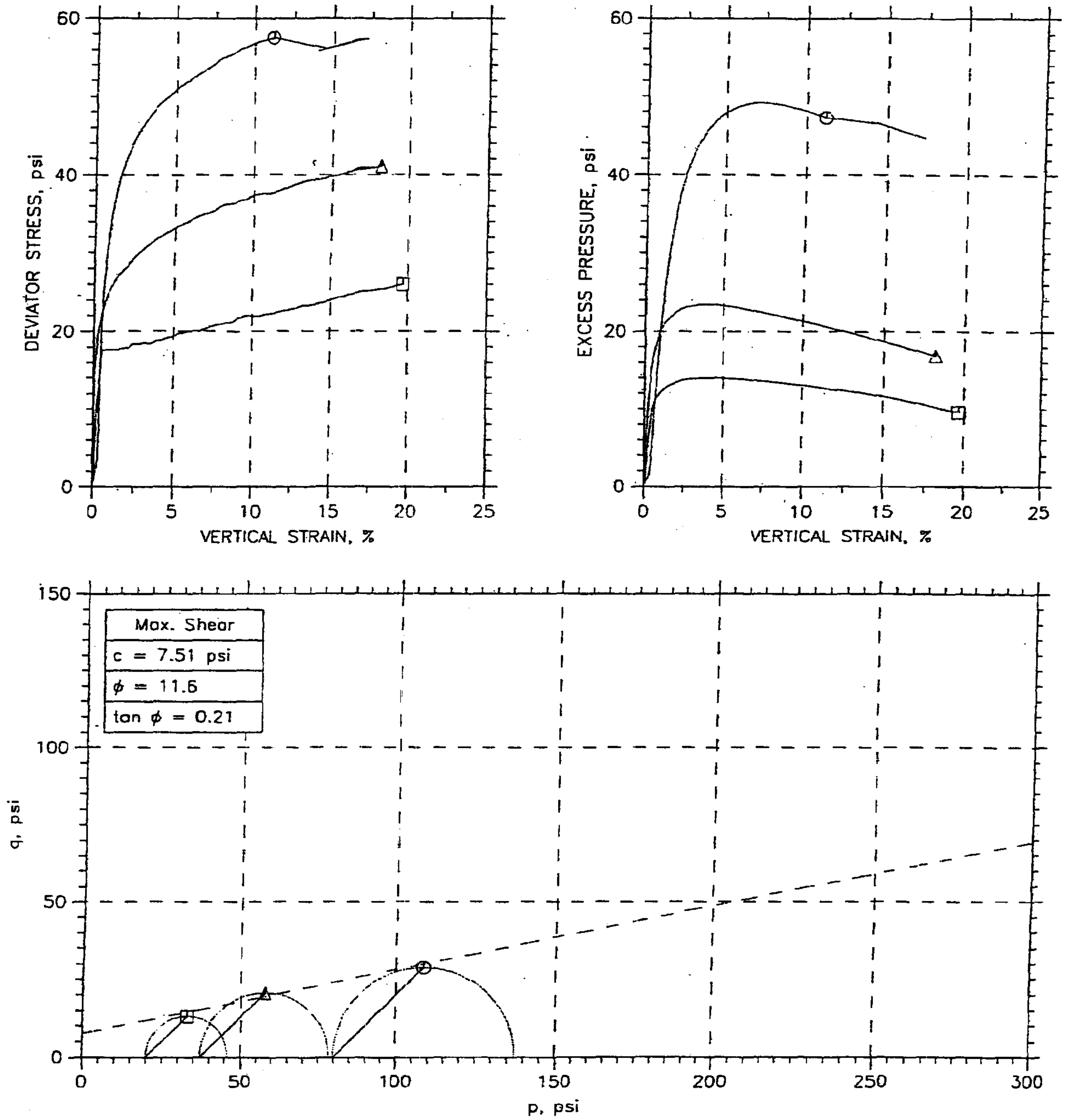
Project: TVA Kingston Gypsym Stack	
Location: NB-25	
Project No.: GTX-G0959	
Boring No.: NB-25	
Sample Type: Remolded	
Description: Orange Brown Fat Clay	
Remarks: Remolded to 95% of Standard Proctor max. dry density and +2% opt. moisture content.	

Phase calculations based on start and end of test.

* Saturation is set to 100% for phase calculations.

Tue, 24-JAN-2006 14:56:06

CONSOLIDATED UNDRAINED TRIAXIAL TEST

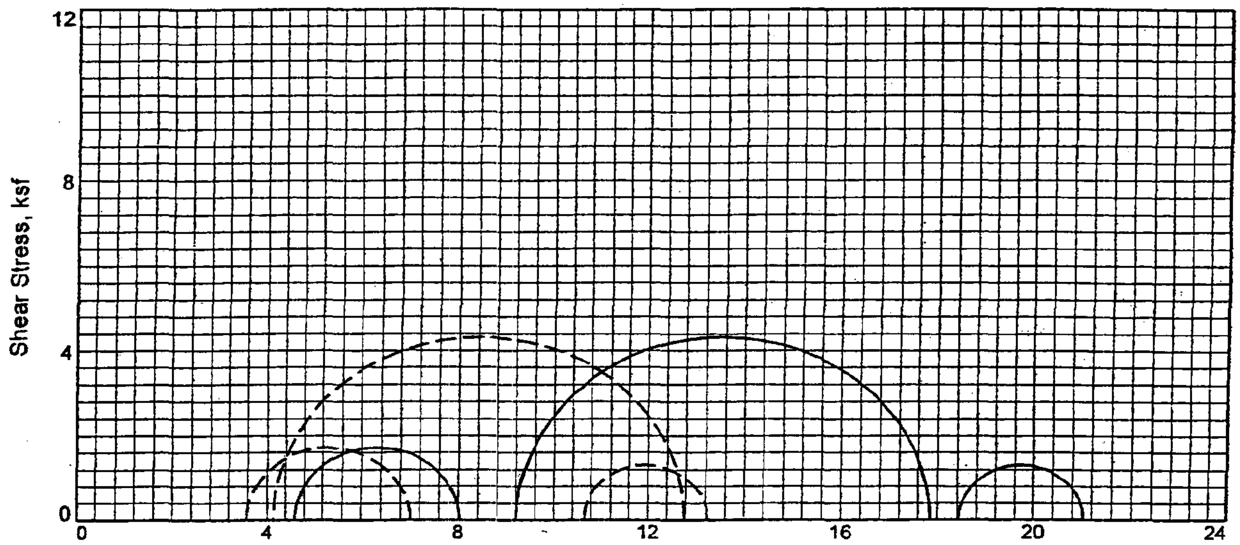


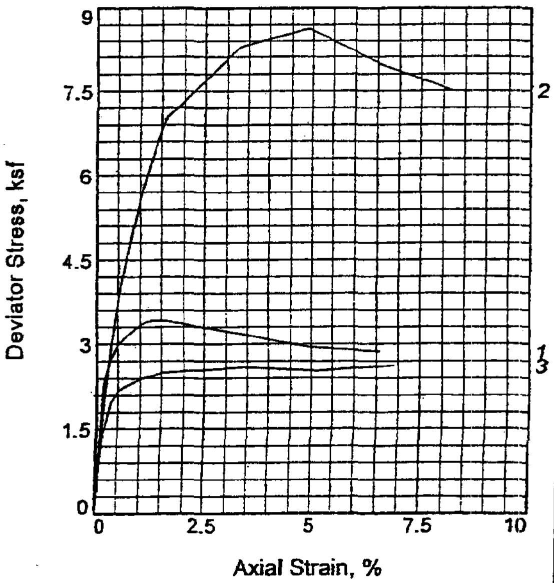
	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	Bag	13924.3	2-10 ft	JW	1/19/06	HJ		13924.3b_1062.dat
△	Bag	13924.2	2-10 ft	JW	1/19/05	HJ		13924.2_1057.dat
□	Bag	13924.1	2-10 ft	HJ	1/19/06	JW		13924.1a_2054.dat

GeoTesting express
the groundwork for success

Project: TVA Kingston Gypsym Std	Location: NB-25	Project No.: GTX-G0959
Boring No.: NB-25	Sample Type: Remolded	
Description: Orange Brown Fat Clay		
Remarks: Remolded to 95% of Standard Proctor max. dry density and +2% opt. moisture content.		

Tue, 24-JAN-2006 14:56:07





Sample No.		1	2	3
Initial	Water Content,	35.7	26.0	40.3
	Dry Density, pcf	84.6	89.5	78.3
	Saturation,	96.2	78.5	93.7
	Void Ratio	1.0137	0.9053	1.1753
	Diameter, in.	2.81	2.84	2.82
	Height, in.	6.14	6.31	6.14
At Test	Water Content,	34.2	26.3	29.8
	Dry Density, pcf	88.2	99.1	94.0
	Saturation,	100.0	100.0	100.0
	Void Ratio	0.9328	0.7193	0.8124
	Diameter, in.	2.78	2.74	2.66
	Height, in.	6.06	6.10	5.78
Strain rate, in./min.		0.02	0.02	0.02
Back Pressure, ksf		2.9	2.9	2.9
Cell Pressure, ksf		7.5	12.1	21.3
Fail. Stress, ksf		3.4	8.6	2.6
Total Pore Pr., ksf		3.9	7.9	10.7
Ult. Stress, ksf				
Total Pore Pr., ksf				
$\bar{\sigma}_1$ Failure, ksf		7.0	12.8	13.3
$\bar{\sigma}_3$ Failure, ksf		3.6	4.1	10.6

Type of Test:
CU with Pore Pressures

Sample Type: undisturbed

Description: Dark yellowish brown fat clay with sand

LL= 54 **PL=** 24 **PI=** 30

Specific Gravity= 2.73

Remarks: CH

Client: TVA

Project: TVA Kingston - Proposed Gypsum Stack

Location: NB-44

Sample Number: UD-3,4 & 5 (CU) **Depth:** 19'-28.5'

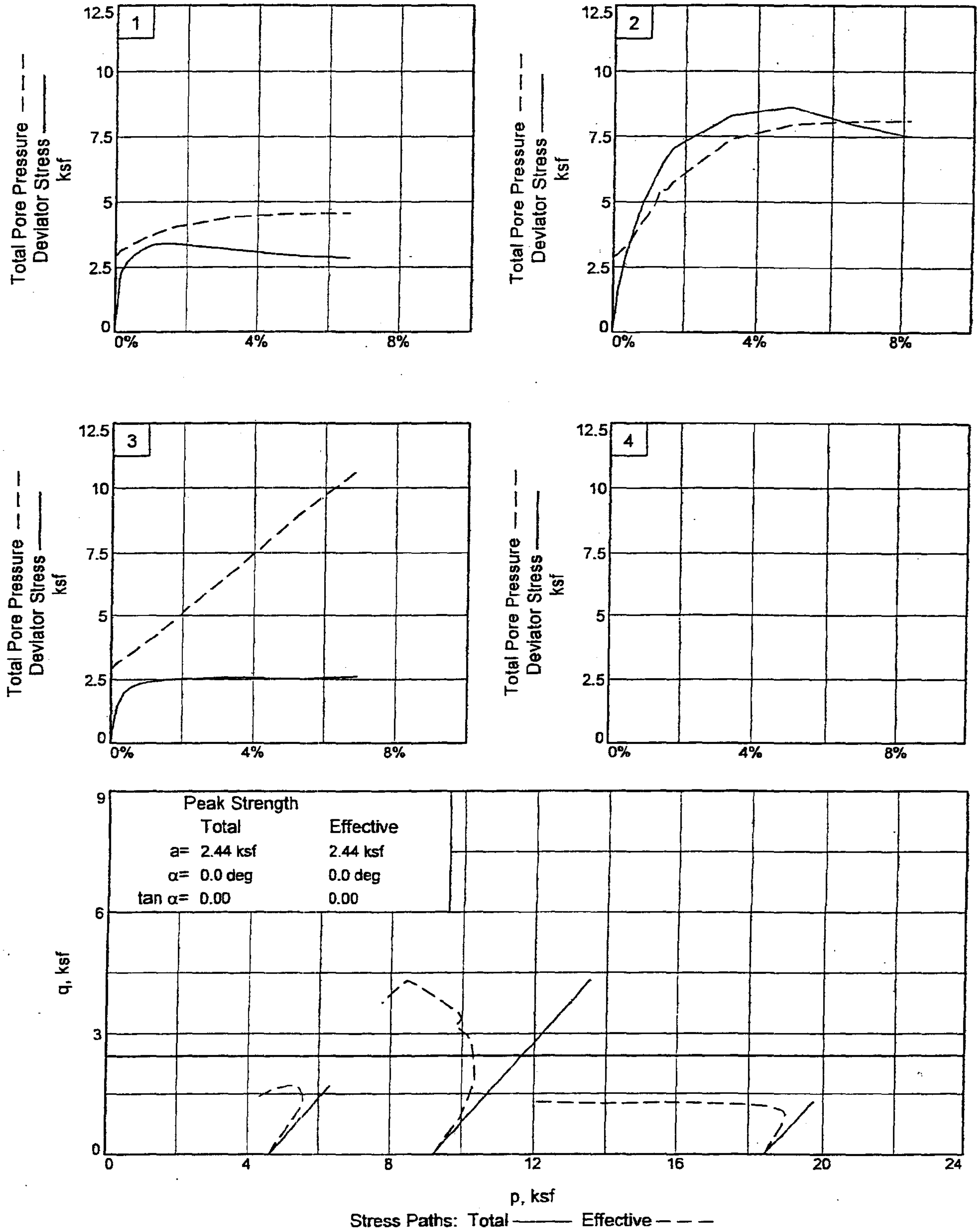
Proj. No.: 3043051021 **Date:**

TRIAXIAL SHEAR TEST REPORT

MACTEC, INC.

Figure ______

Tested By: Alexander **Checked By:** Hamlett



Client: TVA

Project: TVA Kingston - Proposed Gypsum Stack

Location: NB-44 **Depth:** 19'-28.5' **Sample Number:** UD-3,4 & 5 (CU)

Project No.: 3043051021 **Figure** ______ **MACTEC, INC.**

Tested By: Alexander **Checked By:** Hamlett

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

9/13/2005
6:40 PM

Date:
Client: TVA
Project: TVA Kingston - Proposed Gypsum Stack
Project No.: 3043051021
Location: NB-44
Depth: 19'-28.5' **Sample Number:** UD-3,4 & 5 (CU)
Description:
Remarks:
Type of Sample: undisturbed
Specific Gravity=2.73 **LL=**54 **PL=**24 **PI=**30
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1166.600			1374.060
Moisture content: Dry soil+tare, gms.	859.600			1081.580
Moisture content: Tare, gms.	0.000			222.140
Moisture, %	35.7	37.1	34.2	34.0
Moist specimen weight, gms.	1151.9			
Diameter, in.	2.81	2.81	2.78	
Area, in.²	6.22	6.22	6.05	
Height, in.	6.14	6.14	6.06	
Net decrease in height, in.		0.00	0.08	
Wet Density, pcf	114.9	116.1	118.3	
Dry density, pcf	84.6	84.6	88.2	
Void ratio	1.0137	1.0137	0.9328	
Saturation, %	96.2	100.0	100.0	

Test Readings for Specimen No. 1

Load ring constant = 0.72 lbs. per input unit
Consolidation cell pressure = 52.00 psi (7.49 ksf)
Consolidation back pressure = 20.00 psi (2.88 ksf)
Consolidation effective confining stress = 4.61 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 3.42 ksf **at reading no.** 8

MACTEC, INC.

TVA-00021007

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	4.58	4.58	1.00	20.20	4.58	0.00
1	0.0100	134.0	96.5	0.2	2.29	4.33	6.63	1.53	21.90	5.48	1.15
2	0.0200	159.0	114.5	0.3	2.72	4.20	6.92	1.65	22.80	5.56	1.36
3	0.0300	174.0	125.3	0.5	2.97	4.08	7.04	1.73	23.70	5.56	1.48
4	0.0400	183.0	131.8	0.7	3.11	3.96	7.07	1.79	24.50	5.52	1.56
5	0.0500	190.0	136.8	0.8	3.23	3.86	7.09	1.84	25.20	5.47	1.61
6	0.0600	196.0	141.1	1.0	3.32	3.76	7.08	1.88	25.90	5.42	1.66
7	0.0700	200.0	144.0	1.2	3.39	3.66	7.04	1.93	26.60	5.35	1.69
8	0.0800	202.0	145.4	1.3	3.42	3.59	7.00	1.95	27.10	5.29	1.71
9	0.0900	202.0	145.4	1.5	3.41	3.51	6.92	1.97	27.60	5.22	1.70
10	0.1000	202.0	145.4	1.7	3.40	3.44	6.85	1.99	28.10	5.14	1.70
11	0.2000	192.0	138.2	3.3	3.18	3.07	6.25	2.04	30.70	4.66	1.59
12	0.3000	181.0	130.3	5.0	2.95	2.94	5.89	2.00	31.60	4.41	1.47
13	0.4000	179.0	128.9	6.6	2.86	2.91	5.77	1.98	31.80	4.34	1.43

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1158.610			1184.100
Moisture content: Dry soil+tare, gms.	919.300			922.720
Moisture content: Tare, gms.	0.000			14.290
Moisture, %	26.0	33.2	26.3	28.8
Moist specimen weight, gms.	1184.1			
Diameter, in.	2.84	2.84	2.74	
Area, in.²	6.34	6.34	5.92	
Height, in.	6.31	6.31	6.10	
Net decrease in height, in.		0.00	0.21	
Wet Density, pcf	112.7	119.1	125.2	
Dry density, pcf	89.5	89.5	99.1	
Void ratio	0.9053	0.9053	0.7193	
Saturation, %	78.5	100.0	100.0	

Test Readings for Specimen No. 2

Load ring constant = 0.72 lbs. per input unit

Consolidation cell pressure = 84.00 psi (12.10 ksf)

Consolidation back pressure = 20.00 psi (2.88 ksf)

Consolidation effective confining stress = 9.22 ksf

Strain rate, in./min. = 0.02

Fail. Stress = 8.63 ksf **at reading no.** 12

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	9.22	9.22	1.00	20.00	9.22	0.00
1	0.0100	104.0	74.9	0.2	1.82	9.04	10.86	1.20	21.20	9.95	0.91
2	0.0200	165.0	118.8	0.3	2.88	8.78	11.67	1.33	23.00	10.22	1.44
3	0.0300	211.0	151.9	0.5	3.68	8.51	12.19	1.43	24.90	10.35	1.84
4	0.0400	251.0	180.7	0.7	4.37	8.15	12.52	1.54	27.40	10.33	2.18
5	0.0500	287.0	206.6	0.8	4.99	7.82	12.81	1.64	29.70	10.31	2.49
6	0.0600	316.0	227.5	1.0	5.48	7.52	13.00	1.73	31.80	10.26	2.74
7	0.0700	342.0	246.2	1.1	5.92	7.19	13.11	1.82	34.10	10.15	2.96

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
8	0.0800	368.0	265.0	1.3	6.36	6.62	12.99	1.96	38.00	9.81	3.18
9	0.0900	390.0	280.8	1.5	6.73	6.62	13.36	2.02	38.00	9.99	3.37
10	0.1000	409.0	294.5	1.6	7.05	6.35	13.40	2.11	39.90	9.87	3.52
11	0.2000	488.0	351.4	3.3	8.27	4.71	12.98	2.76	51.30	8.84	4.14
12	0.3000	518.0	373.0	4.9	8.63	4.15	12.78	3.08	55.20	8.46	4.31
13	0.4000	487.0	350.6	6.6	7.97	4.02	11.99	2.98	56.10	8.00	3.99
14	0.5000	467.0	336.2	8.2	7.51	4.00	11.52	2.88	56.20	7.76	3.76

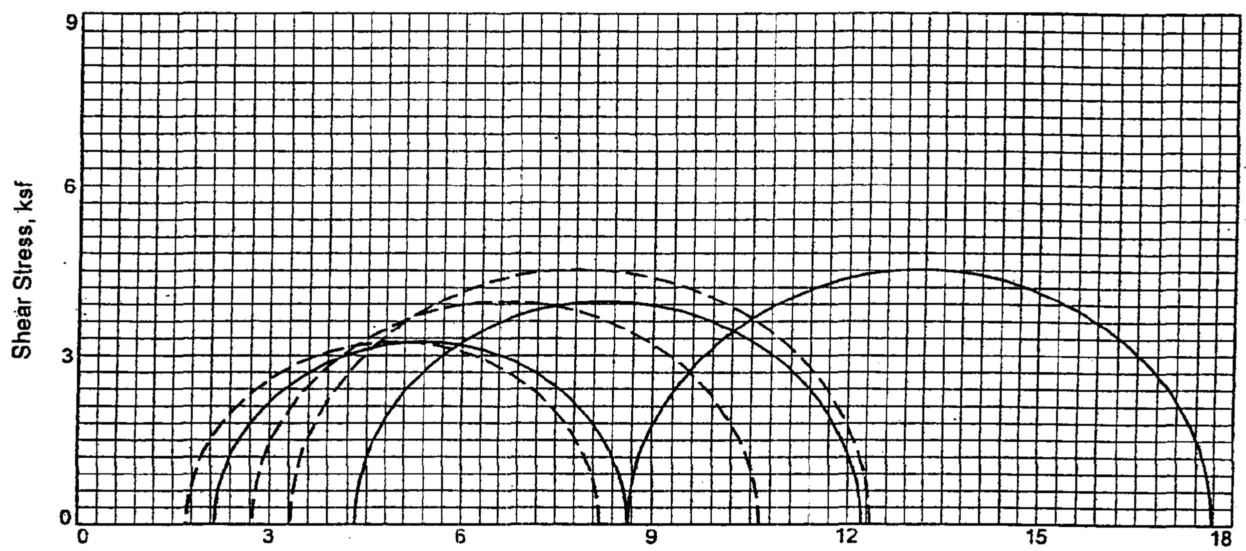
Parameters for Specimen No. 3

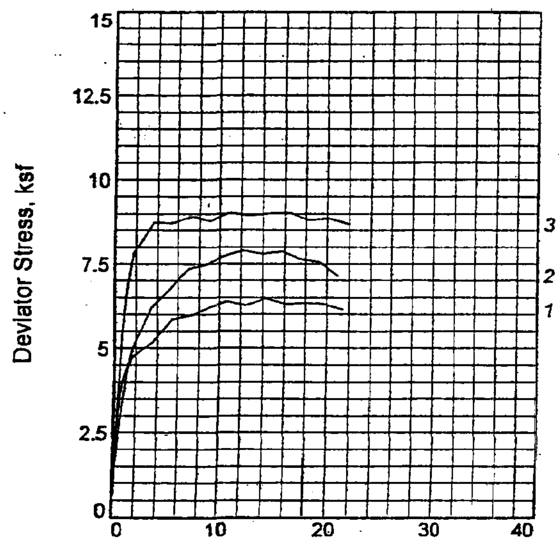
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1101.080			678.520
Moisture content: Dry soil+tare, gms.	784.600			483.890
Moisture content: Tare, gms.	0.000			13.830
Moisture, %	40.3	43.1	29.8	41.4
Moist specimen weight, gms.	1109.4			
Diameter, in.	2.82	2.82	2.66	
Area, in.²	6.26	6.26	5.54	
Height, in.	6.14	6.14	5.78	
Net decrease in height, in.		0.00	0.35	
Wet Density, pcf	109.9	112.1	122.0	
Dry density, pcf	78.3	78.3	94.0	
Void ratio	1.1753	1.1753	0.8124	
Saturation, %	93.7	100.0	100.0	

Test Readings for Specimen No. 3

Load ring constant = 0.72 lbs. per input unit
Consolidation cell pressure = 148.00 psi (21.31 ksf)
Consolidation back pressure = 20.00 psi (2.88 ksf)
Consolidation effective confining stress = 18.43 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 2.61 ksf at **reading no.** 13

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	18.43	18.43	1.00	20.00	18.43	0.00
1	0.0100	76.0	54.7	0.2	1.42	18.17	19.59	1.08	21.80	18.88	0.71
2	0.0200	106.0	76.3	0.3	1.98	17.99	19.96	1.11	23.10	18.97	0.99
3	0.0300	117.0	84.2	0.5	2.18	17.81	19.99	1.12	24.30	18.90	1.09
4	0.0400	122.0	87.8	0.7	2.27	17.65	19.92	1.13	25.40	18.79	1.13
5	0.0500	126.0	90.7	0.9	2.34	17.47	19.81	1.13	26.70	18.64	1.17
6	0.0600	129.0	92.9	1.0	2.39	17.31	19.70	1.14	27.80	18.50	1.19
7	0.0700	131.0	94.3	1.2	2.42	17.12	19.54	1.14	29.10	18.33	1.21
8	0.0800	133.0	95.8	1.4	2.46	16.91	19.36	1.15	30.60	18.13	1.23
9	0.0900	135.0	97.2	1.6	2.49	16.72	19.21	1.15	31.90	17.96	1.24
10	0.1000	136.0	97.9	1.7	2.50	16.56	19.06	1.15	33.00	17.81	1.25
11	0.2000	143.0	103.0	3.5	2.58	14.49	17.07	1.18	47.40	15.78	1.29
12	0.3000	142.0	102.2	5.2	2.52	12.44	14.96	1.20	61.60	13.70	1.26
13	0.4000	150.0	108.0	6.9	2.61	10.64	13.26	1.25	74.10	11.95	1.31





Sample No.		1	2	3
Initial	Water Content,	35.4	27.6	27.2
	Dry Density, pcf	84.0	96.1	93.1
	Saturation,	94.1	97.9	89.9
	Void Ratio	1.0223	0.7675	0.8235
	Diameter, in.	2.82	2.79	2.84
	Height, in.	5.99	5.90	5.66
At Test	Water Content,	23.3	21.9	23.5
	Dry Density, pcf	103.9	106.3	103.6
	Saturation,	100.0	100.0	100.0
	Void Ratio	0.6341	0.5970	0.6393
	Diameter, in.	2.62	2.70	2.74
	Height, in.	5.58	5.71	5.46
Strain rate, in./min.		0.02	0.02	0.02
Back Pressure, ksf		5.8	5.8	5.8
Cell Pressure, ksf		7.9	10.1	14.4
Fail. Stress, ksf		6.5	7.9	9.0
Total Pore Pr., ksf		6.2	7.3	11.1
Ult. Stress, ksf				
Total Pore Pr., ksf				
$\bar{\sigma}_1$ Failure, ksf		8.2	10.6	12.4
$\bar{\sigma}_3$ Failure, ksf		1.7	2.7	3.3

Type of Test:
CU with Pore Pressures

Sample Type: undisturbed

Description: Brown elastic silt with sand

LL= 51 **PL=** 30 **PI=** 21

Specific Gravity= 2.72

Remarks: MH

Client: TVA

Project: TVA Kingston - Proposed Gypsum Stack

Location: NB-47A

Sample Number: UD-1, 2 & 3 (CU) **Depth:** 9'-17'

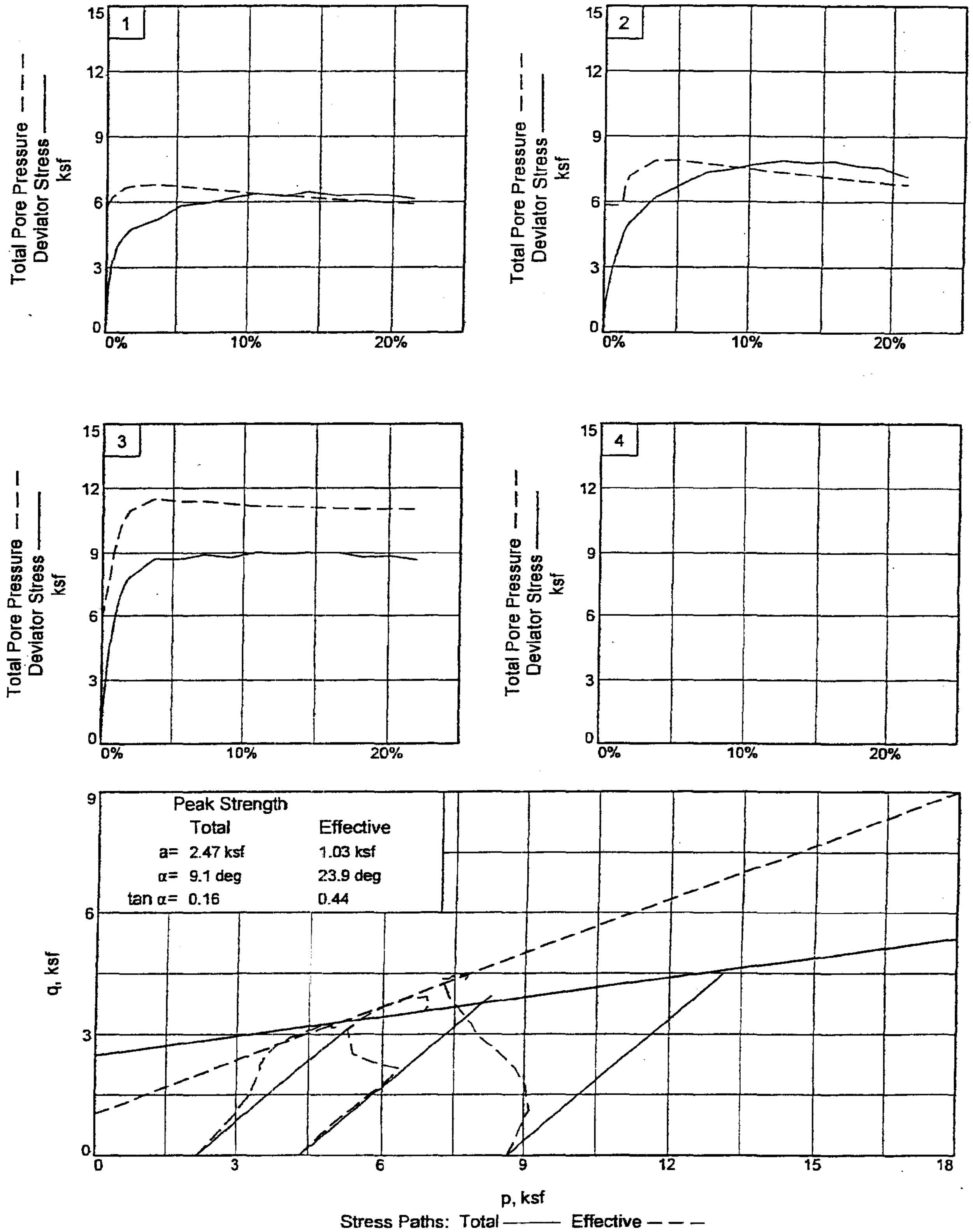
Proj. No.: 3043051021 **Date:**

TRIAXIAL SHEAR TEST REPORT

MACTEC, INC.

Figure ______

Tested By: Alexander **Checked By:** Hamlett



Client: TVA
Project: TVA Kingston - Proposed Gypsum Stack
Location: NB-47A **Depth:** 9'-17' **Sample Number:** UD-1, 2 & 3 (CU)
Project No.: 3043051021 **Figure** ________ **MACTEC, INC.**

Tested By: Alexander **Checked By:** Hamlett

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

9/13/2005
6:52 PM

Date:
Client: TVA
Project: TVA Kingston - Proposed Gypsum Stack
Project No.: 3043051021
Location: NB-47A
Depth: 9'-17' **Sample Number:** UD-1, 2 & 3 (CU)
Description:
Remarks:
Type of Sample: undisturbed
Specific Gravity=2.72 **LL**=51 **PL**=30 **PI**=21
Test Method: COE uniform strain

Parameters for Specimen No. [illegible]

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1094.400			588.200
Moisture content: Dry soil+tare, gms.	808.400			431.340
Moisture content: Tare, gms.	0.000			14.060
Moisture, %	35.4	37.6	23.3	37.6
Moist specimen weight, gms.	1112.4			
Diameter, in.	2.82	2.82	2.62	
Area, in.^{2}	6.23	6.23	5.39	
Height, in.	5.99	5.99	5.58	
Net decrease in height, in.		0.00	0.40	
Wet Density, pcf	113.7	115.5	128.1	
Dry density, pcf	84.0	84.0	103.9	
Void ratio	1.0223	1.0223	0.6341	
Saturation, %	94.1	100.0	100.0	

Test Results for Specimen No. [illegible]

Load ring constant = 0.72 lbs. per input unit
Consolidation cell pressure = 55.00 psi (7.92 ksf)
Consolidation back pressure = 40.00 psi (5.76 ksf)
Consolidation effective confining stress = 2.16 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 6.47 ksf **at reading no.** 17

[illegible]

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	2.16	2.16	1.00	40.00	2.16	0.00
1	0.0100	110.0	79.2	0.2	2.11	1.94	4.05	2.09	41.50	3.00	1.06
2	0.0200	161.0	115.9	0.4	3.08	1.76	4.84	2.76	42.80	3.30	1.54
3	0.0300	183.0	131.8	0.5	3.50	1.61	5.11	3.17	43.80	3.36	1.75
4	0.0400	204.0	146.9	0.7	3.89	1.50	5.39	3.60	44.60	3.44	1.95
5	0.0500	216.0	155.5	0.9	4.11	1.41	5.53	3.92	45.20	3.47	2.06
6	0.0600	226.0	162.7	1.1	4.30	1.35	5.65	4.17	45.60	3.50	2.15
7	0.0700	234.0	168.5	1.3	4.44	1.27	5.71	4.51	46.20	3.49	2.22
8	0.0800	240.0	172.8	1.4	4.55	1.24	5.79	4.67	46.40	3.51	2.27
9	0.0900	248.0	178.6	1.6	4.69	1.22	5.91	4.83	46.50	3.57	2.35
10	0.1000	253.0	182.2	1.8	4.78	1.18	5.96	5.04	46.80	3.57	2.39
11	0.2000	279.0	200.9	3.6	5.17	1.12	6.29	5.60	47.20	3.71	2.59
12	0.3000	321.0	231.1	5.4	5.84	1.20	7.03	5.89	46.70	4.11	2.92
13	0.4000	333.0	239.8	7.2	5.94	1.31	7.25	5.54	45.90	4.28	2.97
14	0.5000	353.0	254.2	9.0	6.18	1.43	7.60	5.33	45.10	4.51	3.09
15	0.6000	372.0	267.8	10.7	6.38	1.53	7.91	5.18	44.40	4.72	3.19
16	0.7000	372.0	267.8	12.5	6.25	1.63	7.88	4.84	43.70	4.75	3.13
17	0.8000	393.0	283.0	14.3	6.47	1.73	8.20	4.75	43.00	4.96	3.24
18	0.9000	391.0	281.5	16.1	6.30	1.80	8.10	4.50	42.50	4.95	3.15
19	1.0000	401.0	288.7	17.9	6.33	1.87	8.20	4.38	42.00	5.04	3.16
20	1.1000	409.0	294.5	19.7	6.31	1.94	8.26	4.25	41.50	5.10	3.16
21	1.2000	406.0	292.3	21.5	6.13	2.02	8.14	4.04	41.00	5.08	3.06

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1158.000			627.200
Moisture content: Dry soil+tare, gms.	907.300			492.760
Moisture content: Tare, gms.	0.000			13.740
Moisture, %	27.6	28.2	21.9	28.1
Moist specimen weight, gms.	1162.2			
Diameter, in.	2.79	2.79	2.70	
Area, in.²	6.12	6.12	5.72	
Height, in.	5.90	5.90	5.71	
Net decrease in height, in.		0.00	0.19	
Wet Density, pcf	122.6	123.2	129.7	
Dry density, pcf	96.1	96.1	106.3	
Void ratio	0.7675	0.7675	0.5970	
Saturation, %	97.9	100.0	100.0	

[illegible] Readings for Specimen No. 2

Load ring constant = 0.72 lbs. per input unit
Consolidation cell pressure = 70.00 psi (10.08 ksf)
Consolidation back pressure = 40.00 psi (5.76 ksf)
Consolidation effective confining stress = 4.32 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 7.89 ksf at reading no. 16

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	4.32	4.32	1.00	40.00	4.32	0.00
1	0.0100	81.0	58.3	0.2	1.47	4.22	5.69	1.35	40.70	4.95	0.73
2	0.0200	116.0	83.5	0.4	2.10	4.23	6.33	1.50	40.60	5.28	1.05
3	0.0300	147.0	105.8	0.5	2.65	4.25	6.90	1.62	40.50	5.57	1.33
4	0.0400	174.0	125.3	0.7	3.13	4.26	7.40	1.74	40.40	5.83	1.57
5	0.0500	196.0	141.1	0.9	3.52	4.26	7.79	1.83	40.40	6.02	1.76
6	0.0600	219.0	157.7	1.1	3.93	4.23	8.16	1.93	40.60	6.20	1.97
7	0.0700	240.0	172.8	1.2	4.30	4.18	8.48	2.03	41.00	6.33	2.15
8	0.0800	259.0	186.5	1.4	4.63	3.46	8.09	2.34	46.00	5.77	2.32
9	0.0900	273.0	196.6	1.6	4.87	3.11	7.98	2.57	48.40	5.55	2.44
10	0.1000	282.0	203.0	1.8	5.03	2.88	7.91	2.75	50.00	5.39	2.51
11	0.2000	355.0	255.6	3.5	6.21	2.19	8.40	3.84	54.80	5.30	3.11
12	0.3000	394.0	283.7	5.3	6.77	2.19	8.96	4.09	54.80	5.57	3.39
13	0.4000	436.0	313.9	7.0	7.35	2.33	9.69	4.15	53.80	6.01	3.68
14	0.5000	452.0	325.4	8.8	7.48	2.48	9.96	4.02	52.80	6.22	3.74
15	0.6000	476.0	342.7	10.5	7.73	2.61	10.33	3.96	51.90	6.47	3.86
16	0.7000	496.0	357.1	12.3	7.89	2.74	10.63	3.89	51.00	6.68	3.95
17	0.8000	499.0	359.3	14.0	7.78	2.85	10.63	3.73	50.20	6.74	3.89
18	0.9000	515.0	370.8	15.8	7.87	2.98	10.85	3.64	49.30	6.92	3.93
19	1.0000	511.0	367.9	17.5	7.65	3.10	10.74	3.47	48.50	6.92	3.82
20	1.1000	516.0	371.5	19.3	7.56	3.21	10.77	3.35	47.70	6.99	3.78
21	1.2000	499.0	359.3	21.0	7.15	3.28	10.43	3.18	47.20	6.86	3.57

Parameters for Specimen No. [illegible]

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1089.500			655.220
Moisture content: Dry soil+tare, gms.	856.500			506.180
Moisture content: Tare, gms.	0.000			13.570
Moisture, %	27.2	30.3	23.5	30.3
Moist specimen weight, gms.	1116.2			
Diameter, in.	2.84	2.84	2.74	
Area, in.²	6.34	6.34	5.91	
Height, in.	5.66	5.66	5.46	
Net decrease in height, in.		0.00	0.20	
Wet Density, pcf	118.5	121.3	127.9	
Dry density, pcf	93.1	93.1	103.6	
Void ratio	0.8235	0.8235	0.6393	
Saturation, %	89.9	100.0	100.0	

Test Readings for Specimen No. [illegible]

Load ring constant = 0.72 lbs. per input unit

Consolidation cell pressure = 100.00 psi (14.40 ksf)

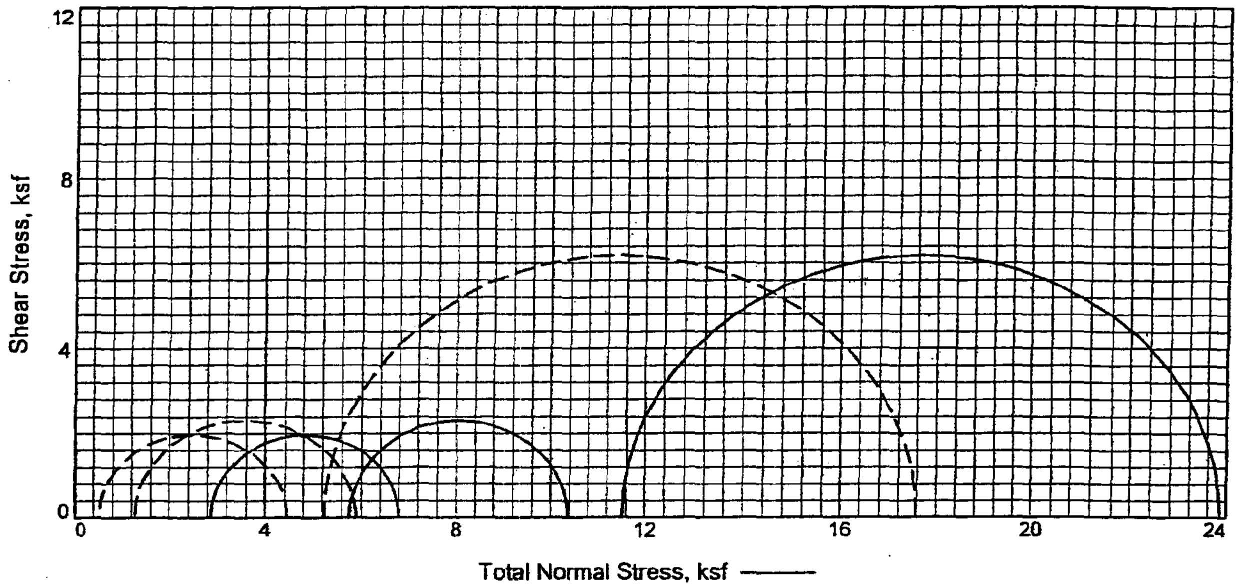
Consolidation back pressure = 40.00 psi (5.76 ksf)

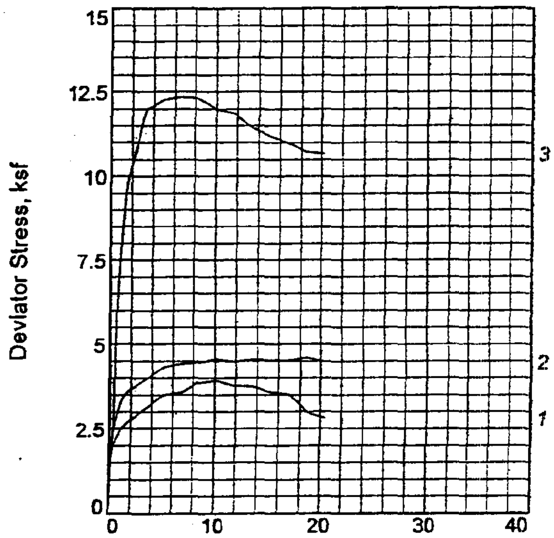
Consolidation effective confining stress = 8.64 ksf

Strain rate, in./min. = 0.02

Fail. Stress = 9.03 ksf **at reading no.** 18

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	8.64	8.64	1.00	40.00	8.64	0.00
1	0.0100	127.0	91.4	0.2	2.23	7.99	10.22	1.28	44.50	9.10	1.11
2	0.0200	200.0	144.0	0.4	3.50	7.27	10.77	1.48	49.50	9.02	1.75
3	0.0300	261.0	187.9	0.5	4.56	6.44	10.99	1.71	55.30	8.71	2.28
4	0.0400	308.0	221.8	0.7	5.37	5.62	10.98	1.96	61.00	8.30	2.68
5	0.0500	340.0	244.8	0.9	5.91	5.05	10.97	2.17	64.90	8.01	2.96
6	0.0600	375.0	270.0	1.1	6.51	4.59	11.10	2.42	68.10	7.85	3.26
7	0.0700	400.0	288.0	1.3	6.93	4.23	11.17	2.64	70.60	7.70	3.47
8	0.0800	420.0	302.4	1.5	7.26	3.96	11.22	2.83	72.50	7.59	3.63
9	0.0900	439.0	316.1	1.6	7.58	3.67	11.25	3.06	74.50	7.46	3.79
10	0.1000	455.0	327.6	1.8	7.84	3.46	11.30	3.27	76.00	7.38	3.92
11	0.2000	516.0	371.5	3.7	8.73	2.88	11.61	4.03	80.00	7.24	4.36
12	0.3000	525.0	378.0	5.5	8.71	3.01	11.72	3.89	79.10	7.36	4.35
13	0.4000	548.0	394.6	7.3	8.92	3.01	11.92	3.96	79.10	7.47	4.46
14	0.5000	550.0	396.0	9.2	8.77	3.12	11.90	3.81	78.30	7.51	4.39
15	0.6000	578.0	416.2	11.0	9.03	3.24	12.27	3.79	77.50	7.76	4.52
16	0.7000	584.0	420.5	12.8	8.94	3.25	12.19	3.75	77.40	7.72	4.47
17	0.8000	601.0	432.7	14.6	9.01	3.28	12.29	3.74	77.20	7.79	4.50
18	0.9000	616.0	443.5	16.5	9.03	3.33	12.36	3.72	76.90	7.84	4.52
19	1.0000	613.0	441.4	18.3	8.79	3.38	12.18	3.60	76.50	7.78	4.40
20	1.1000	632.0	455.0	20.1	8.86	3.36	12.22	3.64	76.70	7.79	4.43
21	1.2000	633.0	455.8	22.0	8.67	3.38	12.06	3.56	76.50	7.72	4.34





Sample No.		1	2	3
Initial	Water Content,	34.3	30.5	30.5
	Dry Density, pcf	83.5	87.6	85.3
	Saturation,	90.2	88.3	83.9
	Void Ratio	1.0327	0.9385	0.9897
	Diameter, in.	2.82	2.82	2.82
	Height, in.	6.01	6.03	6.12
At Test	Water Content,	33.5	29.8	30.6
	Dry Density, pcf	88.9	93.8	92.7
	Saturation,	100.0	100.0	100.0
	Void Ratio	0.9106	0.8112	0.8327
	Diameter, in.	2.77	2.76	2.74
	Height, in.	5.89	5.89	5.96
Strain rate, in./min.		0.02	0.02	0.02
Back Pressure, ksf		2.9	2.9	2.9
Cell Pressure, ksf		5.8	8.6	14.4
Fail. Stress, ksf		3.9	4.6	12.3
Total Pore Pr., ksf		5.2	7.4	9.2
Ult. Stress, ksf				
Total Pore Pr., ksf				
$\bar{\sigma}_1$ Failure, ksf		4.4	5.9	17.6
$\bar{\sigma}_3$ Failure, ksf		0.5	1.3	5.2

Type of Test:
CU with Pore Pressures

Sample Type: undisturbed

Description: Brown sandy elastic silt

LL= 58 **PL=** 34 **PI=** 24

Specific Gravity= 2.72

Remarks: MH

Figure ____

Client: TVA

Project: TVA Kingston - Proposed Gypsum Stack

Location: NB-47A

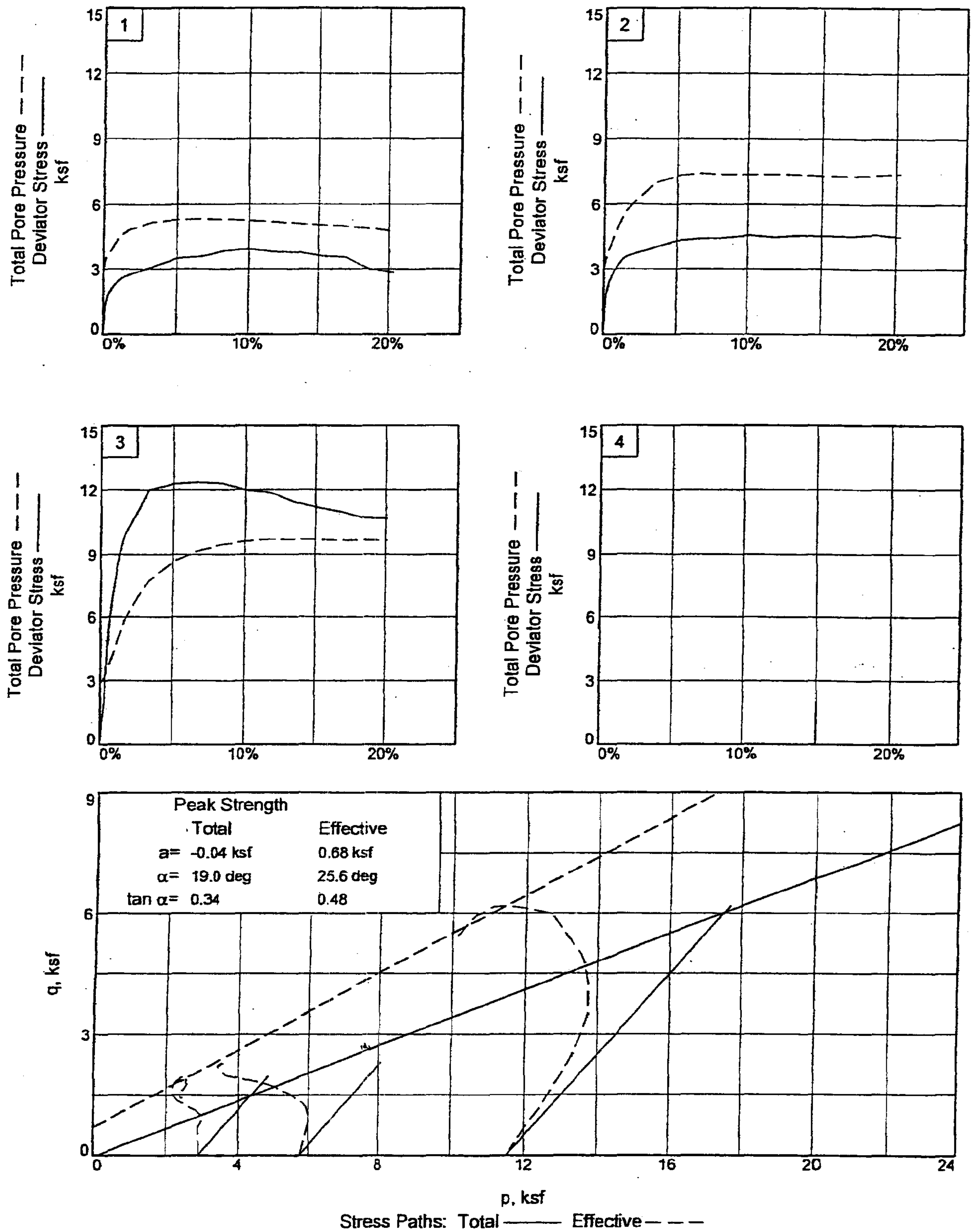
Sample Number: UD-4, 5 & 6 (CU) **Depth:** 18'-27'

Proj. No.: 3043051021 **Date:**

TRIAXIAL SHEAR TEST REPORT

MACTEC, INC.

Tested By: Alexander **Checked By:** Hamlett



Client: TVA

Project: TVA Kingston - Proposed Gypsum Stack

Location: NB-47A **Depth:** 18'-27' **Sample Number:** UD-4, 5 & 6 (CU)

Project No.: 3043051021 **Figure** ______

MACTEC, INC.

Tested By: Alexander **Checked By:** Hamlett

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

9/16/2005
10:50 AM

Date:
Client: TVA
Project: TVA Kingston - Proposed Gypsum Stack
Project No.: 3043051021
Location: NB-47A
Depth: 18'-27' **Sample Number:** UD-4, 5 & 6 (CU)
Description: Brown sandy elastic silt
Remarks: MH
Type of Sample: undisturbed
Specific Gravity=2.72 **LL**=58 **PL**=34 **PI**=24
Test Method: COE uniform strain

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1130.900			1121.520
Moisture content: Dry soil+tare, gms.	842.300			852.460
Moisture content: Tare, gms.	0.000			13.660
Moisture, %	34.3	38.0	33.5	32.1
Moist specimen weight, gms.	1108.5			
Diameter, in.	2.82	2.82	2.77	
Area, in.²	6.26	6.26	6.01	
Height, in.	6.01	6.01	5.89	
Net decrease in height, in.		0.00	0.12	
Wet Density, pcf	112.2	115.3	118.6	
Dry density, pcf	83.5	83.5	88.9	
Void ratio	1.0327	1.0327	0.9106	
Saturation, %	90.2	100.0	100.0	

Load ring constant = 0.72 lbs. per input unit
Consolidation cell pressure = 40.00 psi (5.76 ksf)
Consolidation back pressure = 20.00 psi (2.88 ksf)
Consolidation effective confining stress = 2.88 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 3.92 ksf **at reading no.** 15

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	2.88	2.88	1.00	20.00	2.88	0.00
1	0.0100	78.0	56.2	0.2	1.34	2.19	3.53	1.61	24.80	2.86	0.67
2	0.0200	107.0	77.0	0.3	1.84	2.10	3.94	1.88	25.40	3.02	0.92
3	0.0300	121.0	87.1	0.5	2.08	1.87	3.95	2.11	27.00	2.91	1.04
4	0.0400	131.0	94.3	0.7	2.24	1.67	3.92	2.34	28.40	2.79	1.12
5	0.0500	136.0	97.9	0.8	2.33	1.53	3.85	2.52	29.40	2.69	1.16
6	0.0600	143.0	103.0	1.0	2.44	1.37	3.81	2.79	30.50	2.59	1.22
7	0.0750	151.0	108.7	1.3	2.57	1.20	3.77	3.15	31.70	2.48	1.29
8	0.0800	152.0	109.4	1.4	2.59	1.15	3.74	3.25	32.00	2.45	1.29
9	0.0900	156.0	112.3	1.5	2.65	1.07	3.72	3.49	32.60	2.39	1.33
10	0.1000	159.0	114.5	1.7	2.70	0.98	3.68	3.75	33.20	2.33	1.35
11	0.2000	185.0	133.2	3.4	3.08	0.59	3.67	6.22	35.90	2.13	1.54
12	0.3000	213.0	153.4	5.1	3.49	0.48	3.96	8.34	36.70	2.22	1.74
13	0.4000	222.0	159.8	6.8	3.57	0.45	4.02	9.00	36.90	2.23	1.79
14	0.5000	244.0	175.7	8.5	3.85	0.48	4.33	9.11	36.70	2.40	1.93
15	0.6000	253.0	182.2	10.2	3.92	0.52	4.44	8.56	36.40	2.48	1.96
16	0.7000	248.0	178.6	11.9	3.77	0.59	4.36	7.39	35.90	2.48	1.89
17	0.8000	252.0	181.4	13.6	3.76	0.68	4.43	6.55	35.30	2.56	1.88
18	0.9000	245.0	176.4	15.3	3.58	0.73	4.32	5.88	34.90	2.52	1.79
19	1.0000	247.0	177.8	17.0	3.54	0.79	4.33	5.47	34.50	2.56	1.77
20	1.1000	212.0	152.6	18.7	2.97	0.88	3.85	4.39	33.90	2.37	1.49
21	1.2000	205.0	147.6	20.4	2.82	1.02	3.84	3.75	32.90	2.43	1.41

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1171.700			1145.200
Moisture content: Dry soil+tare, gms.	898.100			908.160
Moisture content: Tare, gms.	0.000			13.550
Moisture, %	30.5	34.5	29.8	26.5
Moist specimen weight, gms.	1132.8			
Diameter, in.	2.82	2.82	2.76	
Area, in.^{2}	6.26	6.26	5.99	
Height, in.	6.03	6.03	5.89	
Net decrease in height, in.		0.00	0.13	
Wet Density, pcf	114.3	117.8	121.7	
Dry density, pcf	87.6	87.6	93.8	
Void ratio	0.9385	0.9385	0.8112	
Saturation, %	88.3	100.0	100.0	

Test Readings for Specimen No. 2

Load ring constant = 0.72 lbs. per input unit
Consolidation cell pressure = 60.00 psi (8.64 ksf)
Consolidation back pressure = 20.00 psi (2.88 ksf)
Consolidation effective confining stress = 5.76 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 4.61 ksf **at reading no.** 20

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	5.76	5.76	1.00	20.00	5.76	0.00
1	0.0100	104.0	74.9	0.2	1.80	5.13	6.92	1.35	24.40	6.03	0.90
2	0.0200	137.0	98.6	0.3	2.37	4.75	7.12	1.50	27.00	5.93	1.18
3	0.0300	155.0	111.6	0.5	2.67	4.45	7.12	1.60	29.10	5.79	1.34
4	0.0400	167.0	120.2	0.7	2.87	4.16	7.03	1.69	31.10	5.60	1.44
5	0.0500	178.0	128.2	0.8	3.06	3.92	6.97	1.78	32.80	5.45	1.53
6	0.0600	187.0	134.6	1.0	3.21	3.61	6.82	1.89	34.90	5.22	1.60
7	0.0700	196.0	141.1	1.2	3.35	3.37	6.72	2.00	36.60	5.05	1.68
8	0.0800	203.0	146.2	1.4	3.47	3.15	6.62	2.10	38.10	4.89	1.73
9	0.0900	208.0	149.8	1.5	3.55	2.97	6.51	2.20	39.40	4.74	1.77
10	0.1000	212.0	152.6	1.7	3.61	2.81	6.42	2.29	40.50	4.61	1.81
11	0.2000	236.0	169.9	3.4	3.95	1.70	5.65	3.32	48.20	3.67	1.97
12	0.3000	262.0	188.6	5.1	4.31	1.31	5.62	4.29	50.90	3.46	2.15
13	0.4000	273.0	196.6	6.8	4.41	1.22	5.63	4.60	51.50	3.43	2.20
14	0.5000	280.0	201.6	8.5	4.44	1.27	5.71	4.50	51.20	3.49	2.22
15	0.6000	293.0	211.0	10.2	4.56	1.27	5.83	4.60	51.20	3.55	2.28
16	0.7000	293.0	211.0	11.9	4.47	1.25	5.73	4.57	51.30	3.49	2.24
17	0.8000	304.0	218.9	13.6	4.55	1.27	5.82	4.59	51.20	3.54	2.28
18	0.9000	309.0	222.5	15.3	4.54	1.32	5.86	4.42	50.80	3.59	2.27
19	1.0000	314.0	226.1	17.0	4.52	1.34	5.86	4.37	50.70	3.60	2.26
20	1.1000	327.0	235.4	18.7	4.61	1.28	5.89	4.60	51.10	3.59	2.30
21	1.2000	325.0	234.0	20.4	4.48	1.22	5.71	4.66	51.50	3.47	2.24

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1095.500			658.130
Moisture content: Dry soil+tare, gms.	839.200			494.670
Moisture content: Tare, gms.	0.000			13.340
Moisture, %	30.5	36.4	30.6	34.0
Moist specimen weight, gms.	1116.1			
Diameter, in.	2.82	2.82	2.74	
Area, in.²	6.23	6.23	5.90	
Height, in.	6.12	6.12	5.96	
Net decrease in height, in.		0.00	0.16	
Wet Density, pcf	111.4	116.4	121.0	
Dry density, pcf	85.3	85.3	92.7	
Void ratio	0.9897	0.9897	0.8327	
Saturation, %	83.9	100.0	100.0	

Test Readings for Specimen No. 3

Load ring constant = 0.72 lbs. per input unit

Consolidation cell pressure = 100.00 psi (14.40 ksf)

Consolidation back pressure = 20.00 psi (2.88 ksf)

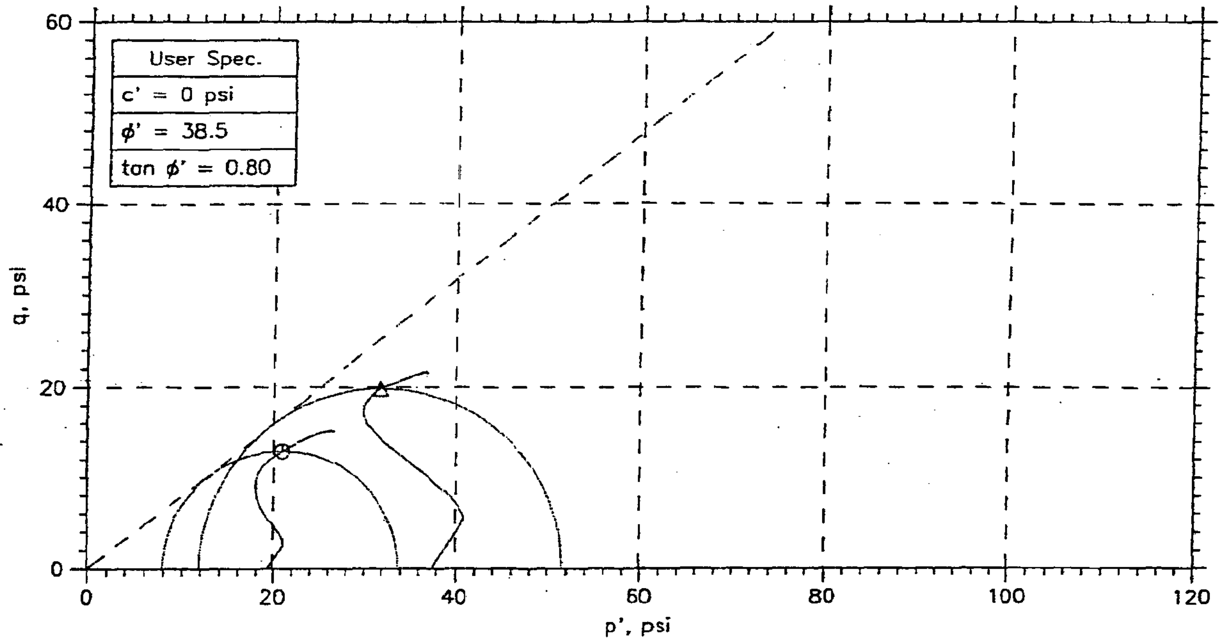
Consolidation effective confining stress = 11.52 ksf

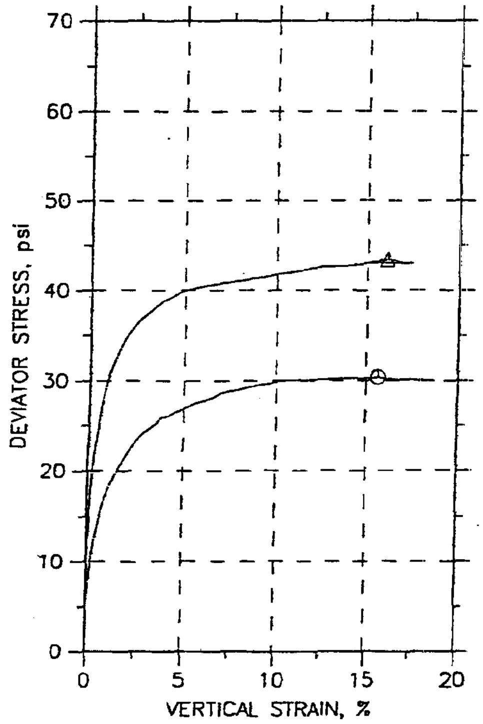
Strain rate, in./min. = 0.02

Fail. Stress = 12.35 ksf **at reading no.** 13

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	11.52	11.52	1.00	20.00	11.52	0.00
1	0.0100	71.0	51.1	0.2	1.25	11.35	12.59	1.11	21.20	11.97	0.62
2	0.0200	131.0	94.3	0.3	2.29	11.25	13.54	1.20	21.90	12.39	1.15
3	0.0300	262.0	188.6	0.5	4.58	10.92	15.50	1.42	24.20	13.21	2.29
4	0.0400	337.0	242.6	0.7	5.88	10.58	16.47	1.56	26.50	13.53	2.94
5	0.0500	399.0	287.3	0.8	6.95	10.25	17.21	1.68	28.80	13.73	3.48
6	0.0600	446.0	321.1	1.0	7.76	9.86	17.62	1.79	31.50	13.74	3.88
7	0.0700	487.0	350.6	1.2	8.46	9.52	17.98	1.89	33.90	13.75	4.23
8	0.0800	519.0	373.7	1.3	9.00	9.20	18.20	1.98	36.10	13.70	4.50
9	0.0900	549.0	395.3	1.5	9.50	8.88	18.39	2.07	38.30	13.64	4.75
10	0.1000	574.0	413.3	1.7	9.92	8.58	18.50	2.16	40.40	13.54	4.96
11	0.2000	706.0	508.3	3.4	11.99	6.68	18.67	2.79	53.60	12.68	6.00
12	0.3000	735.0	529.2	5.0	12.27	5.73	18.00	3.14	60.20	11.87	6.13
13	0.4000	753.0	542.2	6.7	12.35	5.24	17.59	3.36	63.60	11.42	6.17
14	0.5000	764.0	550.1	8.4	12.30	4.95	17.26	3.48	65.60	11.10	6.15
15	0.6000	758.0	545.8	10.1	11.98	4.78	16.76	3.51	66.80	10.77	5.99
16	0.7000	765.0	550.8	11.7	11.87	4.69	16.56	3.53	67.40	10.63	5.93
17	0.8000	752.0	541.4	13.4	11.44	4.69	16.14	3.44	67.40	10.42	5.72
18	0.9000	750.0	540.0	15.1	11.19	4.71	15.90	3.38	67.30	10.30	5.60
19	1.0000	752.0	541.4	16.8	11.00	4.74	15.74	3.32	67.10	10.24	5.50
20	1.1000	748.0	538.6	18.5	10.72	4.72	15.44	3.27	67.20	10.08	5.36
21	1.2000	760.0	547.2	20.1	10.67	4.74	15.41	3.25	67.10	10.07	5.33

CONSOLIDATED UNDRAINED TRIAXIAL TEST





Symbol		⊖	△		
Sample No.		UD-1	UD-1		
Test No.		13774.1	13774.2		
Depth		20-22 Ft.	20-22 ft		
Initial	Diameter, in	2.84	2.821		
	Height, in	5.57	5.57		
	Water Content, %	43.8	40.8		
	Dry Density, pcf	77.03	79.62		
	Saturation, %	98.9	97.9		
	Void Ratio	1.21	1.14		
Before Shear	Water Content, %	43.7	39.5		
	Dry Density, pcf	77.67	81.88		
	Saturation*, %	100.0	100.0		
	Void Ratio	1.19	1.08		
	Back Press., psi	41.99	58		
Ver. Eff. Cons. Stress, psi		20	40		
Shear Strength, psi		15.17	21.71		
Strain at Failure, %		15.6	16.1		
Strain Rate, %/min		0.022	0.022		
B-Value		0.95	0.95		
Estimated Specific Gravity		2.72	2.72		
Liquid Limit		79	79		
Plastic Limit		40	40		

GeoTesting express a groundwork for success

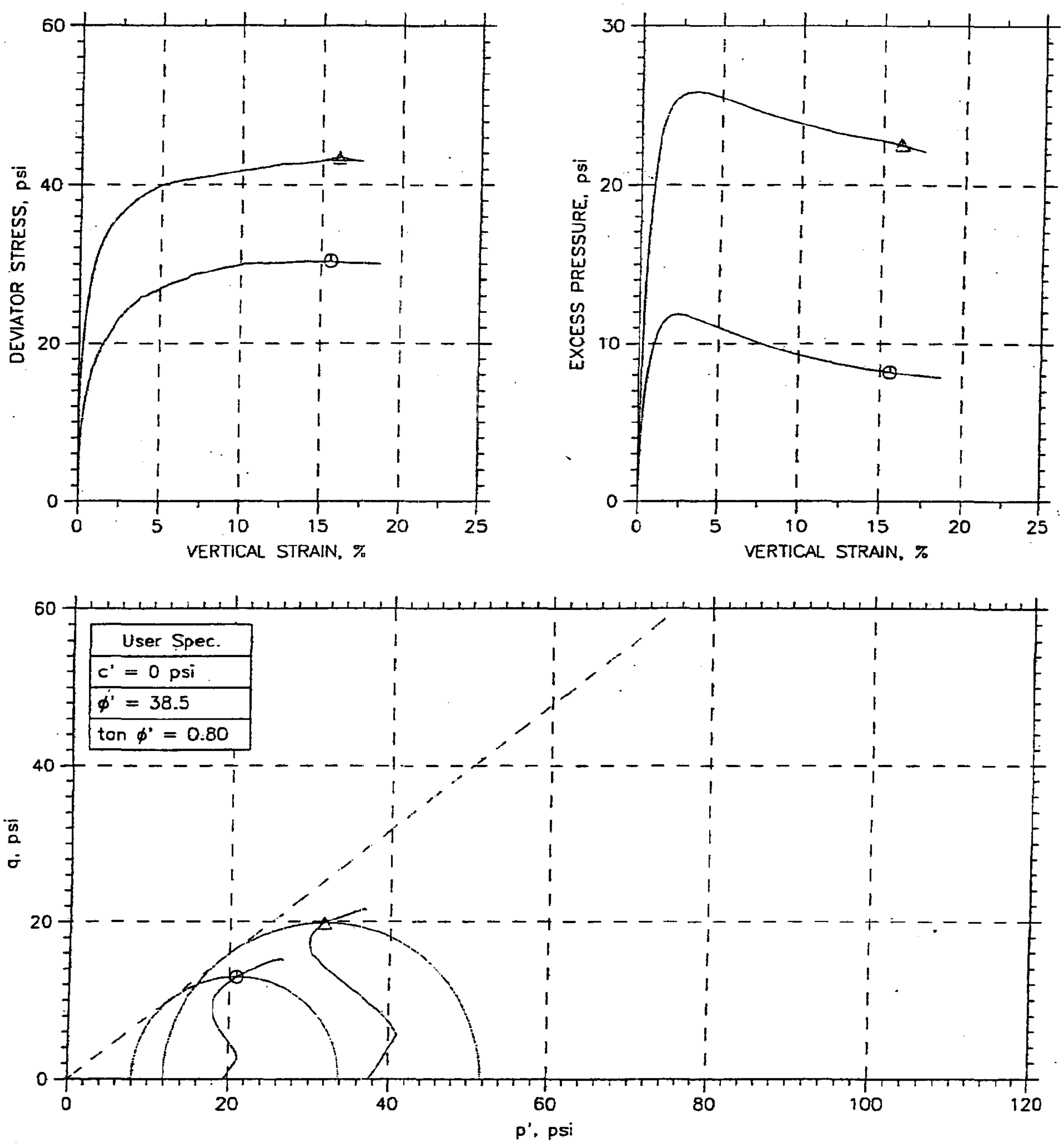
Project: TVA Kingston Gypsym Stack	
Location: NB-47ba	
Project No.: GTX G0959	
Boring No.: NB-47BA	
Sample Type: Shelby Tube	
Description:	
Remarks:	

Phase calculations based on start and end of test.

* Saturation is set to 100% for phase calculations.

Thu, 02-FEB-2006 15:08:21

CONSOLIDATED UNDRAINED TRIAXIAL TEST



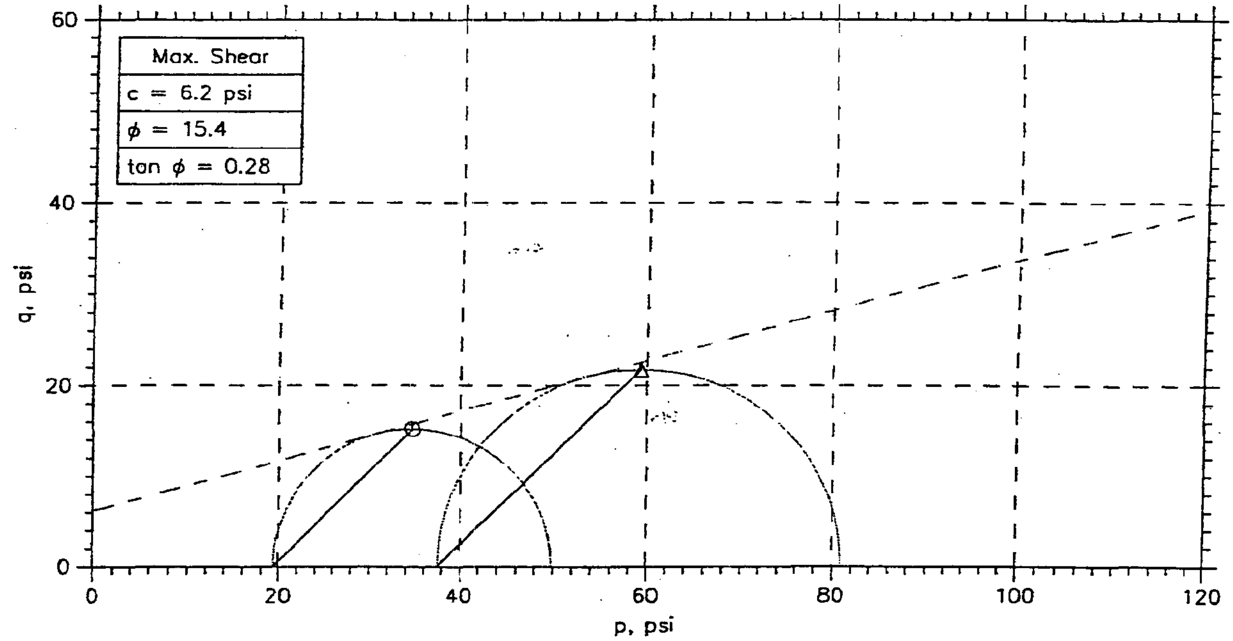
	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	UD-1	13774.1	20-22 Ft.	JW	12/17/05	HJ		13774.1a_2054.dat
△	UD-1	13774.2	20-22 ft	JW	12/17/05	HJ		13774.2a _1057.dat

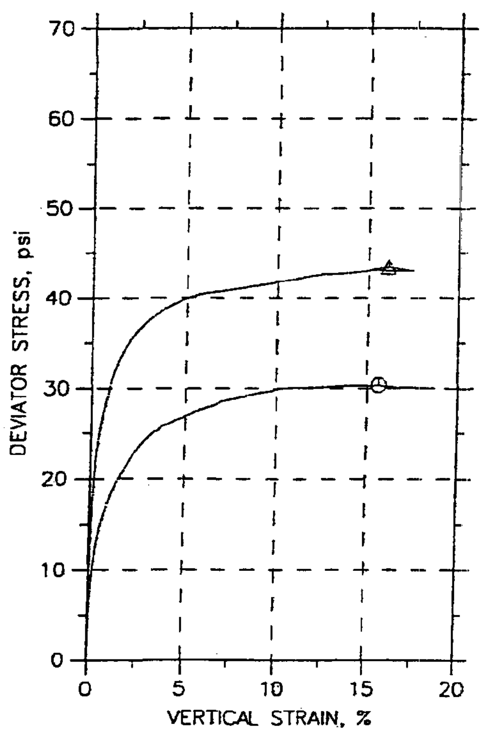
GeoTesting express the groundwork for success

Project: TVA Kingston Gypsym Stddocation: NB-47ba		Project No.: GTX G0959
Boring No.: NB-47BA	Sample Type: Shelby Tube	
Description:		
Remarks:		

Thu, 02-FEB-2006 15:08:21

CONSOLIDATED UNDRAINED TRIAXIAL TEST





Symbol		O	Δ		
Sample No.		UD-1	UD-1		
Test No.		13774.1	13774.2		
Depth		20-22 Ft.	20-22 ft		
Initial	Diameter, in	2.84	2.821		
	Height, in	5.57	5.57		
	Water Content, %	43.8	40.8		
	Dry Density, pcf	77.03	79.62		
	Saturation, %	98.9	97.9		
	Void Ratio	1.21	1.14		
Before Shear	Water Content, %	43.7	39.5		
	Dry Density, pcf	77.67	81.88		
	Saturation*, %	100.0	100.0		
	Void Ratio	1.19	1.08		
	Back Press., psi	41.99	58		
Ver. Eff. Cons. Stress, psi		20	40		
Shear Strength, psi		15.17	21.71		
Strain at Failure, %		15.6	16.1		
Strain Rate, %/min		0.022	0.022		
B-Value		0.95	0.95		
Estimated Specific Gravity		2.72	2.72		
Liquid Limit		79	79		
Plastic Limit		40	40		

GeoTesting express the groundwork for success

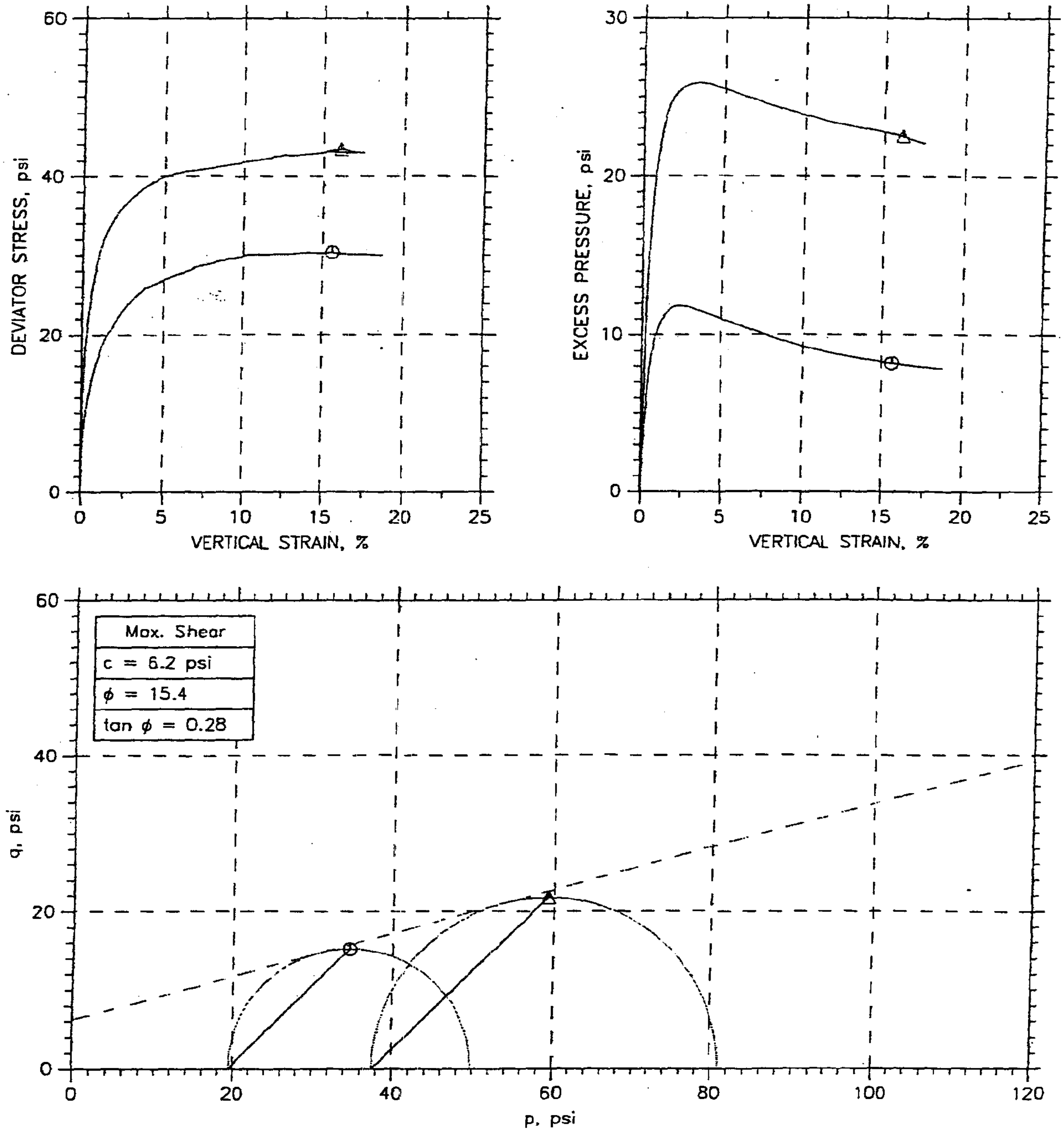
Project: TVA Kingston Gypsym Stack	
Location: NB-47ba	
Project No.: GTX G0959	
Boring No.: NB-47BA	
Sample Type: Shelby Tube	
Description:	
Remarks:	

Thu. 02-FEB-2006 15:07:49

Phase calculations based on start and end of test.

* Saturation is set to 100% for phase calculations.

CONSOLIDATED UNDRAINED TRIAXIAL TEST



	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
ʘ	UD-1	13774.1	20-22 Ft.	JW	12/17/05	HJ		13774.1a_2054.dat
Δ	UD-1	13774.2	20-22 ft	JW	12/17/05	HJ		13774.2a _1057.dat

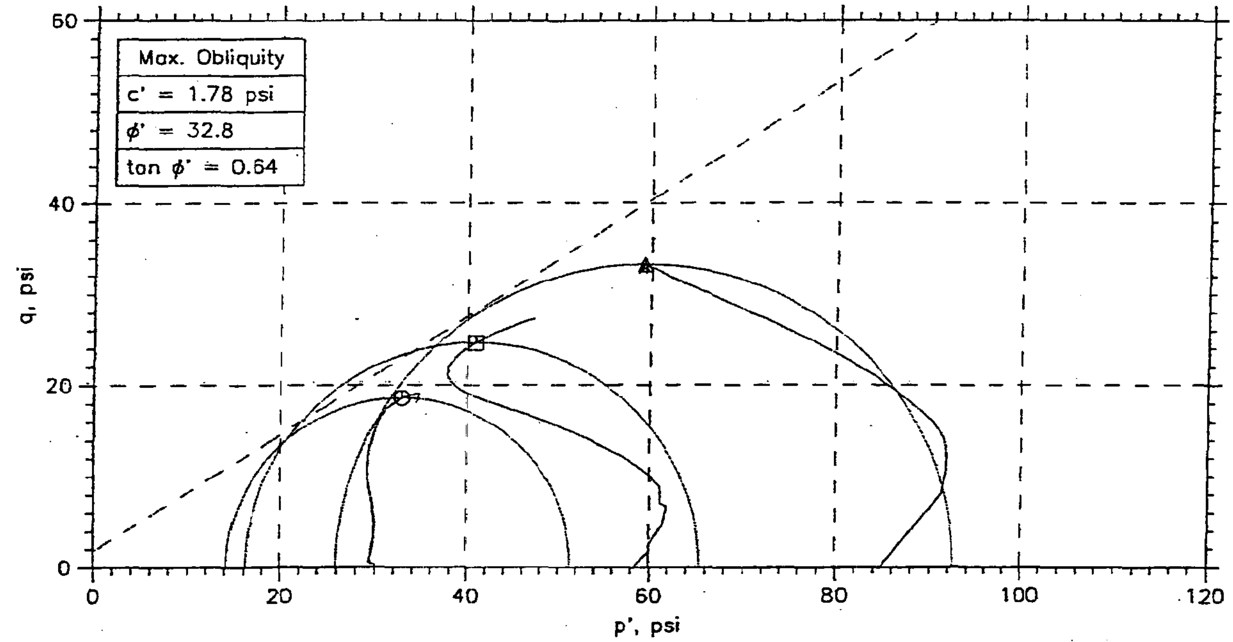
GeoTesting express
the groundwork for success

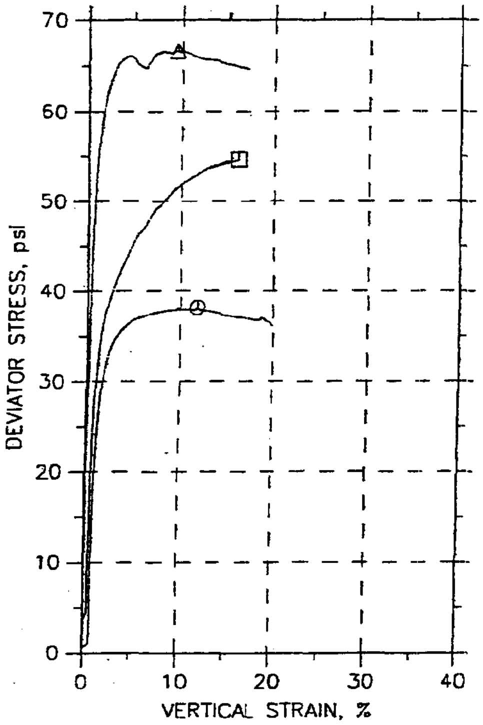
Project: TVA Kingston Gypsym Std	Location: NB-47ba	Project No.: GTX G0959
Boring No.: NB-47BA	Sample Type: Shelby Tube	
Description:		
Remarks:		

Thu, 02-FEB-2006 15:07:49

TVA-00021025

CONSOLIDATED UNDRAINED TRIAXIAL TEST





Symbol		○	△	□	
Sample No.		UD-3	UD-3	UD-1	
Test No.		13767.4	13767.3	13768.1	
Depth		40-42 Ft.	40-42 ft	40-42 ft	
Initial	Diameter, in	2.846	2.83	2.848	
	Height, in	5.57	5.57	5.57	
	Water Content, %	26.2	26.2	29.6	
	Dry Density, pcf	98.67	100.1	95.95	
	Saturation, %	97.9	101.0	103.4	
	Void Ratio	0.735	0.71	0.785	
Before Shear	Water Content, %	24.5	21.8	23.3	
	Dry Density, pcf	102.4	107.2	104.4	
	Saturation*, %	100.0	100.0	100.0	
	Void Ratio	0.672	0.597	0.64	
	Back Press., psi	61.99	54	58	
Ver. Eff. Cons. Stress, psi		30	89.99	60	
Shear Strength, psi		19.08	33.35	27.32	
Strain at Failure, %		11.8	9.46	16.1	
Strain Rate, %/min		0.022	0.022	0.022	
B-Value		0.95	0.95	0.95	
Measured Specific Gravity		2.74	2.74	2.74	
Liquid Limit		51	51	54	
Plastic Limit		24	24	24	

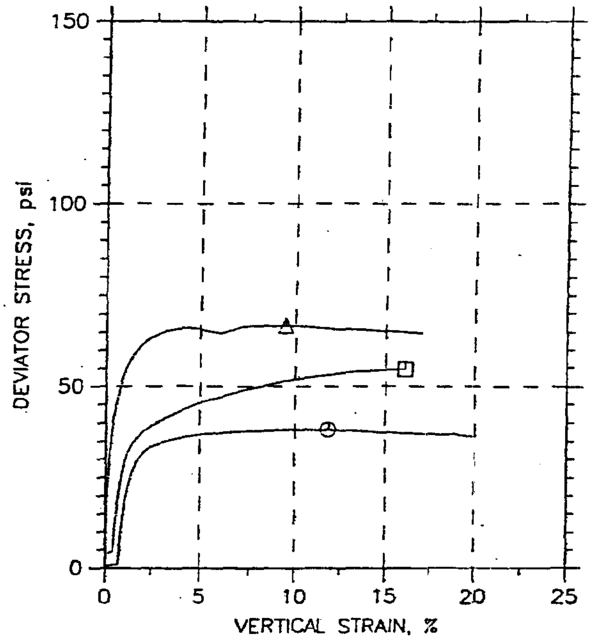
GeoTesting express — the groundwork for success

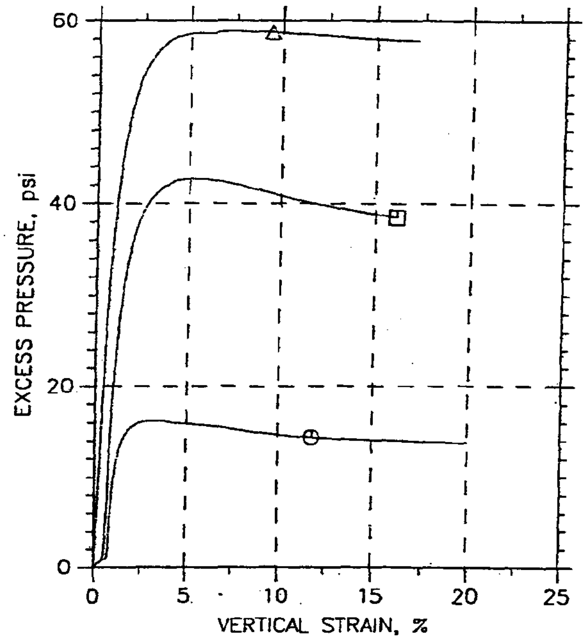
Project: TVA Kingston Gypsym Stack
Location: NB-73
Project No.: GTX G0959
Boring No.: NB-73WB
Sample Type: Shelby Tube
Description:
Remarks:

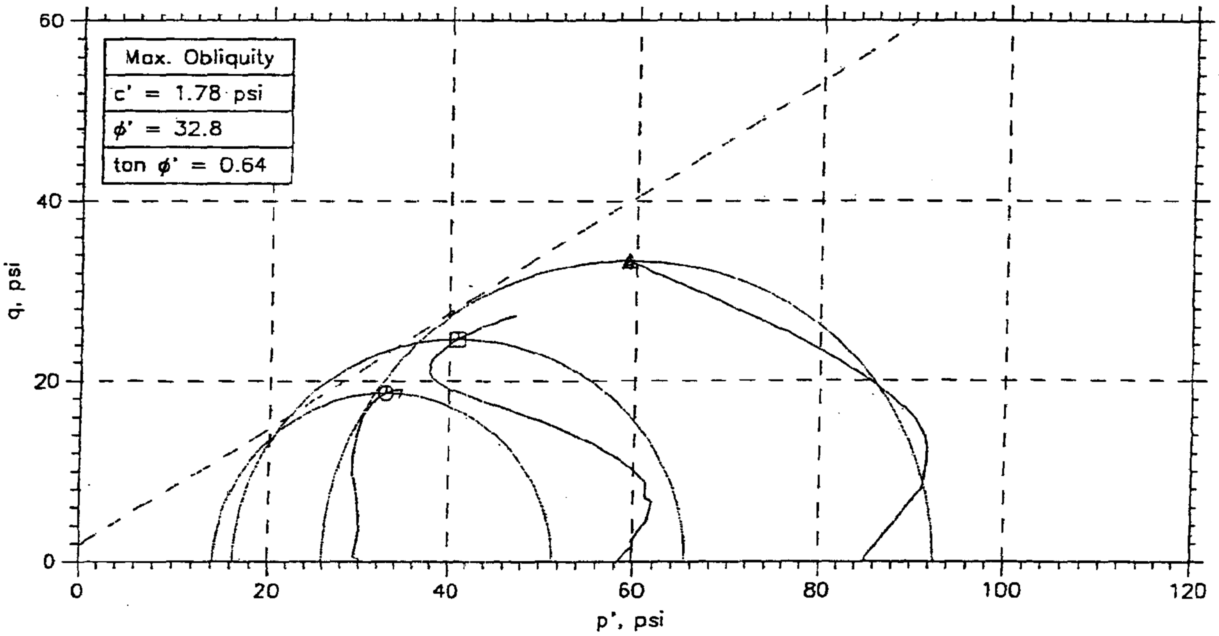
Phase calculations based on start and end of test.
* Saturation is set to 100% for phase calculations.

Thu, 02-FEB-2006 15:21:12

CONSOLIDATED UNDRAINED TRIAXIAL TEST





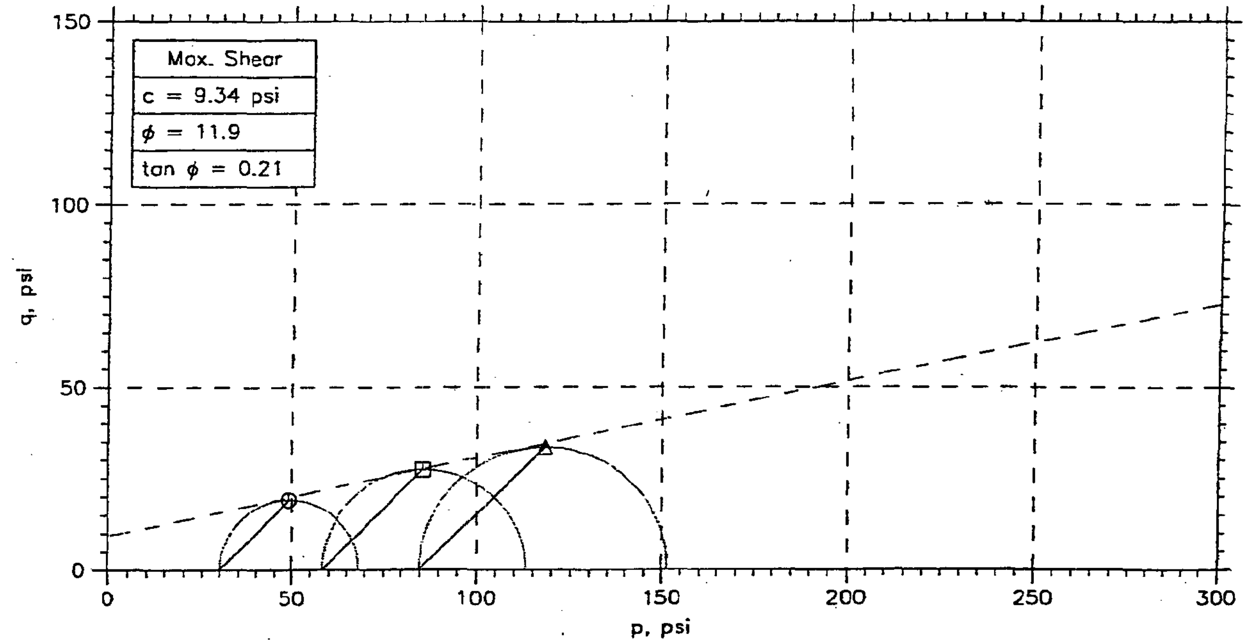


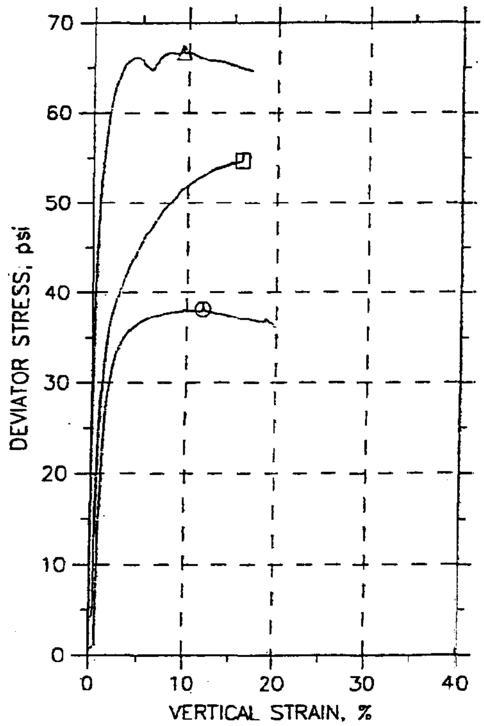
	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
O	UD-3	13767.4	40-42 Ft.	HJ	12/6/05	JW		13767.4_2054.dat
Δ	UD-3	13767.3	40-42 ft	JW	12/3/05	HJ		13767.3_1062.dat
□	UD-1	13768.1	40-42 ft	JW	12/7/05	HJ		13768.1_1062.dat

GeoTesting express the groundwork for success	Project: TVA Kingston Gypsym Std	Location: NB-73	Project No.: GTX G0959
	Boring No.: NB-73WB	Sample Type: Shelby Tube	
	Description:		
	Remarks:		

Thu, 02-FEB-2006 15:21:12

CONSOLIDATED UNDRAINED TRIAXIAL TEST





		○	△	□	
Symbol		○	△	□	
Sample No.		UD-3	UD-3	UD-1	
Test No.		13767.4	13767.3	13768.1	
Depth		40-42 Ft.	40-42 ft	40-42 ft	
Initial	Diameter, in	2.846	2.83	2.848	
	Height, in	5.57	5.57	5.57	
	Water Content, %	26.2	26.2	29.6	
	Dry Density, pcf	98.67	100.1	95.95	
	Saturation, %	97.9	101.0	103.4	
	Void Ratio	0.735	0.71	0.785	
Before Shear	Water Content, %	24.5	21.8	23.3	
	Dry Density, pcf	102.4	107.2	104.4	
	Saturation*, %	100.0	100.0	100.0	
	Void Ratio	0.672	0.597	0.64	
	Back Press., psi	61.99	54	58	
Ver. Eff. Cons. Stress, psi		30	89.99	60	
Shear Strength, psi		19.08	33.35	27.32	
Strain at Failure, %		11.8	9.46	16.1	
Strain Rate, %/min		0.022	0.022	0.022	
B-Value		0.95	0.95	0.95	
Measured Specific Gravity		2.74	2.74	2.74	
Liquid Limit		51	51	54	
Plastic Limit		24	24	24	

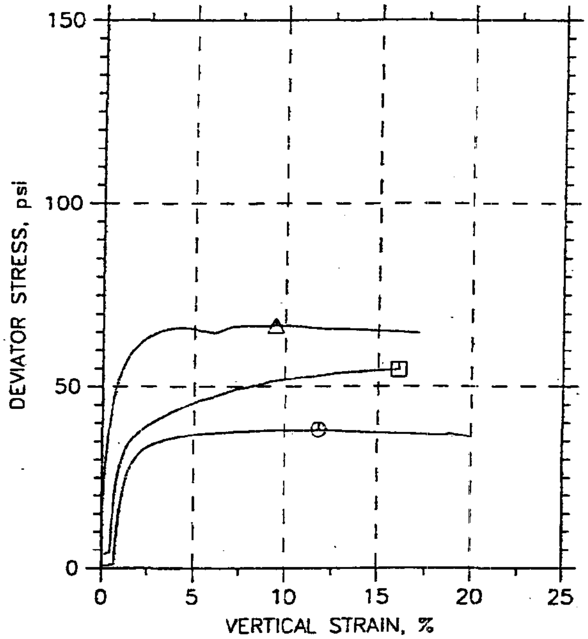
GeoTesting express — the groundwork for success	Project: TVA Kingston Gypsym Stack
	Location: NB-73
	Project No.: GTX G0959
	Boring No.: NB-73 WB
	Sample Type: Shelby Tube
	Description:
	Remarks:

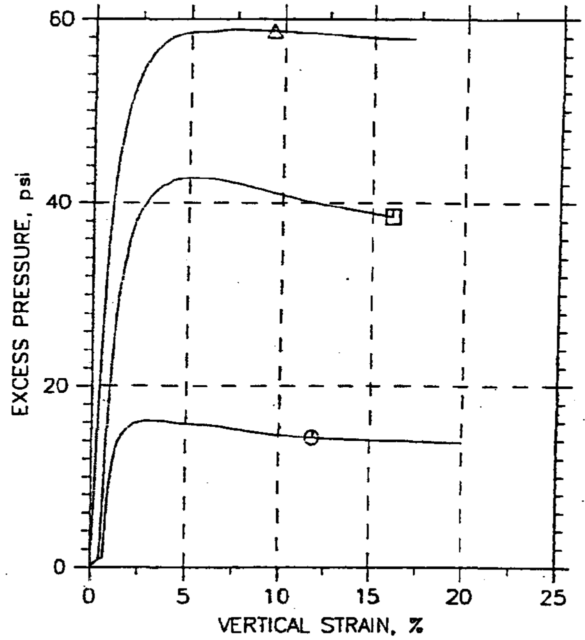
Thu, 02-FEB-2006 15:21:40

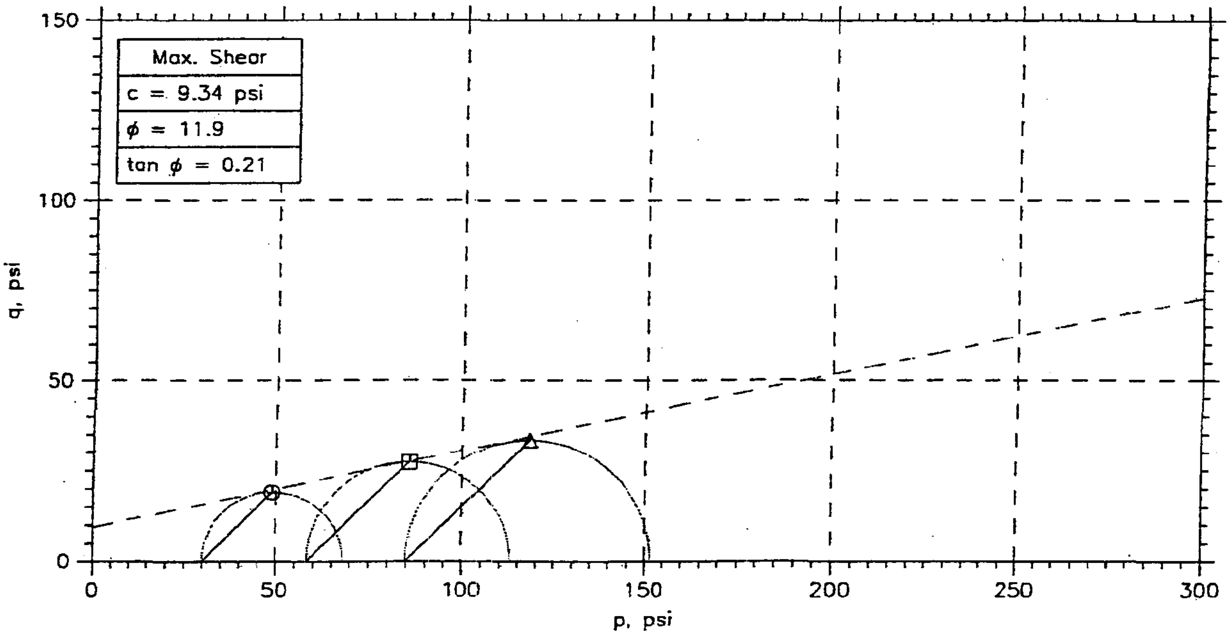
Phase calculations based on start and end of test.

* Saturation is set to 100% for phase calculations.

CONSOLIDATED UNDRAINED TRIAXIAL TEST







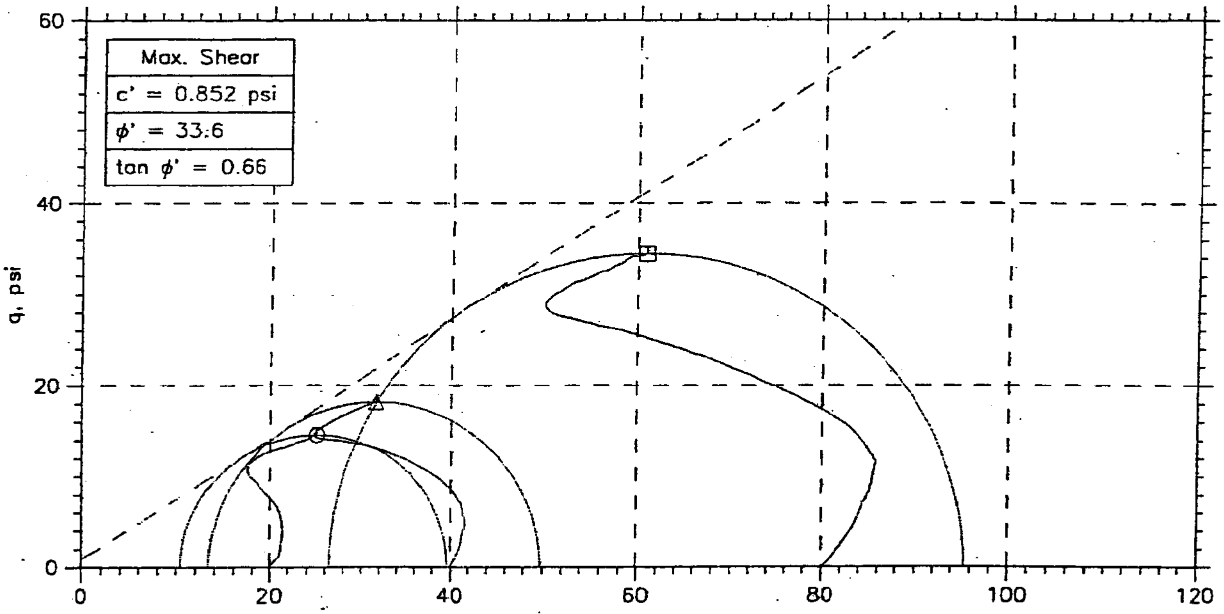
	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
⊕	UD-3	13767.4	40-42 Ft.	HJ	12/6/05	JW		13767.4_2054.dat
△	UD-3	13767.3	40-42 ft	JW	12/3/05	HJ		13767.3_1062.dat
⊡	UD-1	13768.1	40-42 ft	JW	12/7/05	HJ		13768.1_1062.dat

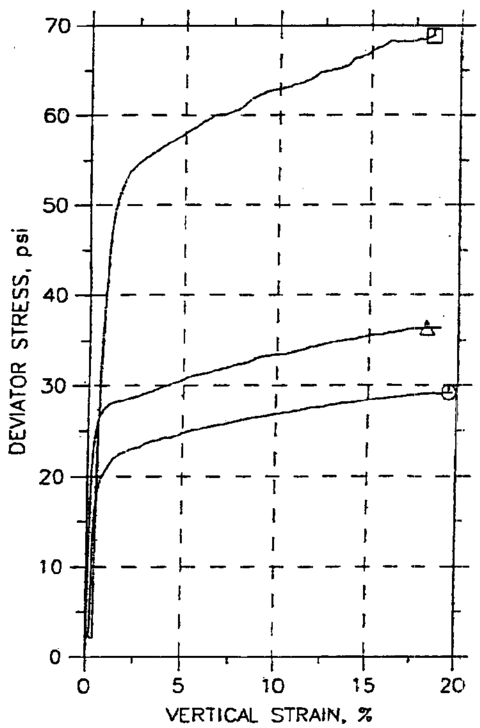
GeoTesting express the groundwork for success

Project: TVA Kingston Gypsym Std	Location: NB-73	Project No.: GTX G0959
Boring No.: NB-73 WB	Sample Type: Shelby Tube	
Description:		
Remarks:		

Thu, 02-FEB-2006 15:21:40

CONSOLIDATED UNDRAINED TRIAXIAL TEST





		○	△	□	
Symbol		○	△	□	
Sample No.		Bag	Bag	Bag	
Test No.		13925.1	13925.2	13925.3	
Depth		5-15 ft	5-15 ft	5-15 ft	
Initial	Diameter, in	2.87	2.87	2.87	
	Height, in	6	6	6	
	Water Content, %	23.1	22.7	23.2	
	Dry Density, pcf	95.94	95.96	95.56	
	Saturation, %	84.6	83.1	84.2	
	Void Ratio	0.724	0.724	0.731	
Before Shear	Water Content, %	25.9	25.4	23.3	
	Dry Density, pcf	98.12	98.9	102.2	
	Saturation*, %	100.0	100.0	100.0	
	Void Ratio	0.686	0.673	0.618	
	Back Press., psi	89.98	90	60.01	
Ver. Eff. Cons. Stress, psi		20.01	40	79.98	
Shear Strength, psi		14.59	18.18	34.4	
Strain at Failure, %		19.5	18.3	18.5	
Strain Rate, %/min		0.022	0.022	0.022	
B-Value		0.95	0.95	0.95	
Measured Specific Gravity		2.65	2.65	2.65	
Liquid Limit		48	48	48	
Plastic Limit		28	28	28	

GeoTesting express the groundwork for success

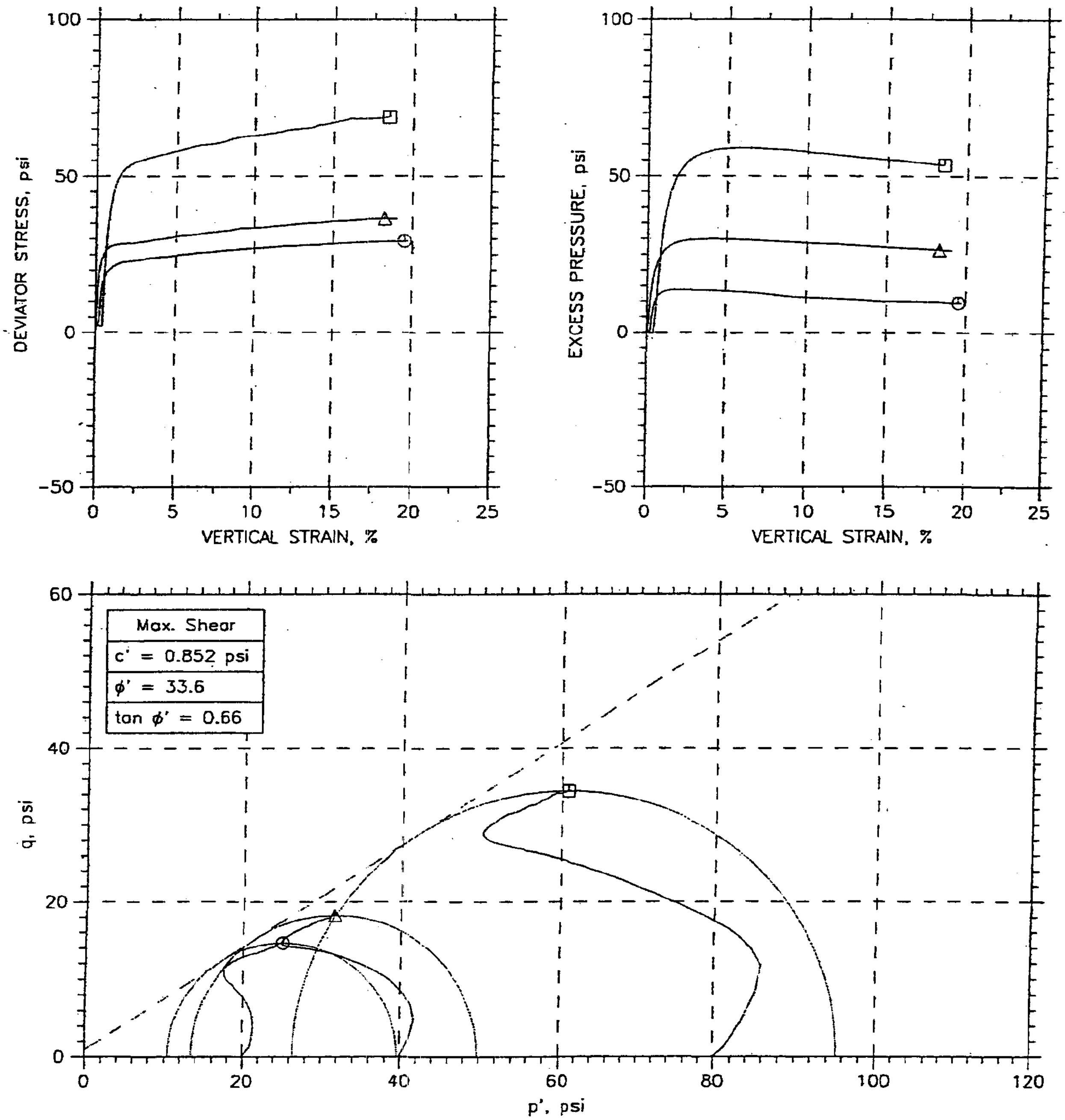
Project: TVA Kingston Gypsym Stack	
Location: NB-76	
Project No.: GTX G0959	
Boring No.: NB-76	
Sample Type: Remolded	
Description: Reddish Brown Sandy Silt	
Remarks: Remolded to 95% of Standard Proctor max. dry density and +2% opt.	

Phase calculations based on start of test.

Tue, 24-JAN-2006 10:47:29

* Saturation is set to 100% for phase calculations.

CONSOLIDATED UNDRAINED TRIAXIAL TEST



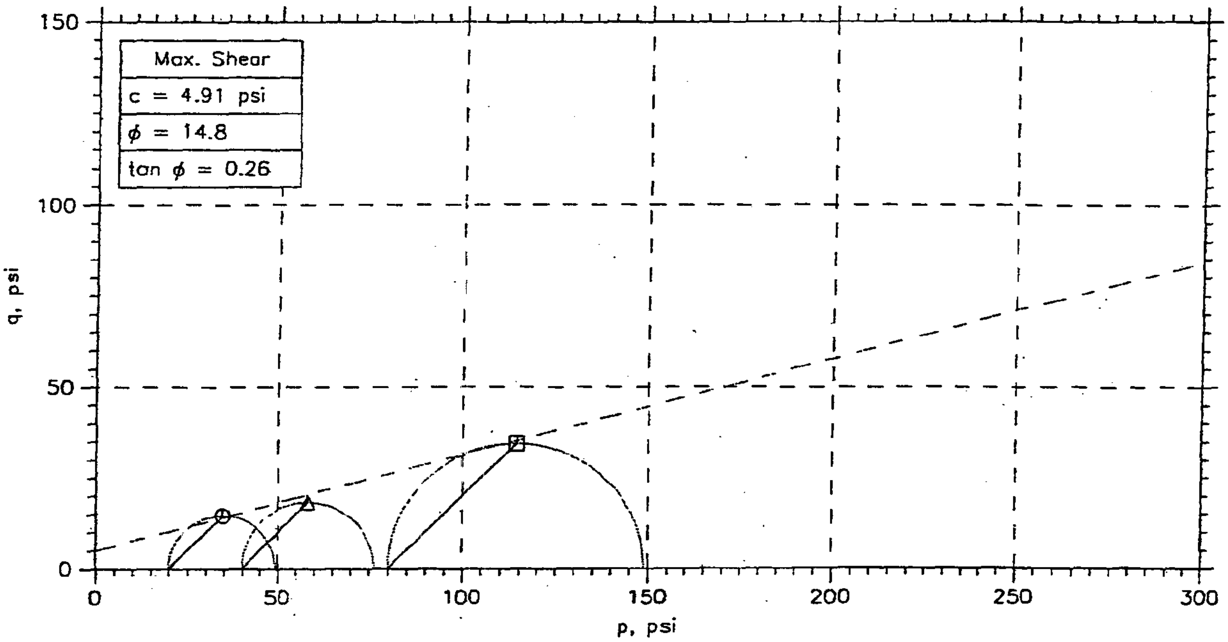
	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	Bag	13925.1	5-15 ft	HJ	1/21/06	JW		13925.1a_2054.dat
△	Bag	13925.2	5-15 ft	JW	1/21/05	HJ		13925.2a_1062.dat
□	Bag	13925.3	5-15 ft	JW	1/19/05	HJ		13925.3a_1057.dat

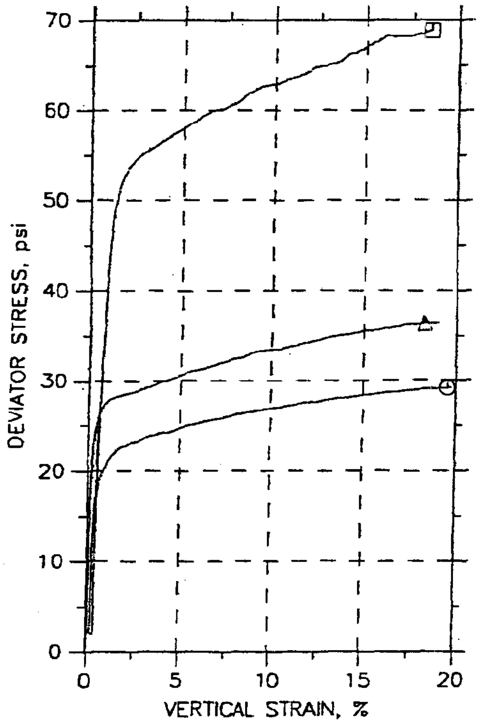
GeoTesting express
the groundwork for success

Project: TVA Kingston Gypsym Stdd	Location: NB-76	Project No.: GTX G0959
Boring No.: NB-76	Sample Type: Remolded	
Description: Reddish Brown Sandy Silt		
Remarks: Remolded to 95% of Standard Proctor max. dry density and +2% opt.		

Tue, 24-JAN-2006 10:47:29

CONSOLIDATED UNDRAINED TRIAXIAL TEST





		Symbol	○	△	□	
		Sample No.	Bag	Bag	Bag	
		Test No.	13925.1	13925.2	13925.3	
		Depth	5-15 ft	5-15 ft	5-15 ft	
Initial		Diameter, in	2.87	2.87	2.87	
		Height, in	6	6	6	
		Water Content, %	23.1	22.7	23.2	
		Dry Density, pcf	95.94	95.96	95.56	
		Saturation, %	84.6	83.1	84.2	
		Void Ratio	0.724	0.724	0.731	
Before Shear		Water Content, %	25.9	25.4	23.3	
		Dry Density, pcf	98.12	98.9	102.2	
		Saturation*, %	100.0	100.0	100.0	
		Void Ratio	0.686	0.673	0.618	
		Back Press., psi	89.98	90	60.01	
		Ver. Eff. Cons. Stress, psi	20.01	40	79.98	
		Shear Strength, psi	14.59	18.18	34.4	
		Strain at Failure, %	19.5	18.3	18.5	
		Strain Rate, %/min	0.022	0.022	0.022	
		B-Value	0.95	0.95	0.95	
		Measured Specific Gravity	2.65	2.65	2.65	
		Liquid Limit	48	48	48	
		Plastic Limit	28	28	28	

GeoTesting express
a groundwork for success

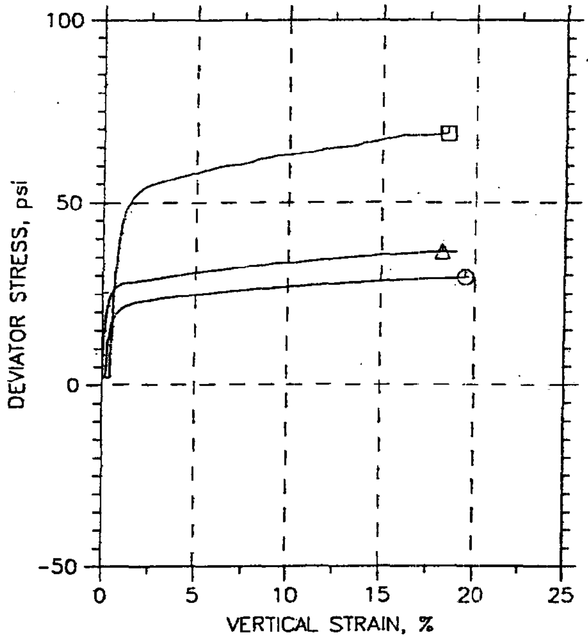
Project: TVA Kingston Gypsym Stack	
Location: NB-76	
Project No.: GTX G0959	
Boring No.: NB-76	
Sample Type: Remolded	
Description: Reddish Brown Sandy Silt	
Remarks: Remolded to 95% of Standard Proctor max. dry density and +2% opt.	

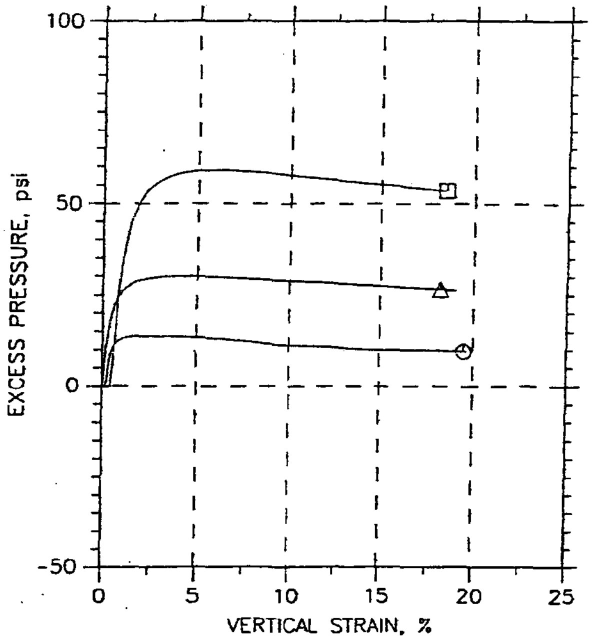
Phase calculations based on start of test.

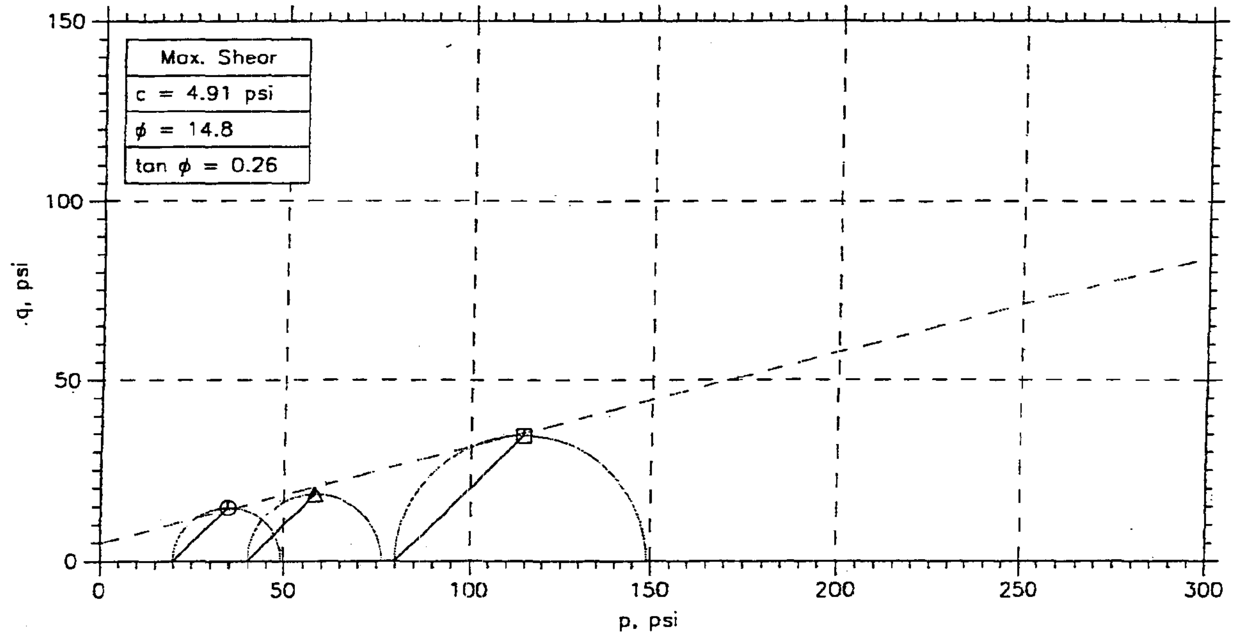
* Saturation is set to 100% for phase calculations.

Tue, 24-JAN-2006 10:47:02

CONSOLIDATED UNDRAINED TRIAXIAL TEST



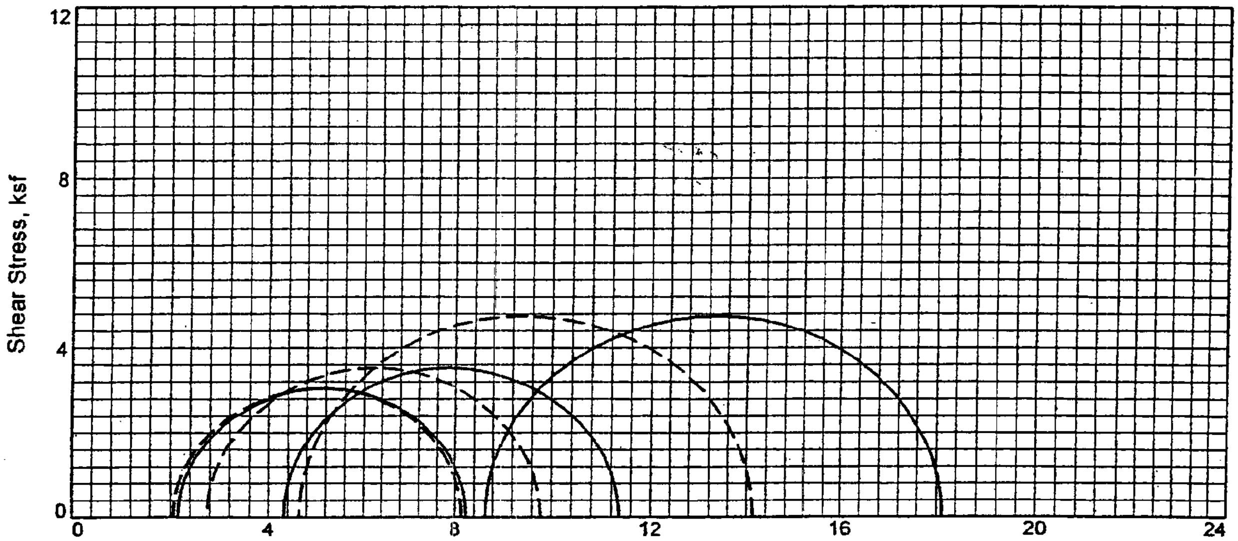


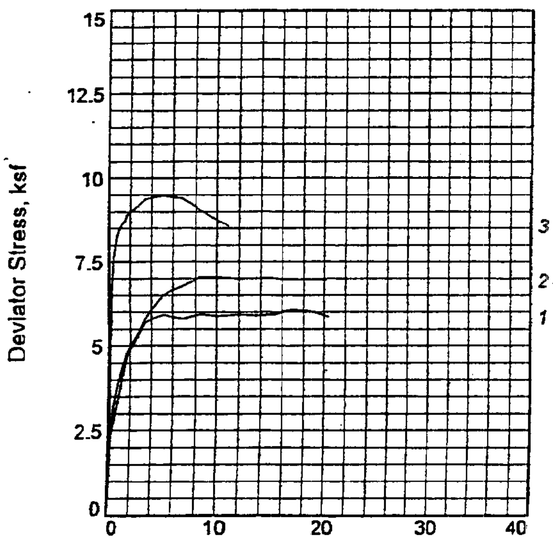


	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
O	Bag	13925.1	5-15 ft	HJ	1/21/06	JW		13925.1a_2054.dat
Δ	Bag	13925.2	5-15 ft	JW	1/21/06	HJ		13925.2a_1062.dat
⊡	Bag	13925.3	5-15 ft	JW	1/19/05	HJ		13925.3a_1057.dat

GeoTesting express the groundwork for success			
	Project: TVA Kingston Gypsym Stdd	Location: NB-76	Project No.: GTX G0959
	Boring No.: NB-76	Sample Type: Remolded	
	Description: Reddish Brown Sandy Silt		
	Remarks: Remolded to 95% of Standard Proctor max. dry density and +2% opt.		

Tue, 24-JAN-2006 10:47:03





	Sample No.	1	2	3
Initial	Water Content,	24.6	19.0	30.2
	Dry Density, pcf	99.2	105.0	87.2
	Saturation,	97.4	87.0	88.8
	Void Ratio	0.6732	0.5815	0.9051
	Diameter, in.	2.84	2.86	2.82
	Height, in.	6.03	6.10	6.07
At Test	Water Content,	20.2	17.4	28.7
	Dry Density, pcf	108.0	113.6	94.2
	Saturation,	100.0	100.0	100.0
	Void Ratio	0.5375	0.4622	0.7625
	Diameter, in.	2.76	2.78	2.74
	Height, in.	5.86	5.94	5.92
	Strain rate, in./min.	0.02	0.02	0.02
	Back Pressure, ksf	5.8	5.8	5.8
	Cell Pressure, ksf	7.9	10.1	14.4
	Fail. Stress, ksf	6.1	7.0	9.5
	Total Pore Pr., ksf	5.9	7.3	9.7
	Ult. Stress, ksf			
	Total Pore Pr., ksf			
	$\bar{\sigma}_1$ Failure, ksf	8.1	9.8	14.1
	$\bar{\sigma}_3$ Failure, ksf	2.1	2.7	4.7

Type of Test:
CU with Pore Pressures

Sample Type: undisturbed

Description: Brownish yellow sandy lean clay

LL= 41 **PL=** 25 **PI=** 16

Specific Gravity= 2.66

Remarks: CL

Figure ________

Client: TVA

Project: TVA Kingston - Proposed Gypsum Stack

Location: NB-77A

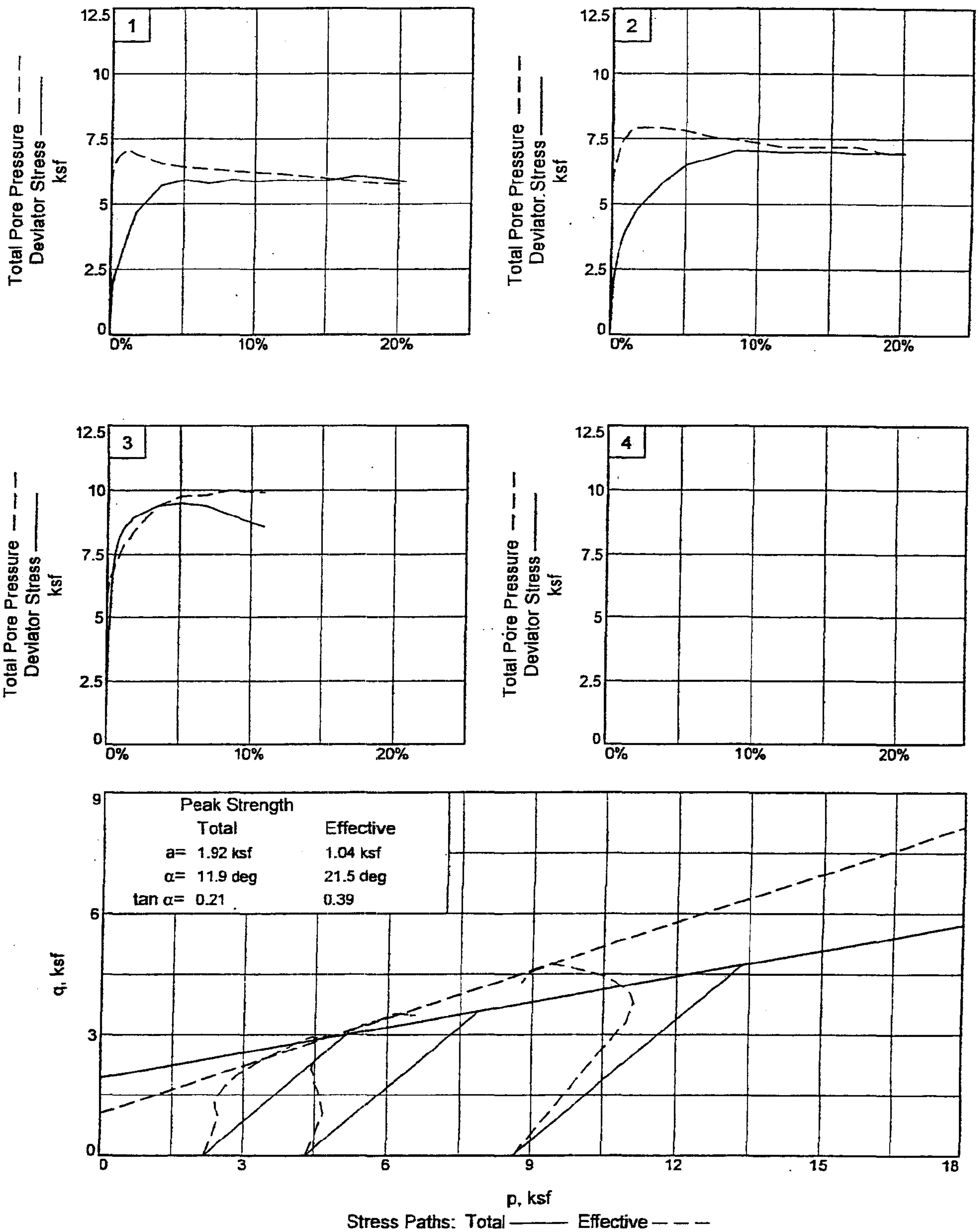
Sample Number: UD-1, 2 & 3 (CU) **Depth:** 4'-14'

Proj. No.: 3043051021 **Date:**

TRIAXIAL SHEAR TEST REPORT

MACTEC, INC.

Tested By: Alexander **Checked By:** Hamlett



Client: TVA

Project: TVA Kingston - Proposed Gypsum Stack

Location: NB-77A **Depth:** 4'-14' **Sample Number:** UD-1, 2 & 3 (CU)

Project No.: 3043051021 **Figure** ______

MACTEC, INC.

Tested By: Alexander **Checked By:** Hamlett

TRIAXIAL COMPRESSION TEST

CU with Pore Pressures

9/16/2005
10:49 AM

Date:
Client: TVA
Project: TVA Kingston - Proposed Gypsum Stack
Project No.: 3043051021
Location: NB-77A
Depth: 4'-14' **Sample Number:** UD-1, 2 & 3 (CU)
Description: Brownish yellow sandy lean clay
Remarks: CL
Type of Sample: undisturbed
Specific Gravity=2.66 **LL**=41 **PL**=25 **PI**=16
Test Method: COE uniform strain

[illegible]

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1227.600			1253.390
Moisture content: Dry soil+tare, gms.	984.900			998.430
Moisture content: Tare, gms.	0.000			13.720
Moisture, %	24.6	25.3	20.2	25.9
Moist specimen weight, gms.	1240.0			
Diameter, in.	2.84	2.84	2.76	
Area, in.²	6.33	6.33	5.99	
Height, in.	6.03	6.03	5.86	
Net decrease in height, in.		0.00	0.17	
Wet Density, pcf	123.7	124.4	129.8	
Dry density, pcf	99.2	99.2	108.0	
Void ratio	0.6732	0.6732	0.5375	
Saturation, %	97.4	100.0	100.0	

[illegible]

Load ring constant = 0.72 lbs. per input unit
Consolidation cell pressure = 55.00 psi (7.92 ksf)
Consolidation back pressure = 40.00 psi (5.76 ksf)
Consolidation effective confining stress = 2.16 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 6.08 ksf **at reading no.** 19

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	2.16	2.16	1.00	40.00	2.16	0.00
1	0.0100	113.0	81.4	0.2	1.95	1.50	3.45	2.30	44.60	2.47	0.98
2	0.0200	136.0	97.9	0.3	2.35	1.22	3.57	2.92	46.50	2.40	1.17
3	0.0300	155.0	111.6	0.5	2.67	1.05	3.72	3.54	47.70	2.39	1.34
4	0.0400	174.0	125.3	0.7	2.99	0.98	3.97	4.06	48.20	2.48	1.50
5	0.0500	192.0	138.2	0.9	3.30	0.92	4.22	4.58	48.60	2.57	1.65
6	0.0600	210.0	151.2	1.0	3.60	0.86	4.46	5.17	49.00	2.66	1.80
7	0.0700	228.0	164.2	1.2	3.90	0.88	4.78	5.44	48.90	2.83	1.95
8	0.0800	245.0	176.4	1.4	4.19	0.91	5.09	5.61	48.70	3.00	2.09
9	0.0900	260.0	187.2	1.5	4.43	0.96	5.40	5.60	48.30	3.18	2.22
10	0.1000	275.0	198.0	1.7	4.68	1.01	5.69	5.64	48.00	3.35	2.34
11	0.2000	341.0	245.5	3.4	5.70	1.37	7.07	5.17	45.50	4.22	2.85
12	0.3000	360.0	259.2	5.1	5.92	1.51	7.43	4.91	44.50	4.47	2.96
13	0.4000	359.0	258.5	6.8	5.79	1.58	7.38	4.66	44.00	4.48	2.90
14	0.5000	374.0	269.3	8.5	5.93	1.64	7.57	4.61	43.60	4.60	2.96
15	0.6000	377.0	271.4	10.2	5.86	1.71	7.58	4.42	43.10	4.64	2.93
16	0.7000	388.0	279.4	11.9	5.92	1.77	7.69	4.34	42.70	4.73	2.96
17	0.8000	394.0	283.7	13.6	5.89	1.86	7.75	4.17	42.10	4.80	2.95
18	0.9000	403.0	290.2	15.4	5.91	1.94	7.85	4.04	41.50	4.90	2.95
19	1.0000	423.0	304.6	17.1	6.08	2.06	8.14	3.95	40.70	5.10	3.04
20	1.1000	427.0	307.4	18.8	6.01	2.13	8.14	3.82	40.20	5.14	3.00
21	1.2000	425.0	306.0	20.5	5.85	2.15	8.00	3.73	40.10	5.07	2.93

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1276.900			1287.540
Moisture content: Dry soil+tare, gms.	1072.800			1079.980
Moisture content: Tare, gms.	0.000			14.190
Moisture, %	19.0	21.9	17.4	19.5
Moist specimen weight, gms.	1282.0			
Diameter, in.	2.86	2.86	2.78	
Area, in.²	6.41	6.41	6.08	
Height, in.	6.10	6.10	5.94	
Net decrease in height, in.		0.00	0.16	
Wet Density, pcf	125.0	128.0	133.3	
Dry density, pcf	105.0	105.0	113.6	
Void ratio	0.5815	0.5815	0.4622	
Saturation, %	87.0	100.0	100.0	

Test Readings for Specimen No. 2

Load ring constant = 0.72 lbs. per input unit
Consolidation cell pressure = 70.00 psi (10.08 ksf)
Consolidation back pressure = 40.00 psi (5.76 ksf)
Consolidation effective confining stress = 4.32 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 7.05 ksf **at reading no.** 15

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	4.32	4.32	1.00	40.00	4.32	0.00
1	0.0100	121.0	87.1	0.2	2.06	3.66	5.72	1.56	44.60	4.69	1.03
2	0.0200	161.0	115.9	0.3	2.74	3.25	5.99	1.84	47.40	4.62	1.37
3	0.0300	190.0	136.8	0.5	3.22	2.97	6.19	2.09	49.40	4.58	1.61
4	0.0400	209.0	150.5	0.7	3.54	2.72	6.26	2.30	51.10	4.49	1.77
5	0.0500	225.0	162.0	0.8	3.80	2.59	6.39	2.47	52.00	4.49	1.90
6	0.0600	238.0	171.4	1.0	4.02	2.46	6.48	2.63	52.90	4.47	2.01
7	0.0700	252.0	181.4	1.2	4.24	2.30	6.55	2.84	54.00	4.43	2.12
8	0.0800	264.0	190.1	1.3	4.44	2.22	6.66	3.00	54.60	4.44	2.22
9	0.0900	275.0	198.0	1.5	4.62	2.17	6.79	3.12	54.90	4.48	2.31
10	0.1000	285.0	205.2	1.7	4.78	2.16	6.94	3.21	55.00	4.55	2.39
11	0.2000	351.0	252.7	3.4	5.78	2.16	7.94	3.68	55.00	5.05	2.89
12	0.3000	401.0	288.7	5.1	6.49	2.26	8.75	3.87	54.30	5.51	3.24
13	0.4000	425.0	306.0	6.7	6.76	2.49	9.25	3.71	52.70	5.87	3.38
14	0.5000	451.0	324.7	8.4	7.04	2.62	9.66	3.69	51.80	6.14	3.52
15	0.6000	460.0	331.2	10.1	7.05	2.74	9.78	3.58	51.00	6.26	3.52
16	0.7000	465.0	334.8	11.8	6.99	2.89	9.89	3.42	49.90	6.39	3.50
17	0.8000	475.0	342.0	13.5	7.01	2.89	9.90	3.42	49.90	6.40	3.50
18	0.9000	485.0	349.2	15.2	7.01	2.89	9.91	3.42	49.90	6.40	3.51
19	1.0000	490.0	352.8	16.8	6.95	2.89	9.84	3.40	49.90	6.37	3.47
20	1.1000	502.0	361.4	18.5	6.97	3.07	10.04	3.27	48.70	6.55	3.49
21	1.2000	510.0	367.2	20.2	6.94	3.10	10.03	3.24	48.50	6.56	3.47

Parameters for Specimen No. [illegible]

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1129.800			1141.260
Moisture content: Dry soil+tare, gms.	867.600			881.520
Moisture content: Tare, gms.	0.000			14.240
Moisture, %	30.2	34.0	28.7	29.9
Moist specimen weight, gms.	1127.0			
Diameter, in.	2.82	2.82	2.74	
Area, in.²	6.23	6.23	5.92	
Height, in.	6.07	6.07	5.92	
Net decrease in height, in.		0.00	0.15	
Wet Density, pcf	113.5	116.8	121.2	
Dry density, pcf	87.2	87.2	94.2	
Void ratio	0.9051	0.9051	0.7625	
Saturation, %	88.8	100.0	100.0	

Test Readings for Specimen No. [illegible]

Load ring constant = 0.72 lbs. per input unit

Consolidation cell pressure = 100.00 psi (14.40 ksf)

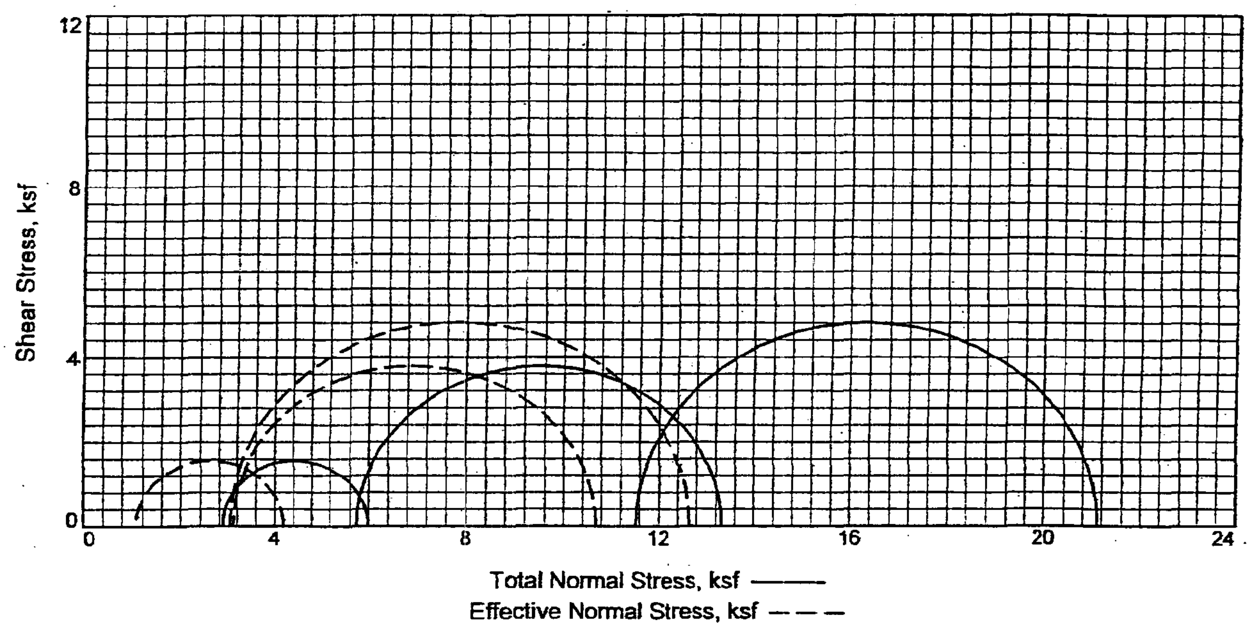
Consolidation back pressure = 40.00 psi (5.76 ksf)

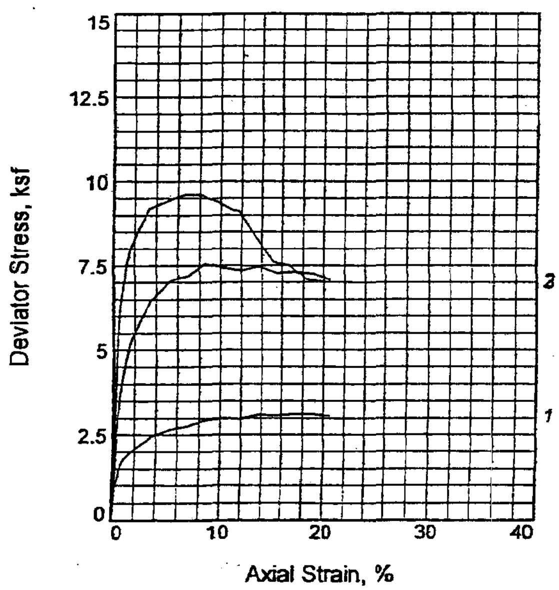
Consolidation effective confining stress = 8.64 ksf

Strain rate, in./min. = 0.02

Fail. Stress = 9.48 ksf **at reading no.** 12

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	8.64	8.64	1.00	40.00	8.64	0.00
1	0.0100	246.0	177.1	0.2	4.30	7.98	12.28	1.54	44.60	10.13	2.15
2	0.0200	378.0	272.2	0.3	6.60	7.68	14.28	1.86	46.70	10.98	3.30
3	0.0300	436.0	313.9	0.5	7.60	7.32	14.92	2.04	49.20	11.12	3.80
4	0.0400	461.0	331.9	0.7	8.02	7.04	15.07	2.14	51.10	11.05	4.01
5	0.0500	476.0	342.7	0.8	8.27	6.83	15.10	2.21	52.60	10.96	4.14
6	0.0600	487.0	350.6	1.0	8.45	6.62	15.07	2.28	54.00	10.85	4.22
7	0.0700	496.0	357.1	1.2	8.59	6.47	15.05	2.33	55.10	10.76	4.29
8	0.0800	502.0	361.4	1.4	8.68	6.35	15.03	2.37	55.90	10.69	4.34
9	0.0900	507.0	365.0	1.5	8.75	6.26	15.01	2.40	56.50	10.64	4.37
10	0.1000	517.0	372.2	1.7	8.91	6.06	14.97	2.47	57.90	10.52	4.45
11	0.2000	553.0	398.2	3.4	9.36	5.04	14.40	2.86	65.00	9.72	4.68
12	0.3000	570.0	410.4	5.1	9.48	4.65	14.13	3.04	67.70	9.39	4.74
13	0.4000	575.0	414.0	6.8	9.40	4.62	14.02	3.03	67.90	9.32	4.70
14	0.5000	564.0	406.1	8.5	9.05	4.41	13.45	3.05	69.40	8.93	4.52
15	0.6000	554.0	398.9	10.1	8.72	4.46	13.19	2.95	69.00	8.83	4.36
16	0.6500	550.0	396.0	11.0	8.58	4.49	13.07	2.91	68.80	8.78	4.29





	Sample No.	1	2	3
Initial	Water Content,	39.1	21.6	26.5
	Dry Density, pcf	81.0	100.1	94.0
	Saturation,	99.8	88.2	92.9
	Void Ratio	1.0350	0.6468	0.7536
	Diameter, in.	2.85	2.75	2.84
	Height, in.	5.98	5.96	6.11
At Test	Water Content,	32.8	19.3	24.4
	Dry Density, pcf	88.3	109.2	100.3
	Saturation,	100.0	100.0	100.0
	Void Ratio	0.8666	0.5095	0.6432
	Diameter, in.	2.77	2.67	2.78
	Height, in.	5.81	5.79	5.98
	Strain rate, in./min.	0.02	0.02	0.02
	Back Pressure, ksf	2.9	2.9	2.9
	Cell Pressure, ksf	5.8	8.6	14.4
	Fail. Stress, ksf	3.1	7.6	9.6
	Total Pore Pr., ksf	4.7	5.5	11.4
	Ult. Stress, ksf			
	Total Pore Pr., ksf			
	$\bar{\sigma}_1$ Failure, ksf	4.2	10.7	12.6
	$\bar{\sigma}_3$ Failure, ksf	1.1	3.1	3.0

Type of Test:
CU with Pore Pressures

Sample Type: undisturbed

Description: Brown sandy elastic silt

LL= 53 **PL=** 29 **PI=** 24

Specific Gravity= 2.64

Remarks: MH

Client: TVA

Project: TVA Kingston - Proposed Gypsum Stack

Location: NB-77A

Sample Number: UD-4, 5 & 7 (CU) **Depth:** 15'-26'

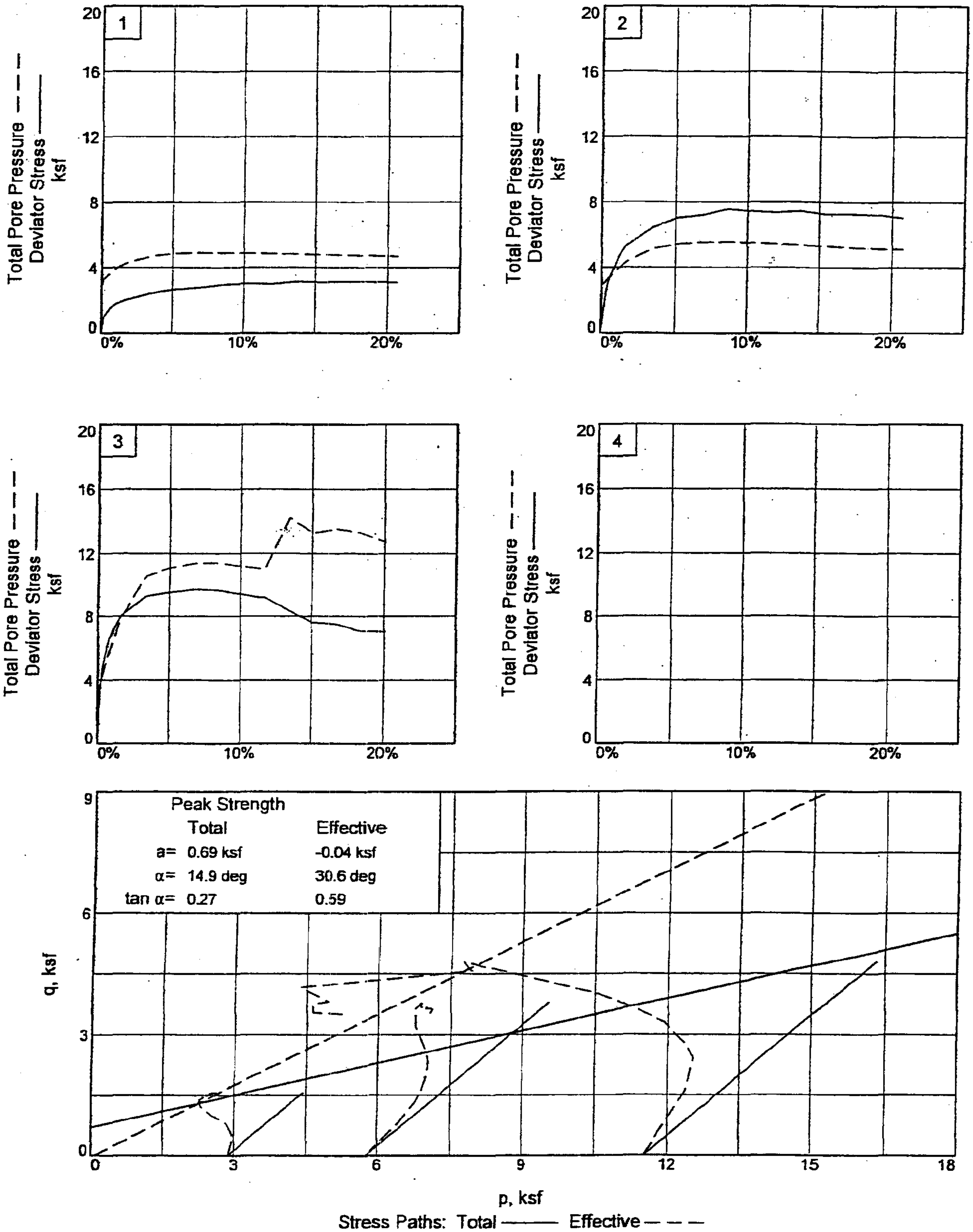
Proj. No.: 3043051021 **Date:**

TRIAXIAL SHEAR TEST REPORT

MACTEC, INC.

Figure ________

Tested By: Alexander **Checked By:** Hamlett



Client: TVA
Project: TVA Kingston - Proposed Gypsum Stack
Location: NB-77A **Depth:** 15'-26' **Sample Number:** UD-4, 5 & 7 (CU)
Project No.: 3043051021 **Figure** ______ **MACTEC, INC.**

Tested By: Alexander **Checked By:** Hamlett

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

9/16/2005
10:57 AM

Date:
Client: TVA
Project: TVA Kingston - Proposed Gypsum Stack
Project No.: 3043051021
Location: NB-77A
Depth: 15'-26' **Sample Number:** UD-4, 5 & 7 (CU)
Description: Brown sandy elastic silt
Remarks: MH
Type of Sample: undisturbed
Specific Gravity=2.64 **LL**=53 **PL**=29 **PI**=24
Test Method: COE uniform strain

[illegible]

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1119.100			550.490
Moisture content: Dry soil+tare, gms.	804.330			392.810
Moisture content: Tare, gms.	0.000			13.640
Moisture, %	39.1	39.2	32.8	41.6
Moist specimen weight, gms.	1126.9			
Diameter, in.	2.85	2.85	2.77	
Area, in.^{2}	6.37	6.37	6.02	
Height, in.	5.98	5.98	5.81	
Net decrease in height, in.		0.00	0.17	
Wet Density, pcf	112.7	112.7	117.3	
Dry density, pcf	81.0	81.0	88.3	
Void ratio	1.0350	1.0350	0.8666	
Saturation, %	99.8	100.0	100.0	

[illegible]

Load ring constant = 0.72 lbs. per input unit
Consolidation cell pressure = 40.00 psi (5.76 ksf)
Consolidation back pressure = 20.00 psi (2.88 ksf)
Consolidation effective confining stress = 2.88 ksf
Strain rate, in./min. = 0.02
Fail. Stress = 3.12 ksf **at reading no.** 20

[illegible] Readings for Specimen No. [illegible]

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	2.88	2.88	1.00	20.00	2.88	0.00
1	0.0100	54.0	38.9	0.2	0.93	2.52	3.45	1.37	22.50	2.98	0.46
2	0.0200	67.0	48.2	0.3	1.15	2.36	3.51	1.49	23.60	2.94	0.58
3	0.0300	80.0	57.6	0.5	1.37	2.20	3.57	1.62	24.70	2.89	0.69
4	0.0400	92.0	66.2	0.7	1.57	2.06	3.63	1.76	25.70	2.85	0.79
5	0.0500	99.0	71.3	0.9	1.69	1.94	3.64	1.87	26.50	2.79	0.85
6	0.0600	105.0	75.6	1.0	1.79	1.81	3.61	1.99	27.40	2.71	0.90
7	0.0700	108.0	77.8	1.2	1.84	1.71	3.55	2.07	28.10	2.63	0.92
8	0.0800	112.0	80.6	1.4	1.90	1.66	3.56	2.15	28.50	2.61	0.95
9	0.0900	116.0	83.5	1.5	1.97	1.57	3.54	2.25	29.10	2.55	0.98
10	0.1000	119.0	85.7	1.7	2.02	1.51	3.53	2.33	29.50	2.52	1.01
11	0.2000	145.0	104.4	3.4	2.41	1.09	3.51	3.20	32.40	2.30	1.21
12	0.3000	162.0	116.6	5.2	2.65	0.94	3.58	3.83	33.50	2.26	1.32
13	0.4000	171.0	123.1	6.9	2.74	0.89	3.64	4.07	33.80	2.26	1.37
14	0.5000	186.0	133.9	8.6	2.93	0.91	3.84	4.23	33.70	2.37	1.46
15	0.6000	194.0	139.7	10.3	3.00	0.92	3.92	4.25	33.60	2.42	1.50
16	0.7000	196.0	141.1	12.1	2.97	0.95	3.92	4.13	33.40	2.44	1.49
17	0.8000	209.0	150.5	13.8	3.11	0.98	4.08	4.17	33.20	2.53	1.55
18	0.9000	211.0	151.9	15.5	3.07	1.01	4.08	4.05	33.00	2.54	1.54
19	1.0000	218.0	157.0	17.2	3.11	1.04	4.15	4.00	32.80	2.59	1.55
20	1.1000	223.0	160.6	18.9	3.12	1.07	4.18	3.92	32.60	2.62	1.56
21	1.2000	224.0	161.3	20.7	3.06	1.11	4.17	3.76	32.30	2.64	1.53

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1077.430			648.960
Moisture content: Dry soil+tare, gms.	886.000			507.890
Moisture content: Tare, gms.	0.000			13.720
Moisture, %	21.6	24.5	19.3	28.5
Moist specimen weight, gms.	1132.3			
Diameter, in.	2.75	2.75	2.67	
Area, in.²	5.94	5.94	5.61	
Height, in.	5.96	5.96	5.79	
Net decrease in height, in.		0.00	0.17	
Wet Density, pcf	121.7	124.6	130.3	
Dry density, pcf	100.1	100.1	109.2	
Void ratio	0.6468	0.6468	0.5095	
Saturation, %	88.2	100.0	100.0	

Test Readings for Specimen No. 2

Load ring constant = 0.72 lbs. per input unit

Consolidation cell pressure = 60.00 psi (8.64 ksf)

Consolidation back pressure = 20.00 psi (2.88 ksf)

Consolidation effective confining stress = 5.76 ksf

Strain rate, in./min. = 0.02

Fail. Stress = 7.57 ksf at reading no. 14

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	5.76	5.76	1.00	20.00	5.76	0.00
1	0.0100	88.0	63.4	0.2	1.62	5.62	7.24	1.29	21.00	6.43	0.81
2	0.0200	144.0	103.7	0.3	2.65	5.44	8.10	1.49	22.20	6.77	1.33
3	0.0300	175.0	126.0	0.5	3.22	5.28	8.50	1.61	23.30	6.89	1.61
4	0.0400	200.0	144.0	0.7	3.67	5.13	8.80	1.72	24.40	6.96	1.84
5	0.0500	221.0	159.1	0.9	4.05	4.98	9.03	1.81	25.40	7.01	2.03
6	0.0600	240.0	172.8	1.0	4.39	4.82	9.22	1.91	26.50	7.02	2.20
7	0.0700	256.0	184.3	1.2	4.68	4.69	9.37	2.00	27.40	7.03	2.34
8	0.0800	270.0	194.4	1.4	4.92	4.55	9.47	2.08	28.40	7.01	2.46
9	0.0900	283.0	203.8	1.6	5.15	4.42	9.57	2.17	29.30	7.00	2.58
10	0.1000	292.0	210.2	1.7	5.31	4.31	9.61	2.23	30.10	6.96	2.65
11	0.2000	360.0	259.2	3.5	6.43	3.54	9.97	2.81	35.40	6.76	3.21
12	0.3000	401.0	288.7	5.2	7.03	3.24	10.27	3.17	37.50	6.76	3.52
13	0.4000	418.0	301.0	6.9	7.20	3.14	10.33	3.29	38.20	6.74	3.60
14	0.5000	448.0	322.6	8.6	7.57	3.11	10.68	3.43	38.40	6.89	3.78
15	0.6000	448.0	322.6	10.4	7.43	3.17	10.59	3.34	38.00	6.88	3.71
16	0.7000	452.0	325.4	12.1	7.35	3.21	10.56	3.29	37.70	6.89	3.67
17	0.8000	468.0	337.0	13.8	7.46	3.28	10.74	3.27	37.20	7.01	3.73
18	0.9000	465.0	334.8	15.5	7.26	3.36	10.62	3.16	36.70	6.99	3.63
19	1.0000	477.0	343.4	17.3	7.30	3.43	10.73	3.13	36.20	7.08	3.65
20	1.1000	484.0	348.5	19.0	7.25	3.50	10.75	3.07	35.70	7.12	3.63
21	1.2000	482.0	347.0	20.7	7.07	3.54	10.61	2.99	35.40	7.08	3.53

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1224.760			724.820
Moisture content: Dry soil+tare, gms.	968.090			580.180
Moisture content: Tare, gms.	0.000			13.810
Moisture, %	26.5	28.5	24.4	25.5
Moist specimen weight, gms.	1209.2			
Diameter, in.	2.84	2.84	2.78	
Area, in.²	6.34	6.34	6.07	
Height, in.	6.11	6.11	5.98	
Net decrease in height, in.		0.00	0.13	
Wet Density, pcf	118.9	120.8	124.7	
Dry density, pcf	94.0	94.0	100.3	
Void ratio	0.7536	0.7536	0.6432	
Saturation, %	92.9	100.0	100.0	

Test Readings for Specimen No. 3

Load ring constant = 0.72 lbs. per input unit

Consolidation cell pressure = 100.00 psi (14.40 ksf)

Consolidation back pressure = 20.00 psi (2.88 ksf)

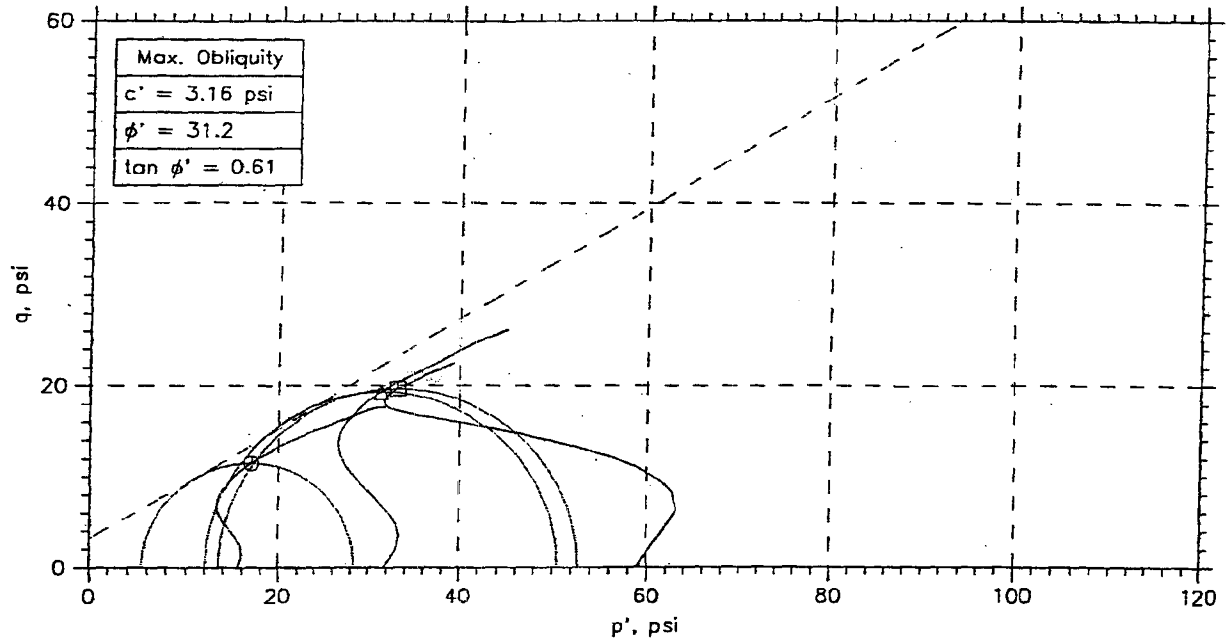
Consolidation effective confining stress = 11.52 ksf

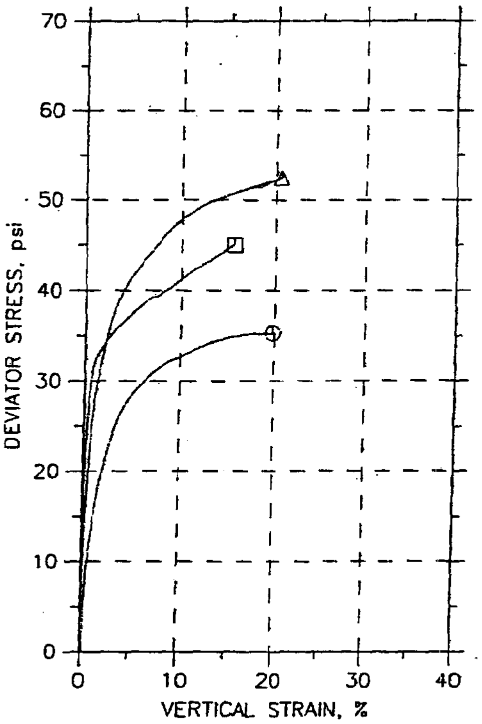
Strain rate, in./min. = 0.02

Fail. Stress = 9.60 ksf **at reading no.** 13

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	11.52	11.52	1.00	20.00	11.52	0.00
1	0.0100	189.0	136.1	0.2	3.22	10.76	13.98	1.30	25.30	12.37	1.61
2	0.0200	282.0	203.0	0.3	4.80	10.14	14.94	1.47	29.60	12.54	2.40
3	0.0300	324.0	233.3	0.5	5.50	9.62	15.12	1.57	33.20	12.37	2.75
4	0.0400	363.0	261.4	0.7	6.16	9.03	15.18	1.68	37.30	12.11	3.08
5	0.0500	390.0	280.8	0.8	6.60	8.63	15.23	1.77	40.10	11.93	3.30
6	0.0600	412.0	296.6	1.0	6.96	8.14	15.10	1.86	43.50	11.62	3.48
7	0.0700	433.0	311.8	1.2	7.31	7.66	14.97	1.95	46.80	11.31	3.65
8	0.0800	451.0	324.7	1.3	7.60	7.23	14.82	2.05	49.80	11.03	3.80
9	0.0900	467.0	336.2	1.5	7.85	6.81	14.66	2.15	52.70	10.74	3.93
10	0.1000	480.0	345.6	1.7	8.06	6.49	14.55	2.24	54.90	10.52	4.03
11	0.2000	557.0	401.0	3.3	9.19	3.89	13.08	3.36	73.00	8.48	4.60
12	0.3000	581.0	418.3	5.0	9.42	3.34	12.76	3.82	76.80	8.05	4.71
13	0.4000	603.0	434.2	6.7	9.60	3.04	12.64	4.16	78.90	7.84	4.80
14	0.5000	613.0	441.4	8.4	9.59	2.98	12.57	4.22	79.30	7.78	4.79
15	0.6750	603.0	434.2	11.3	9.13	3.37	12.50	3.71	76.60	7.94	4.57
16	0.7000	606.0	436.3	11.7	9.13	3.40	12.53	3.69	76.40	7.97	4.57
17	0.8000	564.0	406.1	13.4	8.34	0.20	8.54	42.37	98.60	4.37	4.17
18	0.9000	525.0	378.0	15.1	7.61	1.15	8.76	7.61	92.00	4.96	3.81
19	1.0000	528.0	380.2	16.7	7.51	0.88	8.38	9.54	93.90	4.63	3.75
20	1.1000	508.0	365.8	18.4	7.08	1.11	8.18	7.38	92.30	4.65	3.54
21	1.2000	514.0	370.1	20.1	7.01	1.73	8.74	5.06	88.00	5.23	3.51

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767





Symbol		○	△	□	
Sample No.		UD-2	UD-1	UD-1	
Test No.		13766.1	13765.2	13765.4	
Depth		13-15 Ft.	11-12.8 Ft	11-12.8 ft	
Initial	Diameter, in	2.852	2.833	2.848	
	Height, in	5.57	5.57	5.57	
	Water Content, %	35.2	24.8	22.6	
	Dry Density, pcf	85.2	97.98	98.28	
	Saturation, %	95.2	90.6	83.1	
	Void Ratio	1.02	0.754	0.749	
Before Shear	Water Content, %	36.2	25.3	22.0	
	Dry Density, pcf	86.05	101.2	107.	
	Saturation*, %	100.0	100.0	100.0	
	Void Ratio	0.997	0.698	0.606	
	Back Press., psi	64	49.99	90	
Ver. Eff. Cons. Stress, psi		15	30	60	
Shear Strength, psi		17.62	26.2	22.48	
Strain at Failure, %		19.8	20.6	15.5	
Strain Rate, %/min		0.022	0.00124	0.022	
B-Value		0.95	0.95	0.95	
Measured Specific Gravity		2.75	2.75	2.75	
Liquid Limit		75	50	50	
Plastic Limit		31	24	24	

GeoTesting
xpress
groundwork for success

Project: TVA Kingston Gypsym Stack
Location: NB-77B
Project No.: GTX G0959
Boring No.: NB-77B
Sample Type: Shelby Tube
Description:
Remarks:

Phase calculations based on start and end of test.
* Saturation is set to 100% for phase calculations.

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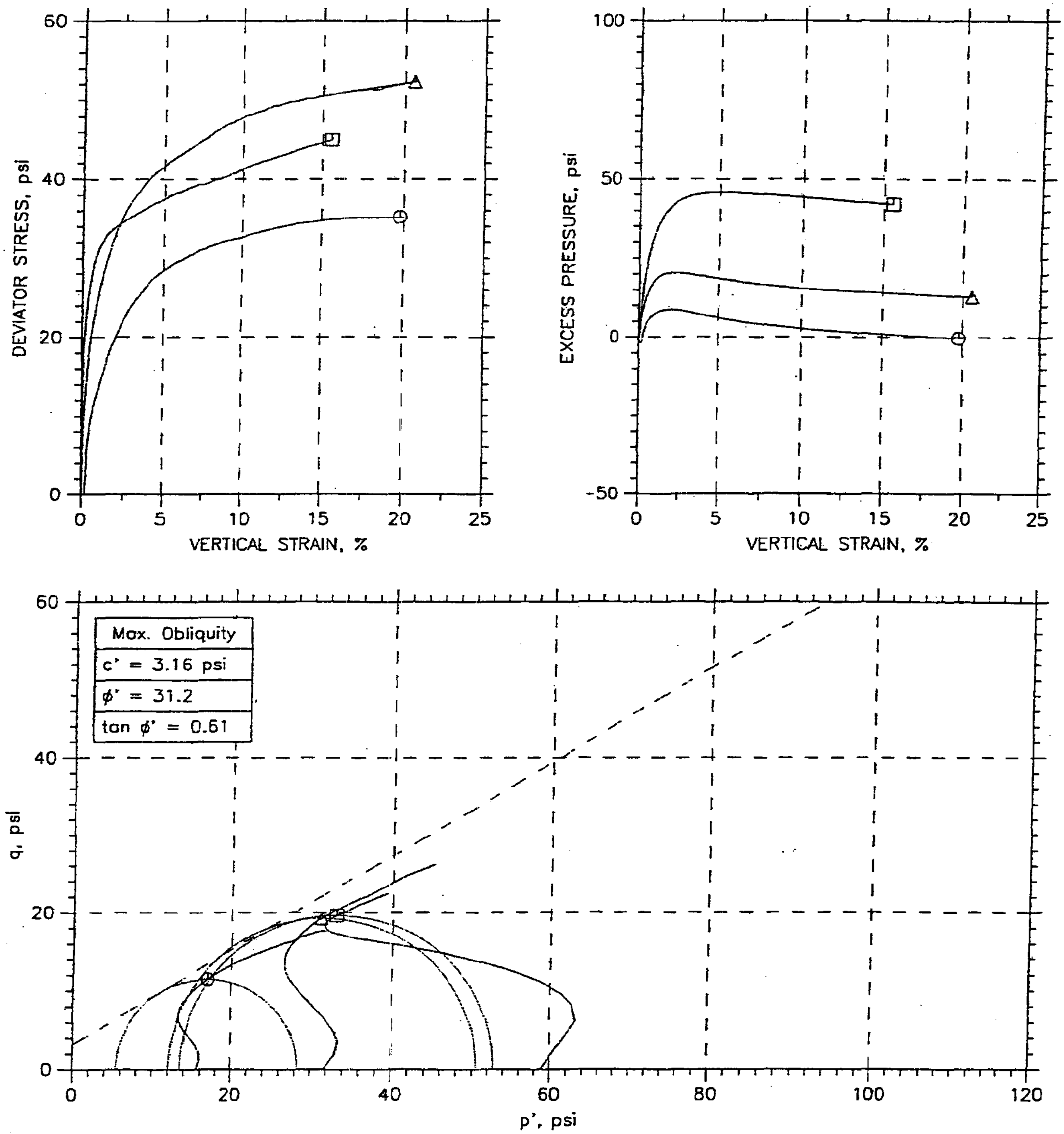
CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767



	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
O	UD-2	13766.1	13-15 Ft.	HJ	11/30/05	JW		13766.1a_1057.dat
△	UD-1	13765.2	11-12.8 Ft.	HJ	11/30/05	JW		13765.2_2054.dat
□	UD-1	13765.4	11-12.8 ft	JW	12/5/05	HJ		13765.4_1057.dat

GeoTesting express the groundwork for success			
	Project: TVA Kingston Gypsym Std	Location: NB-77B	Project No.: GTX G0959
	Boring No.: NB-77B	Sample Type: Shelby Tube	
	Description:		
	Remarks:		

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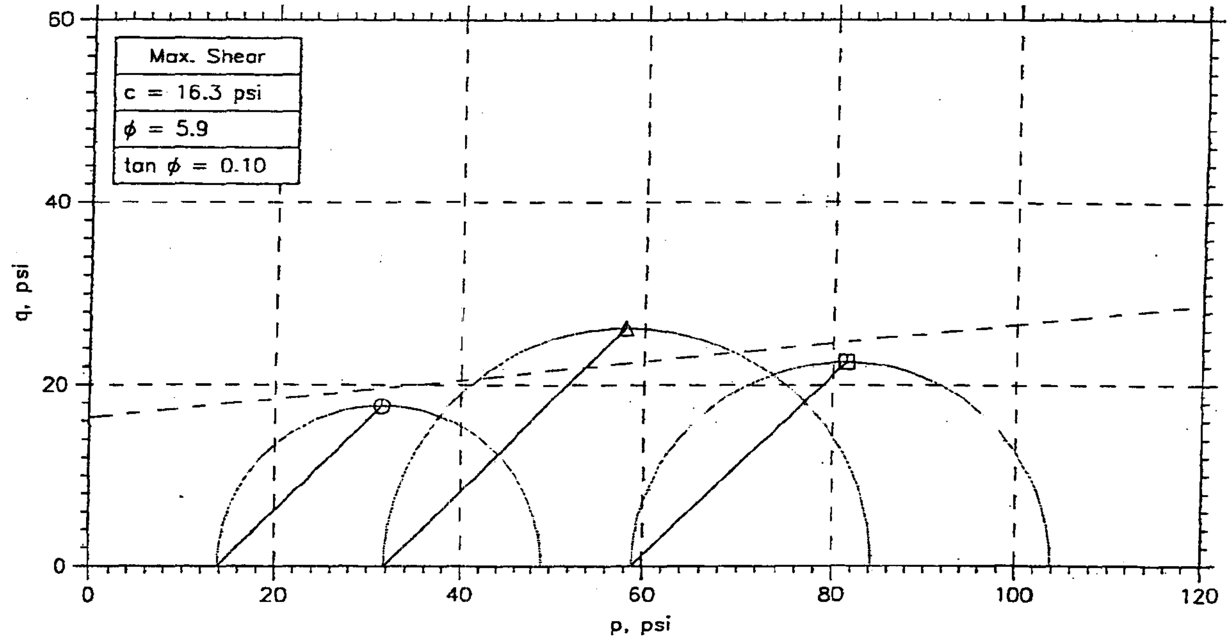
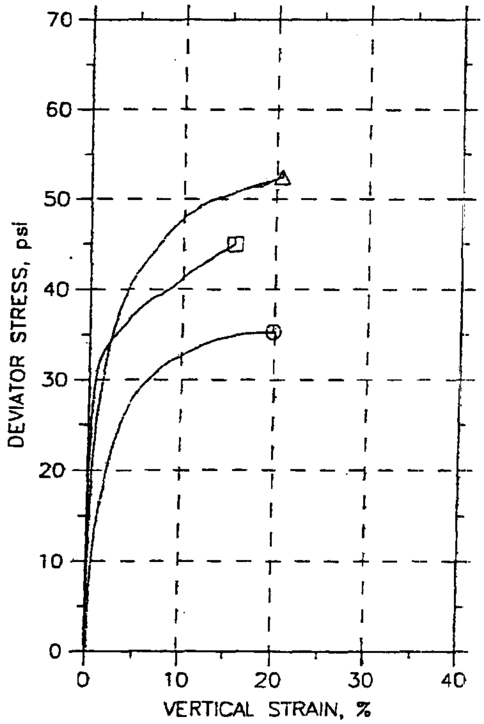
CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767





Symbol		○	△	□	
Sample No.		UD-2	UD-1	UD-1	
Test No.		13766.1	13765.2	13765.4	
Depth		13-15 Ft.	1-12.8 Ft	11-12.8 ft	
Initial	Diameter, in	2.852	2.833	2.848	
	Height, in	5.57	5.57	5.57	
	Water Content, %	35.2	24.8	22.6	
	Dry Density, pcf	85.2	97.98	98.28	
	Saturation, %	95.2	90.6	83.1	
	Void Ratio	1.02	0.754	0.749	
Before Shear	Water Content, %	36.2	25.3	22.0	
	Dry Density, pcf	86.05	101.2	107.	
	Saturation*, %	100.0	100.0	100.0	
	Void Ratio	0.997	0.698	0.606	
	Back Press., psi	64	49.99	90	
Ver. Eff. Cons. Stress, psi		15	30	60	
Shear Strength, psi		17.62	26.2	22.48	
Strain at Failure, %		19.8	20.6	15.5	
Strain Rate, %/min		0.022	0.00124	0.022	
B-Value		0.95	0.95	0.95	
Measured Specific Gravity		2.75	2.75	2.75	
Liquid Limit		75	50	50	
Plastic Limit		31	24	24	

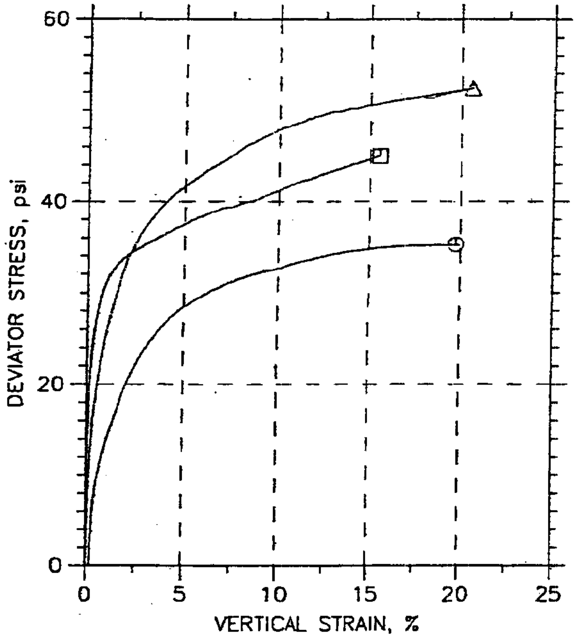
GeoTesting express the groundwork for success	Project: TVA Kingston Gypsym Stack
	Location: NB-77B
	Project No.: GTX G0959
	Boring No.: NB-77B
	Sample Type: Shelby Tube
	Description:
	Remarks:

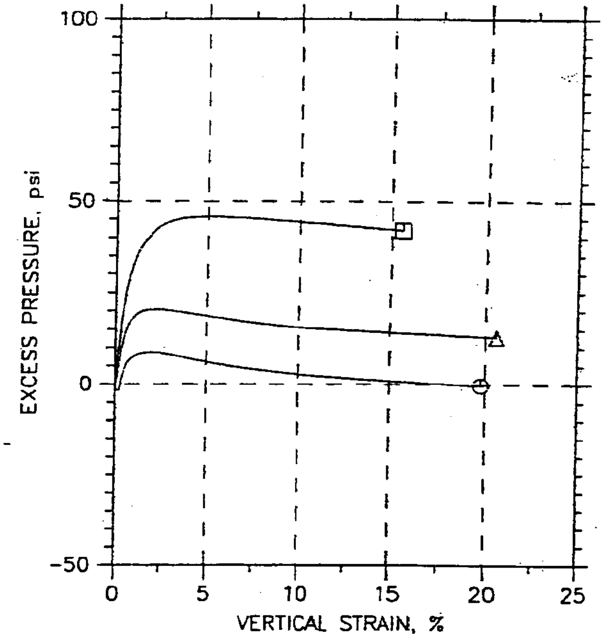
Thu, 02-FEB-2006 15:34:09

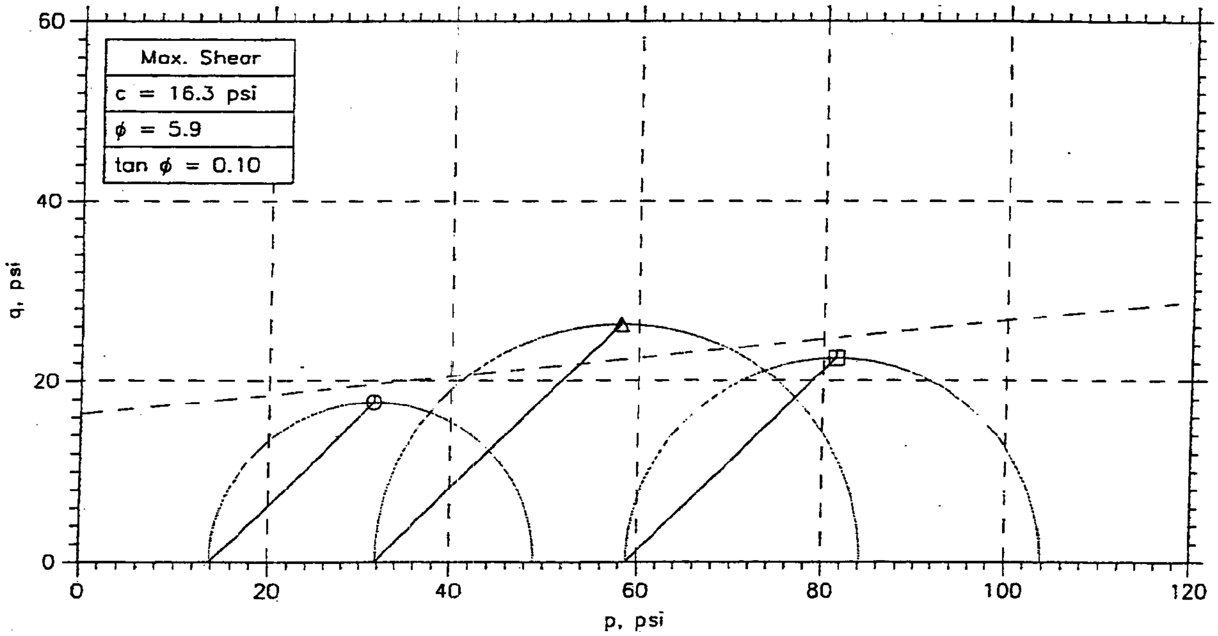
Phase calculations based on start and end of test.

* Saturation is set to 100% for phase calculations.

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767







	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	UD-2	13766.1	13-15 Ft.	HJ	11/30/05	JW		13766.1a_1057.dat
△	UD-1	13765.2	11-12.8 Ft.	HJ	11/30/05	JW		13765.2_2054.dat
□	UD-1	13765.4	11-12.8 ft	JW	12/5/05	HJ		13765.4_1057.dat

GeoTesting express the groundwork for success

Project: TVA Kingston Gypsym Std	Location: NB-77B	Project No.: GTX G0959
Boring No.: NB-77B	Sample Type: Shelby Tube	
Description:		
Remarks:		

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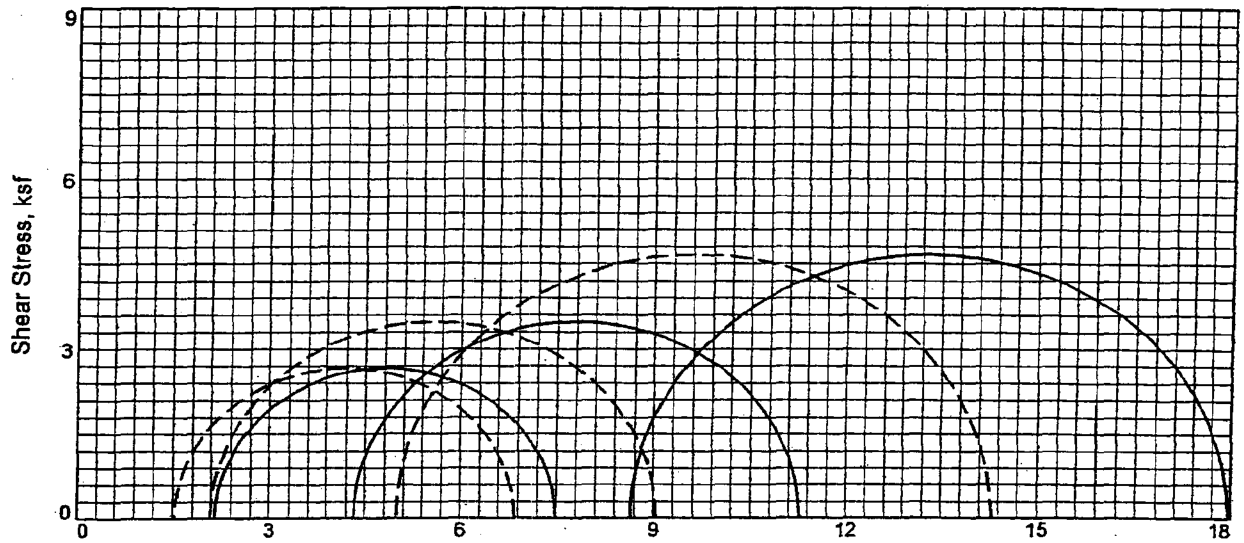
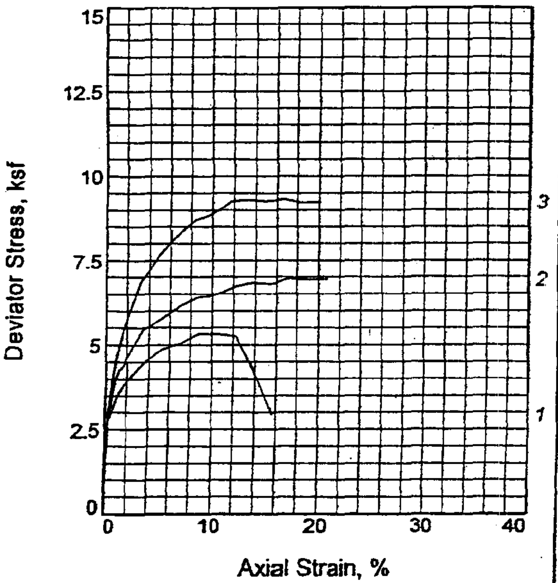




Sample No.		1	2	3
Initial	Water Content,	18.7	19.5	23.0
	Dry Density, pcf	104.0	104.7	101.7
	Saturation,	83.3	88.7	96.5
	Void Ratio	0.5963	0.5862	0.6330
	Diameter, in.	2.94	2.94	2.85
	Height, in.	5.76	5.85	6.05
At Test	Water Content,	20.4	19.9	21.4
	Dry Density, pcf	107.6	108.6	105.8
	Saturation,	100.0	100.0	100.0
	Void Ratio	0.5435	0.5297	0.5696
	Diameter, in.	2.91	2.91	2.81
	Height, in.	5.70	5.78	5.98
Strain rate, in./min.		0.01	0.01	0.01
Back Pressure, ksf		5.8	5.8	5.8
Cell Pressure, ksf		7.9	10.1	14.4
Fail. Stress, ksf		5.3	7.0	9.3
Total Pore Pr., ksf		6.4	8.0	9.4
Ult. Stress, ksf				
Total Pore Pr., ksf				
$\bar{\sigma}_1$ Failure, ksf		6.8	9.0	14.3
$\bar{\sigma}_3$ Failure, ksf		1.5	2.1	5.0

Type of Test:
CU with Pore Pressures

Sample Type: undisturbed

Description: Brownish yellow clayey sand with gravel

LL= 59 **PL=** 30 **PI=** 29

Specific Gravity= 2.66

Remarks: SC

Figure ______

Client: TVA

Project: TVA Kingston - Proposed Gypsum Stack

Location: NB-85A/B

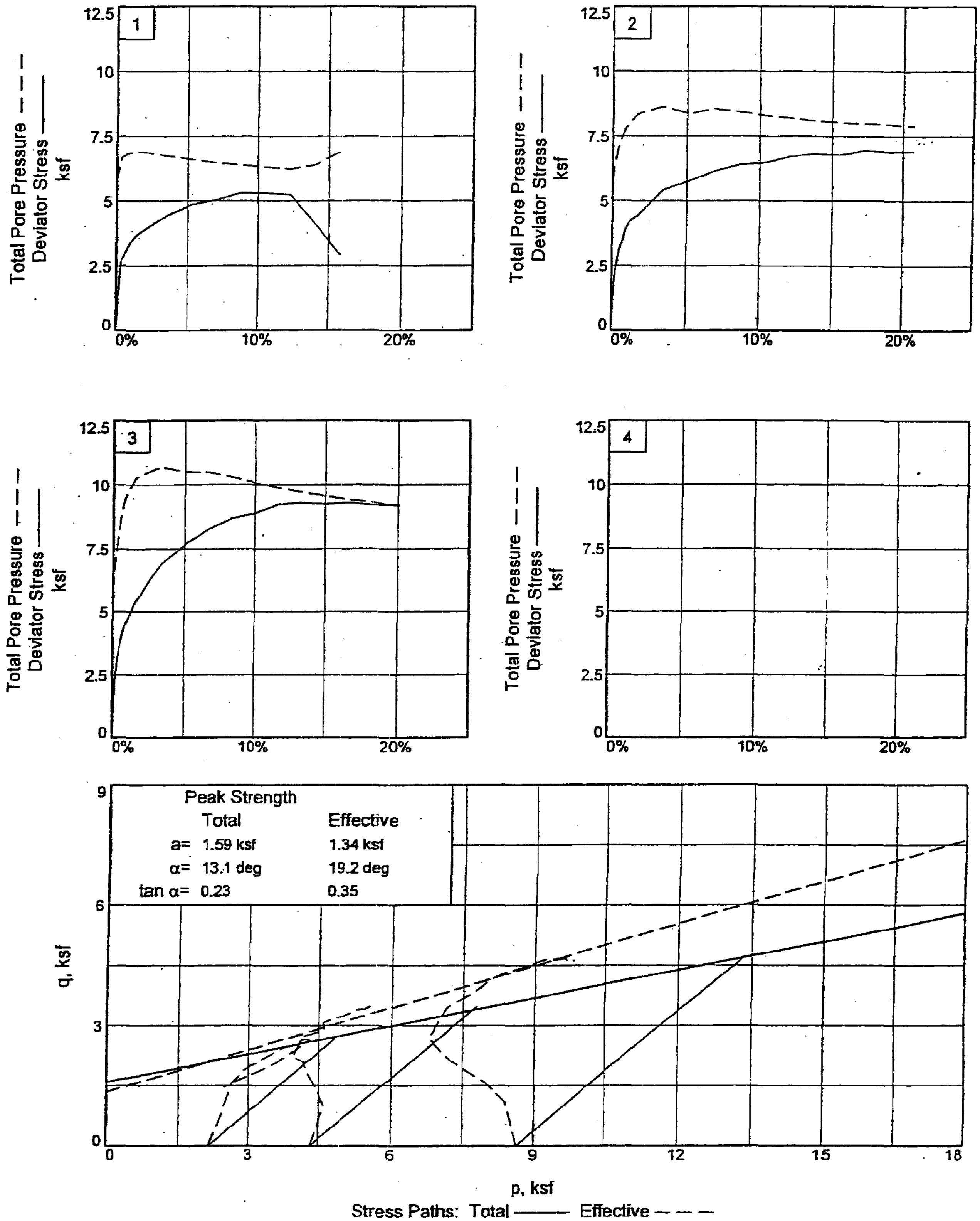
Sample Number: UD-1, 2 & 3 (CU) **Depth:** 13'-19'

Proj. No.: 3043051021 **Date:**

TRIAXIAL SHEAR TEST REPORT

MACTEC, INC.

Tested By: Alexander **Checked By:** Hamlett



Client: TVA
Project: TVA Kingston - Proposed Gypsum Stack
Location: NB-85A and NB-85B **Depth:** 13'-19' **Sample Number:** UD-1, 2 & 3 (CU)
Project No.: 3043051021 **Figure** ________ **MACTEC, INC.**

Tested By: Alexander **Checked By:** Hamlett

TRIAXIAL COMPRESSION TEST

CU with Pore Pressures

9/13/2005
9:30 PM

Date:
Client: TVA
Project: TVA Kingston - Proposed Gypsum Stack
Project No.: 3043051021
Location: NB-85A and NB-85B
Depth: 13'-19' **Sample Number:** UD-1, 2 & 3 (CU)
Description:
Remarks:
Type of Sample: undisturbed
Specific Gravity=2.66 LL=59 PL=30 PI=29
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1269.400			885.450
Moisture content: Dry soil+tare, gms.	1069.600			758.920
Moisture content: Tare, gms.	0.000			157.180
Moisture, %	18.7	22.4	20.4	21.0
Moist specimen weight, gms.	1269.4			
Diameter, in.	2.94	2.94	2.91	
Area, in.²	6.80	6.80	6.65	
Height, in.	5.76	5.76	5.70	
Net decrease in height, in.		0.00	0.06	
Wet Density, pcf	123.5	127.3	129.6	
Dry density, pcf	104.0	104.0	107.6	
Void ratio	0.5963	0.5963	0.5435	
Saturation, %	83.3	100.0	100.0	

Test Results for Specimen No. 1

Load ring constant = 0.72 lbs. per input unit
Consolidation cell pressure = 55.00 psi (7.92 ksf)
Consolidation back pressure = 40.00 psi (5.76 ksf)
Consolidation effective confining stress = 2.16 ksf
Strain rate, in./min. = 0.01
Fail. Stress = 5.32 ksf **at reading no.** 14

Test Readings for Specimen No. [illegible]

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	2.16	2.16	1.00	40.00	2.16	0.00
1	0.0100	101.0	72.7	0.2	1.57	1.63	3.20	1.97	43.70	2.41	0.79
2	0.0200	175.0	126.0	0.4	2.72	1.22	3.94	3.22	46.50	2.58	1.36
3	0.0300	184.0	132.5	0.5	2.85	1.17	4.02	3.45	46.90	2.59	1.43
4	0.0400	197.0	141.8	0.7	3.05	1.11	4.16	3.75	47.30	2.63	1.53
5	0.0500	211.0	151.9	0.9	3.26	1.07	4.33	4.06	47.60	2.70	1.63
6	0.0600	224.0	161.3	1.1	3.46	1.07	4.52	4.24	47.60	2.79	1.73
7	0.0700	233.0	167.8	1.2	3.59	1.04	4.63	4.46	47.80	2.83	1.79
8	0.0800	240.0	172.8	1.4	3.69	1.02	4.71	4.61	47.90	2.87	1.85
9	0.0900	246.0	177.1	1.6	3.78	1.02	4.80	4.69	47.90	2.91	1.89
10	0.1000	250.0	180.0	1.8	3.83	1.02	4.85	4.75	47.90	2.94	1.92
11	0.2000	295.0	212.4	3.5	4.44	1.17	5.61	4.81	46.90	3.39	2.22
12	0.3000	328.0	236.2	5.3	4.85	1.31	6.16	4.70	45.90	3.73	2.42
13	0.4000	347.0	249.8	7.0	5.03	1.44	6.47	4.49	45.00	3.96	2.52
14	0.5000	374.0	269.3	8.8	5.32	1.53	6.85	4.49	44.40	4.19	2.66
15	0.6000	381.0	274.3	10.5	5.32	1.60	6.92	4.33	43.90	4.26	2.66
16	0.7000	384.0	276.5	12.3	5.25	1.68	6.94	4.12	43.30	4.31	2.63
17	0.8000	307.0	221.0	14.0	4.12	1.53	5.64	3.70	44.40	3.58	2.06
18	0.9000	222.0	159.8	15.8	2.92	1.02	3.94	3.85	47.90	2.48	1.46

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1306.600			673.800
Moisture content: Dry soil+tare, gms.	1093.000			562.000
Moisture content: Tare, gms.	0.000			13.940
Moisture, %	19.5	22.0	19.9	20.4
Moist specimen weight, gms.	1306.6			
Diameter, in.	2.94	2.94	2.91	
Area, in.^{2}	6.80	6.80	6.64	
Height, in.	5.85	5.85	5.78	
Net decrease in height, in.		0.00	0.07	
Wet Density, pcf	125.1	127.8	130.2	
Dry density, pcf	104.7	104.7	108.6	
Void ratio	0.5862	0.5862	0.5297	
Saturation, %	88.7	100.0	100.0	

Test Readings for Specimen No. 2

Load ring constant = 0.72 lbs. per input unit

Consolidation cell pressure = 70.00 psi (10.08 ksf)

Consolidation back pressure = 40.00 psi (5.76 ksf)

Consolidation effective confining stress = 4.32 ksf

Strain rate, in./min. = 0.01

Fail. Stress = 6.96 ksf **at reading no.** 19

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	4.32	4.32	1.00	40.00	4.32	0.00
1	0.0100	127.0	91.4	0.2	1.98	3.61	5.59	1.55	44.90	4.60	0.99
2	0.0200	173.0	124.6	0.3	2.69	3.14	5.83	1.86	48.20	4.49	1.35
3	0.0300	203.0	146.2	0.5	3.15	2.78	5.93	2.13	50.70	4.36	1.58
4	0.0400	228.0	164.2	0.7	3.54	2.52	6.06	2.40	52.50	4.29	1.77
5	0.0500	253.0	182.2	0.9	3.92	2.26	6.18	2.73	54.30	4.22	1.96
6	0.0600	266.0	191.5	1.0	4.11	2.15	6.26	2.92	55.10	4.20	2.06
7	0.0700	275.0	198.0	1.2	4.24	2.02	6.26	3.10	56.00	4.14	2.12
8	0.0800	280.0	201.6	1.4	4.31	1.92	6.23	3.25	56.70	4.07	2.16
9	0.0900	284.0	204.5	1.6	4.37	1.81	6.18	3.41	57.40	4.00	2.18
10	0.1000	289.0	208.1	1.7	4.43	1.73	6.16	3.57	58.00	3.95	2.22
11	0.2000	360.0	259.2	3.5	5.43	1.44	6.87	4.77	60.00	4.15	2.71
12	0.3000	389.0	280.1	5.2	5.76	1.73	7.49	4.33	58.00	4.61	2.88
13	0.4000	422.0	303.8	6.9	6.13	1.53	7.66	5.02	59.40	4.59	3.07
14	0.5000	448.0	322.6	8.7	6.39	1.66	8.05	4.86	58.50	4.85	3.20
15	0.6000	462.0	332.6	10.4	6.46	1.79	8.25	4.62	57.60	5.02	3.23
16	0.7000	489.0	352.1	12.1	6.71	1.87	8.58	4.58	57.00	5.23	3.36
17	0.8000	508.0	365.8	13.8	6.83	1.97	8.81	4.46	56.30	5.39	3.42
18	0.9000	515.0	370.8	15.6	6.79	2.04	8.83	4.32	55.80	5.44	3.39
19	1.0000	539.0	388.1	17.3	6.96	2.09	9.05	4.33	55.50	5.57	3.48
20	1.1000	547.0	393.8	19.0	6.92	2.12	9.03	4.27	55.30	5.57	3.46
21	1.2000	560.0	403.2	20.8	6.93	2.19	9.12	4.17	54.80	5.65	3.46

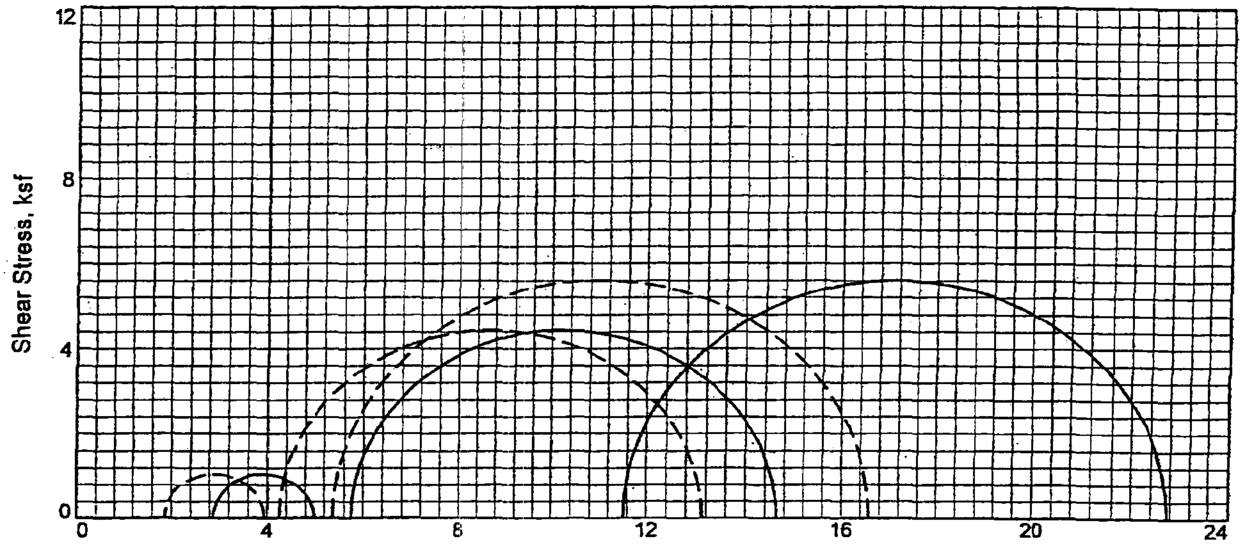
Parameters for Specimen No. 2

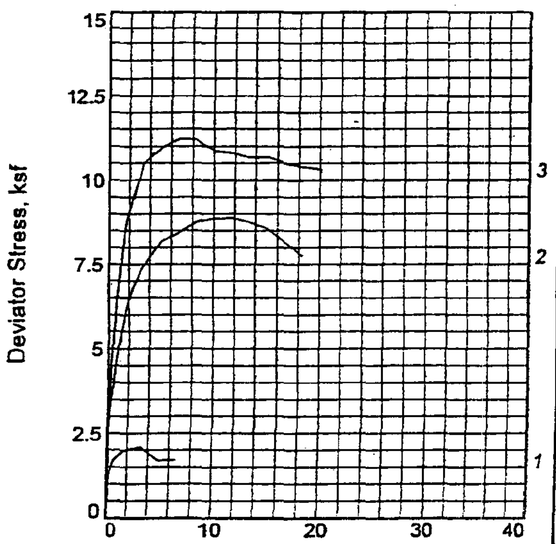
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1264.200			574.400
Moisture content: Dry soil+tare, gms.	1028.200			470.640
Moisture content: Tare, gms.	0.000			14.220
Moisture, %	23.0	23.8	21.4	22.7
Moist specimen weight, gms.	1264.2			
Diameter, in.	2.85	2.85	2.81	
Area, in.^{2}	6.36	6.36	6.20	
Height, in.	6.05	6.05	5.98	
Net decrease in height, in.		0.00	0.08	
Wet Density, pcf	125.0	125.9	128.5	
Dry density, pcf	101.7	101.7	105.8	
Void ratio	0.6330	0.6330	0.5696	
Saturation, %	96.5	100.0	100.0	

Test Readings for Specimen No. 2

Load ring constant = 0.72 lbs. per input unit
Consolidation cell pressure = 100.00 psi (14.40 ksf)
Consolidation back pressure = 40.00 psi (5.76 ksf)
Consolidation effective confining stress = 8.64 ksf
Strain rate, in./min. = 0.01
Fail. Stress = 9.32 ksf at reading no. 19

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	8.64	8.64	1.00	40.00	8.64	0.00
1	0.0100	131.0	94.3	0.2	2.19	7.29	9.47	1.30	49.40	8.38	1.09
2	0.0200	185.0	133.2	0.3	3.09	6.47	9.55	1.48	55.10	8.01	1.54
3	0.0300	214.0	154.1	0.5	3.56	5.92	9.48	1.60	58.90	7.70	1.78
4	0.0400	242.0	174.2	0.7	4.02	5.39	9.41	1.75	62.60	7.40	2.01
5	0.0500	262.0	188.6	0.8	4.35	5.01	9.36	1.87	65.20	7.19	2.17
6	0.0600	280.0	201.6	1.0	4.64	4.75	9.39	1.98	67.00	7.07	2.32
7	0.0700	295.0	212.4	1.2	4.88	4.54	9.41	2.08	68.50	6.98	2.44
8	0.0800	308.0	221.8	1.3	5.09	4.35	9.43	2.17	69.80	6.89	2.54
9	0.0900	323.0	232.6	1.5	5.32	4.16	9.49	2.28	71.10	6.82	2.66
10	0.1000	332.0	239.0	1.7	5.46	4.09	9.55	2.34	71.60	6.82	2.73
11	0.2000	425.0	306.0	3.3	6.87	3.72	10.59	2.85	74.20	7.15	3.44
12	0.3000	482.0	347.0	5.0	7.66	3.90	11.56	2.96	72.90	7.73	3.83
13	0.4000	529.0	380.9	6.7	8.26	3.92	12.18	3.11	72.80	8.05	4.13
14	0.5000	566.0	407.5	8.4	8.68	4.09	12.77	3.12	71.60	8.43	4.34
15	0.6000	590.0	424.8	10.0	8.88	4.32	13.20	3.06	70.00	8.76	4.44
16	0.7000	626.0	450.7	11.7	9.25	4.54	13.78	3.04	68.50	9.16	4.62
17	0.8000	642.0	462.2	13.4	9.31	4.68	13.99	2.99	67.50	9.33	4.65
18	0.9000	651.0	468.7	15.1	9.25	4.84	14.09	2.91	66.40	9.47	4.63
19	1.0000	669.0	481.7	16.7	9.32	4.98	14.30	2.87	65.40	9.64	4.66
20	1.1000	675.0	486.0	18.4	9.22	5.07	14.29	2.82	64.80	9.68	4.61
21	1.2000	690.0	496.8	20.1	9.23	5.21	14.44	2.77	63.80	9.83	4.61





Sample No.		1	2	3
Initial	Water Content,	32.5	30.7	27.4
	Dry Density, pcf	88.6	91.0	94.2
	Saturation,	99.9	100.0	96.6
	Void Ratio	0.8597	0.8103	0.7488
	Diameter, in.	2.84	2.85	2.84
	Height, in.	6.04	6.11	6.13
At Test	Water Content,	32.6	27.1	22.5
	Dry Density, pcf	88.6	96.1	103.3
	Saturation,	100.0	100.0	100.0
	Void Ratio	0.8597	0.7155	0.5953
	Diameter, in.	2.84	2.80	2.75
	Height, in.	6.04	6.01	5.95
Strain rate, in./min.		0.00	0.00	0.00
Back Pressure, ksf		2.9	2.9	2.9
Cell Pressure, ksf		5.8	8.6	14.4
Fail. Stress, ksf		2.1	8.9	11.2
Total Pore Pr., ksf		3.9	4.4	9.0
Ult. Stress, ksf				
Total Pore Pr., ksf				
$\bar{\sigma}_1$ Failure, ksf		4.0	13.1	16.6
$\bar{\sigma}_3$ Failure, ksf		1.9	4.2	5.4

Type of Test:
CU with Pore Pressures

Sample Type: undisturbed

Description: Brown sandy fat clay

LL= 50 **PL=** 24 **PI=** 26

Specific Gravity= 2.64

Remarks: CH

Figure ______

Client: TVA

Project: TVA Kingston - Proposed Gypsum Stack

Location: NB-85 **A/B**

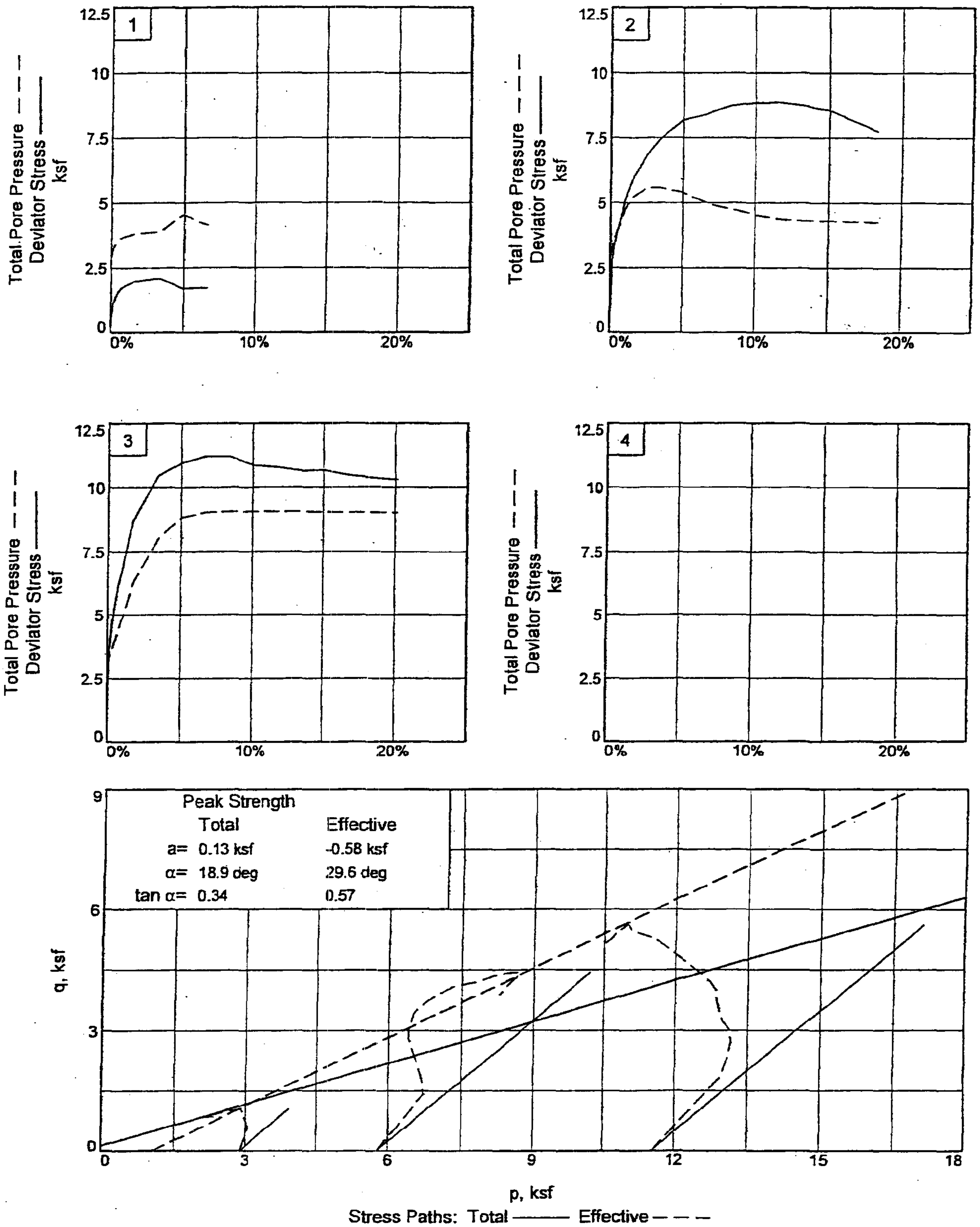
Sample Number: UD-6, 7 & 8 (CU) **Depth:** 23'-29'

Proj. No.: 3043051021 **Date:**

TRIAXIAL SHEAR TEST REPORT

MACTEC, INC.

Tested By: Alexander **Checked By:** Hamlett



Client: TVA
Project: TVA Kingston - Proposed Gypsum Stack
Location: NB-85B **Depth:** 23'-29' **Sample Number:** UD-6, 7 & 8 (CU)
Project No.: 3043051021 **Figure** ________ **MACTEC, INC.**

Tested By: Alexander **Checked By:** Hamlett

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

9/13/2005
10:13 PM

Date:
Client: TVA
Project: TVA Kingston - Proposed Gypsum Stack
Project No.: 3043051021
Location: NB-85B
Depth: 23'-29' **Sample Number:** UD-6, 7 & 8 (CU)
Description:
Remarks:
Type of Sample: undisturbed
Specific Gravity=2.64 **LL**=50 **PL**=24 **PI**=26
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1176.400			679.710
Moisture content: Dry soil+tare, gms.	887.600			531.300
Moisture content: Tare, gms.	0.000			94.030
Moisture, %	32.5	32.6	32.6	33.9
Moist specimen weight, gms.	1176.4			
Diameter, in.	2.84	2.84	2.84	
Area, in.²	6.32	6.32	6.32	
Height, in.	6.04	6.04	6.04	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	117.5	117.5	117.5	
Dry density, pcf	88.6	88.6	88.6	
Void ratio	0.8597	0.8597	0.8597	
Saturation, %	99.9	100.0	100.0	

Test Readings for Specimen No. 1

Load ring constant = 0.72 lbs. per input unit
Consolidation cell pressure = 40.00 psi (5.76 ksf)
Consolidation back pressure = 20.00 psi (2.88 ksf)
Consolidation effective confining stress = 2.88 ksf
Strain rate, in./min. = 0.00
Fail. Stress = 2.09 ksf **at reading no.** 11

Test Readings for Specimen No. [illegible]

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	2.88	2.88	1.00	20.00	2.88	0.00
1	0.0100	67.0	48.2	0.2	1.10	2.51	3.60	1.44	22.60	3.05	0.55
2	0.0200	85.0	61.2	0.3	1.39	2.32	3.71	1.60	23.90	3.01	0.69
3	0.0300	96.0	69.1	0.5	1.57	2.20	3.77	1.71	24.70	2.99	0.78
4	0.0400	104.0	74.9	0.7	1.69	2.12	3.81	1.80	25.30	2.96	0.85
5	0.0500	108.0	77.8	0.8	1.76	2.07	3.83	1.85	25.60	2.95	0.88
6	0.0600	111.0	79.9	1.0	1.80	2.03	3.83	1.89	25.90	2.93	0.90
7	0.0700	114.0	82.1	1.2	1.85	2.02	3.86	1.92	26.00	2.94	0.92
8	0.0800	117.0	84.2	1.3	1.89	1.99	3.88	1.95	26.20	2.93	0.95
9	0.0900	120.0	86.4	1.5	1.94	1.96	3.90	1.99	26.40	2.93	0.97
10	0.1000	122.0	87.8	1.7	1.97	1.94	3.91	2.01	26.50	2.93	0.98
11	0.2000	132.0	95.0	3.3	2.09	1.86	3.95	2.13	27.10	2.90	1.05
12	0.3000	108.0	77.8	5.0	1.68	1.21	2.89	2.39	31.60	2.05	0.84
13	0.3500	110.0	79.2	5.8	1.70	1.45	3.15	2.17	29.90	2.30	0.85
14	0.4000	111.0	79.9	6.6	1.70	1.61	3.31	2.05	28.80	2.46	0.85

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1216.500			669.040
Moisture content: Dry soil+tare, gms.	930.800			534.240
Moisture content: Tare, gms.	0.000			87.490
Moisture, %	30.7	30.7	27.1	30.2
Moist specimen weight, gms.	1216.5			
Diameter, in.	2.85	2.85	2.80	
Area, in.²	6.37	6.37	6.15	
Height, in.	6.11	6.11	6.01	
Net decrease in height, in.		0.00	0.11	
Wet Density, pcf	119.0	119.0	122.1	
Dry density, pcf	91.0	91.0	96.1	
Void ratio	0.8103	0.8103	0.7155	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No. 2

Load ring constant = 0.72 lbs. per input unit

Consolidation cell pressure = 60.00 psi (8.64 ksf)

Consolidation back pressure = 20.00 psi (2.88 ksf)

Consolidation effective confining stress = 5.76 ksf

Strain rate, in./min. = 0.00

Fail. Stress = 8.88 ksf **at reading no.** 20

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	5.76	5.76	1.00	20.00	5.76	0.00
1	0.0100	168.0	121.0	0.2	2.83	5.31	8.14	1.53	23.10	6.73	1.41
2	0.0200	208.0	149.8	0.3	3.50	4.95	8.45	1.71	25.60	6.70	1.75
3	0.0300	233.0	167.8	0.5	3.91	4.69	8.61	1.83	27.40	6.65	1.96
4	0.0400	258.0	185.8	0.7	4.32	4.44	8.76	1.97	29.20	6.60	2.16
5	0.0500	281.0	202.3	0.8	4.70	4.18	8.88	2.13	31.00	6.53	2.35
6	0.0600	305.0	219.6	1.0	5.09	3.92	9.01	2.30	32.80	6.46	2.55
7	0.0700	321.0	231.1	1.2	5.35	3.74	9.10	2.43	34.00	6.42	2.68
8	0.0800	337.0	242.6	1.3	5.61	3.59	9.20	2.56	35.10	6.39	2.80
9	0.0900	352.0	253.4	1.5	5.85	3.47	9.32	2.69	35.90	6.40	2.92
10	0.1000	367.0	264.2	1.7	6.09	3.36	9.44	2.81	36.70	6.40	3.04
11	0.1500	417.0	300.2	2.5	6.86	3.08	9.94	3.23	38.60	6.51	3.43
12	0.2000	455.0	327.6	3.3	7.42	3.05	10.47	3.43	38.80	6.76	3.71
13	0.3000	510.0	367.2	5.0	8.17	3.24	11.41	3.52	37.50	7.33	4.09
14	0.4000	534.0	384.5	6.7	8.41	3.63	12.04	3.32	34.80	7.83	4.20
15	0.4500	551.0	396.7	7.5	8.60	3.77	12.37	3.28	33.80	8.07	4.30
16	0.5000	565.0	406.8	8.3	8.74	3.87	12.61	3.26	33.10	8.24	4.37
17	0.5500	574.0	413.3	9.2	8.80	3.97	12.77	3.21	32.40	8.37	4.40
18	0.6000	583.0	419.8	10.0	8.85	4.09	12.94	3.16	31.60	8.52	4.43
19	0.6500	588.0	423.4	10.8	8.85	4.18	13.02	3.12	31.00	8.60	4.42
20	0.7000	596.0	429.1	11.7	8.88	4.25	13.13	3.09	30.50	8.69	4.44
21	0.8000	599.0	431.3	13.3	8.76	4.32	13.08	3.03	30.00	8.70	4.38
22	0.9000	598.0	430.6	15.0	8.58	4.32	12.90	2.99	30.00	8.61	4.29
23	1.0000	581.0	418.3	16.7	8.17	4.35	12.52	2.88	29.80	8.43	4.09
24	1.1000	563.0	405.4	18.3	7.76	4.39	12.15	2.77	29.50	8.27	3.88

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1221.900			617.770
Moisture content: Dry soil+tare, gms.	959.100			503.750
Moisture content: Tare, gms.	0.000			87.190
Moisture, %	27.4	28.4	22.5	27.4
Moist specimen weight, gms.	1221.9			
Diameter, in.	2.84	2.84	2.75	
Area, in.²	6.33	6.33	5.95	
Height, in.	6.13	6.13	5.95	
Net decrease in height, in.		0.00	0.18	
Wet Density, pcf	120.1	121.0	126.6	
Dry density, pcf	94.2	94.2	103.3	
Void ratio	0.7488	0.7488	0.5953	
Saturation, %	96.6	100.0	100.0	

Test Readings for Specimen No. 3

Load ring constant = 0.72 lbs. per input unit

Consolidation cell pressure = 100.00 psi (14.40 ksf)

Consolidation back pressure = 20.00 psi (2.88 ksf)

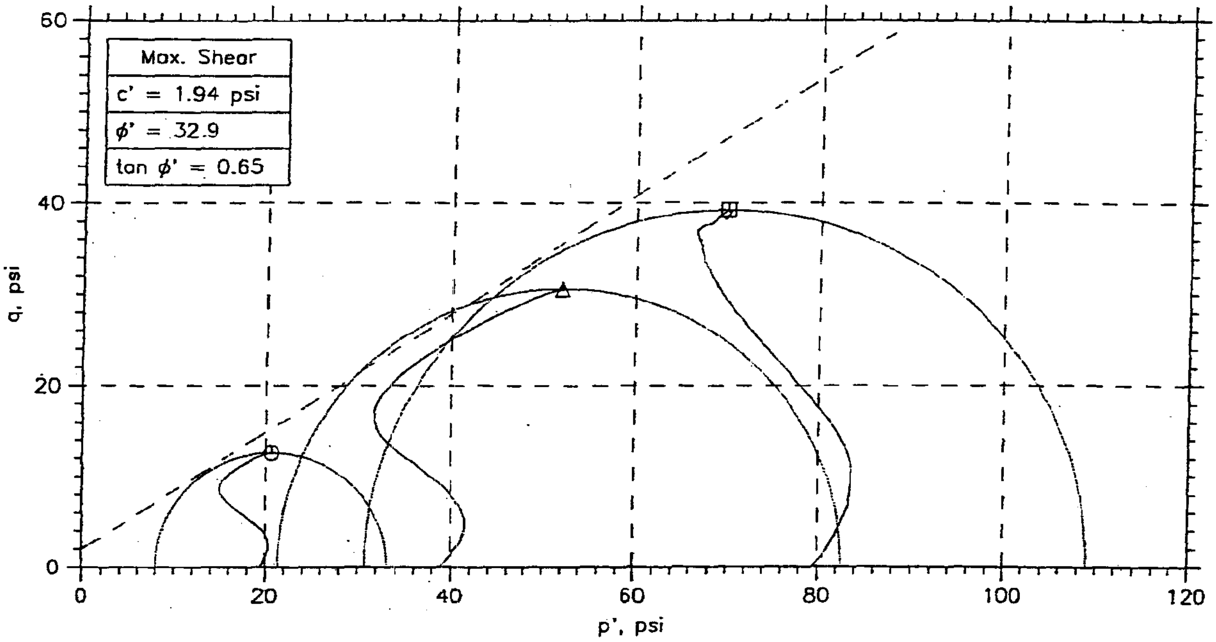
Consolidation effective confining stress = 11.52 ksf

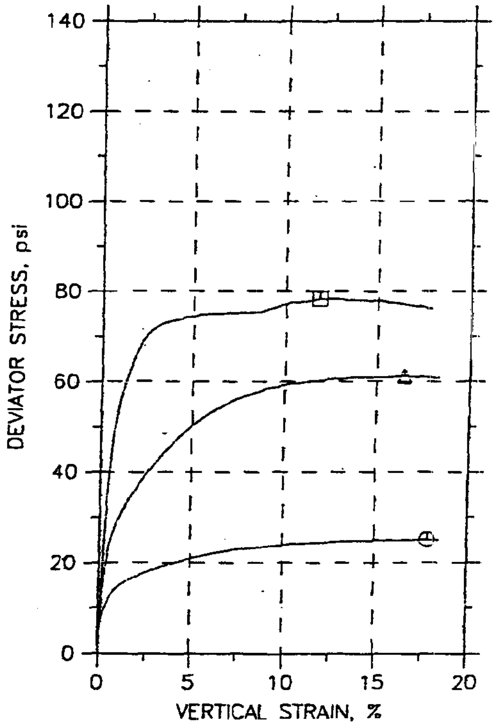
Strain rate, in./min. = 0.00

Fail. Stress = 11.22 ksf **at reading no.** 13

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	11.52	11.52	1.00	20.00	11.52	0.00
1	0.0100	208.0	149.8	0.2	3.62	11.12	14.74	1.33	22.80	12.93	1.81
2	0.0200	270.0	194.4	0.3	4.69	10.76	15.45	1.44	25.30	13.10	2.35
3	0.0300	314.0	226.1	0.5	5.45	10.44	15.89	1.52	27.50	13.16	2.72
4	0.0400	349.0	251.3	0.7	6.04	10.11	16.15	1.60	29.80	13.13	3.02
5	0.0500	374.0	269.3	0.8	6.46	9.75	16.21	1.66	32.30	12.98	3.23
6	0.0600	402.0	289.4	1.0	6.94	9.45	16.38	1.73	34.40	12.91	3.47
7	0.0700	435.0	313.2	1.2	7.49	9.12	16.61	1.82	36.70	12.86	3.75
8	0.0800	465.0	334.8	1.3	8.00	8.84	16.84	1.90	38.60	12.84	4.00
9	0.0900	486.0	349.9	1.5	8.34	8.57	16.91	1.97	40.50	12.74	4.17
10	0.1000	509.0	366.5	1.7	8.72	8.22	16.95	2.06	42.90	12.58	4.36
11	0.2000	622.0	447.8	3.4	10.48	6.38	16.86	2.64	55.70	11.62	5.24
12	0.3000	662.0	476.6	5.0	10.96	5.57	16.53	2.97	61.30	11.05	5.48
13	0.4000	690.0	496.8	6.7	11.22	5.37	16.59	3.09	62.70	10.98	5.61
14	0.5000	702.0	505.4	8.4	11.21	5.34	16.55	3.10	62.90	10.95	5.60
15	0.6000	693.0	499.0	10.1	10.86	5.34	16.20	3.03	62.90	10.77	5.43
16	0.7000	702.0	505.4	11.8	10.80	5.34	16.14	3.02	62.90	10.74	5.40
17	0.8000	706.0	508.3	13.5	10.65	5.34	15.99	2.99	62.90	10.67	5.33
18	0.9000	721.0	519.1	15.1	10.67	5.36	16.02	2.99	62.80	10.69	5.33
19	1.0000	723.0	520.6	16.8	10.48	5.37	15.85	2.95	62.70	10.61	5.24
20	1.1000	731.0	526.3	18.5	10.38	5.37	15.76	2.93	62.70	10.56	5.19
21	1.2000	741.0	533.5	20.2	10.31	5.39	15.70	2.91	62.60	10.54	5.15

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767





Symbol		○	△	□	
Sample No.		UD-5	UD-6	UD-5	
Test No.		13772.1	13772.2	13771.3	
Depth		28-30 ft	30-32 Ft.	28-30 ft	
Initial	Diameter, in	2.84	2.831	2.844	
	Height, in	5.57	5.57	5.57	
	Water Content, %	46.9	26.7	37.2	
	Dry Density, pcf	76.13	98.14	85.6	
	Saturation, %	103.2	98.8	102.4	
	Void Ratio	1.24	0.739	0.993	
Before Shear	Water Content, %	44.8	25.8	34.5	
	Dry Density, pcf	76.74	100.	87.83	
	Saturation*, %	100.0	100.0	100.0	
	Void Ratio	1.22	0.705	0.942	
	Back Press., psi	54	57.99	60	
Ver. Eff. Cons. Stress, psi		20	40.01	80	
Shear Strength, psi		12.57	30.6	39.17	
Strain at Failure, %		17.8	16.5	11.8	
Strain Rate, %/min		0.022	0.022	0.022	
B-Value		0.95	0.95	0.95	
Measured Specific Gravity		2.73	2.73	2.73	
Liquid Limit		74	53	74	
Plastic Limit		36	27	36	

GeoTesting express
the groundwork for success

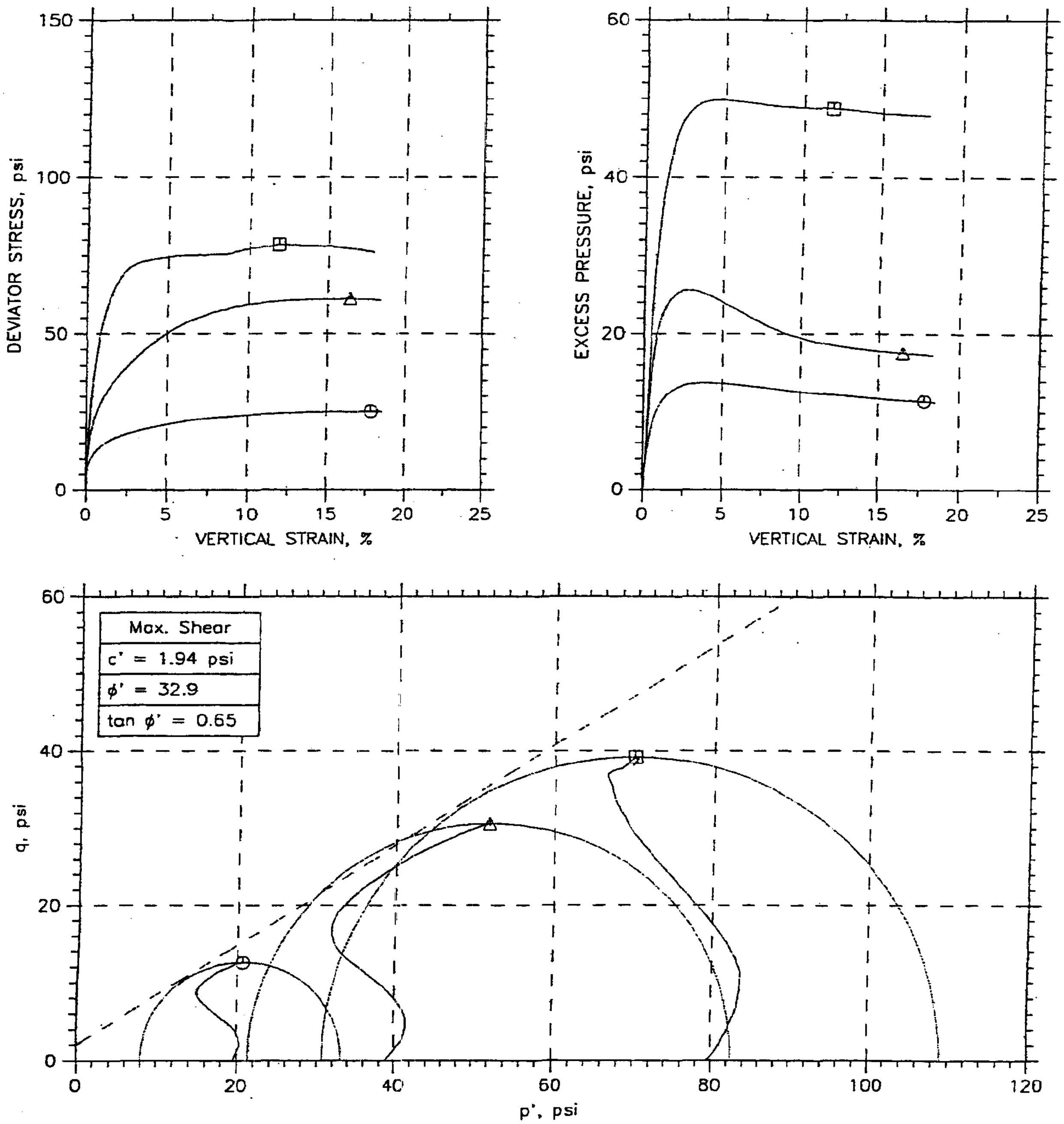
Project: TVA Kingston Gypsym Stack	
Location: NB-85B	
Project No.: GTX G0959	
Boring No.: NB-85B	
Sample Type: Shelby Tube	
Description:	
Remarks:	

Phase calculations based on start and end of test.

* Saturation is set to 100% for phase calculations.

Thu, 02-FEB-2006 15:26:40

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767



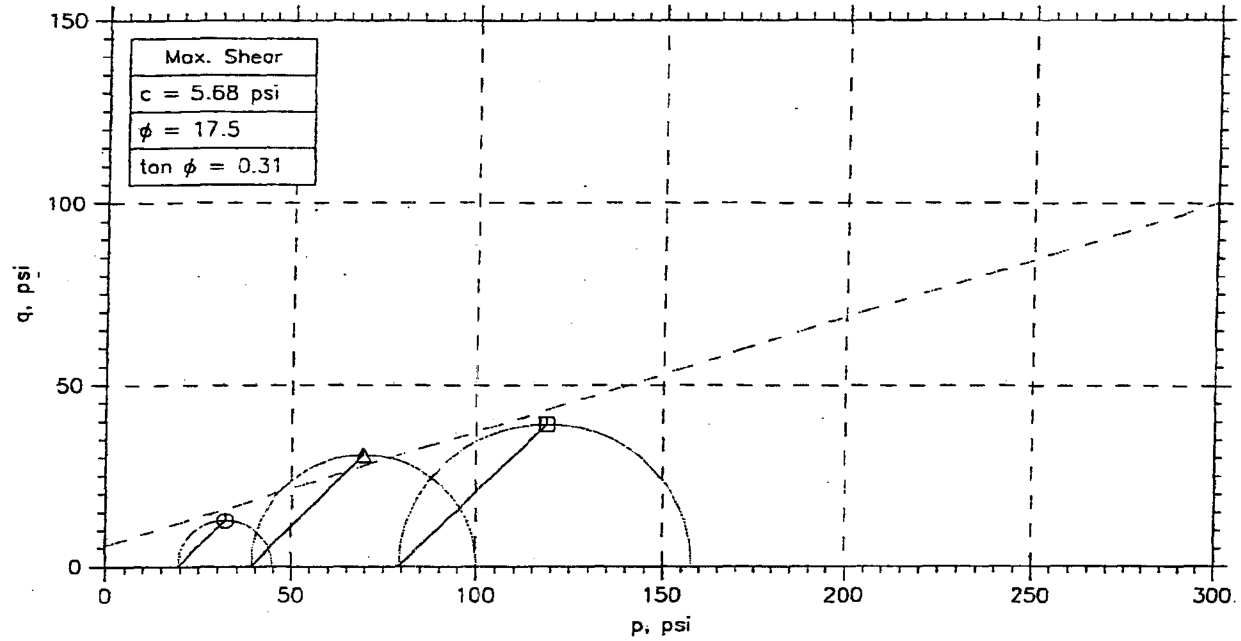
	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	UD-5	13772.1	28-30 ft	JW	12/9/05	HJ		13771.1_1057.dat
△	UD-6	13772.2	30-32 Ft.	JW	12/9/05	HJ		13772.2_2054.dat
□	UD-5	13771.3	28-30 ft	JW	12/9/05	HJ		13771.3_1062.dat

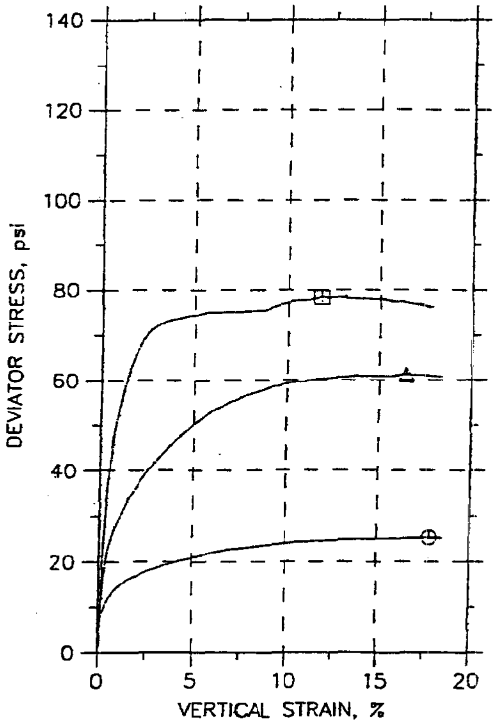
GeoTesting express the groundwork for success

Project: TVA Kingston Gypsym Std	Location: NB-85B	Project No.: GTX G0959
Boring No.: NB-85B	Sample Type: Shelby Tube	
Description:		
Remarks:		

Thu, 02-FEB-2006 15:26:40

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767





		○	△	□	
Symbol		○	△	□	
Sample No.		UD-5	UD-6	UD-5	
Test No.		13772.1	13772.2	13771.3	
Depth		28-30 ft	30-32 Ft.	28-30 ft	
Initial	Diameter, in	2.84	2.831	2.844	
	Height, in	5.57	5.57	5.57	
	Water Content, %	46.9	26.7	37.2	
	Dry Density, pcf	76.13	98.14	85.6	
	Saturation, %	103.2	98.8	102.4	
	Void Ratio	1.24	0.739	0.993	
Before Shear	Water Content, %	44.8	25.8	34.5	
	Dry Density, pcf	76.74	100.	87.83	
	Saturation*, %	100.0	100.0	100.0	
	Void Ratio	1.22	0.705	0.942	
	Back Press., psi	54	57.99	60	
Ver. Eff. Cons. Stress, psi		20	40.01	80	
Shear Strength, psi		12.57	30.6	39.17	
Strain at Failure, %		17.8	16.5	11.8	
Strain Rate, %/min		0.022	0.022	0.022	
B-Value		0.95	0.95	0.95	
Measured Specific Gravity		2.73	2.73	2.73	
Liquid Limit		74	53	74	
Plastic Limit		36	27	36	

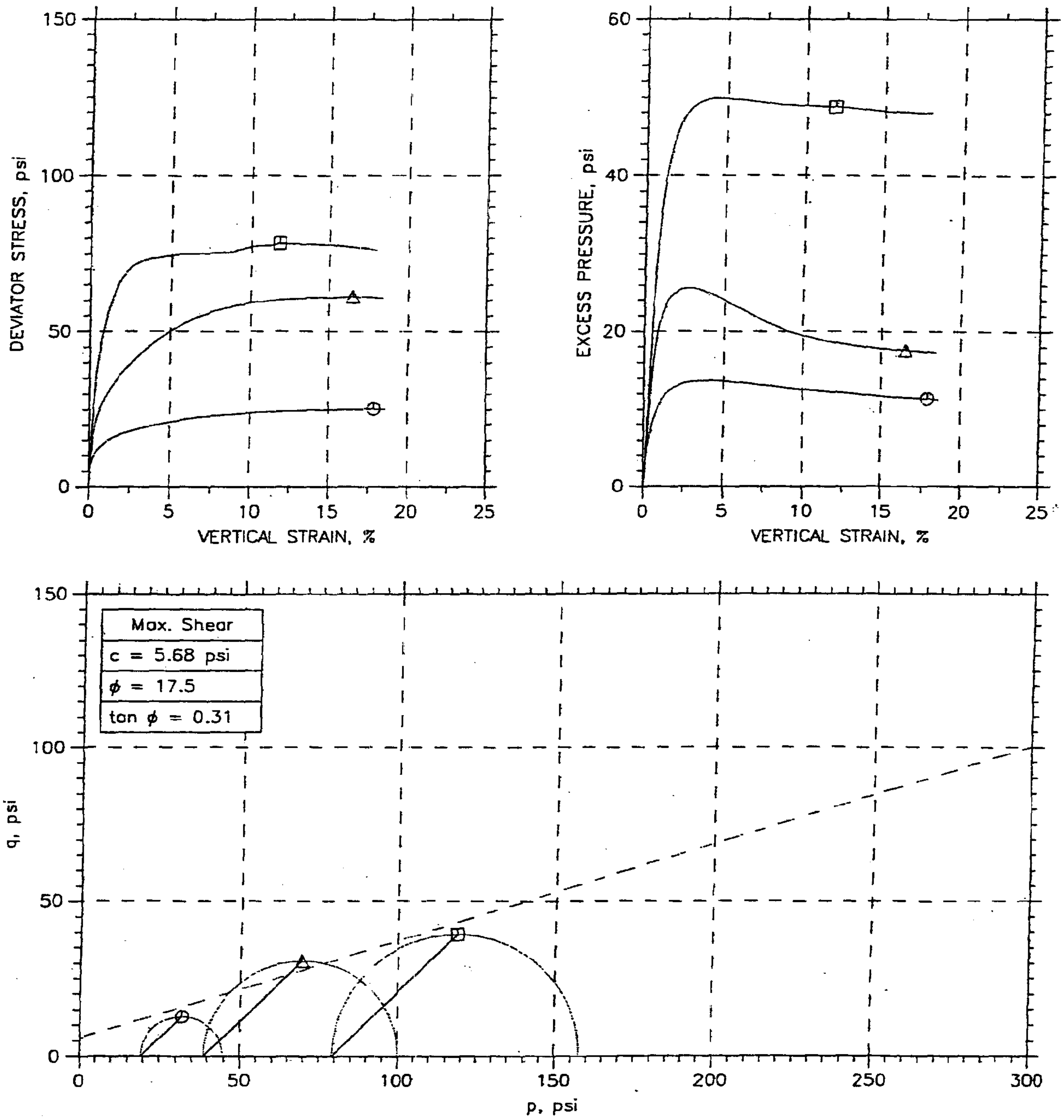
GeoTesting express
the groundwork for success

Project: TVA Kingston Gypsym Stack
Location: NB-85B
Project No.: GTX G0959
Boring No.: NB-85B
Sample Type: Shelby Tube
Description:
Remarks:

Phase calculations based on start and end of test.
* Saturation is set to 100% for phase calculations.

Thu, 02-FEB-2006 15:27:10

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767



	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
O	UD-5	13772.1	28-30 ft	JW	12/9/05	HJ		13771.1_1057.dat
△	UD-6	13772.2	30-32 Ft.	JW	12/9/05	HJ		13772.2_2054.dat
□	UD-5	13771.3	28-30 ft	JW	12/9/05	HJ		13771.3_1062.dat

GeoTesting Express
the groundwork for success

Project: TVA Kingston Gypsym Std	Location: NB-85B	Project No.: GTX G0959
Boring No.: NB-85B	Sample Type: Shelby Tube	
Description:		
Remarks:		

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PERMEABILITY TEST RESULTS

PERMEABILITY TEST RESULTS

TVA Kingston - Gypsum Disposal
MACTEC Project No.
3043-05-1064-01
Summary of Laboratory Testing for Hydraulic Conductivity

Boring	Sample	Depth (ft)	Moisture (%)	Dry Unit wt (pcf)	Hydraulic Conductivity (cm/sec)
K-11	UD	12-14	22.9	102.4	9.1×10^{-7}
K-12	UD	12-14	24.3	96.1	7.6×10^{-6}
K-13	UD	12-14	29.9	87.4	1.6×10^{-6}
K-14	UD	12-14	29.4	94.2	1.7×10^{-8}
K-15A	UD	12-13	37.3	80.3	2.2×10^{-6}
K-16	Bulk	10-15	24.6	95.7	2.6×10^{-8}
K-17	Bulk	10-15	31.7	86.6	1.3×10^{-8}
K-18	Bulk	10-15	31.6	87.1	2.7×10^{-8}

Note: Bulk soil samples were remolded to approximately 95% of their respective standard Proctor maximum dry densities and 2% over optimum moisture content.

CJA

DESIGN AND ANALYSIS OF THE SURFACE WATER MANAGEMENT SYSTEM

GEOSYNTEC CONSULTANTS

COMPUTATION COVER SHEET

Client: TVA **Project:** KIP Gypsum Disposal Facility **Project/Proposal #:** GR3731 **Task #:** 06

TITLE OF COMPUTATIONS DESIGN & ANALYSIS OF THE SURFACE WATER MANAGEMENT SYSTEM (See Note below)

COMPUTATIONS BY: Signature Alexander Maestre — DATE 12/7/06
Printed Name and Title: Alexander Maestre, Senior Staff Engineer

ASSUMPTIONS AND PROCEDURES CHECKED BY: (Peer Reviewer) Signature Ganesh Krishnan — DATE 12/13/2006
Printed Name and Title: Ganesh Gopalakrishnan, PE, CPESC, Senior Engineer

COMPUTATIONS CHECKED BY: Signature Ganesh Krishnan — DATE 12/13/2006
Printed Name and Title: Ganesh Gopalakrishnan, PE, CPESC, Senior Engineer

COMPUTATIONS BACKCHECKED BY: (Originator) Signature Alexander Maestre — DATE 12/19/06
Printed Name and Title: Alexander Maestre, Senior Staff Engineer

APPROVED BY: (PM or Designate) Signature RNeil Davies — DATE 1/15/2007
Printed Name and Title: Neil Davies, Principal/Vice President

APPROVAL NOTES: Calculations revised based on client-review to reflect re-routing storm water (previously passing through a culvert under the pond) around the pond. No revisions to runoff from the cover system. Revisions only affect the run-on areas. GK 12/13/06

REVISIONS (Number and initial all revisions)

NO.	SHEET	DATE	BY	CHECKED BY	APPROVAL

GEOSYNTEC CONSULTANTS

COMPUTATION COVER SHEET

Client: TVA **Project:** KIF Gypsum Disposal Facility **Project/Proposal #:** GR3731 **Task #:** 06

TITLE OF COMPUTATIONS DESIGN & ANALYSIS OF THE SURFACE WATER MANAGEMENT SYSTEM

COMPUTATIONS BY: Signature [signature] 04/04/06 DATE

Printed Name and Title: Sowmya Bulusu, Staff Engineer

ASSUMPTIONS AND PROCEDURES CHECKED BY: (Peer Reviewer) Signature [signature] 5/8/2006 DATE

Printed Name and Title: Ganesh Gopalakrishnan, PE, CPESC, Senior Engineer

COMPUTATIONS CHECKED BY: Signature [signature] 5/8/2006 DATE

Printed Name and Title: Ganesh Gopalakrishnan, PE, CPESC, Senior Engineer

COMPUTATIONS BACKCHECKED BY: Originator) Signature [signature] 05/08/06 DATE

Printed Name and Title: Sowmya Bulusu, Staff Engineer

APPROVED BY: (PM or Designate) Signature R. Neil Davies 5/8/06 DATE

Printed Name and Title: Neil Davies, Principal/Vice President

APPROVAL NOTES: This was revised on 12/13/06. Please see new cover sheet dated 12/13/06.

See comment

REVISIONS (Number and initial all revisions)

NO.	SHEET	DATE	BY	CHECKED BY	APPROVAL

DESIGN & ANALYSIS OF THE SURFACE WATER MANAGEMENT SYSTEM

BACKGROUND

This calculation package was prepared in support of the engineering design activities performed by GeoSyntec on behalf of Tennessee Valley Authority (TVA) for the proposed TVA Kingston Fossil Plant Gypsum Disposal Facility (herein referred as KIF Gypsum disposal facility), Roane County, Tennessee. GeoSyntec understands that TVA will submit this package (and other associated design packages) to the Tennessee Department of Environment and Conservation (TDEC).

PURPOSE

The purpose of this calculation package is to present the analyses and design of the proposed surface water management system for the KIF Gypsum Disposal Facility. The specific goals of this package are to present:

- an overview of the proposed surface water management system for the disposal facility;
- the regulatory requirements and the design criteria;
- the design of the various components of the surface water management system, including run-on control system, sediment basin, drainage benches, downdrains, downchutes, perimeter drainage channels, and culverts; and
- the results of the calculations for post-development peak discharges from the site.

SURFACE WATER MANAGEMENT SYSTEM - OVERVIEW

The proposed grading plan of the surface water management system for the KIF Gypsum Disposal Facility is provided in Attachment 1. The cover system will have a 4 percent slope from the crest to an elevation of 980 ft, and then a 33 percent (i.e., 3 horizontal: 1 vertical) slope from the elevation of 980 ft downwards. Benches will intercept surface water runoff from the cover slopes and convey the runoff to downdrain pipes, which will convey the runoff to the perimeter drainage channels located at the toe of the cover system. The perimeter drainage channels are sloped towards the south-west corner of the disposal facility and will connect to a drop-inlet and three 48-inch diameter culvert system under the perimeter access road conveying runoff to the stormwater pond located to the south-west of the disposal facility. The stormwater pond will not have a primary outlet structure. The water levels in the pond will be controlled by pumping. Storm water collected in the pond will be pumped using a storm water lift station and conveyed via a force main to the currently permitted National Pollutant Discharge Elimination System (NPDES) discharge point near the plant (i.e., plant discharge channel). The stormwater lift station was designed to have three pumps, each pump having a different turn-on elevation. The first pump is designed to start pumping out water when the water level in the pond reaches an elevation of 756 feet. The pump turnoff elevation is 755 feet.

Runoff from primarily undisturbed areas to the north of the disposal facility (hereinafter referred to as "run-on") will be intercepted by a system of drainage channels to prevent from "running-on" to the active portion of the disposal area. This system of drainage channels will collect and convey run-on to two different locations. Run-on from approximately 55.42 acres in the northwest portion of the site will be diverted and conveyed to Watts Bar Lake-Clinch River through an outfall that will be located in the southwestern corner of the site, west of the Proposed Gypsum Dewatering Facility Area. Run-on from approximately 43.18 acres in the northeastern portion of the site will be diverted and conveyed through a previously existing drainage path east of the disposal facility leading to the Clinch River. The stormwater management system for this facility is designed such that run-on from undisturbed areas (i.e., outside the limits of the disposal facility) will bypass the stormwater pond.

REGULATORY CRITERIA & DESIGN APPROACH

The surface water management system is designed to meet (and exceed) regulatory requirements of the "Rules of TDEC, Division of Solid Waste Management" [TDEC, 2005]. Specifically, the following requirements of TDEC Rule Chapter 1200-1-7 were considered in the design.

- *The operator must design, construct, operate, and maintain a run-off management system to collect and control at least the peak flow volume resulting from a 24 hour, 25 year storm.*

- *Holding facilities (e.g., sediment basins) associated with run-on and run-off control systems must be designed to detain at least the water volume resulting from a 24-hour, 25-year storm, and to divert through emergency spillways at least the peak flow resulting from a 24-hour, 100-year storm.*

- *The operator must design, construct, operate, and maintain a run-on control system capable of preventing flow onto the active portion of the facility for all flow up to and including the peak discharge from a 24-hour, 25-year storm.*

In addition to the above, sediment storage requirements provided in the "Tennessee Erosion and Sediment Control Handbook" [TDEC, 2002] were considered in the design of the stormwater pond. Specifically, the handbook states that "*In order to maximize trapping and* *retaining the incoming sediment, the basin should have a permanent pool, or wet storage component and a dry storage component that dewaters over time. The volume of permanent pool (needed to protect against re-suspension of sediment and to promote better settling conditions between runoff events) must be at least 67 cubic yard per acre of drainage area and the volume of dry storage above the permanent pool (needed to prevent "short-circuiting" of the basin during larger storm events) must be at least an additional 67 cubic yards per acre of drainage area*".

The runoff and run-on management system for the facility was designed such that all conveyances (such as channels and pipes) will be able to convey calculated peak discharges from a 25-year 24-hour design storm with sufficient free-board, and will be able to convey calculated peak discharge from a 100-year 24-hour design storm without reaching full capacity (i.e., overtopping in the case of channels). The stormwater pond for the site is designed to detain flows from the cover system of the disposal facility, and will be able to hold the calculated sediment storage volume and the calculated runoff volume from a 25-year 24-hour design storm without the water elevation reaching the elevation of the emergency spillway. For the 100-year 24-hour storm event, discharge from the emergency spillway is negligible (i.e., 0.14 cfs).

ANALYSIS METHODS & SOFTWARE

Hydrologic analysis procedures presented in TR-55 [SCS, 1986] are adopted for analyses performed for the design of the stormwater management system for this project. Standard hydraulic design procedures (as identified subsequently within this package) are adopted to design the various components of the stormwater management system based on the results of hydrologic analyses.

Computer program HydroCAD™ [2004] is used as a tool to perform hydrologic analyses. The program uses hydrology procedures provided in TR-55, combined with other hydrology and hydraulics calculations. In addition to the hydrologic analyses performed using HydroCAD, culverts were modeled using CulvertMaster® [1986]. This computer program uses Federal Highway Administration (FHWA) recommended methodologies for analyses/design of culvert systems.

MAJOR CALCULATION PARAMETERS

- **Drainage Area Delineation:** Attachment 2 presents a schematic plan of the post development surface water management system for the disposal facility. The plan shows the delineation of subareas on the cover system and adjoining runon areas. The schematic plan also shows other design components such as channels and pipes.

- **Rainfall Distribution**: Attachment 3A [SCS TR-55, 1986] shows the location of the site on a rainfall distribution map of the United States. The site is located in Roane County, Tennessee, which is categorized by SCS Type II Rainfall Distribution.

- **Rainfall Depths:** Attachment 3B presents the site location and the rainfall depth for the 2-year, 25-year, and 100-year 24-hour design storms. The 2-year rainfall depth is used for calculating the times of concentration for hydrologic modeling. The rainfall depths are shown in the following table.

Return Period (years)	Design Rainfall Depth (inches)
2	3.4
25	5.7
100	6.7

- **Hydrologic Soil Groups (HSG):** Attachment 4 presents the regional soils map for the vicinity of the site. Major soil units found within the areas of interest are listed in the table in Attachment 4. Hydrologic Soil Group B was used for the run-on areas for analyses performed in this package. For the final cover subareas, it is anticipated that the vegetative/ protective cover of the final cover, will consist of permeable silty sands of hydrologic soil group C, to promote growth of vegetation; however hydrologic soil group D was used in the analyses to represent the more conservative condition (i.e., higher runoff).

- **Curve Numbers (CN):** CNs were selected based on Attachment 5 [SCS TR-55, 1986]. The following table summarizes the CNs chosen for the analyses performed in this package.

Area Description	**Condition**	**HSG**	**CN**
Run-on Areas Outside Cover Limits	Woods – Grass combination	B	73
Disposal Area Cover System	Open Space, Good Hydrologic Condition (Grass Cover>75%)	D	80
Streets and Roads	Impervious – Paved Areas	D	98
Stormwater Pond	N/A	N/A	98

- **Nodal Network Diagram:** Attachment 6 presents a diagram of the nodal network used in HydroCAD for hydrologic analyses which parallels the schematic plan shown in Attachment 2.

- **Properties of Subareas:** Attachment 7 presents the properties of the subareas of included in the nodal network above. The calculated areas (in acres) of each subarea, curve number, and computations for the times of concentration are included in Attachment 7.

  Time of concentration for each area was calculated as the travel time along the assumed longest flow line within the subarea. Along each flow line, the flow was subdivided into various segments based on the flow type (i.e., sheet flow, shallow concentrated flow, ditch flow, and culvert/pipe flow). Computations for travel time for sheet flow are performed using the equation for Manning's kinematic solution [SCS TR-55, 1986]:

$$T_t = \frac{0.007(nL)^{0.8}}{(P)^{0.5} S^{0.4}}$$

  where, T_t=travel time (hr), n=Manning's roughness coefficient, L=flow length (ft), P=2-year, 24-hour rainfall depth (inches), and S=land slope (ft/ft). After a maximum of 300 feet, sheet flow is assumed to become shallow concentrated flow. After calculating the average velocity, travel time is calculated using the following equation [SCS TR-55, 1986]:

$$T_t = \frac{L}{3600 \times V}$$

  where, T_t=travel time (hr), L=flow length (ft), and V=velocity (ft/s).

COMPUTATIONS USING HydroCAD

Calculations were performed using HydroCAD for the input parameters discussed in the previous section for the 25-year, 24-hour design storm, and the 100-year, 24-hour storm. The computer program results are presented in Attachment 8.

DESIGN OF SURFACE WATER MANAGEMENT SYSTEM COMPONENTS

Stormwater Pond

A sediment storage capacity of 67 cubic yards per acre of disturbed area is recommended by the TDEC in the "Tennessee Erosion and Sediment Control Handbook" [TDEC, 2002]. This translates to a minimum required sediment storage volume of 4.01 acre-ft for the stormwater pond (referred to as SP in HydroCAD analyses) based on the disturbed area draining storm water into the pond. It is recommended that the sediment be cleaned out when two-thirds (66 percent) of the required sediment storage volume has been filled with sediment. Based on a stage-storage relationship as shown in Attachment 9, a sediment cleanout elevation of 753.2 feet is recommended. As stated earlier, the first pump for the stormwater pond is designed to turn on at an elevation of 756 feet. Therefore, the analysis was performed assuming that the available storage capacity of the pond is from elevation 756 feet to the elevation of the emergency spillway (i.e., 764 feet).

Drainage Benches

Drainage benches on the cover system are designed as V-shaped with a minimum longitudinal slope of 1 percent. Benches will have left and right side slopes of 3H:1V (i.e. 33.3 percent) and 10H:1V (10 percent), respectively, and an available flow depth of 1.5 feet. The design methodology is presented in Attachment 13. The allowable discharge in the drainage benches is estimated using Manning's equation [Chow, 1959] which is expressed as:

$$Q = \frac{1.49}{n} AR^{2/3} S_o^{1/2}$$

where, Q=discharge (cfs), n=Manning's roughness coefficient, A=area of cross-section of flow (ft^2), R=hydraulic radius=A/P, P=wetted perimeter (ft), and S_o=longitudinal slope (ft/ft).

The final cover area contributing to the critical drainage bench is 2.33 acres. The peak discharge of 12.98 cfs is calculated for the critical drainage bench as shown in Attachment 10. The drainage benches shall be vegetated to prevent scour during peak flows. The calculated depth of flow from a 25-year, 24-hour design storm is 0.75 ft, resulting in a freeboard of 0.75 ft.

Downdrains

The downdrains are designed as 24-inch diameter, corrugated High Density Polyethylene (HDPE) pipes with smooth interiors and will be installed on the top of the final cover system. The downdrains will have longitudinal slopes varying from 17.3 percent to 27.2 percent on the final cover, with the slope being 4 percent at the drainage bench intersections on the final cover. Downdrains are designed in this package using a 4 percent longitudinal slope representing the most critical design condition. For design purposes the highest peak discharge from a subarea on the final cover (58.2 cfs from Subarea 202; obtained from HydroCAD) is assumed as the peak discharge for downdrain design. The design methodology is presented in Attachment 11. The capacity of a 24-inch diameter pipe sloped at 4 percent (70.47 cfs) is greater than the highest flow from a subarea (i.e., 58.2 from Subarea 202) to a downdrain as presented in Attachment 11.

Drainage Channels

Drainage channels were modeled in HydroCAD in the post-development analysis of the cover system as "reaches". The summary of drainage channel properties is presented in Attachment 12 along with the related output of the HydroCAD analysis.

In order to design the type of lining, the following procedure was followed. According to [ASCE 1992], the permissible tractive stress for Class B grass was 1 psf. The tractive stress at design discharge is calculated for each reach, and grass lining was recommended for those with a tractive stress less than 1 psf. At reaches, where tractive stresses higher than 1 psf were calculated, riprap lining was recommended. The following equation was used to calculate the size of riprap [ASCE 1992] required for lining the channels:

$$d_{50} = 12\left[64.4QS_o^{\frac{13}{6}}\left(\frac{z}{z^2+1}\right)\right]^{\frac{2}{5}}$$

where, d_{50}=minimum median riprap diameter (in), Q=discharge (cfs), S_o=longitudinal slope (ft/ft), and z=side slope of the channel.

The d_{50} of the recommended riprap is also presented in Attachment 12.

Culverts

Geometric properties and other calculation parameters of culverts were input in HydroCAD as reaches: C1, C2, C3, C4, C5, C6, C7, and C8 for overall hydrologic analyses. The summary of the culvert sizes and geometric properties is presented in Table 1 of Attachment 13. Table 1 also shows the 25-year, 24-hour peak discharge from hydrologic analyses and demonstrates that each culvert pipe will have sufficient capacity to convey the 25-year, 24-hour design storm when analyzed using the Manning's Equation.

In addition to the above, CulvertMaster® was used to analyze the hydraulic condition for each culvert system for the 100-year, 24-hour peak discharge, such that the design would not result in headwater buildup in the inlets that would overtop the inflow channels. All the culverts were controlled at the entrance except for C1 that conveys the runoff collected from the final cover system of the disposal area to the stormwater pond. For the 100-year, 24-hour peak design discharge, it was assumed that the tailwater elevation of C1 corresponded to the invert elevation of the emergency spillway (a conservative assumption representing the worst case water level in the pond). The summary of outputs from CulvertMaster, for culverts C1 through C8, is presented in Table 2 in Attachment 13. The ditches will be provided with sufficient depth at the culvert intersections to accommodate the headwater buildup without overtopping.

REFERENCES

ASCE, "*Design and Construction of Urban Stormwater Management Systems*", ASCE Manuals and Reports of Engineering Practice No. 77, New York, 1992.

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TDEC, "*Tennessee Erosion and Sediment Control Handbook*", Division of Water Pollution Control, Tennessee Department of Environment and Conservation, 2nd ed., March 2002.

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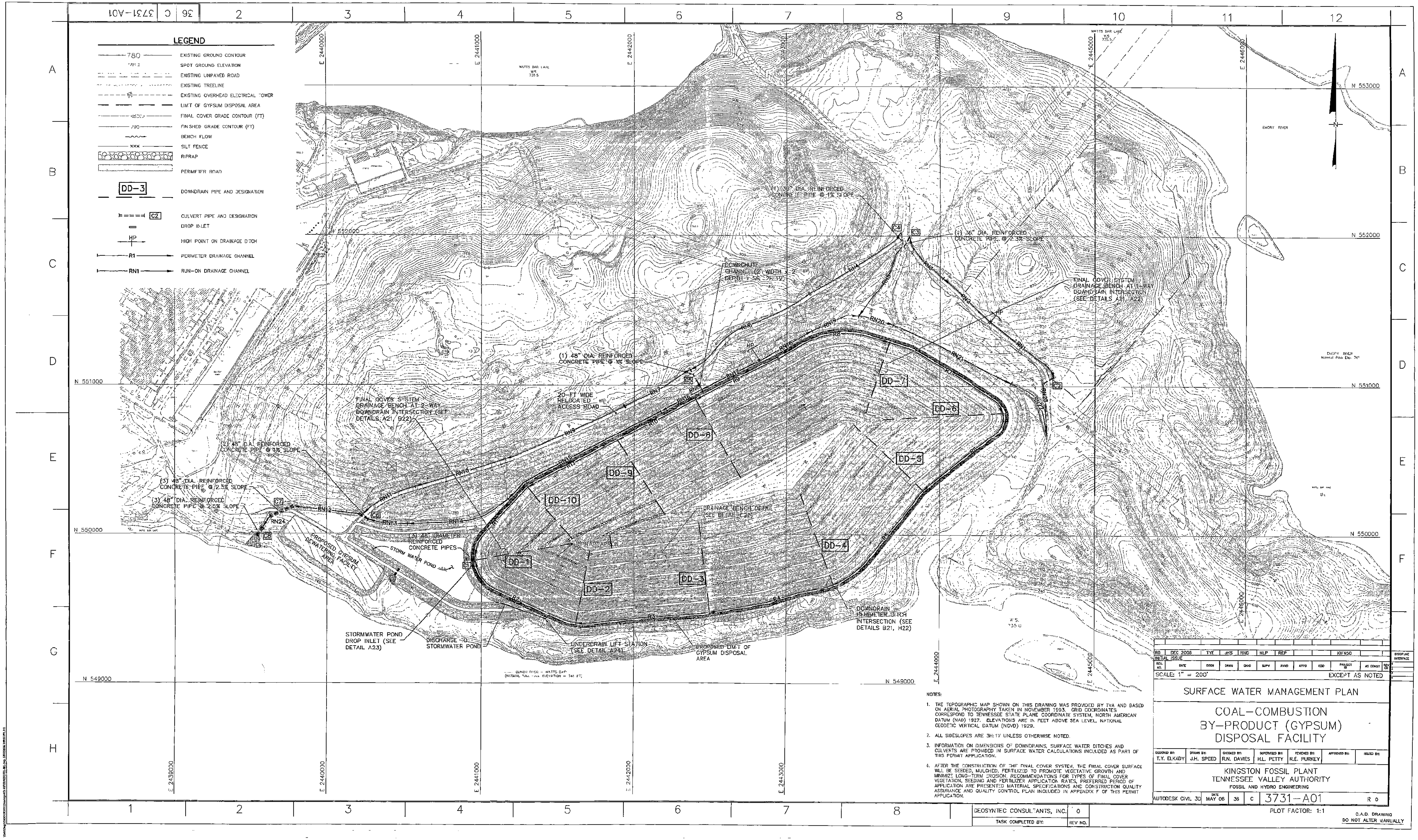
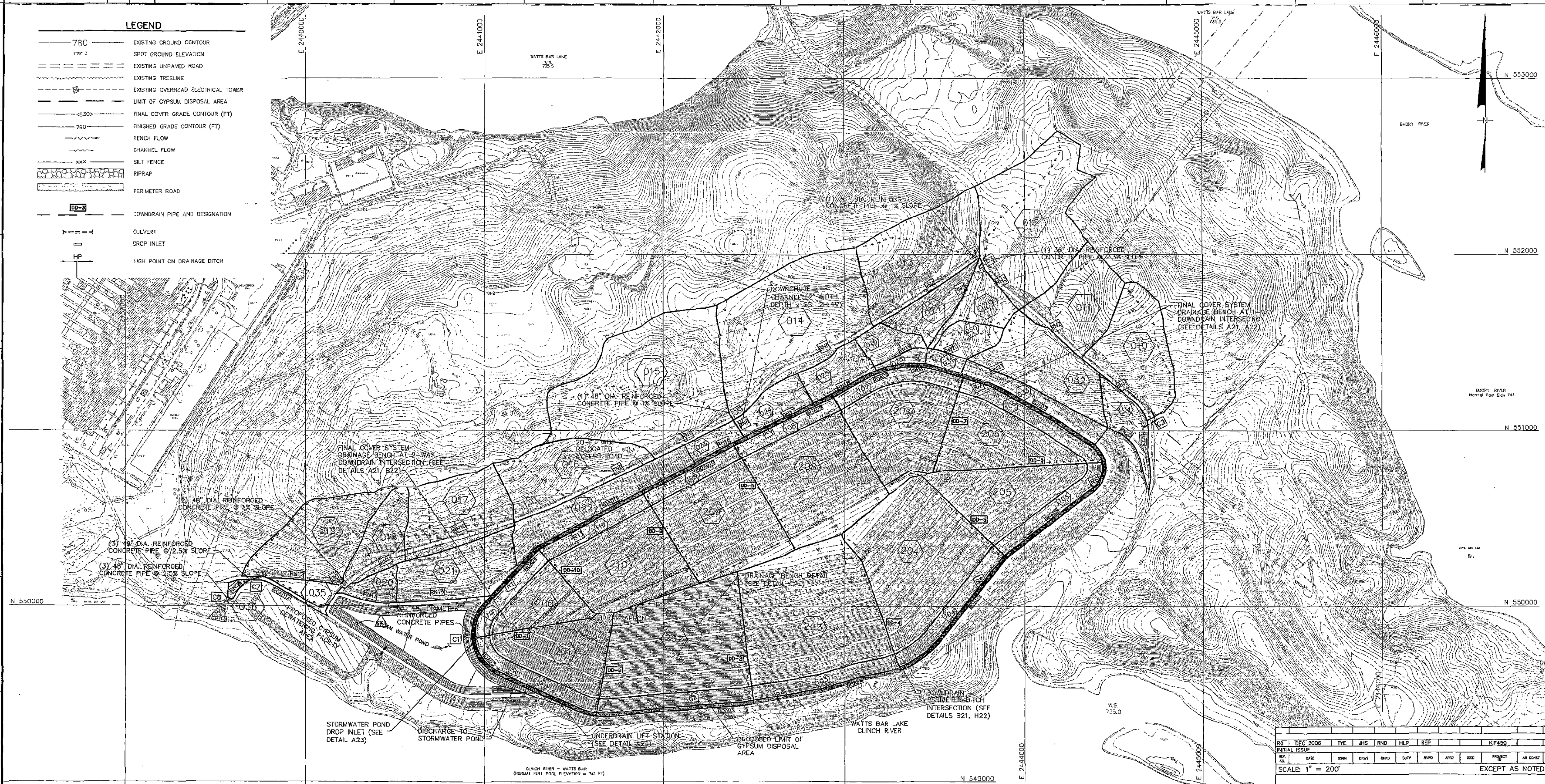
Attachment 1

Surface Water Management System Plan


LEGEND
EXISTING GROUND CONTOUR
SPOT GROUND ELEVATION
EXISTING UNPAVED ROAD
EXISTING TREELINE
EXISTING OVERHEAD ELECTRICAL TOWER
LIMIT OF GYPSUM DISPOSAL AREA
FINAL COVER GRADE CONTOUR (FT)
FINISHED GRADE CONTOUR (FT)
BENCH FLOW
SILT FENCE
RIPRAP
PERIMETER ROAD
DD-3
DOWNDRAIN PIPE AND DESIGNATION
C2
CULVERT PIPE AND DESIGNATION
DROP INLET
HP
HIGH POINT ON DRAINAGE DITCH
R1
PERIMETER DRAINAGE CHANNEL
RN1
RUN-ON DRAINAGE CHANNEL
N 553000
N 552000
N 551000
N 550000
N 549000
E 2439000
E 2440000
E 2441000
E 2442000
E 2443000
E 2444000
E 2445000
E 2446000
(1) 30" DIA. REINFORCED CONCRETE PIPE @ 1% SLOPE
(1) 36" DIA. REINFORCED CONCRETE PIPE @ 2.3% SLOPE
DOWNCHUTE CHANNEL
FINAL COVER SYSTEM DRAINAGE BENCH AT 1-WAY DOWNDRAIN INTERSECTION (SEE DETAILS A21, A22)
(1) 48" DIA. REINFORCED CONCRETE PIPE @ 1% SLOPE
20-FT WIDE RELOCATED ACCESS ROAD
FINAL COVER SYSTEM DRAINAGE BENCH AT 2-WAY DOWNDRAIN INTERSECTION (SEE DETAILS A21, B22)
(2) 48" DIA. REINFORCED CONCRETE PIPE @ 3% SLOPE
(3) 48" DIA. REINFORCED CONCRETE PIPE @ 2.5% SLOPE
(3) 48" DIA. REINFORCED CONCRETE PIPE @ 2.5% SLOPE
(3) 48" DIAMETER REINFORCED CONCRETE PIPES
DRAINAGE BENCH DETAIL (SEE DETAIL C22)
PROPOSED GYPSUM DEWATERING FACILITY AREA
STORM WATER POND
STORMWATER POND DROP INLET (SEE DETAIL A23)
DISCHARGE TO STORMWATER POND
UNDERDRAIN LIFT STATION (SEE DETAIL A24)
PROPOSED LIMIT OF GYPSUM DISPOSAL AREA
DOWNDRAIN PERIMETER DITCH INTERSECTION (SEE DETAILS B21, H22)
DD-1
DD-2
DD-3
DD-4
DD-5
DD-6
DD-7
DD-8
DD-9
DD-10
C1
C2
C3
C4
C5
C6
C7
C8
EMORY RIVER
N
NOTES:
1. THE TOPOGRAPHIC MAP SHOWN ON THIS DRAWING WAS PROVIDED BY TVA AND BASED ON AERIAL PHOTOGRAPHY TAKEN IN NOVEMBER 1993. GRID COORDINATES CORRESPOND TO TENNESSEE STATE PLANE COORDINATE SYSTEM, NORTH AMERICAN DATUM (NAD) 1927. ELEVATIONS ARE IN FEET ABOVE SEA LEVEL, NATIONAL GEODETIC VERTICAL DATUM (NGVD) 1929.
2. ALL SIDESLOPES ARE 3H:1V UNLESS OTHERWISE NOTED.
3. INFORMATION ON DIMENSIONS OF DOWNDRAINS, SURFACE WATER DITCHES AND CULVERTS ARE PROVIDED IN SURFACE WATER CALCULATIONS INCLUDED AS PART OF THIS PERMIT APPLICATION.
4. AFTER THE CONSTRUCTION OF THE FINAL COVER SYSTEM, THE FINAL COVER SURFACE WILL BE SEEDED, MULCHED, FERTILIZED TO PROMOTE VEGETATIVE GROWTH AND MINIMIZE LONG-TERM EROSION. RECOMMENDATIONS FOR TYPES OF FINAL COVER VEGETATION, SEEDING AND FERTILIZER APPLICATION RATES, PREFERRED PERIOD OF APPLICATION ARE PRESENTED MATERIAL SPECIFICATIONS AND CONSTRUCTION QUALITY ASSURANCE AND QUALITY CONTROL PLAN INCLUDED IN APPENDIX F OF THIS PERMIT APPLICATION.
R0 DEC 2006 TYE JHS RND HLP REP KIF450
INITIAL ISSUE
REV. NO. DATE DSGN DRWN CHKD SUPV RVWD APPD ISSD PROJECT ID AS CONST REV CD
DISCIPLINE INTERFACE
SCALE: 1" = 200' EXCEPT AS NOTED
SURFACE WATER MANAGEMENT PLAN
COAL-COMBUSTION BY-PRODUCT (GYPSUM) DISPOSAL FACILITY
DESIGNED BY: T.Y. ELKADY
DRAWN BY: J.H. SPEED
CHECKED BY: R.N. DAVIES
SUPERVISED BY: H.L. PETTY
REVIEWED BY: R.E. PURKEY
APPROVED BY:
ISSUED BY:
KINGSTON FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING
AUTODESK CIVIL 3D
DATE MAY 06
36
C
3731-A01
R 0
PLOT FACTOR: 1:1
GEOSYNTEC CONSULTANTS, INC.
0
TASK COMPLETED BY:
REV NO.
C.A.D. DRAWING
DO NOT ALTER MANUALLY

Attachment 2

Schematic Surface Water Management Plan



NOTES:

1. THE TOPOGRAPHIC MAP SHOWN ON THIS DRAWING WAS PROVIDED BY TVA AND BASED ON AERIAL PHOTOGRAPHY TAKEN IN NOVEMBER 1993. GRID COORDINATES CORRESPOND TO TENNESSEE STATE PLANE COORDINATE SYSTEM, NORTH AMERICAN DATUM (NAD) 1927. ELEVATIONS ARE IN FEET ABOVE SEA LEVEL. NATIONAL GEODETIC VERTICAL DATUM (NGVD) 1929.
2. ALL SIDESLOPES ARE 3H:1V UNLESS OTHERWISE NOTED.
3. INFORMATION ON DIMENSIONS OF DOWNDRAINS, SURFACE WATER DITCHES AND CULVERTS ARE PROVIDED IN SURFACE WATER CALCULATIONS INCLUDED AS PART OF THIS PERMIT APPLICATION.
4. AFTER THE CONSTRUCTION OF THE FINAL COVER SYSTEM, THE FINAL COVER SURFACE WILL BE SEEDED, MULCHED, FERTILIZED TO PROMOTE VEGETATIVE GROWTH AND MINIMIZE LONG-TERM EROSION. RECOMMENDATIONS FOR TYPES OF FINAL COVER VEGETATION, SEEDING AND FERTILIZER APPLICATION RATES, PREFERRED PERIOD OF APPLICATION ARE PRESENTED MATERIAL SPECIFICATIONS AND CONSTRUCTION QUALITY ASSURANCE AND QUALITY CONTROL PLAN INCLUDED IN APPENDIX F OF THIS PERMIT APPLICATION.

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST
R0	DEC 2006	TYE	JHS	RND	HLP	REP			KIF450	
INITIAL ISSUE										

SCALE: 1" = 200' EXCEPT AS NOTED

SURFACE WATER MANAGEMENT PLAN

COAL-COMBUSTION BY-PRODUCT (GYPSUM) DISPOSAL FACILITY

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
T.Y. ELKADY	J.H. SPEED	R.N. DAVIES	H.L. PETTY	R.E. FURKEY		

KINGSTON FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTODESK CIVIL 3D | DATE MAY 06 | 36 | C | 3731-A02 | R 0

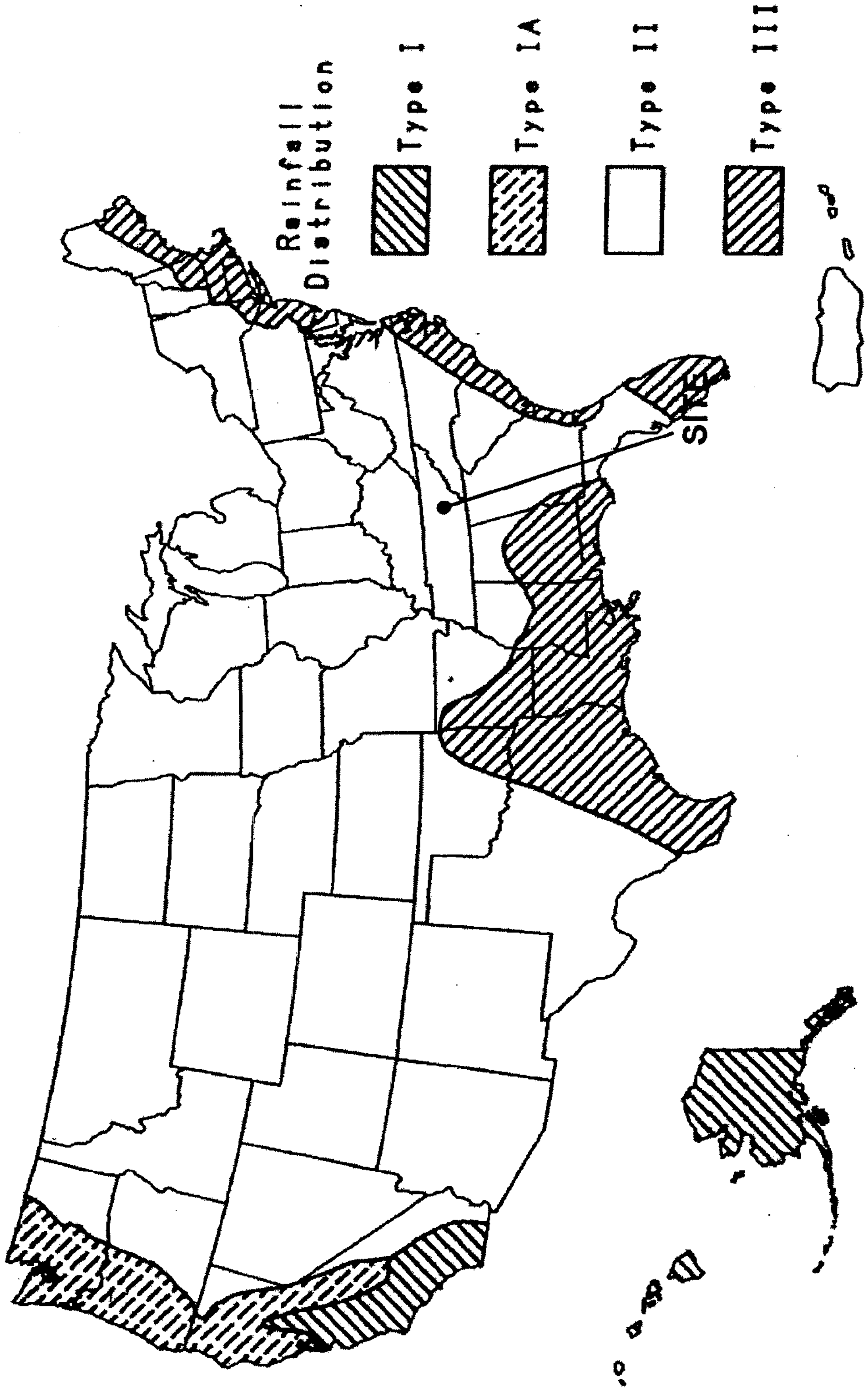
PLOT FACTOR: 1:1

C.A.D. DRAWING
DO NOT ALTER MANUALLY

GEOSYNTEC CONSULTANTS, INC.	0
TASK COMPLETED BY:	REV NO.

Attachment 3A

Rainfall Distribution



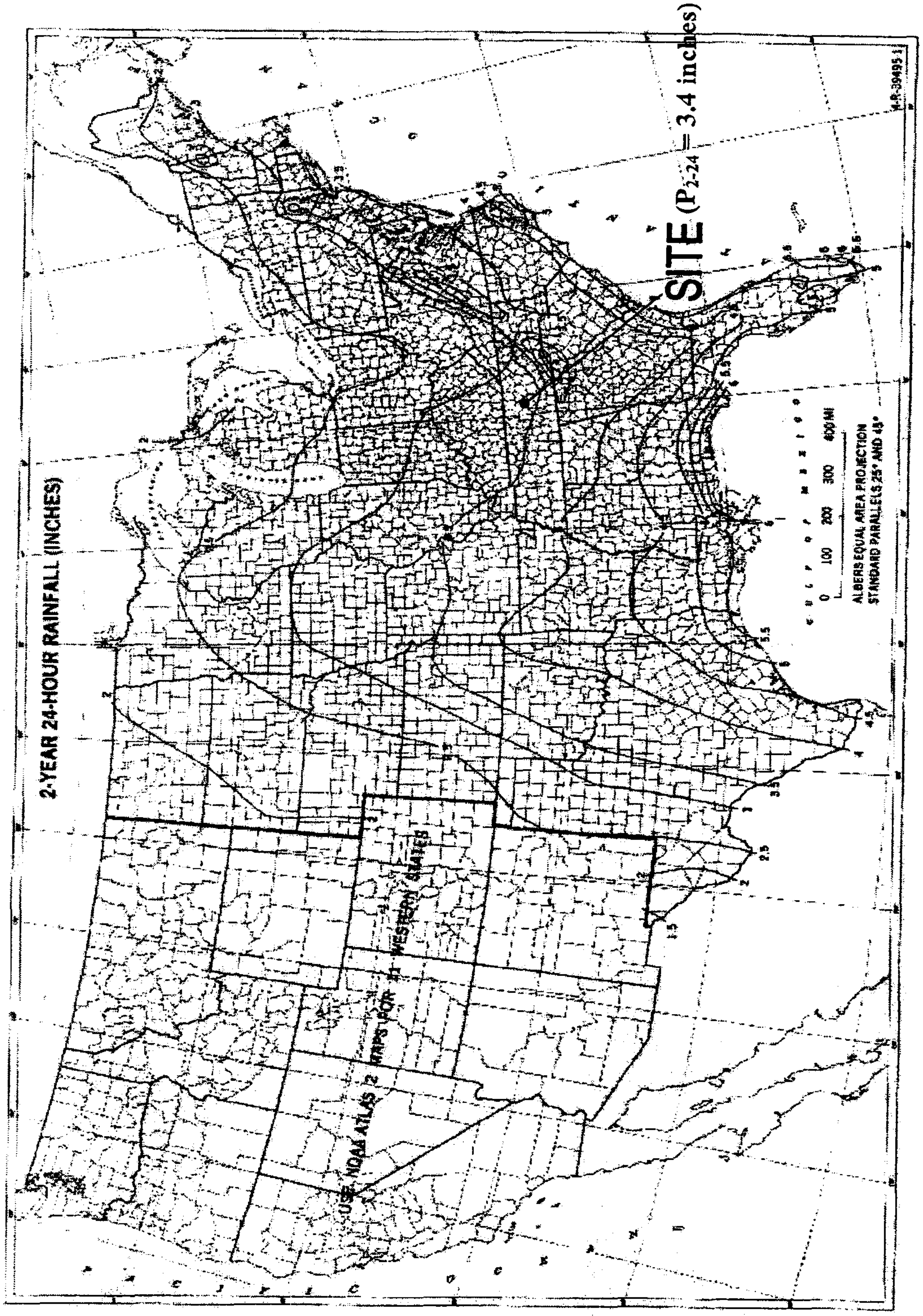
Rainfall Distribution
Type I
Type IA
Type II
Type III
SITE

Attachment 3B

Rainfall Depths

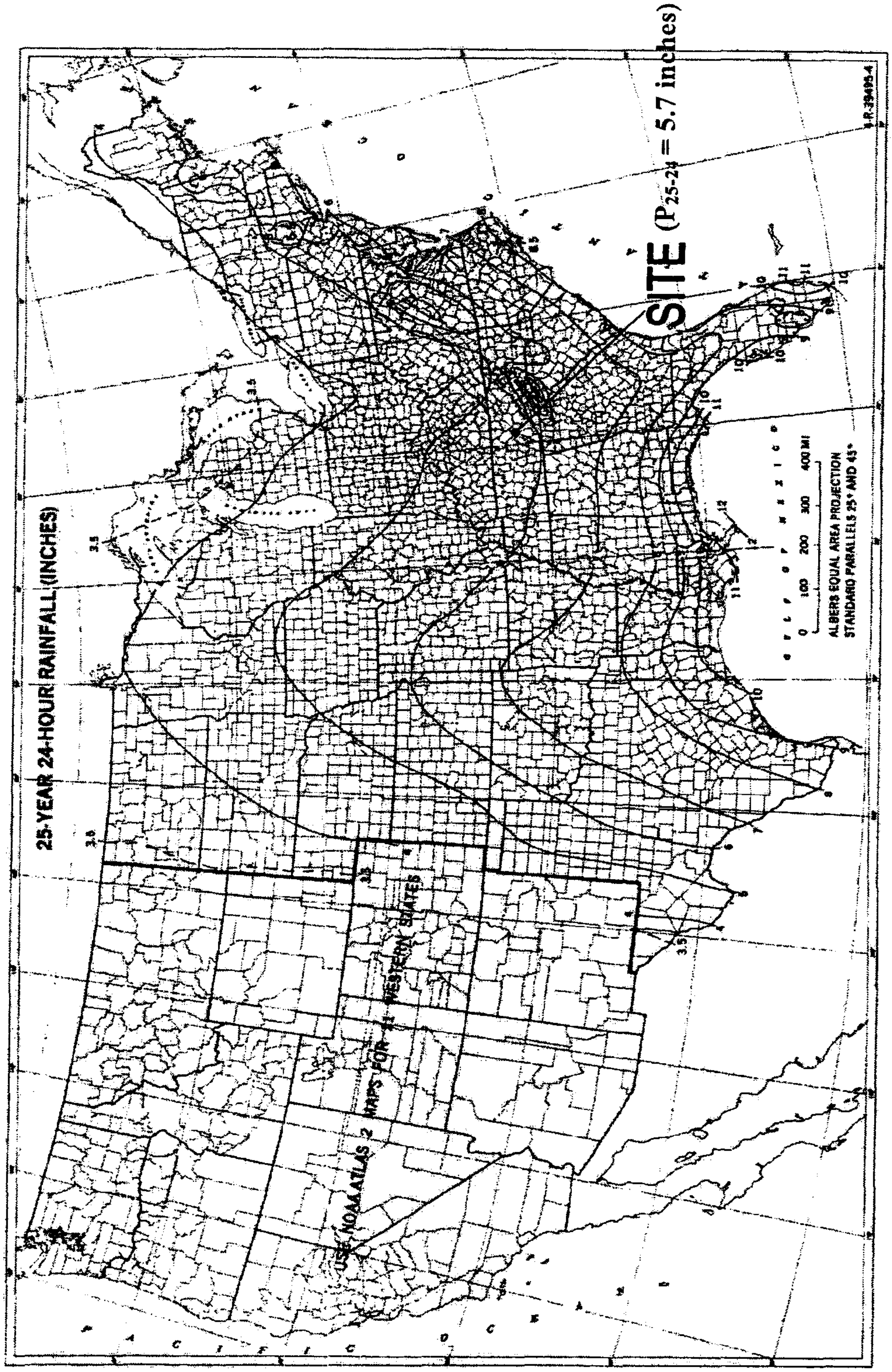
Written by: Sowmya Bulusu / Alexander Maestre Date: 12/07/06 Reviewed by: Ganesh Gopalakrishnan Date: 12/13/06

Client: TVA Project: Kingston Fossil Plant Gypsum Disposal Facility Project/Proposal No.: GR3731 Task No.: 06



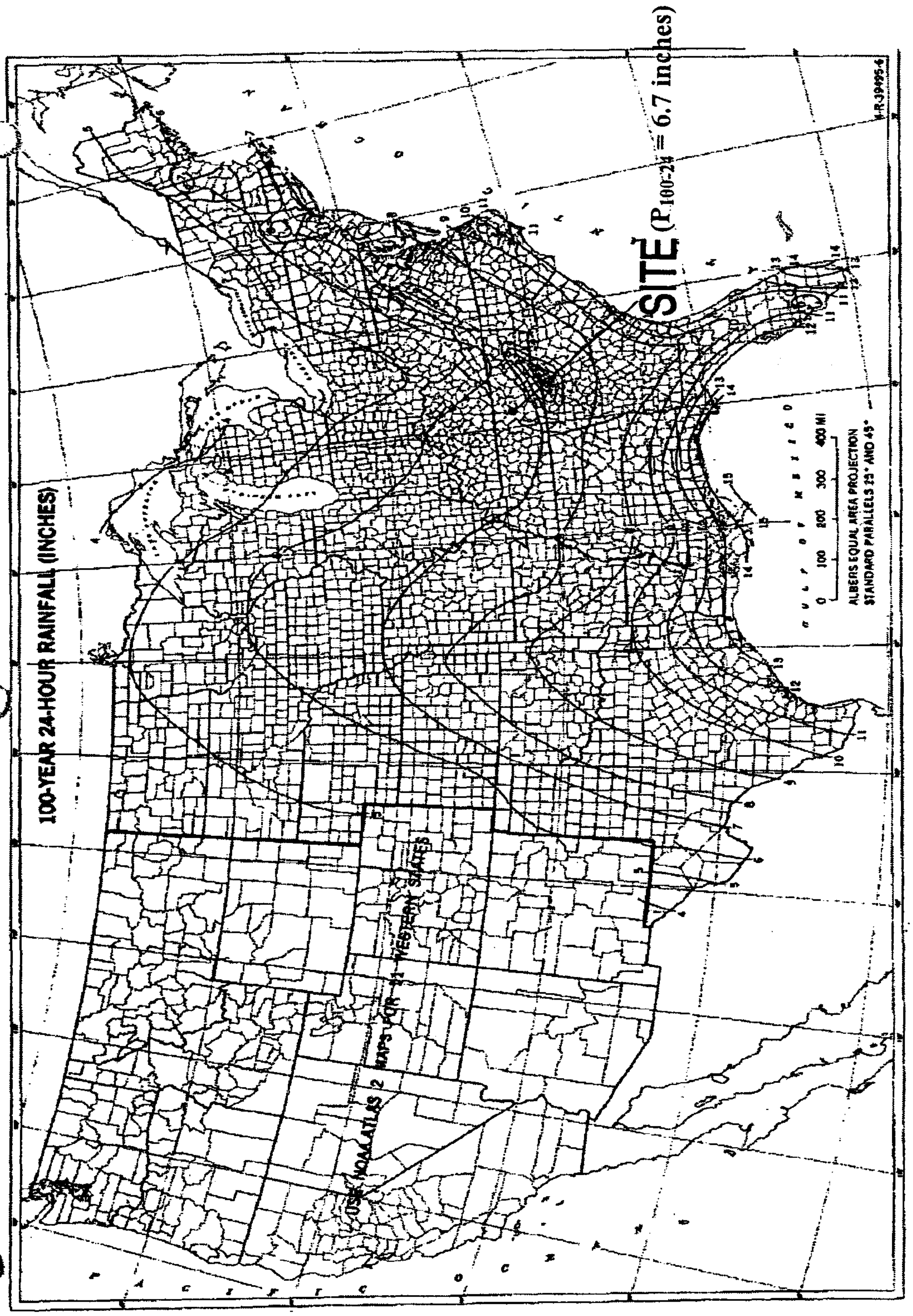
Written by: Sowmya Bulusu / Alexander Maestre Date: 12/07/06 Reviewed by: Ganesh Gopalakrishnan Date: 12/13/06

Client: TVA Project: Kingston Fossil Plant Gypsum Disposal Facility Project/Proposal No.: GR3731 Task No.: 06



Written by: Sowmya Bulusu / Alexander Maestre Date: 12/07/06 Reviewed by: Ganesh Gopalakrishnan Date: 12/13/06

Client: TVA Project: Kingston Fossil Plant Gypsum Disposal Facility Project/Proposal No.: GR3731 Task No.: 06



Attachment 4

Hydrologic Soil Groups

Source: Natural Resources Conservation Service (NRCS) Web Soil Survey [http://websoilsurvey.nrcs.usda.gov/app/]

REGIONAL SOILS MAP FOR THE VICINITY OF THE SITE

NOTES:
1. THE SOIL MAP SHOWN ON THIS DRAWING IS OBTAINED FROM THE REPORT TITLED "SOIL SURVEY, ROANE COUNTY, TENNESSEE", BY USDA BUREAU OF PLANT INDUSTRY, SERIES 1936, NO. 15, ISSUED MAY 1942.
2. THE LIMITS OF DISPOSAL AREA , AND RUN-ON AREAS ARE DELINEATED APPROXIMATELY AND NOT TO SCALE.

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vmya

TVA Kingston Peninsula

SURFACE WATER MANAGEMENT SYSTEM CALCULATIONS

AREAS, AND TIMES OF CONCENTRATION (Tc) CALCULATIONS FOR POST-DEVELOPMENT SUBAREAS

2-year, 24-hr Design Rainfall Depth, P_{2-24} = 3.40 inches

SUBAREA DESIGNATION in HydroCAD		AREA (acres)	CURVE NUMBER	SHEET FLOW				SHALLOW CONCENTRATED FLOW				BENCH FLOW		DOWNDRAIN (PIPE) FLOW		Travel Times (Tt) and Tc Calculation					Peak Discharge (cfs)
No.	Description			Length (ft)	Surf Desc	Manning n	Slope (ft/ft)	Length (ft)	Surf Desc	Slope (ft/ft)	Avg Vel (ft/s)	Length (ft)	Vel (ft/s)	Length (ft)	Vel (ft/s)	Tt (Sheet) (min)	Tt (Sh Con.) (hour)	Tt(Bench) (min)	Tt(Pipe) (min)	Tc (min)	
010	Woods/Grass combination, Poor hydrologic condition	5.32	73	300	GRASS	0.150	0.087	562.27	GRASS	0.153	7.95					12.73	1.179			13.91	
011	Woods/Grass combination, Poor hydrologic condition	4.38	73	300	GRASS	0.150	0.073	187.53	GRASS	0.160	8.13					13.62	0.384			14.00	
012	Woods/Grass combination, Poor hydrologic condition	9.36	73	300	GRASS	0.150	0.033	576.66	GRASS	0.038	3.97					18.67	2.419			21.09	
013	Woods/Grass combination, Poor hydrologic condition	7.00	73	300	GRASS	0.150	0.062	380.69	GRASS	0.247	10.09					14.53	0.629			15.16	
014	Woods/Grass combination, Poor hydrologic condition	11.31	73	300	GRASS	0.150	0.105	396.52	GRASS	0.064	5.16					11.79	1.281			13.07	
015	Woods/Grass combination, Poor hydrologic condition	13.20	73	300	GRASS	0.150	0.093	971.48	GRASS	0.036	3.84					12.36	4.221			16.58	
016	Woods/Grass combination, Poor hydrologic condition	5.38	73	300	GRASS	0.150	0.117	149.26	GRASS	0.198	9.05					11.30	0.275			11.58	
017	Woods/Grass combination, Poor hydrologic condition	5.08	73	300	GRASS	0.150	0.147	80.17	GRASS	0.345	11.94					10.32	0.112			10.43	
018	Woods/Grass combination, Poor hydrologic condition	2.36	73	300	GRASS	0.150	0.227	210.49	GRASS	0.308	11.28					8.67	0.311			8.98	
019	Woods/Grass combination, Poor hydrologic condition	5.59	73	300	GRASS	0.150	0.093	910	GRASS	0.145	2.52					12.38	6.019			18.40	
020	Woods/Grass combination, Poor hydrologic condition	0.96	73	174.73	GRASS	0.150	0.272									5.23				5.23	
021	Woods/Grass combination, Poor hydrologic condition	4.24	73	289.99	GRASS	0.150	0.236									8.30				8.30	
022	Woods/Grass combination, Poor hydrologic condition	3.69	73	152.05	GRASS	0.150	0.335									4.30				4.30	
023	Woods/Grass combination, Poor hydrologic condition	0.81	73	115.2	GRASS	0.150	0.212									4.14				4.14	
024	Woods/Grass combination, Poor hydrologic condition	1.64	73	233.8	GRASS	0.150	0.134									8.75				8.75	
025	Woods/Grass combination, Poor hydrologic condition	1.68	73	256.33	GRASS	0.150	0.187									8.26				8.26	
026	Woods/Grass combination, Poor hydrologic condition	1.23	73	224.21	GRASS	0.150	0.276									6.35				6.35	
027	Woods/Grass combination, Poor hydrologic condition	2.06	73	300	GRASS	0.150	0.235	58.17	GRASS	0.020	2.87					8.54	0.337			8.88	
028	Woods/Grass combination, Poor hydrologic condition	0.39	73	89.2	GRASS	0.150	0.333									2.82				2.82	
029	Woods/Grass combination, Poor hydrologic condition	1.82	73	300	GRASS	0.150	0.103	95.45	GRASS	0.071	5.50					11.90	0.289			12.19	
030	Woods/Grass combination, Poor hydrologic condition	1.25	73	300	GRASS	0.150	0.127	98.79	GRASS	0.020	2.87					10.94	0.573			11.51	
031	Woods/Grass combination, Poor hydrologic condition	0.45	73	89.82	GRASS	0.150	0.328									2.85				2.85	
032	Woods/Grass combination, Poor hydrologic condition	4.84	73	300	GRASS	0.150	0.070	149.03	GRASS	0.153	7.94					13.85	0.313			14.17	
033	Woods/Grass combination, Poor hydrologic condition	1.76	73	118.77	GRASS	0.150	0.336									3.53				3.53	
034	Woods/Grass combination, Poor hydrologic condition	1.64	73	300	GRASS	0.150	0.161	4.1	GRASS	0.161	8.16					9.94	0.008			9.95	
035	Woods/Grass combination, Poor hydrologic condition	0.79	73	300	GRASS	0.150	0.017	40	GRASS	0.017	0.90					24.43	0.741			25.17	
036	Woods/Grass combination, Poor hydrologic condition	0.14	73	40	GRASS	0.150	0.250					90	12.9			1.66		0.10		1.76	
200	Grass, Good hydrologic condition	2.76	80	94.58	GRASS	0.150	0.333					510.61	5	82.39	15	2.95		1.70	0.09	4.74	17.35
201	Grass, Good hydrologic condition	4.49	80	87.44	GRASS	0.150	0.333					221.98	5	464.44	15	2.77		0.74	0.52	4.03	28.99
202	Grass, Good hydrologic condition	10.06	80	8.63	GRASS	0.150	0.040					709.85	5	564.86	15	1.01		2.37	0.63	7.33	58.20
			80	109.55	GRASS	0.150	0.333						5			3.32					
203	Grass, Good hydrologic condition	11.71	80	105.85	GRASS	0.150	0.040					604.95	5	601.21	15	7.54		2.02	0.67	12.60	56.80
			80	72.11	GRASS	0.150	0.333						5			2.37					
204	Grass, Good hydrologic condition	10.36	80	104.41	GRASS	0.150	0.040					52.6	5	626.16	15	7.46		0.18	0.70	10.44	53.75
			80	62.34	GRASS	0.150	0.333						5			2.11					
205	Grass, Good hydrologic condition	5.33	80	37.58	GRASS	0.150	0.040					245.91	5	621.86	15	3.29		0.82	0.69	5.19	32.79
			80	7.43	GRASS	0.150	0.333									0.39					
206	Grass, Good hydrologic condition	4.87	80	83.52	GRASS	0.150	0.333					287.56	5	608.84	15	2.67		0.96	0.68	4.31	31.11
207	Grass, Good hydrologic condition	5.86	80	90.08	GRASS	0.150	0.333					701.63	5	83.51	15	2.84		2.34	0.09	5.27	35.90
208	Grass, Good hydrologic condition	8.33	80	114.29	GRASS	0.150	0.040					257.34	5	600.56	15	8.02		0.86	0.67	9.54	44.70
			80																		
209	Grass, Good hydrologic condition	7.41	80	70.9	GRASS	0.150	0.040					553.26	5	575.4	15	5.47		1.84	0.64	7.95	42.09
210	Grass, Good hydrologic condition	6.50	80	87.26	GRASS	0.150	0.333					570.17	5	437.14	15	2.77		1.90	0.49	5.15	39.99
100	Grass, Good hydrologic condition	1.09	80	60.1	GRASS	0.150	0.3333									2.05				2.05	7.21
101	Grass, Good hydrologic condition	1.46	80	60	GRASS	0.150	0.3333									2.05				2.05	9.54
102	Grass, Good hydrologic condition	1.60	80	60.83	GRASS	0.150	0.3333									2.07				2.07	10.41
103	Grass, Good hydrologic condition	1.52	80	60.02	GRASS	0.150	0.3333									2.05				2.05	9.93
104	Grass, Good hydrologic condition	1.58	80	60.22	GRASS	0.150	0.3333									2.06				2.06	10.28
105	Grass, Good hydrologic condition	1.40	80	62.52	GRASS	0.150	0.3333									2.12				2.12	9.11
106	Grass, Good hydrologic condition	1.61	80	60.66	GRASS	0.150	0.3333									2.07				2.07	10.48
107	Grass, Good hydrologic condition	1.37	80	60.41	GRASS	0.150	0.3333									2.06				2.06	8.92
108	Grass, Good hydrologic condition	1.13	80	60.03	GRASS	0.150	0.3333									2.05				2.05	7.38
109	Grass, Good hydrologic condition	1.07	80	60.03	GRASS	0.150	0.3333									2.05				2.05	6.99
110	Grass, Good hydrologic condition	1.20	80	60.34	GRASS	0.150	0.3333									2.06				2.06	7.81
ROAD1	Road	0.30	98																	1.00	
ROAD2	Road	0.39	98																	1.00	
ROAD3	Road	0.40	98																	1.00	
ROAD4	Road	0.38	98																	1.00	
ROAD5	Road	0.40	98																	1.00	
ROAD6	Road	0.36	98																	1.00	
ROAD7	Road	0.43	98																	1.00	
ROAD8	Road	0.36	98																	1.00	
ROAD9	Road	0.29	98																	1.00	
ROAD10	Road	0.27	98																	1.00	
ROAD11	Road	0.30	98																	1.00	
POND1	Stormwater Pond	6.87	98																	1.00	

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Attachment 8

Computations Using HydroCAD: Post-development

25-year, 24-hour Design Storm

100-year, 24-hour Storm

Time span=0.00-30.00 hrs, dt=0.05 hrs, 601 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 100: Runoff Area=1.090 ac Runoff Depth=3.51"
Tc=2.0 min CN=80 Runoff=7.12 cfs 0.319 af

Subcatchment 101: Runoff Area=1.460 ac Runoff Depth=3.51"
Tc=2.0 min CN=80 Runoff=9.54 cfs 0.427 af

Subcatchment 102: Runoff Area=1.600 ac Runoff Depth=3.51"
Tc=2.1 min CN=80 Runoff=10.41 cfs 0.468 af

Subcatchment 103: Runoff Area=1.520 ac Runoff Depth=3.51"
Tc=2.0 min CN=80 Runoff=9.93 cfs 0.445 af

Subcatchment 104: Runoff Area=1.580 ac Runoff Depth=3.51"
Tc=2.1 min CN=80 Runoff=10.28 cfs 0.462 af

Subcatchment 105: Runoff Area=1.400 ac Runoff Depth=3.51"
Tc=2.1 min CN=80 Runoff=9.11 cfs 0.410 af

Subcatchment 106: Runoff Area=1.610 ac Runoff Depth=3.51"
Tc=2.1 min CN=80 Runoff=10.48 cfs 0.471 af

Subcatchment 107: Runoff Area=1.370 ac Runoff Depth=3.51"
Tc=2.1 min CN=80 Runoff=8.92 cfs 0.401 af

Subcatchment 108: Runoff Area=1.130 ac Runoff Depth=3.51"
Tc=2.0 min CN=80 Runoff=7.38 cfs 0.331 af

Subcatchment 109: Runoff Area=1.070 ac Runoff Depth=3.51"
Tc=2.0 min CN=80 Runoff=6.99 cfs 0.313 af

Subcatchment 110: Runoff Area=1.200 ac Runoff Depth=3.51"
Tc=2.1 min CN=80 Runoff=7.81 cfs 0.351 af

Subcatchment 200: Runoff Area=2.760 ac Runoff Depth=3.51"
Tc=4.7 min CN=80 Runoff=17.35 cfs 0.808 af

Subcatchment 201: Runoff Area=4.490 ac Runoff Depth=3.51"
Tc=4.0 min CN=80 Runoff=28.99 cfs 1.314 af

Subcatchment 202: Runoff Area=10.060 ac Runoff Depth=3.51"
Tc=7.3 min CN=80 Runoff=58.20 cfs 2.944 af

Subcatchment 203: Runoff Area=11.710 ac Runoff Depth=3.51"
Tc=12.6 min CN=80 Runoff=56.80 cfs 3.427 af

Subcatchment 204: Runoff Area=10.360 ac Runoff Depth=3.51"
Tc=10.4 min CN=80 Runoff=53.75 cfs 3.032 af

Subcatchment 205: Runoff Area=5.330 ac Runoff Depth=3.51"
Tc=5.2 min CN=80 Runoff=32.79 cfs 1.560 af

Subcatchment 206: Runoff Area=4.870 ac Runoff Depth=3.51"
Tc=4.3 min CN=80 Runoff=31.11 cfs 1.425 af

Subcatchment 207: Runoff Area=5.860 ac Runoff Depth=3.51"
Tc=5.3 min CN=80 Runoff=35.90 cfs 1.715 af

Subcatchment 208: Runoff Area=8.330 ac Runoff Depth=3.51"
Tc=9.5 min CN=80 Runoff=44.70 cfs 2.438 af

Subcatchment 209: Runoff Area=7.410 ac Runoff Depth=3.51"
Tc=7.9 min CN=80 Runoff=42.09 cfs 2.168 af

Subcatchment 210: Runoff Area=6.500 ac Runoff Depth=3.51"
Tc=5.2 min CN=80 Runoff=39.99 cfs 1.902 af

Subcatchment Pond1: Runoff Area=6.870 ac Runoff Depth=5.46"
Tc=2.0 min CN=98 Runoff=59.07 cfs 3.127 af

Subcatchment Road1: Runoff Area=0.300 ac Runoff Depth=5.46"
Tc=1.0 min CN=98 Runoff=2.70 cfs 0.137 af

Subcatchment Road10: Runoff Area=0.270 ac Runoff Depth=5.46"
Tc=1.0 min CN=98 Runoff=2.43 cfs 0.123 af

Subcatchment Road11: Runoff Area=0.300 ac Runoff Depth=5.46"
Tc=1.0 min CN=98 Runoff=2.70 cfs 0.137 af

Subcatchment Road2: Runoff Area=0.390 ac Runoff Depth=5.46"
Tc=1.0 min CN=98 Runoff=3.51 cfs 0.178 af

Subcatchment Road3: Runoff Area=0.400 ac Runoff Depth=5.46"
Tc=1.0 min CN=98 Runoff=3.60 cfs 0.182 af

Subcatchment Road4: Runoff Area=0.380 ac Runoff Depth=5.46"
Tc=1.0 min CN=98 Runoff=3.42 cfs 0.173 af

Subcatchment Road5: Runoff Area=0.400 ac Runoff Depth=5.46"
Tc=1.0 min CN=98 Runoff=3.60 cfs 0.182 af

Subcatchment Road6: Runoff Area=0.360 ac Runoff Depth=5.46"
Tc=1.0 min CN=98 Runoff=3.24 cfs 0.164 af

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Subcatchment Road7: Runoff Area=0.430 ac Runoff Depth=5.46"
Tc=1.0 min CN=98 Runoff=3.87 cfs 0.196 af

Subcatchment Road8: Runoff Area=0.360 ac Runoff Depth=5.46"
Tc=1.0 min CN=98 Runoff=3.24 cfs 0.164 af

Subcatchment Road9: Runoff Area=0.290 ac Runoff Depth=5.46"
Tc=1.0 min CN=98 Runoff=2.61 cfs 0.132 af

Reach C1: culvert Peak Depth=2.11' Max Vel=16.5 fps Inflow=332.62 cfs 28.896 af
D=48.0" n=0.013 L=54.2' S=0.0199 '/' Capacity=608.30 cfs Outflow=332.41 cfs 28.896 af

Reach R1: Peak Depth=1.57' Max Vel=9.6 fps Inflow=143.35 cfs 9.158 af
n=0.030 L=617.6' S=0.0351 '/' Capacity=536.55 cfs Outflow=139.50 cfs 9.158 af

Reach R10: Peak Depth=1.27' Max Vel=5.0 fps Inflow=57.43 cfs 3.336 af
n=0.030 L=578.9' S=0.0120 '/' Capacity=313.17 cfs Outflow=54.71 cfs 3.336 af

Reach R11: Peak Depth=1.28' Max Vel=8.6 fps Inflow=96.78 cfs 5.993 af
n=0.030 L=655.3' S=0.0348 '/' Capacity=534.29 cfs Outflow=93.72 cfs 5.993 af

Reach R2: Peak Depth=2.62' Max Vel=6.8 fps Inflow=216.31 cfs 19.739 af
n=0.030 L=822.6' S=0.0100 '/' Capacity=285.99 cfs Outflow=213.01 cfs 19.738 af

Reach R3: Peak Depth=2.49' Max Vel=6.4 fps Inflow=200.54 cfs 14.876 af
n=0.030 L=870.4' S=0.0093 '/' Capacity=288.98 cfs Outflow=194.36 cfs 14.876 af

Reach R4: Peak Depth=2.23' Max Vel=6.0 fps Inflow=153.80 cfs 10.799 af
n=0.030 L=828.1' S=0.0095 '/' Capacity=278.89 cfs Outflow=148.17 cfs 10.799 af

Reach R5: Peak Depth=1.71' Max Vel=6.0 fps Inflow=104.36 cfs 7.149 af
n=0.030 L=869.2' S=0.0126 '/' Capacity=321.50 cfs Outflow=100.50 cfs 7.149 af

Reach R6: Peak Depth=1.56' Max Vel=5.2 fps Inflow=79.37 cfs 4.945 af
n=0.030 L=777.2' S=0.0104 '/' Capacity=291.88 cfs Outflow=75.51 cfs 4.945 af

Reach R7: Peak Depth=1.27' Max Vel=4.7 fps Inflow=56.26 cfs 2.947 af
n=0.030 L=908.9' S=0.0103 '/' Capacity=291.30 cfs Outflow=51.19 cfs 2.947 af

Reach R8: Peak Depth=0.53' Max Vel=2.9 fps Inflow=12.05 cfs 0.565 af
n=0.030 L=767.1' S=0.0103 '/' Capacity=290.87 cfs Outflow=10.01 cfs 0.565 af

Reach R9: Peak Depth=0.47' Max Vel=2.8 fps Inflow=9.92 cfs 0.463 af
n=0.030 L=611.2' S=0.0113 '/' Capacity=304.79 cfs Outflow=8.74 cfs 0.463 af

Pond SP: Stormwater Pond Peak Elev=762.77' Storage=32.023 af Inflow=340.48 cfs 32.024 af
Outflow=0.00 cfs 0.000 af

Subcatchment 100:

Runoff = 7.12 cfs @ 11.92 hrs, Volume= 0.319 af, Depth= 3.51"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
1.090	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.0					Direct Entry,

Subcatchment 101:

Runoff = 9.54 cfs @ 11.92 hrs, Volume= 0.427 af, Depth= 3.51"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
1.460	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.0					Direct Entry,

Subcatchment 102:

Runoff = 10.41 cfs @ 11.92 hrs, Volume= 0.468 af, Depth= 3.51"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
1.600	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.1					Direct Entry,

Subcatchment 103:

Runoff = 9.93 cfs @ 11.92 hrs, Volume= 0.445 af, Depth= 3.51"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

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Area (ac)	CN	Description
1.520	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.0					Direct Entry,

Subcatchment 104:

Runoff = 10.28 cfs @ 11.92 hrs, Volume= 0.462 af, Depth= 3.51"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
1.580	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.1					Direct Entry,

Subcatchment 105:

Runoff = 9.11 cfs @ 11.92 hrs, Volume= 0.410 af, Depth= 3.51"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
1.400	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.1					Direct Entry,

Subcatchment 106:

Runoff = 10.48 cfs @ 11.92 hrs, Volume= 0.471 af, Depth= 3.51"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
1.610	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.1					Direct Entry,

Subcatchment 107:

Runoff = 8.92 cfs @ 11.92 hrs, Volume= 0.401 af, Depth= 3.51"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
1.370	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.1					Direct Entry,

Subcatchment 108:

Runoff = 7.38 cfs @ 11.92 hrs, Volume= 0.331 af, Depth= 3.51"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
1.130	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.0					Direct Entry,

Subcatchment 109:

Runoff = 6.99 cfs @ 11.92 hrs, Volume= 0.313 af, Depth= 3.51"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
1.070	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.0					Direct Entry,

Subcatchment 110:

Runoff = 7.81 cfs @ 11.92 hrs, Volume= 0.351 af, Depth= 3.51"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
1.200	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.1					Direct Entry,

Subcatchment 200:

Runoff = 17.35 cfs @ 11.95 hrs, Volume= 0.808 af, Depth= 3.51"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
2.760	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.7					Direct Entry,

Subcatchment 201:

Runoff = 28.99 cfs @ 11.94 hrs, Volume= 1.314 af, Depth= 3.51"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
4.490	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.0					Direct Entry,

Subcatchment 202:

Runoff = 58.20 cfs @ 11.99 hrs, Volume= 2.944 af, Depth= 3.51"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
10.060	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.3					Direct Entry,

Subcatchment 203:

Runoff = 56.80 cfs @ 12.04 hrs, Volume= 3.427 af, Depth= 3.51"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
11.710	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.6					Direct Entry,

Subcatchment 204:

Runoff = 53.75 cfs @ 12.02 hrs, Volume= 3.032 af, Depth= 3.51"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
10.360	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.4					Direct Entry,

Subcatchment 205:

Runoff = 32.79 cfs @ 11.96 hrs, Volume= 1.560 af, Depth= 3.51"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
5.330	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.2					Direct Entry,

Subcatchment 206:

Runoff = 31.11 cfs @ 11.95 hrs, Volume= 1.425 af, Depth= 3.51"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
4.870	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.3					Direct Entry,

Subcatchment 207:

Runoff = 35.90 cfs @ 11.96 hrs, Volume= 1.715 af, Depth= 3.51"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
5.860	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.3					Direct Entry,

Subcatchment 208:

Runoff = 44.70 cfs @ 12.01 hrs, Volume= 2.438 af, Depth= 3.51"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
8.330	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.5					Direct Entry,

Subcatchment 209:

Runoff = 42.09 cfs @ 11.99 hrs, Volume= 2.168 af, Depth= 3.51"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
7.410	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.9					Direct Entry,

Subcatchment 210:

Runoff = 39.99 cfs @ 11.96 hrs, Volume= 1.902 af, Depth= 3.51"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
6.500	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.2					Direct Entry,

Subcatchment Pond1:

Runoff = 59.07 cfs @ 11.91 hrs, Volume= 3.127 af, Depth= 5.46"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
6.870	98	Paved parking & roofs

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.0					Direct Entry,

Subcatchment Road1:

Runoff = 2.70 cfs @ 11.90 hrs, Volume= 0.137 af, Depth= 5.46"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
0.300	98	Paved parking & roofs

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Subcatchment Road10:

Runoff = 2.43 cfs @ 11.90 hrs, Volume= 0.123 af, Depth= 5.46"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
0.270	98	Paved parking & roofs

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Subcatchment Road11:

Runoff = 2.70 cfs @ 11.90 hrs, Volume= 0.137 af, Depth= 5.46"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
0.300	98	Paved parking & roofs

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Subcatchment Road2:

Runoff = 3.51 cfs @ 11.90 hrs, Volume= 0.178 af, Depth= 5.46"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
0.390	98	Paved parking & roofs

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Subcatchment Road3:

Runoff = 3.60 cfs @ 11.90 hrs, Volume= 0.182 af, Depth= 5.46"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
0.400	98	Paved parking & roofs

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Subcatchment Road4:

Runoff = 3.42 cfs @ 11.90 hrs, Volume= 0.173 af, Depth= 5.46"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
0.380	98	Paved parking & roofs

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Subcatchment Road5:

Runoff = 3.60 cfs @ 11.90 hrs, Volume= 0.182 af, Depth= 5.46"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
0.400	98	Paved parking & roofs

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Subcatchment Road6:

Runoff = 3.24 cfs @ 11.90 hrs, Volume= 0.164 af, Depth= 5.46"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
0.360	98	Paved parking & roofs

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Subcatchment Road7:

Runoff = 3.87 cfs @ 11.90 hrs, Volume= 0.196 af, Depth= 5.46"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
0.430	98	Paved parking & roofs

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Subcatchment Road8:

Runoff = 3.24 cfs @ 11.90 hrs, Volume= 0.164 af, Depth= 5.46"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
0.360	98	Paved parking & roofs

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Subcatchment Road9:

Runoff = 2.61 cfs @ 11.90 hrs, Volume= 0.132 af, Depth= 5.46"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=5.70"

Area (ac)	CN	Description
0.290	98	Paved parking & roofs

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Reach C1: culvert

Inflow Area = 96.590 ac, Inflow Depth = 3.59"
Inflow = 332.62 cfs @ 12.06 hrs, Volume= 28.896 af
Outflow = 332.41 cfs @ 12.06 hrs, Volume= 28.896 af, Atten= 0%, Lag= 0.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Max. Velocity= 16.5 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 4.4 fps, Avg. Travel Time= 0.2 min

Peak Depth= 2.11' @ 12.06 hrs
Capacity at bank full= 608.30 cfs
Inlet Invert= 759.39', Outlet Invert= 758.31'
A factor of 3.00 has been applied to the supplied storage and discharge data
48.0" Diameter Pipe, n= 0.013 Concrete pipe, straight & clean
Length= 54.2' Slope= 0.0199 '/'

Reach R1:

Inflow Area = 30.650 ac, Inflow Depth = 3.59"
Inflow = 143.35 cfs @ 11.98 hrs, Volume= 9.158 af
Outflow = 139.50 cfs @ 12.02 hrs, Volume= 9.158 af, Atten= 3%, Lag= 1.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Max. Velocity= 9.6 fps, Min. Travel Time= 1.1 min
Avg. Velocity = 2.2 fps, Avg. Travel Time= 4.7 min

Peak Depth= 1.57' @ 12.00 hrs
Capacity at bank full= 536.55 cfs
Inlet Invert= 786.58', Outlet Invert= 764.91'
5.53' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 3.0 '/' Top Width= 20.53'
Length= 617.6' Slope= 0.0351 '/'

Reach R10:

Inflow Area = 11.090 ac, Inflow Depth = 3.61"
Inflow = 57.43 cfs @ 11.99 hrs, Volume= 3.336 af
Outflow = 54.71 cfs @ 12.05 hrs, Volume= 3.336 af, Atten= 5%, Lag= 3.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.0 fps, Min. Travel Time= 1.9 min
Avg. Velocity = 1.1 fps, Avg. Travel Time= 8.6 min

Peak Depth= 1.27' @ 12.02 hrs
Capacity at bank full= 313.17 cfs
Inlet Invert= 816.31', Outlet Invert= 809.39'
5.53' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 3.0 '/' Top Width= 20.53'
Length= 578.9' Slope= 0.0120 '/'

Reach R11:

Inflow Area = 20.000 ac, Inflow Depth = 3.60"
Inflow = 96.78 cfs @ 12.00 hrs, Volume= 5.993 af
Outflow = 93.72 cfs @ 12.04 hrs, Volume= 5.993 af, Atten= 3%, Lag= 2.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Max. Velocity= 8.6 fps, Min. Travel Time= 1.3 min
Avg. Velocity = 1.9 fps, Avg. Travel Time= 5.6 min

Peak Depth= 1.28' @ 12.02 hrs
Capacity at bank full= 534.29 cfs
Inlet Invert= 809.39', Outlet Invert= 786.59'
5.53' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 3.0 '/' Top Width= 20.53'
Length= 655.3' Slope= 0.0348 '/'

Reach R2:

Inflow Area = 65.940 ac, Inflow Depth = 3.59"
Inflow = 216.31 cfs @ 12.13 hrs, Volume= 19.739 af
Outflow = 213.01 cfs @ 12.16 hrs, Volume= 19.738 af, Atten= 2%, Lag= 2.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Max. Velocity= 6.8 fps, Min. Travel Time= 2.0 min
Avg. Velocity = 1.7 fps, Avg. Travel Time= 7.9 min

Peak Depth= 2.62' @ 12.14 hrs
Capacity at bank full= 285.99 cfs
Inlet Invert= 773.10', Outlet Invert= 764.90'
5.53' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 3.0 '/' Top Width= 20.53'
Length= 822.6' Slope= 0.0100 '/'

Reach R3:

Inflow Area = 49.540 ac, Inflow Depth = 3.60"
Inflow = 200.54 cfs @ 12.08 hrs, Volume= 14.876 af
Outflow = 194.36 cfs @ 12.15 hrs, Volume= 14.876 af, Atten= 3%, Lag= 3.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Max. Velocity= 6.4 fps, Min. Travel Time= 2.3 min
Avg. Velocity = 1.5 fps, Avg. Travel Time= 9.5 min

Peak Depth= 2.49' @ 12.11 hrs
Capacity at bank full= 288.98 cfs
Inlet Invert= 781.20', Outlet Invert= 773.10'
6.00' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 3.0 2.0 '/' Top Width= 21.00'
Length= 870.4' Slope= 0.0093 '/'

Reach R4:

Inflow Area = 35.830 ac, Inflow Depth = 3.62"
Inflow = 153.80 cfs @ 12.04 hrs, Volume= 10.799 af
Outflow = 148.17 cfs @ 12.11 hrs, Volume= 10.799 af, Atten= 4%, Lag= 4.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Max. Velocity= 6.0 fps, Min. Travel Time= 2.3 min
Avg. Velocity = 1.4 fps, Avg. Travel Time= 9.8 min

Peak Depth= 2.23' @ 12.07 hrs
Capacity at bank full= 278.89 cfs
Inlet Invert= 789.05', Outlet Invert= 781.20'
5.53' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 3.0 2.0 '/' Top Width= 20.53'
Length= 828.1' Slope= 0.0095 '/'

Reach R5:

Inflow Area = 23.570 ac, Inflow Depth = 3.64"
Inflow = 104.36 cfs @ 11.99 hrs, Volume= 7.149 af
Outflow = 100.50 cfs @ 12.06 hrs, Volume= 7.149 af, Atten= 4%, Lag= 4.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Max. Velocity= 6.0 fps, Min. Travel Time= 2.4 min
Avg. Velocity = 1.4 fps, Avg. Travel Time= 10.5 min

Peak Depth= 1.71' @ 12.02 hrs
Capacity at bank full= 321.50 cfs
Inlet Invert= 800.00', Outlet Invert= 789.05'
5.53' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 3.0 2.0 '/' Top Width= 20.53'
Length= 869.2' Slope= 0.0126 '/'

Reach R6:

Inflow Area = 16.260 ac, Inflow Depth = 3.65"
Inflow = 79.37 cfs @ 11.97 hrs, Volume= 4.945 af
Outflow = 75.51 cfs @ 12.05 hrs, Volume= 4.945 af, Atten= 5%, Lag= 4.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.2 fps, Min. Travel Time= 2.5 min
Avg. Velocity = 1.2 fps, Avg. Travel Time= 11.3 min

Peak Depth= 1.56' @ 12.01 hrs
Capacity at bank full= 291.88 cfs
Inlet Invert= 805.92', Outlet Invert= 797.85'
5.53' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 3.0 2.0 '/' Top Width= 20.53'
Length= 777.2' Slope= 0.0104 '/'

Reach R7:

Inflow Area = 9.630 ac, Inflow Depth = 3.67"
Inflow = 56.26 cfs @ 11.95 hrs, Volume= 2.947 af
Outflow = 51.19 cfs @ 12.04 hrs, Volume= 2.947 af, Atten= 9%, Lag= 5.4 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.7 fps, Min. Travel Time= 3.3 min
Avg. Velocity = 1.0 fps, Avg. Travel Time= 15.1 min

Peak Depth= 1.27' @ 11.99 hrs
Capacity at bank full= 291.30 cfs
Inlet Invert= 815.32', Outlet Invert= 805.92'
5.53' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 3.0 2.0 '/' Top Width= 20.53'
Length= 908.9' Slope= 0.0103 '/'

Reach R8:

Inflow Area = 1.730 ac, Inflow Depth = 3.92"
Inflow = 12.05 cfs @ 11.91 hrs, Volume= 0.565 af
Outflow = 10.01 cfs @ 12.02 hrs, Volume= 0.565 af, Atten= 17%, Lag= 6.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.9 fps, Min. Travel Time= 4.4 min
Avg. Velocity = 0.6 fps, Avg. Travel Time= 19.8 min

Peak Depth= 0.53' @ 11.95 hrs
Capacity at bank full= 290.87 cfs
Inlet Invert= 823.23', Outlet Invert= 815.32'
5.53' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 3.0 2.0 '/' Top Width= 20.53'
Length= 767.1' Slope= 0.0103 '/'

Reach R9:

Inflow Area = 1.420 ac, Inflow Depth = 3.91"
Inflow = 9.92 cfs @ 11.91 hrs, Volume= 0.463 af
Outflow = 8.74 cfs @ 12.00 hrs, Volume= 0.463 af, Atten= 12%, Lag= 5.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.8 fps, Min. Travel Time= 3.6 min
Avg. Velocity = 0.6 fps, Avg. Travel Time= 16.0 min

Peak Depth= 0.47' @ 11.94 hrs
Capacity at bank full= 304.79 cfs
Inlet Invert= 823.23', Outlet Invert= 816.31'
5.53' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 3.0 '/' Top Width= 20.53'
Length= 611.2' Slope= 0.0113 '/'

Pond SP: Stormwater Pond

Inflow Area = 103.460 ac, Inflow Depth = 3.71"
Inflow = 340.48 cfs @ 12.05 hrs, Volume= 32.024 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Peak Elev= 762.77' @ 30.00 hrs Surf.Area= 5.322 ac Storage= 32.023 af
Plug-Flow detention time= (not calculated: initial storage excedes outflow)
Center-of-Mass det. time= (not calculated: no outflow)

Volume	Invert	Avail.Storage	Storage Description
#1	756.00'	62.383 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
756.00	4.158	0.000	0.000
758.00	4.488	8.646	8.646
760.00	4.829	9.317	17.963
762.00	5.182	10.011	27.974
764.00	5.545	10.727	38.701
766.00	5.920	11.465	50.166
768.00	6.297	12.217	62.383

TVA-00021107

Pond SP: Stormwater Pond

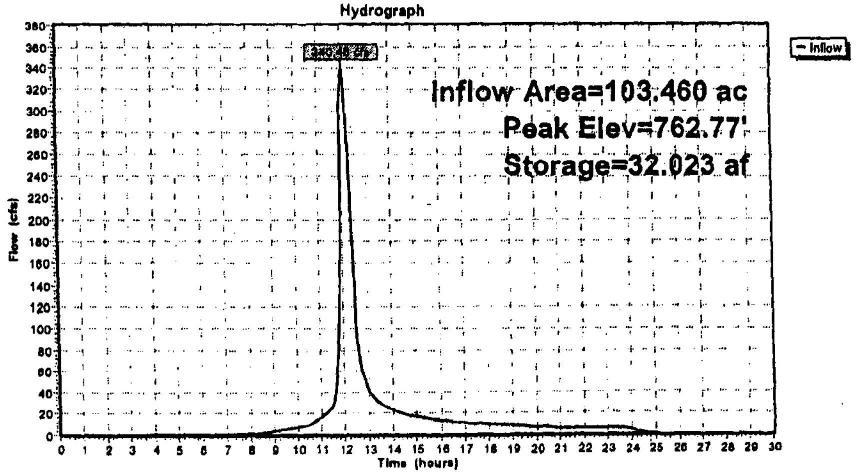
Inflow Area = 103.460 ac, Inflow Depth = 3.71"
Inflow = 340.48 cfs @ 12.05 hrs, Volume= 32.024 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Peak Elev= 762.77' @ 30.00 hrs Surf.Area= 5.322 ac Storage= 32.023 af
Plug-Flow detention time= (not calculated: initial storage excedes outflow)
Center-of-Mass det. time= (not calculated: no outflow)

Volume	Invert	Avail.Storage	Storage Description
#1	756.00'	62.383 af	Custom Stage Data (Prismatic) Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
756.00	4.158	0.000	0.000
758.00	4.488	8.646	8.646
760.00	4.829	9.317	17.963
762.00	5.182	10.011	27.974
764.00	5.545	10.727	38.701
766.00	5.920	11.465	50.166
768.00	6.297	12.217	62.383

Pond SP: Stormwater Pond



TVA-00021108

Time span=5.00-24.00 hrs, dt=0.05 hrs, 381 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 010: Runoff Area=5.320 ac Runoff Depth>2.83"
Tc=13.9 min CN=73 Runoff=20.15 cfs 1.255 af

Subcatchment 011: Runoff Area=4.380 ac Runoff Depth>2.83"
Tc=14.0 min CN=73 Runoff=16.53 cfs 1.034 af

Subcatchment 012: Runoff Area=9.360 ac Runoff Depth>2.83"
Tc=21.1 min CN=73 Runoff=28.47 cfs 2.204 af

Subcatchment 013: Runoff Area=7.000 ac Runoff Depth>2.83"
Tc=15.2 min CN=73 Runoff=25.33 cfs 1.651 af

Subcatchment 014: Runoff Area=11.310 ac Runoff Depth>2.83"
Tc=13.1 min CN=73 Runoff=44.02 cfs 2.670 af

Subcatchment 015: Runoff Area=13.200 ac Runoff Depth>2.83"
Tc=16.6 min CN=73 Runoff=45.85 cfs 3.113 af

Subcatchment 016: Runoff Area=5.380 ac Runoff Depth>2.83"
Tc=11.6 min CN=73 Runoff=21.99 cfs 1.270 af

Subcatchment 017: Runoff Area=5.080 ac Runoff Depth>2.83"
Tc=10.4 min CN=73 Runoff=21.54 cfs 1.200 af

Subcatchment 018: Runoff Area=2.360 ac Runoff Depth>2.84"
Tc=9.0 min CN=73 Runoff=10.57 cfs 0.558 af

Subcatchment 019: Runoff Area=5.590 ac Runoff Depth>2.83"
Flow Length=1,210' Tc=18.4 min CN=73 Runoff=18.39 cfs 1.317 af

Subcatchment 020: Runoff Area=0.960 ac Runoff Depth>2.84"
Tc=5.2 min CN=73 Runoff=4.86 cfs 0.227 af

Subcatchment 021: Runoff Area=4.240 ac Runoff Depth>2.84"
Tc=8.3 min CN=73 Runoff=19.50 cfs 1.002 af

Subcatchment 022: Runoff Area=3.690 ac Runoff Depth>2.84"
Tc=4.3 min CN=73 Runoff=19.45 cfs 0.873 af

Subcatchment 023: Runoff Area=0.810 ac Runoff Depth>2.84"
Tc=4.1 min CN=73 Runoff=4.30 cfs 0.192 af

Subcatchment 024: Runoff Area=1.640 ac Runoff Depth>2.84"
Tc=8.7 min CN=73 Runoff=7.43 cfs 0.388 af

Subcatchment 025: Runoff Area=1.680 ac Runoff Depth>2.84"
Tc=8.3 min CN=73 Runoff=7.73 cfs 0.397 af

Subcatchment 026: Runoff Area=1.230 ac Runoff Depth>2.84"
Tc=6.3 min CN=73 Runoff=6.02 cfs 0.291 af

Subcatchment 027: Runoff Area=2.060 ac Runoff Depth>2.84"
Tc=8.9 min CN=73 Runoff=9.26 cfs 0.487 af

Subcatchment 028: Runoff Area=0.390 ac Runoff Depth>2.84"
Tc=2.8 min CN=73 Runoff=2.14 cfs 0.092 af

Subcatchment 029: Runoff Area=1.820 ac Runoff Depth>2.83"
Tc=12.2 min CN=73 Runoff=7.30 cfs 0.430 af

Subcatchment 030: Runoff Area=1.250 ac Runoff Depth>2.83"
Tc=11.5 min CN=73 Runoff=5.13 cfs 0.295 af

Subcatchment 031: Runoff Area=0.450 ac Runoff Depth>2.84"
Tc=2.8 min CN=73 Runoff=2.47 cfs 0.107 af

Subcatchment 032: Runoff Area=4.840 ac Runoff Depth>2.83"
Tc=14.2 min CN=73 Runoff=18.14 cfs 1.142 af

Subcatchment 033: Runoff Area=1.760 ac Runoff Depth>2.84"
Tc=3.5 min CN=73 Runoff=9.55 cfs 0.417 af

Subcatchment 034: Runoff Area=1.640 ac Runoff Depth>2.83"
Tc=9.9 min CN=73 Runoff=7.09 cfs 0.387 af

Subcatchment 035: Runoff Area=0.790 ac Runoff Depth>2.82"
Flow Length=340' Tc=25.1 min CN=73 Runoff=2.17 cfs 0.186 af

Subcatchment 036: Runoff Area=0.140 ac Runoff Depth>2.84"
Flow Length=130' Tc=1.8 min CN=73 Runoff=0.76 cfs 0.033 af

Subcatchment ROAD12: Runoff Area=0.230 ac Runoff Depth>5.27"
Flow Length=480' Tc=3.1 min CN=98 Runoff=1.99 cfs 0.101 af

Reach C2: culvert Peak Depth=1.11' Max Vel=8.2 fps Inflow=19.59 cfs 1.253 af
D=36.0" n=0.013 L=69.8' S=0.0100 '/' Capacity=66.79 cfs Outflow=19.53 cfs 1.253 af

Reach C3: culvert Peak Depth=1.36' Max Vel=13.8 fps Inflow=43.26 cfs 3.231 af
D=36.0" n=0.013 L=69.8' S=0.0234 '/' Capacity=101.93 cfs Outflow=43.19 cfs 3.230 af

Reach C4: culvert Peak Depth=1.26' Max Vel=8.7 fps Inflow=24.57 cfs 1.647 af
D=36.0" n=0.013 L=63.5' S=0.0099 '/' Capacity=66.44 cfs Outflow=24.49 cfs 1.647 af

Reach C5: culvert Peak Depth=2.24' Max Vel=11.9 fps Inflow=86.59 cfs 5.769 af
D=48.0" n=0.013 L=80.0' S=0.0100 '/' Capacity=143.64 cfs Outflow=86.30 cfs 5.768 af

Reach C6: culvert Peak Depth=1.80' Max Vel=11.2 fps Inflow=123.53 cfs 11.401 af
D=48.0" n=0.013 L=80.4' S=0.0106 '/' Capacity=295.39 cfs Outflow=123.48 cfs 11.399 af

Reach C7: culvert Peak Depth=1.25' Max Vel=14.1 fps Inflow=141.62 cfs 12.990 af
D=48.0" n=0.013 L=160.0' S=0.0241 '/' Capacity=669.33 cfs Outflow=140.82 cfs 12.987 af

Reach C8: culvert Peak Depth=1.23' Max Vel=14.4 fps Inflow=140.77 cfs 13.017 af
D=48.0" n=0.013 L=60.0' S=0.0257 '/' Capacity=690.38 cfs Outflow=140.71 cfs 13.016 af

Reach RN1: Peak Depth=0.54' Max Vel=9.1 fps Inflow=20.15 cfs 1.255 af
n=0.030 L=528.7' S=0.1133 '/' Capacity=259.53 cfs Outflow=19.59 cfs 1.253 af

Reach RN10: Peak Depth=0.88' Max Vel=8.8 fps Inflow=37.64 cfs 2.464 af
n=0.030 L=627.6' S=0.0625 '/' Capacity=192.74 cfs Outflow=36.67 cfs 2.460 af

Reach RN11: Peak Depth=0.91' Max Vel=9.9 fps Inflow=44.06 cfs 3.017 af
n=0.030 L=378.5' S=0.0760 '/' Capacity=212.47 cfs Outflow=43.39 cfs 3.014 af

Reach RN12: Peak Depth=1.89' Max Vel=8.4 fps Inflow=123.48 cfs 11.399 af
n=0.030 L=430.0' S=0.0229 '/' Capacity=1,005.31 cfs Outflow=122.81 cfs 11.386 af

Reach RN13: Peak Depth=1.75' Max Vel=7.1 fps Inflow=93.86 cfs 8.393 af
n=0.030 L=246.6' S=0.0179 '/' Capacity=890.17 cfs Outflow=93.10 cfs 8.386 af

Reach RN14: Peak Depth=1.82' Max Vel=6.7 fps Inflow=95.09 cfs 8.185 af
n=0.030 L=712.3' S=0.0155 '/' Capacity=1,031.01 cfs Outflow=93.22 cfs 8.166 af

Reach RN15: Peak Depth=1.32' Max Vel=8.0 fps Inflow=93.79 cfs 7.209 af
n=0.030 L=1,158.2' S=0.0282 '/' Capacity=451.72 cfs Outflow=90.89 cfs 7.183 af

Reach RN16: Peak Depth=1.72' Max Vel=5.6 fps Inflow=92.65 cfs 6.345 af
n=0.030 L=311.5' S=0.0104 '/' Capacity=274.05 cfs Outflow=90.87 cfs 6.336 af

Reach RN17: Peak Depth=1.05' Max Vel=3.2 fps Inflow=7.43 cfs 0.388 af
n=0.030 L=416.6' S=0.0117 '/' Capacity=117.14 cfs Outflow=6.87 cfs 0.387 af

Reach RN18: Peak Depth=0.54' Max Vel=3.3 fps Inflow=7.73 cfs 0.397 af
n=0.030 L=392.0' S=0.0149 '/' Capacity=735.37 cfs Outflow=7.19 cfs 0.396 af

Reach RN19: Peak Depth=0.50' Max Vel=6.6 fps Inflow=13.30 cfs 0.779 af
n=0.030 L=391.7' S=0.0639 '/' Capacity=2,352.84 cfs Outflow=12.89 cfs 0.778 af

Reach RN2: Peak Depth=0.74' Max Vel=4.9 fps Inflow=16.53 cfs 1.034 af
n=0.030 L=432.3' S=0.0231 '/' Capacity=117.25 cfs Outflow=15.94 cfs 1.031 af

Reach RN20: Peak Depth=2.37' Max Vel=4.7 fps Inflow=86.23 cfs 6.964 af
n=0.030 L=229.0' S=0.0060 '/' Capacity=38,244.53 cfs Outflow=85.46 cfs 6.957 af

Reach RN21: Peak Depth=1.86' Max Vel=8.0 fps Inflow=101.17 cfs 8.516 af
n=0.030 L=872.8' S=0.0231 '/' Capacity=2,841.91 cfs Outflow=99.45 cfs 8.495 af

Reach RN22: Peak Depth=1.08' Max Vel=5.4 fps Inflow=118.74 cfs 10.135 af
n=0.030 L=465.1' S=0.0129 '/' Capacity=704.13 cfs Outflow=117.29 cfs 10.111 af

Reach RN23: Peak Depth=0.89' Max Vel=5.8 fps Inflow=19.53 cfs 1.253 af
n=0.030 L=116.9' S=0.0289 '/' Capacity=271.53 cfs Outflow=19.35 cfs 1.253 af

Reach RN24: Peak Depth=2.03' Max Vel=8.6 fps Inflow=140.82 cfs 12.987 af
n=0.030 L=91.5' S=0.0224 '/' Capacity=995.23 cfs Outflow=140.67 cfs 12.984 af

Reach RN3: Peak Depth=1.26' Max Vel=6.3 fps Inflow=43.91 cfs 3.235 af
n=0.030 L=371.4' S=0.0215 '/' Capacity=113.14 cfs Outflow=43.26 cfs 3.231 af

Reach RN4: Peak Depth=0.69' Max Vel=8.4 fps Inflow=25.33 cfs 1.651 af
n=0.030 L=731.1' S=0.0727 '/' Capacity=207.86 cfs Outflow=24.57 cfs 1.647 af

Reach RN5: Peak Depth=1.55' Max Vel=8.0 fps Inflow=76.24 cfs 5.794 af
n=0.030 L=591.7' S=0.0281 '/' Capacity=312.31 cfs Outflow=74.96 cfs 5.784 af

Reach RN6: Peak Depth=1.11' Max Vel=7.3 fps Inflow=44.02 cfs 2.670 af
n=0.030 L=947.6' S=0.0337 '/' Capacity=141.62 cfs Outflow=41.85 cfs 2.661 af

Reach RN7: Peak Depth=1.12' Max Vel=7.7 fps Inflow=45.85 cfs 3.113 af
n=0.030 L=490.9' S=0.0368 '/' Capacity=147.95 cfs Outflow=44.78 cfs 3.108 af

Reach RN8: downchute Peak Depth=1.37' Max Vel=10.9 fps Inflow=86.30 cfs 5.768 af
n=0.050 L=69.0' S=0.1664 '/' Capacity=188.67 cfs Outflow=85.91 cfs 5.767 af

Reach RN9: Peak Depth=0.92' Max Vel=4.6 fps Inflow=21.99 cfs 1.270 af
n=0.030 L=855.7' S=0.0162 '/' Capacity=98.04 cfs Outflow=20.59 cfs 1.264 af

Total Runoff Area = 98.600 ac Runoff Volume = 23.318 af Average Runoff Depth = 2.84"

Subcatchment 010:

Runoff = 20.15 cfs @ 12.06 hrs, Volume= 1.255 af, Depth> 2.83"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25 Y 24 H Rainfall=5.70"

Area (ac)	CN	Description
5.320	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.9					Direct Entry,

Subcatchment 011:

Runoff = 16.53 cfs @ 12.06 hrs, Volume= 1.034 af, Depth> 2.83"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25 Y 24 H Rainfall=5.70"

Area (ac)	CN	Description
4.380	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.0					Direct Entry,

Subcatchment 012:

Runoff = 28.47 cfs @ 12.14 hrs, Volume= 2.204 af, Depth> 2.83"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25 Y 24 H Rainfall=5.70"

Area (ac)	CN	Description
9.360	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
21.1					Direct Entry,

Subcatchment 013:

Runoff = 25.33 cfs @ 12.08 hrs, Volume= 1.651 af, Depth> 2.83"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25 Y 24 H Rainfall=5.70"

Area (ac)	CN	Description
7.000	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
15.2					Direct Entry,

Subcatchment 014:

Runoff = 44.02 cfs @ 12.05 hrs, Volume= 2.670 af, Depth> 2.83"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25 Y 24 H Rainfall=5.70"

Area (ac)	CN	Description
11.310	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.1					Direct Entry,

Subcatchment 015:

Runoff = 45.85 cfs @ 12.09 hrs, Volume= 3.113 af, Depth> 2.83"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25 Y 24 H Rainfall=5.70"

Area (ac)	CN	Description
13.200	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
16.6					Direct Entry,

Subcatchment 016:

Runoff = 21.99 cfs @ 12.04 hrs, Volume= 1.270 af, Depth> 2.83"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25 Y 24 H Rainfall=5.70"

Area (ac)	CN	Description
5.380	73	Woods/grass comb., Poor, HSG B

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Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.6					Direct Entry,

Subcatchment 017:

Runoff = 21.54 cfs @ 12.02 hrs, Volume= 1.200 af, Depth> 2.83"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25 Y 24 H Rainfall=5.70"

Area (ac)	CN	Description
5.080	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.4					Direct Entry,

Subcatchment 018:

Runoff = 10.57 cfs @ 12.01 hrs, Volume= 0.558 af, Depth> 2.84"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25 Y 24 H Rainfall=5.70"

Area (ac)	CN	Description
2.360	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.0					Direct Entry,

Subcatchment 019:

Runoff = 18.39 cfs @ 12.11 hrs, Volume= 1.317 af, Depth> 2.83"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25 Y 24 H Rainfall=5.70"

Area (ac)	CN	Description
5.590	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.4	300	0.0930	0.4		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.40"
1.4	180	0.0890	2.1		**Shallow Concentrated Flow, Shallow Flow** Short Grass Pasture Kv= 7.0 fps
3.3	590	0.1800	3.0		**Shallow Concentrated Flow, Shallow Flow segment 2** Short Grass Pasture Kv= 7.0 fps
1.3	140	0.0700	1.9		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
18.4	1,210	Total			

Subcatchment 020:

Runoff = 4.86 cfs @ 11.96 hrs, Volume= 0.227 af, Depth> 2.84"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25 Y 24 H Rainfall=5.70"

Area (ac)	CN	Description
0.960	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.2					Direct Entry,

Subcatchment 021:

Runoff = 19.50 cfs @ 12.00 hrs, Volume= 1.002 af, Depth> 2.84"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25 Y 24 H Rainfall=5.70"

Area (ac)	CN	Description
4.240	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.3					Direct Entry,

Subcatchment 022:

Runoff = 19.45 cfs @ 11.95 hrs, Volume= 0.873 af, Depth> 2.84"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25 Y 24 H Rainfall=5.70"

Area (ac)	CN	Description
3.690	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.3					Direct Entry,

Subcatchment 023:

Runoff = 4.30 cfs @ 11.95 hrs, Volume= 0.192 af, Depth> 2.84"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25 Y 24 H Rainfall=5.70"

Area (ac)	CN	Description
0.810	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.1					Direct Entry,

Subcatchment 024:

Runoff = 7.43 cfs @ 12.00 hrs, Volume= 0.388 af, Depth> 2.84"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25 Y 24 H Rainfall=5.70"

Area (ac)	CN	Description
1.640	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.7					Direct Entry,

Subcatchment 025:

Runoff = 7.73 cfs @ 12.00 hrs, Volume= 0.397 af, Depth> 2.84"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25 Y 24 H Rainfall=5.70"

Area (ac)	CN	Description
1.680	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.3					Direct Entry,

Subcatchment 026:

Runoff = 6.02 cfs @ 11.98 hrs, Volume= 0.291 af, Depth> 2.84"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25 Y 24 H Rainfall=5.70"

Area (ac)	CN	Description
1.230	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.3					Direct Entry,

Subcatchment 027:

Runoff = 9.26 cfs @ 12.00 hrs, Volume= 0.487 af, Depth> 2.84"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25 Y 24 H Rainfall=5.70"

Area (ac)	CN	Description
2.060	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.9					Direct Entry,

Subcatchment 028:

Runoff = 2.14 cfs @ 11.93 hrs, Volume= 0.092 af, Depth> 2.84"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25 Y 24 H Rainfall=5.70"

Area (ac)	CN	Description
0.390	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.8					Direct Entry,

Subcatchment 029:

Runoff = 7.30 cfs @ 12.04 hrs, Volume= 0.430 af, Depth> 2.83"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25 Y 24 H Rainfall=5.70"

Area (ac)	CN	Description
1.820	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.2					Direct Entry,

Subcatchment 030:

Runoff = 5.13 cfs @ 12.04 hrs, Volume= 0.295 af, Depth> 2.83"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25 Y 24 H Rainfall=5.70"

Area (ac)	CN	Description
1.250	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.5					Direct Entry,

Subcatchment 031:

Runoff = 2.47 cfs @ 11.93 hrs, Volume= 0.107 af, Depth> 2.84"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25 Y 24 H Rainfall=5.70"

Area (ac)	CN	Description
0.450	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.8					Direct Entry,

Subcatchment 032:

Runoff = 18.14 cfs @ 12.06 hrs, Volume= 1.142 af, Depth> 2.83"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25 Y 24 H Rainfall=5.70"

Area (ac)	CN	Description
4.840	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.2					Direct Entry,

Subcatchment 033:

Runoff = 9.55 cfs @ 11.94 hrs, Volume= 0.417 af, Depth> 2.84"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25 Y 24 H Rainfall=5.70"

Area (ac)	CN	Description
1.760	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.5					Direct Entry,

Subcatchment 034:

Runoff = 7.09 cfs @ 12.02 hrs, Volume= 0.387 af, Depth> 2.83"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25 Y 24 H Rainfall=5.70"

Area (ac)	CN	Description
1.640	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.9					Direct Entry,

Subcatchment 035:

Runoff = 2.17 cfs @ 12.19 hrs, Volume= 0.186 af, Depth> 2.82"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25 Y 24 H Rainfall=5.70"

Area (ac)	CN	Description
0.790	73	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
24.4	300	0.0170	0.2		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.40"
0.7	40	0.0170	0.9		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
25.1	340	Total			

Subcatchment 036:

Runoff = 0.76 cfs @ 11.92 hrs, Volume= 0.033 af, Depth> 2.84"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25 Y 24 H Rainfall=5.70"

Area (ac)	CN	Description
0.140	73	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.7	40	0.2500	0.4		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.40"
0.1	90	0.0440	12.9	905.39	**Channel Flow, channel** Area= 70.0 sf Perim= 50.4' r= 1.39' n= 0.030
1.8	130	Total			

Subcatchment ROAD12:

Runoff = 1.99 cfs @ 11.93 hrs, Volume= 0.101 af, Depth> 5.27"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25 Y 24 H Rainfall=5.70"

Area (ac)	CN	Description
0.230	98	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.2	10	0.0100	0.7		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.40"
2.9	470	0.0170	2.7	0.54	**Channel Flow,** Area= 0.2 sf Perim= 2.6' r= 0.08' n= 0.013
3.1	480	Total			

Reach C2: culvert

Inflow Area = 5.320 ac, Inflow Depth > 2.83" for 25 Y 24 H event
Inflow = 19.59 cfs @ 12.09 hrs, Volume= 1.253 af
Outflow = 19.53 cfs @ 12.09 hrs, Volume= 1.253 af, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 8.2 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 2.8 fps, Avg. Travel Time= 0.4 min

Peak Depth= 1.11' @ 12.09 hrs
Capacity at bank full= 66.79 cfs
Inlet Invert= 768.08', Outlet Invert= 767.38'
36.0" Diameter Pipe, n= 0.013 Concrete pipe, straight & clean
Length= 69.8' Slope= 0.0100 '/'

Reach C3: culvert

Inflow Area = 13.740 ac, Inflow Depth > 2.82" for 25 Y 24 H event
Inflow = 43.26 cfs @ 12.16 hrs, Volume= 3.231 af
Outflow = 43.19 cfs @ 12.16 hrs, Volume= 3.230 af, Atten= 0%, Lag= 0.1 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 13.8 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 5.1 fps, Avg. Travel Time= 0.2 min

Peak Depth= 1.36' @ 12.16 hrs
Capacity at bank full= 101.93 cfs
Inlet Invert= 810.00', Outlet Invert= 808.37'
36.0" Diameter Pipe, n= 0.013 Concrete pipe, straight & clean
Length= 69.8' Slope= 0.0234 '/'

Reach C4: culvert

Inflow Area = 7.000 ac, Inflow Depth > 2.82" for 25 Y 24 H event
Inflow = 24.57 cfs @ 12.12 hrs, Volume= 1.647 af
Outflow = 24.49 cfs @ 12.12 hrs, Volume= 1.647 af, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 8.7 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 3.1 fps, Avg. Travel Time= 0.3 min

Peak Depth= 1.26' @ 12.12 hrs
Capacity at bank full= 66.44 cfs
Inlet Invert= 808.75', Outlet Invert= 808.12'
36.0" Diameter Pipe, n= 0.013 Concrete pipe, straight & clean
Length= 63.5' Slope= 0.0099 '/'

Reach C5: culvert

Inflow Area = 24.510 ac, Inflow Depth > 2.82" for 25 Y 24 H event
Inflow = 86.59 cfs @ 12.12 hrs, Volume= 5.769 af
Outflow = 86.30 cfs @ 12.12 hrs, Volume= 5.768 af, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 11.9 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 4.3 fps, Avg. Travel Time= 0.3 min

Peak Depth= 2.24' @ 12.12 hrs
Capacity at bank full= 143.64 cfs
Inlet Invert= 829.92', Outlet Invert= 829.12'
48.0" Diameter Pipe, n= 0.013 Concrete pipe, straight & clean
Length= 80.0' Slope= 0.0100 '/'

Reach C6: culvert

Inflow Area = 48.670 ac, Inflow Depth > 2.81" for 25 Y 24 H event
Inflow = 123.53 cfs @ 12.17 hrs, Volume= 11.401 af
Outflow = 123.48 cfs @ 12.17 hrs, Volume= 11.399 af, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 11.2 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 4.3 fps, Avg. Travel Time= 0.3 min

Peak Depth= 1.80' @ 12.17 hrs
Capacity at bank full= 295.39 cfs
Inlet Invert= 766.18', Outlet Invert= 765.33'
A factor of 2.00 has been applied to the supplied storage and discharge data
48.0" Diameter Pipe, n= 0.013 Concrete pipe, straight & clean
Length= 80.4' Slope= 0.0106 '/'

Reach C7: culvert

Inflow Area = 55.280 ac, Inflow Depth > 2.82" for 25 Y 24 H event
Inflow = 141.62 cfs @ 12.17 hrs, Volume= 12.990 af
Outflow = 140.82 cfs @ 12.18 hrs, Volume= 12.987 af, Atten= 1%, Lag= 0.5 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 14.1 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 4.7 fps, Avg. Travel Time= 0.6 min

Peak Depth= 1.25' @ 12.18 hrs
Capacity at bank full= 669.33 cfs
Inlet Invert= 755.50', Outlet Invert= 751.64'
A factor of 3.00 has been applied to the supplied storage and discharge data
48.0" Diameter Pipe, n= 0.013 Concrete pipe, straight & clean
Length= 160.0' Slope= 0.0241 '/'

Reach C8: culvert

Inflow Area = 55.420 ac, Inflow Depth > 2.82" for 25 Y 24 H event
Inflow = 140.77 cfs @ 12.19 hrs, Volume= 13.017 af
Outflow = 140.71 cfs @ 12.19 hrs, Volume= 13.016 af, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 14.4 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 4.8 fps, Avg. Travel Time= 0.2 min

Peak Depth= 1.23' @ 12.19 hrs
Capacity at bank full= 690.38 cfs
Inlet Invert= 749.59', Outlet Invert= 748.05'
A factor of 3.00 has been applied to the supplied storage and discharge data
48.0" Diameter Pipe, n= 0.013
Length= 60.0' Slope= 0.0257 '/'

Reach RN1:

Inflow Area = 5.320 ac, Inflow Depth > 2.83" for 25 Y 24 H event
Inflow = 20.15 cfs @ 12.06 hrs, Volume= 1.255 af
Outflow = 19.59 cfs @ 12.09 hrs, Volume= 1.253 af, Atten= 3%, Lag= 1.8 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 9.1 fps, Min. Travel Time= 1.0 min
Avg. Velocity = 2.7 fps, Avg. Travel Time= 3.3 min

Peak Depth= 0.54' @ 12.07 hrs
Capacity at bank full= 259.53 cfs
Inlet Invert= 828.00', Outlet Invert= 768.08'
3.00' x 2.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 11.00'
Length= 528.7' Slope= 0.1133 '/'

Reach RN10:

Inflow Area = 10.460 ac, Inflow Depth > 2.83" for 25 Y 24 H event
Inflow = 37.64 cfs @ 12.06 hrs, Volume= 2.464 af
Outflow = 36.67 cfs @ 12.10 hrs, Volume= 2.460 af, Atten= 3%, Lag= 2.2 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 8.8 fps, Min. Travel Time= 1.2 min
Avg. Velocity = 2.8 fps, Avg. Travel Time= 3.7 min

Peak Depth= 0.88' @ 12.08 hrs
Capacity at bank full= 192.74 cfs
Inlet Invert= 834.16', Outlet Invert= 794.93'
3.00' x 2.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 11.00'
Length= 627.6' Slope= 0.0625 '/'

Reach RN11:

Inflow Area = 12.820 ac, Inflow Depth > 2.82" for 25 Y 24 H event
Inflow = 44.06 cfs @ 12.07 hrs, Volume= 3.017 af
Outflow = 43.39 cfs @ 12.09 hrs, Volume= 3.014 af, Atten= 2%, Lag= 1.3 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 9.9 fps, Min. Travel Time= 0.6 min
Avg. Velocity = 3.2 fps, Avg. Travel Time= 2.0 min

Peak Depth= 0.91' @ 12.08 hrs
Capacity at bank full= 212.47 cfs
Inlet Invert= 794.93', Outlet Invert= 766.18'
3.00' x 2.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 11.00'
Length= 378.5' Slope= 0.0760 '/'

Reach RN12:

Inflow Area = 48.670 ac, Inflow Depth > 2.81" for 25 Y 24 H event
Inflow = 123.48 cfs @ 12.17 hrs, Volume= 11.399 af
Outflow = 122.81 cfs @ 12.20 hrs, Volume= 11.386 af, Atten= 1%, Lag= 2.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 8.4 fps, Min. Travel Time= 0.9 min
Avg. Velocity = 3.2 fps, Avg. Travel Time= 2.3 min

Peak Depth= 1.89' @ 12.18 hrs
Capacity at bank full= 1,005.31 cfs
Inlet Invert= 765.33', Outlet Invert= 755.50'
4.00' x 5.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 24.00'
Length= 430.0' Slope= 0.0229 '/'

Reach RN13:

Inflow Area = 35.850 ac, Inflow Depth > 2.81" for 25 Y 24 H event
Inflow = 93.86 cfs @ 12.25 hrs, Volume= 8.393 af
Outflow = 93.10 cfs @ 12.26 hrs, Volume= 8.386 af, Atten= 1%, Lag= 0.9 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 7.1 fps, Min. Travel Time= 0.6 min
Avg. Velocity = 2.6 fps, Avg. Travel Time= 1.6 min

Peak Depth= 1.75' @ 12.26 hrs
Capacity at bank full= 890.17 cfs
Inlet Invert= 770.60', Outlet Invert= 766.18'
4.00' x 5.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 24.00'
Length= 246.6' Slope= 0.0179 '/'

Reach RN14:

Inflow Area = 34.890 ac, Inflow Depth > 2.82" for 25 Y 24 H event
Inflow = 95.09 cfs @ 12.20 hrs, Volume= 8.185 af
Outflow = 93.22 cfs @ 12.25 hrs, Volume= 8.166 af, Atten= 2%, Lag= 2.8 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 6.7 fps, Min. Travel Time= 1.8 min
Avg. Velocity = 2.5 fps, Avg. Travel Time= 4.8 min

Peak Depth= 1.82' @ 12.23 hrs
Capacity at bank full= 1,031.01 cfs
Inlet Invert= 781.64', Outlet Invert= 770.60'
4.00' x 5.50' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 26.00'
Length= 712.3' Slope= 0.0155 '/'

Reach RN15:

Inflow Area = 30.650 ac, Inflow Depth > 2.82" for 25 Y 24 H event
Inflow = 93.79 cfs @ 12.14 hrs, Volume= 7.209 af
Outflow = 90.89 cfs @ 12.21 hrs, Volume= 7.183 af, Atten= 3%, Lag= 4.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 8.0 fps, Min. Travel Time= 2.4 min
Avg. Velocity = 2.6 fps, Avg. Travel Time= 7.4 min

Peak Depth= 1.32' @ 12.17 hrs
Capacity at bank full= 451.72 cfs
Inlet Invert= 814.27', Outlet Invert= 781.64'
6.00' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 18.00'
Length= 1,158.2' Slope= 0.0282 '/'

Reach RN16:

Inflow Area = 26.960 ac, Inflow Depth > 2.82" for 25 Y 24 H event
Inflow = 92.65 cfs @ 12.12 hrs, Volume= 6.345 af
Outflow = 90.87 cfs @ 12.15 hrs, Volume= 6.336 af, Atten= 2%, Lag= 1.7 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.6 fps, Min. Travel Time= 0.9 min
Avg. Velocity = 1.8 fps, Avg. Travel Time= 2.9 min

Peak Depth= 1.72' @ 12.13 hrs
Capacity at bank full= 274.05 cfs
Inlet Invert= 817.50', Outlet Invert= 814.27'
6.00' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 18.00'
Length= 311.5' Slope= 0.0104 '/'

Reach RN17:

Inflow Area = 1.640 ac, Inflow Depth > 2.84" for 25 Y 24 H event
Inflow = 7.43 cfs @ 12.00 hrs, Volume= 0.388 af
Outflow = 6.87 cfs @ 12.07 hrs, Volume= 0.387 af, Atten= 8%, Lag= 3.8 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.2 fps, Min. Travel Time= 2.2 min
Avg. Velocity = 1.2 fps, Avg. Travel Time= 5.6 min

Peak Depth= 1.05' @ 12.03 hrs
Capacity at bank full= 117.14 cfs
Inlet Invert= 822.36', Outlet Invert= 817.50'
0.00' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 12.00'
Length= 416.6' Slope= 0.0117 '/'

Reach RN18:

Inflow Area = 1.680 ac, Inflow Depth > 2.84" for 25 Y 24 H event
Inflow = 7.73 cfs @ 12.00 hrs, Volume= 0.397 af
Outflow = 7.19 cfs @ 12.05 hrs, Volume= 0.396 af, Atten= 7%, Lag= 3.4 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.3 fps, Min. Travel Time= 2.0 min
Avg. Velocity = 1.0 fps, Avg. Travel Time= 6.6 min

Peak Depth= 0.54' @ 12.02 hrs
Capacity at bank full= 735.37 cfs
Inlet Invert= 822.36', Outlet Invert= 816.53'
3.00' x 5.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 23.00'
Length= 392.0' Slope= 0.0149 '/'

Reach RN19:

Inflow Area = 3.300 ac, Inflow Depth > 2.83" for 25 Y 24 H event
Inflow = 13.30 cfs @ 11.99 hrs, Volume= 0.779 af
Outflow = 12.89 cfs @ 12.02 hrs, Volume= 0.778 af, Atten= 3%, Lag= 1.7 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 6.6 fps, Min. Travel Time= 1.0 min
Avg. Velocity = 2.1 fps, Avg. Travel Time= 3.0 min

Peak Depth= 0.50' @ 12.01 hrs
Capacity at bank full= 2,352.84 cfs
Inlet Invert= 816.53', Outlet Invert= 791.50'
3.00' x 6.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 27.00'
Length= 391.7' Slope= 0.0639 '/'

Reach RN2:

Inflow Area = 4.380 ac, Inflow Depth > 2.83" for 25 Y 24 H event
Inflow = 16.53 cfs @ 12.06 hrs, Volume= 1.034 af
Outflow = 15.94 cfs @ 12.11 hrs, Volume= 1.031 af, Atten= 4%, Lag= 2.6 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.9 fps, Min. Travel Time= 1.5 min
Avg. Velocity = 1.5 fps, Avg. Travel Time= 4.8 min

Peak Depth= 0.74' @ 12.08 hrs
Capacity at bank full= 117.25 cfs
Inlet Invert= 828.00', Outlet Invert= 818.00'
3.00' x 2.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 11.00'
Length= 432.3' Slope= 0.0231 '/'

Reach RN20:

Inflow Area = 29.620 ac, Inflow Depth > 2.82" for 25 Y 24 H event
Inflow = 86.23 cfs @ 12.13 hrs, Volume= 6.964 af
Outflow = 85.46 cfs @ 12.16 hrs, Volume= 6.957 af, Atten= 1%, Lag= 1.5 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.7 fps, Min. Travel Time= 0.8 min
Avg. Velocity = 1.9 fps, Avg. Travel Time= 2.0 min

Peak Depth= 2.37' @ 12.14 hrs
Capacity at bank full= 38,244.53 cfs
Inlet Invert= 791.50', Outlet Invert= 790.12'
3.00' x 29.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 119.00'
Length= 229.0' Slope= 0.0060 '/'

Reach RN21:

Inflow Area = 36.220 ac, Inflow Depth > 2.82" for 25 Y 24 H event
Inflow = 101.17 cfs @ 12.13 hrs, Volume= 8.515 af
Outflow = 99.45 cfs @ 12.19 hrs, Volume= 8.495 af, Atten= 2%, Lag= 3.3 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 8.0 fps, Min. Travel Time= 1.8 min
Avg. Velocity = 3.1 fps, Avg. Travel Time= 4.7 min

Peak Depth= 1.86' @ 12.16 hrs
Capacity at bank full= 2,841.91 cfs
Inlet Invert= 790.12', Outlet Invert= 770.00'
3.00' x 8.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 35.00'
Length= 872.8' Slope= 0.0231 '/'

Reach RN22:

Inflow Area = 43.180 ac, Inflow Depth > 2.82" for 25 Y 24 H event
Inflow = 118.74 cfs @ 12.16 hrs, Volume= 10.135 af
Outflow = 117.29 cfs @ 12.20 hrs, Volume= 10.111 af, Atten= 1%, Lag= 2.5 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.4 fps, Min. Travel Time= 1.4 min
Avg. Velocity = 1.6 fps, Avg. Travel Time= 4.8 min

Peak Depth= 1.08' @ 12.17 hrs
Capacity at bank full= 704.13 cfs
Inlet Invert= 770.00', Outlet Invert= 764.00'
18.00' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 30.00'
Length= 465.1' Slope= 0.0129 '/'

Reach RN23:

Inflow Area = 5.320 ac, Inflow Depth > 2.83" for 25 Y 24 H event
Inflow = 19.53 cfs @ 12.09 hrs, Volume= 1.253 af
Outflow = 19.35 cfs @ 12.10 hrs, Volume= 1.253 af, Atten= 1%, Lag= 0.6 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.8 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 1.9 fps, Avg. Travel Time= 1.0 min

Peak Depth= 0.89' @ 12.10 hrs
Capacity at bank full= 271.53 cfs
Inlet Invert= 767.38', Outlet Invert= 764.00'
2.00' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 14.00'
Length= 116.9' Slope= 0.0289 '/'

Reach RN24:

Inflow Area = 55.280 ac, Inflow Depth > 2.82" for 25 Y 24 H event
Inflow = 140.82 cfs @ 12.18 hrs, Volume= 12.987 af
Outflow = 140.67 cfs @ 12.19 hrs, Volume= 12.984 af, Atten= 0%, Lag= 0.4 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 8.6 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 2.9 fps, Avg. Travel Time= 0.5 min

Peak Depth= 2.03' @ 12.19 hrs
Capacity at bank full= 995.23 cfs
Inlet Invert= 751.64', Outlet Invert= 749.59'
4.00' x 5.00' deep channel, n= 0.030
Side Slope Z-value= 2.0 '/' Top Width= 24.00'
Length= 91.5' Slope= 0.0224 '/'

Reach RN3:

Inflow Area = 13.740 ac, Inflow Depth > 2.83" for 25 Y 24 H event
Inflow = 43.91 cfs @ 12.13 hrs, Volume= 3.235 af
Outflow = 43.26 cfs @ 12.16 hrs, Volume= 3.231 af, Atten= 1%, Lag= 1.8 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 6.3 fps, Min. Travel Time= 1.0 min
Avg. Velocity = 2.2 fps, Avg. Travel Time= 2.8 min

Peak Depth= 1.26' @ 12.14 hrs
Capacity at bank full= 113.14 cfs
Inlet Invert= 818.00', Outlet Invert= 810.00'
3.00' x 2.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 11.00'
Length= 371.4' Slope= 0.0215 '/'

Reach RN4:

Inflow Area = 7.000 ac, Inflow Depth > 2.83" for 25 Y 24 H event
Inflow = 25.33 cfs @ 12.08 hrs, Volume= 1.651 af
Outflow = 24.57 cfs @ 12.12 hrs, Volume= 1.647 af, Atten= 3%, Lag= 2.6 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 8.4 fps, Min. Travel Time= 1.5 min
Avg. Velocity = 2.6 fps, Avg. Travel Time= 4.8 min

Peak Depth= 0.69' @ 12.09 hrs
Capacity at bank full= 207.86 cfs
Inlet Invert= 861.90', Outlet Invert= 808.75'
3.00' x 2.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 11.00'
Length= 731.1' Slope= 0.0727 '/'

Reach RN5:

Inflow Area = 24.620 ac, Inflow Depth > 2.82" for 25 Y 24 H event
Inflow = 76.24 cfs @ 12.12 hrs, Volume= 5.794 af
Outflow = 74.96 cfs @ 12.16 hrs, Volume= 5.784 af, Atten= 2%, Lag= 2.2 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 8.0 fps, Min. Travel Time= 1.2 min
Avg. Velocity = 2.9 fps, Avg. Travel Time= 3.4 min

Peak Depth= 1.55' @ 12.14 hrs
Capacity at bank full= 312.31 cfs
Inlet Invert= 808.12', Outlet Invert= 791.50'
3.00' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 15.00'
Length= 591.7' Slope= 0.0281 '/'

Reach RN6:

Inflow Area = 11.310 ac, Inflow Depth > 2.83" for 25 Y 24 H event
Inflow = 44.02 cfs @ 12.05 hrs, Volume= 2.670 af
Outflow = 41.85 cfs @ 12.12 hrs, Volume= 2.661 af, Atten= 5%, Lag= 3.8 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 7.3 fps, Min. Travel Time= 2.2 min
Avg. Velocity = 2.4 fps, Avg. Travel Time= 6.7 min

Peak Depth= 1.11' @ 12.08 hrs
Capacity at bank full= 141.62 cfs
Inlet Invert= 861.90', Outlet Invert= 829.92'
3.00' x 2.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 11.00'
Length= 947.6' Slope= 0.0337 '/'

Reach RN7:

Inflow Area = 13.200 ac, Inflow Depth > 2.83" for 25 Y 24 H event
Inflow = 45.85 cfs @ 12.09 hrs, Volume= 3.113 af
Outflow = 44.78 cfs @ 12.12 hrs, Volume= 3.108 af, Atten= 2%, Lag= 1.8 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 7.7 fps, Min. Travel Time= 1.1 min
Avg. Velocity = 2.6 fps, Avg. Travel Time= 3.2 min

Peak Depth= 1.12' @ 12.11 hrs
Capacity at bank full= 147.95 cfs
Inlet Invert= 848.00', Outlet Invert= 829.92'
3.00' x 2.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 11.00'
Length= 490.9' Slope= 0.0368 '/'

Reach RN8: downchute

Inflow Area = 24.510 ac, Inflow Depth > 2.82" for 25 Y 24 H event
Inflow = 86.30 cfs @ 12.12 hrs, Volume= 5.768 af
Outflow = 85.91 cfs @ 12.13 hrs, Volume= 5.767 af, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 10.9 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 3.7 fps, Avg. Travel Time= 0.3 min

Peak Depth= 1.37' @ 12.12 hrs
Capacity at bank full= 188.67 cfs
Inlet Invert= 829.12', Outlet Invert= 817.64'
3.00' x 2.00' deep channel, n= 0.050 Earth, cobble bottom, clean sides
Side Slope Z-value= 2.0 '/' Top Width= 11.00'
Length= 69.0' Slope= 0.1664 '/'

Reach RN9:

Inflow Area = 5.380 ac, Inflow Depth > 2.83" for 25 Y 24 H event
Inflow = 21.99 cfs @ 12.04 hrs, Volume= 1.270 af
Outflow = 20.59 cfs @ 12.12 hrs, Volume= 1.264 af, Atten= 6%, Lag= 5.2 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.6 fps, Min. Travel Time= 3.1 min
Avg. Velocity = 1.4 fps, Avg. Travel Time= 10.0 min

Peak Depth= 0.92' @ 12.07 hrs
Capacity at bank full= 98.04 cfs
Inlet Invert= 848.00', Outlet Invert= 834.16'
3.00' x 2.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 11.00'
Length= 855.7' Slope= 0.0162 '/'

100-year, 24-hour Storm

Subcatchment Road7: Runoff Area=0.430 ac Runoff Depth=6.46"
Tc=1.0 min CN=98 Runoff=4.55 cfs 0.232 af

Subcatchment Road8: Runoff Area=0.360 ac Runoff Depth=6.46"
Tc=1.0 min CN=98 Runoff=3.81 cfs 0.194 af

Subcatchment Road9: Runoff Area=0.290 ac Runoff Depth=6.46"
Tc=1.0 min CN=98 Runoff=3.07 cfs 0.156 af

Reach C1: culvert Peak Depth=2.47' Max Vel=17.5 fps Inflow=427.95 cfs 36.224 af
D=48.0" n=0.013 L=54.2' S=0.0199 '/' Capacity=608.30 cfs Outflow=427.71 cfs 36.224 af

Reach R1: Peak Depth=1.77' Max Vel=10.3 fps Inflow=181.03 cfs 11.483 af
n=0.030 L=617.6' S=0.0351 '/' Capacity=536.55 cfs Outflow=176.47 cfs 11.483 af

Reach R10: Peak Depth=1.43' Max Vel=5.4 fps Inflow=71.73 cfs 4.179 af
n=0.030 L=578.9' S=0.0120 '/' Capacity=313.17 cfs Outflow=68.39 cfs 4.179 af

Reach R11: Peak Depth=1.44' Max Vel=9.1 fps Inflow=121.67 cfs 7.510 af
n=0.030 L=655.3' S=0.0348 '/' Capacity=534.29 cfs Outflow=117.85 cfs 7.510 af

Reach R2: Peak Depth=2.95' Max Vel=7.2 fps Inflow=276.89 cfs 24.742 af
n=0.030 L=822.6' S=0.0100 '/' Capacity=285.99 cfs Outflow=275.23 cfs 24.742 af

Reach R3: Peak Depth=2.81' Max Vel=6.9 fps Inflow=255.40 cfs 18.637 af
n=0.030 L=870.4' S=0.0093 '/' Capacity=288.98 cfs Outflow=247.61 cfs 18.637 af

Reach R4: Peak Depth=2.51' Max Vel=6.5 fps Inflow=195.62 cfs 13.521 af
n=0.030 L=828.1' S=0.0095 '/' Capacity=278.89 cfs Outflow=188.61 cfs 13.521 af

Reach R5: Peak Depth=1.94' Max Vel=6.5 fps Inflow=133.14 cfs 8.942 af
n=0.030 L=869.2' S=0.0126 '/' Capacity=321.50 cfs Outflow=128.19 cfs 8.942 af

Reach R6: Peak Depth=1.76' Max Vel=5.6 fps Inflow=100.79 cfs 6.183 af
n=0.030 L=777.2' S=0.0104 '/' Capacity=291.88 cfs Outflow=95.84 cfs 6.183 af

Reach R7: Peak Depth=1.43' Max Vel=5.0 fps Inflow=70.29 cfs 3.660 af
n=0.030 L=908.9' S=0.0103 '/' Capacity=291.30 cfs Outflow=64.63 cfs 3.660 af

Reach R8: Peak Depth=0.60' Max Vel=3.1 fps Inflow=14.79 cfs 0.698 af
n=0.030 L=767.1' S=0.0103 '/' Capacity=290.87 cfs Outflow=12.53 cfs 0.698 af

Reach R9: Peak Depth=0.54' Max Vel=3.0 fps Inflow=12.18 cfs 0.572 af
n=0.030 L=611.2' S=0.0113 '/' Capacity=304.79 cfs Outflow=10.96 cfs 0.572 af

Pond SP: Stormwater Pond Peak Elev=764.21' Storage=39.882 af Inflow=438.14 cfs 39.923 af
24.0" x 100.0' Culvert Outflow=0.14 cfs 0.071 af

Subcatchment 100:

Runoff = 8.86 cfs @ 11.92 hrs, Volume= 0.401 af, Depth= 4.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
1.090	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.0					Direct Entry,

Subcatchment 101:

Runoff = 11.86 cfs @ 11.92 hrs, Volume= 0.538 af, Depth= 4.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
1.460	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.0					Direct Entry,

Subcatchment 102:

Runoff = 12.95 cfs @ 11.92 hrs, Volume= 0.589 af, Depth= 4.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
1.600	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.1					Direct Entry,

Subcatchment 103:

Runoff = 12.35 cfs @ 11.92 hrs, Volume= 0.560 af, Depth= 4.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
1.520	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.0					Direct Entry,

Subcatchment 104:

Runoff = 12.79 cfs @ 11.92 hrs, Volume= 0.582 af, Depth= 4.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
1.580	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.1					Direct Entry,

Subcatchment 105:

Runoff = 11.33 cfs @ 11.92 hrs, Volume= 0.515 af, Depth= 4.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
1.400	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.1					Direct Entry,

Subcatchment 106:

Runoff = 13.03 cfs @ 11.92 hrs, Volume= 0.593 af, Depth= 4.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
1.610	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.1					Direct Entry,

Subcatchment 107:

Runoff = 11.09 cfs @ 11.92 hrs, Volume= 0.504 af, Depth= 4.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
1.370	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.1					Direct Entry,

Subcatchment 108:

Runoff = 9.18 cfs @ 11.92 hrs, Volume= 0.416 af, Depth= 4.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
1.130	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.0					Direct Entry,

Subcatchment 109:

Runoff = 8.69 cfs @ 11.92 hrs, Volume= 0.394 af, Depth= 4.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
1.070	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.0					Direct Entry,

Subcatchment 110:

Runoff = 9.71 cfs @ 11.92 hrs, Volume= 0.442 af, Depth= 4.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
1.200	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.1					Direct Entry,

Subcatchment 200:

Runoff = 21.60 cfs @ 11.95 hrs, Volume= 1.016 af, Depth= 4.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
2.760	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.7					Direct Entry,

Subcatchment 201:

Runoff = 36.06 cfs @ 11.94 hrs, Volume= 1.653 af, Depth= 4.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
4.490	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.0					Direct Entry,

Subcatchment 202:

Runoff = 72.49 cfs @ 11.98 hrs, Volume= 3.704 af, Depth= 4.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
10.060	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.3					Direct Entry,

Subcatchment 203:

Runoff = 70.94 cfs @ 12.04 hrs, Volume= 4.312 af, Depth= 4.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
11.710	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.6					Direct Entry,

Subcatchment 204:

Runoff = 67.09 cfs @ 12.02 hrs, Volume= 3.815 af, Depth= 4.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
10.360	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.4					Direct Entry,

Subcatchment 205:

Runoff = 40.84 cfs @ 11.96 hrs, Volume= 1.963 af, Depth= 4.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
5.330	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.2					Direct Entry,

Subcatchment 206:

Runoff = 38.70 cfs @ 11.95 hrs, Volume= 1.793 af, Depth= 4.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
4.870	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.3					Direct Entry,

Subcatchment 207:

Runoff = 44.71 cfs @ 11.96 hrs, Volume= 2.158 af, Depth= 4.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
5.860	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.3					Direct Entry,

Subcatchment 208:

Runoff = 55.77 cfs @ 12.01 hrs, Volume= 3.067 af, Depth= 4.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
8.330	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.5					Direct Entry,

Subcatchment 209:

Runoff = 52.45 cfs @ 11.99 hrs, Volume= 2.728 af, Depth= 4.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
7.410	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.9					Direct Entry,

Subcatchment 210:

Runoff = 49.80 cfs @ 11.96 hrs, Volume= 2.393 af, Depth= 4.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
6.500	80	>75% Grass cover, Good, HSG D

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.2					Direct Entry,

Subcatchment Pond1:

Runoff = 69.51 cfs @ 11.91 hrs, Volume= 3.699 af, Depth= 6.46"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
6.870	98	Paved parking & roofs

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.0					Direct Entry,

Subcatchment Road1:

Runoff = 3.18 cfs @ 11.90 hrs, Volume= 0.162 af, Depth= 6.46"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
0.300	98	Paved parking & roofs

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Subcatchment Road10:

Runoff = 2.86 cfs @ 11.90 hrs, Volume= 0.145 af, Depth= 6.46"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
0.270	98	Paved parking & roofs

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Subcatchment Road11:

Runoff = 3.18 cfs @ 11.90 hrs, Volume= 0.162 af, Depth= 6.46"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
0.300	98	Paved parking & roofs

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Subcatchment Road2:

Runoff = 4.13 cfs @ 11.90 hrs, Volume= 0.210 af, Depth= 6.46"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
0.390	98	Paved parking & roofs

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Subcatchment Road3:

Runoff = 4.23 cfs @ 11.90 hrs, Volume= 0.215 af, Depth= 6.46"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
0.400	98	Paved parking & roofs

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Subcatchment Road4:

Runoff = 4.02 cfs @ 11.90 hrs, Volume= 0.205 af, Depth= 6.46"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
0.380	98	Paved parking & roofs

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Subcatchment Road5:

Runoff = 4.23 cfs @ 11.90 hrs, Volume= 0.215 af, Depth= 6.46"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
0.400	98	Paved parking & roofs

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Subcatchment Road6:

Runoff = 3.81 cfs @ 11.90 hrs, Volume= 0.194 af, Depth= 6.46"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
0.360	98	Paved parking & roofs

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Subcatchment Road7:

Runoff = 4.55 cfs @ 11.90 hrs, Volume= 0.232 af, Depth= 6.46"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
0.430	98	Paved parking & roofs

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Subcatchment Road8:

Runoff = 3.81 cfs @ 11.90 hrs, Volume= 0.194 af, Depth= 6.46"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
0.360	98	Paved parking & roofs

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Subcatchment Road9:

Runoff = 3.07 cfs @ 11.90 hrs, Volume= 0.156 af, Depth= 6.46"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=6.70"

Area (ac)	CN	Description
0.290	98	Paved parking & roofs

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Reach C1: culvert

Inflow Area = 96.590 ac, Inflow Depth = 4.50"
Inflow = 427.95 cfs @ 12.06 hrs, Volume= 36.224 af
Outflow = 427.71 cfs @ 12.06 hrs, Volume= 36.224 af, Atten= 0%, Lag= 0.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Max. Velocity= 17.5 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 4.7 fps, Avg. Travel Time= 0.2 min

Peak Depth= 2.47' @ 12.06 hrs
Capacity at bank full= 608.30 cfs
Inlet Invert= 759.39', Outlet Invert= 758.31'
A factor of 3.00 has been applied to the supplied storage and discharge data
48.0" Diameter Pipe, n= 0.013 Concrete pipe, straight & clean
Length= 54.2' Slope= 0.0199 '/'

Reach R1:

Inflow Area = 30.650 ac, Inflow Depth = 4.50"
Inflow = 181.03 cfs @ 11.98 hrs, Volume= 11.483 af
Outflow = 176.47 cfs @ 12.01 hrs, Volume= 11.483 af, Atten= 3%, Lag= 1.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Max. Velocity= 10.3 fps, Min. Travel Time= 1.0 min
Avg. Velocity = 2.4 fps, Avg. Travel Time= 4.3 min

Peak Depth= 1.77' @ 12.00 hrs
Capacity at bank full= 536.55 cfs
Inlet Invert= 786.58', Outlet Invert= 764.91'
5.53' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 3.0 '/' Top Width= 20.53'
Length= 617.6' Slope= 0.0351 '/'

Reach R10:

Inflow Area = 11.090 ac, Inflow Depth = 4.52"
Inflow = 71.73 cfs @ 11.99 hrs, Volume= 4.179 af
Outflow = 68.39 cfs @ 12.04 hrs, Volume= 4.179 af, Atten= 5%, Lag= 3.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.4 fps, Min. Travel Time= 1.8 min
Avg. Velocity = 1.2 fps, Avg. Travel Time= 8.0 min

Peak Depth= 1.43' @ 12.01 hrs
Capacity at bank full= 313.17 cfs
Inlet Invert= 816.31', Outlet Invert= 809.39'
5.53' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 3.0 '/' Top Width= 20.53'
Length= 578.9' Slope= 0.0120 '/'

Reach R11:

Inflow Area = 20.000 ac, Inflow Depth = 4.51"
Inflow = 121.67 cfs @ 12.00 hrs, Volume= 7.510 af
Outflow = 117.85 cfs @ 12.04 hrs, Volume= 7.510 af, Atten= 3%, Lag= 2.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Max. Velocity= 9.1 fps, Min. Travel Time= 1.2 min
Avg. Velocity = 2.1 fps, Avg. Travel Time= 5.2 min

Peak Depth= 1.44' @ 12.02 hrs
Capacity at bank full= 534.29 cfs
Inlet Invert= 809.39', Outlet Invert= 786.59'
5.53' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 3.0 '/' Top Width= 20.53'
Length= 655.3' Slope= 0.0348 '/'

Reach R2:

Inflow Area = 65.940 ac, Inflow Depth = 4.50"
Inflow = 276.89 cfs @ 12.09 hrs, Volume= 24.742 af
Outflow = 275.23 cfs @ 12.14 hrs, Volume= 24.742 af, Atten= 1%, Lag= 2.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Max. Velocity= 7.2 fps, Min. Travel Time= 1.9 min
Avg. Velocity = 1.9 fps, Avg. Travel Time= 7.3 min

Peak Depth= 2.95' @ 12.11 hrs
Capacity at bank full= 285.99 cfs
Inlet Invert= 773.10', Outlet Invert= 764.90'
5.53' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 3.0 '/' Top Width= 20.53'
Length= 822.6' Slope= 0.0100 '/'

Reach R3:

Inflow Area = 49.540 ac, Inflow Depth = 4.51"
Inflow = 255.40 cfs @ 12.08 hrs, Volume= 18.637 af
Outflow = 247.61 cfs @ 12.14 hrs, Volume= 18.637 af, Atten= 3%, Lag= 3.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Max. Velocity= 6.9 fps, Min. Travel Time= 2.1 min
Avg. Velocity = 1.6 fps, Avg. Travel Time= 8.8 min

Peak Depth= 2.81' @ 12.10 hrs
Capacity at bank full= 288.98 cfs
Inlet Invert= 781.20', Outlet Invert= 773.10'
6.00' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 3.0 2.0 '/' Top Width= 21.00'
Length= 870.4' Slope= 0.0093 '/'

Reach R4:

Inflow Area = 35.830 ac, Inflow Depth = 4.53"
Inflow = 195.62 cfs @ 12.04 hrs, Volume= 13.521 af
Outflow = 188.61 cfs @ 12.10 hrs, Volume= 13.521 af, Atten= 4%, Lag= 3.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Max. Velocity= 6.5 fps, Min. Travel Time= 2.1 min
Avg. Velocity = 1.5 fps, Avg. Travel Time= 9.0 min

Peak Depth= 2.51' @ 12.06 hrs
Capacity at bank full= 278.89 cfs
Inlet Invert= 789.05', Outlet Invert= 781.20'
5.53' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 3.0 2.0 '/' Top Width= 20.53'
Length= 828.1' Slope= 0.0095 '/'

Reach R5:

Inflow Area = 23.570 ac, Inflow Depth = 4.55"
Inflow = 133.14 cfs @ 11.99 hrs, Volume= 8.942 af
Outflow = 128.19 cfs @ 12.06 hrs, Volume= 8.942 af, Atten= 4%, Lag= 4.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Max. Velocity= 6.5 fps, Min. Travel Time= 2.2 min
Avg. Velocity = 1.5 fps, Avg. Travel Time= 9.8 min

Peak Depth= 1.94' @ 12.02 hrs
Capacity at bank full= 321.50 cfs
Inlet Invert= 800.00', Outlet Invert= 789.05'
5.53' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 3.0 2.0 '/' Top Width= 20.53'
Length= 869.2' Slope= 0.0126 '/'

Reach R6:

Inflow Area = 16.260 ac, Inflow Depth = 4.56"
Inflow = 100.79 cfs @ 11.97 hrs, Volume= 6.183 af
Outflow = 95.84 cfs @ 12.04 hrs, Volume= 6.183 af, Atten= 5%, Lag= 4.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.6 fps, Min. Travel Time= 2.3 min
Avg. Velocity = 1.2 fps, Avg. Travel Time= 10.5 min

Peak Depth= 1.76' @ 12.00 hrs
Capacity at bank full= 291.88 cfs
Inlet Invert= 805.92', Outlet Invert= 797.85'
5.53' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 3.0 2.0 '/' Top Width= 20.53'
Length= 777.2' Slope= 0.0104 '/'

Reach R7:

Inflow Area = 9.630 ac, Inflow Depth = 4.59"
Inflow = 70.29 cfs @ 11.95 hrs, Volume= 3.680 af
Outflow = 64.83 cfs @ 12.04 hrs, Volume= 3.680 af, Atten= 8%, Lag= 5.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.0 fps, Min. Travel Time= 3.1 min
Avg. Velocity = 1.1 fps, Avg. Travel Time= 14.1 min

Peak Depth= 1.43' @ 11.98 hrs
Capacity at bank full= 291.30 cfs
Inlet Invert= 815.32', Outlet Invert= 805.92'
5.53' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 3.0 2.0 '/' Top Width= 20.53'
Length= 908.9' Slope= 0.0103 '/'

Reach R8:

Inflow Area = 1.730 ac, Inflow Depth = 4.84"
Inflow = 14.79 cfs @ 11.91 hrs, Volume= 0.698 af
Outflow = 12.53 cfs @ 12.01 hrs, Volume= 0.698 af, Atten= 15%, Lag= 6.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.1 fps, Min. Travel Time= 4.1 min
Avg. Velocity = 0.7 fps, Avg. Travel Time= 18.7 min

Peak Depth= 0.60' @ 11.95 hrs
Capacity at bank full= 290.87 cfs
Inlet Invert= 823.23', Outlet Invert= 815.32'
5.53' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 3.0 2.0 '/' Top Width= 20.53'
Length= 767.1' Slope= 0.0103 '/'

Reach R9:

Inflow Area = 1.420 ac, Inflow Depth = 4.84"
Inflow = 12.18 cfs @ 11.91 hrs, Volume= 0.572 af
Outflow = 10.96 cfs @ 12.00 hrs, Volume= 0.572 af, Atten= 10%, Lag= 5.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.0 fps, Min. Travel Time= 3.4 min
Avg. Velocity = 0.7 fps, Avg. Travel Time= 15.1 min

Peak Depth= 0.54' @ 11.94 hrs
Capacity at bank full= 304.79 cfs
Inlet Invert= 823.23', Outlet Invert= 816.31'
5.53' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 3.0 '/' Top Width= 20.53'
Length= 611.2' Slope= 0.0113 '/'

Pond SP: Stormwater Pond

Inflow Area = 103.460 ac, Inflow Depth = 4.63"
Inflow = 438.14 cfs @ 12.04 hrs, Volume= 39.923 af
Outflow = 0.14 cfs @ 26.12 hrs, Volume= 0.071 af, Atten= 100%, Lag= 845.0 min
Primary = 0.14 cfs @ 26.12 hrs, Volume= 0.071 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Peak Elev= 764.21' @ 26.12 hrs Surf.Area= 5.585 ac Storage= 39.882 af
Plug-Flow detention time= 1,476.5 min calculated for 0.071 af (0% of inflow)
Center-of-Mass det. time= 803.0 min (1,615.1 - 812.1)

Volume	Invert	Avail.Storage	Storage Description
#1	756.00'	62.383 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
756.00	4.158	0.000	0.000
758.00	4.488	8.646	8.646
760.00	4.829	9.317	17.963
762.00	5.182	10.011	27.974
764.00	5.545	10.727	38.701
766.00	5.920	11.465	50.166
768.00	6.297	12.217	62.383

Device	Routing	Invert	Outlet Devices
#1	Primary	764.00'	**24.0" x 100.0' long Culvert X 2.00** RCP, sq.cut end projecting, Ke= 0.500 Outlet Invert= 764.00' S= 0.0000 '/' Cc= 0.900 n= 0.013 Concrete pipe, straight & clean

Primary OutFlow Max=0.13 cfs @ 26.12 hrs HW=764.21' (Free Discharge)
↑—1=Culvert (Barrel Controls 0.13 cfs @ 0.5 fps)

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Pond SP: Stormwater Pond

Inflow Area = 103.460 ac, Inflow Depth = 4.63"
Inflow = 438.14 cfs @ 12.04 hrs, Volume= 39.923 af
Outflow = 0.14 cfs @ 26.12 hrs, Volume= 0.071 af, Atten= 100%, Lag= 845.0 min
Primary = 0.14 cfs @ 26.12 hrs, Volume= 0.071 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Peak Elev= 764.21' @ 26.12 hrs Surf.Area= 5.585 ac Storage= 39.882 af
Plug-Flow detention time= 1,476.5 min calculated for 0.071 af (0% of inflow)
Center-of-Mass det. time= 803.0 min (1,615.1 - 812.1)

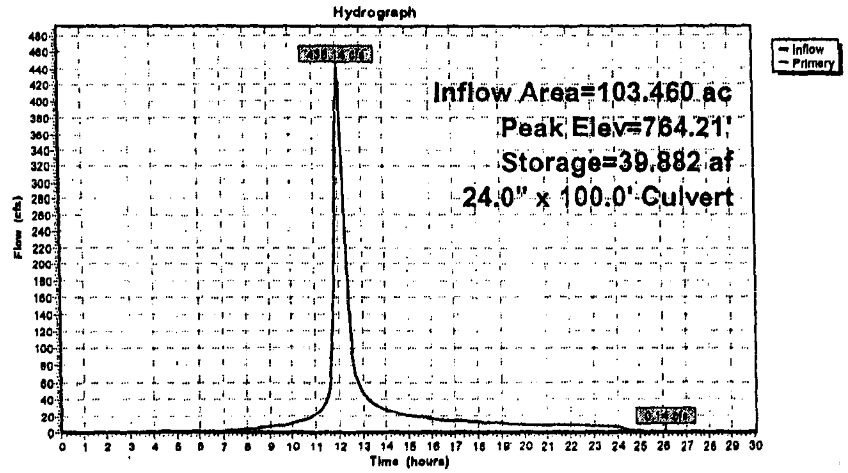
Volume	Invert	Avail.Storage	Storage Description
#1	756.00'	62.383 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

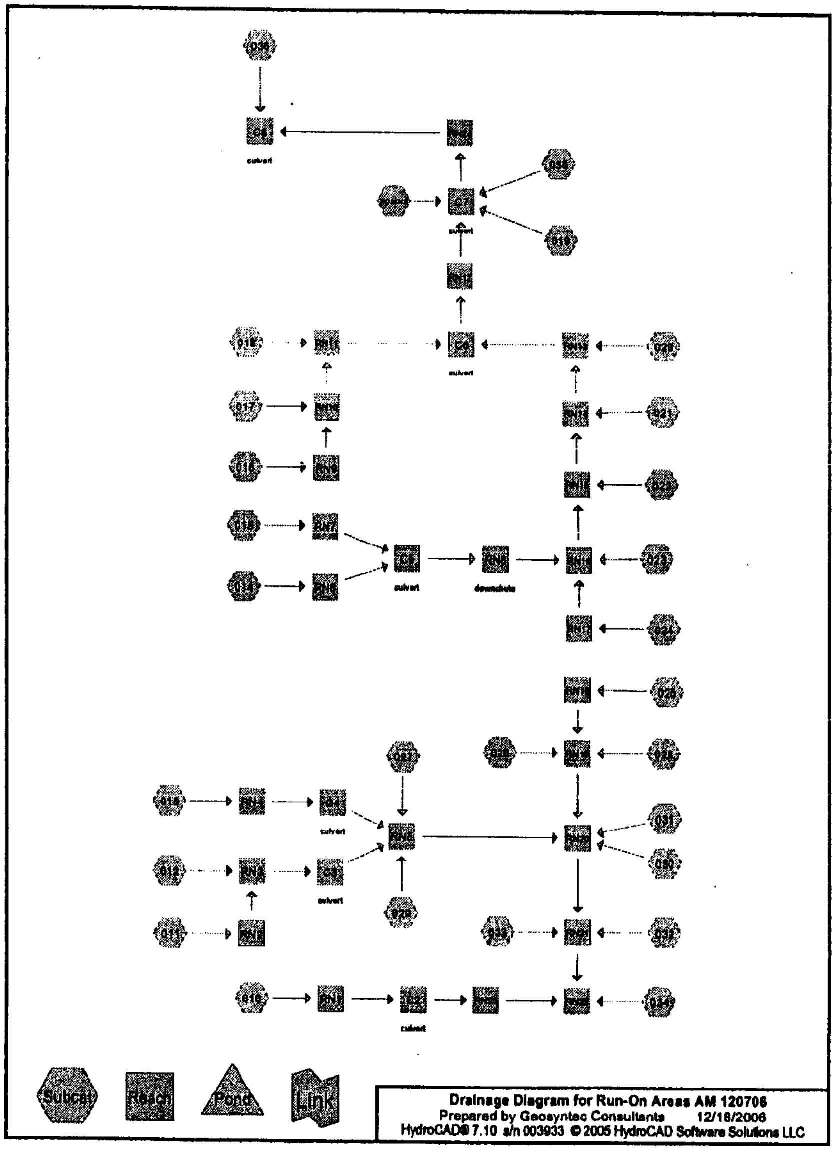
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
756.00	4.158	0.000	0.000
758.00	4.488	8.646	8.646
760.00	4.829	9.317	17.963
762.00	5.182	10.011	27.974
764.00	5.545	10.727	38.701
766.00	5.920	11.465	50.166
768.00	6.297	12.217	62.383

Device	Routing	Invert	Outlet Devices
#1	Primary	764.00'	**24.0" x 100.0' long Culvert X 2.00** RCP, sq.cut end projecting, Ke= 0.500 Outlet Invert= 764.00' S= 0.0000 '/' Cc= 0.900 n= 0.013 Concrete pipe, straight & clean

Primary OutFlow Max=0.13 cfs @ 26.12 hrs HW=764.21' (Free Discharge)
└─**1=Culvert** (Barrel Controls 0.13 cfs @ 0.5 fps)

Pond SP: Stormwater Pond





Time span=5.00-24.00 hrs, dt=0.05 hrs, 381 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 010: Runoff Area=5.320 ac Runoff Depth>3.67"
Tc=13.9 min CN=73 Runoff=26.07 cfs 1.625 af

Subcatchment 011: Runoff Area=4.380 ac Runoff Depth>3.67"
Tc=14.0 min CN=73 Runoff=21.39 cfs 1.338 af

Subcatchment 012: Runoff Area=9.360 ac Runoff Depth>3.66"
Tc=21.1 min CN=73 Runoff=36.96 cfs 2.854 af

Subcatchment 013: Runoff Area=7.000 ac Runoff Depth>3.66"
Tc=15.2 min CN=73 Runoff=32.85 cfs 2.138 af

Subcatchment 014: Runoff Area=11.310 ac Runoff Depth>3.67"
Tc=13.1 min CN=73 Runoff=56.93 cfs 3.456 af

Subcatchment 015: Runoff Area=13.200 ac Runoff Depth>3.66"
Tc=16.6 min CN=73 Runoff=59.39 cfs 4.030 af

Subcatchment 016: Runoff Area=5.380 ac Runoff Depth>3.67"
Tc=11.6 min CN=73 Runoff=28.40 cfs 1.645 af

Subcatchment 017: Runoff Area=5.080 ac Runoff Depth>3.67"
Tc=10.4 min CN=73 Runoff=27.82 cfs 1.553 af

Subcatchment 018: Runoff Area=2.360 ac Runoff Depth>3.67"
Tc=9.0 min CN=73 Runoff=13.63 cfs 0.722 af

Subcatchment 019: Runoff Area=5.590 ac Runoff Depth>3.66"
Flow Length=1,210' Tc=18.4 min CN=73 Runoff=23.85 cfs 1.706 af

Subcatchment 020: Runoff Area=0.960 ac Runoff Depth>3.67"
Tc=5.2 min CN=73 Runoff=6.26 cfs 0.294 af

Subcatchment 021: Runoff Area=4.240 ac Runoff Depth>3.67"
Tc=8.3 min CN=73 Runoff=25.14 cfs 1.297 af

Subcatchment 022: Runoff Area=3.690 ac Runoff Depth>3.68"
Tc=4.3 min CN=73 Runoff=25.01 cfs 1.130 af

Subcatchment 023: Runoff Area=0.810 ac Runoff Depth>3.68"
Tc=4.1 min CN=73 Runoff=5.53 cfs 0.248 af

Subcatchment 024: Runoff Area=1.640 ac Runoff Depth>3.67"
Tc=8.7 min CN=73 Runoff=9.58 cfs 0.502 af

Subcatchment 025: Runoff Area=1.680 ac Runoff Depth>3.67"
Tc=8.3 min CN=73 Runoff=9.96 cfs 0.514 af

Subcatchment 026: Runoff Area=1.230 ac Runoff Depth>3.67"
Tc=6.3 min CN=73 Runoff=7.75 cfs 0.377 af

Subcatchment 027: Runoff Area=2.060 ac Runoff Depth>3.67"
Tc=8.9 min CN=73 Runoff=11.95 cfs 0.630 af

Subcatchment 028: Runoff Area=0.390 ac Runoff Depth>3.68"
Tc=2.8 min CN=73 Runoff=2.75 cfs 0.119 af

Subcatchment 029: Runoff Area=1.820 ac Runoff Depth>3.67"
Tc=12.2 min CN=73 Runoff=9.43 cfs 0.556 af

Subcatchment 030: Runoff Area=1.250 ac Runoff Depth>3.67"
Tc=11.5 min CN=73 Runoff=6.62 cfs 0.382 af

Subcatchment 031: Runoff Area=0.450 ac Runoff Depth>3.68"
Tc=2.8 min CN=73 Runoff=3.17 cfs 0.138 af

Subcatchment 032: Runoff Area=4.840 ac Runoff Depth>3.67"
Tc=14.2 min CN=73 Runoff=23.48 cfs 1.478 af

Subcatchment 033: Runoff Area=1.760 ac Runoff Depth>3.68"
Tc=3.5 min CN=73 Runoff=12.26 cfs 0.539 af

Subcatchment 034: Runoff Area=1.640 ac Runoff Depth>3.67"
Tc=9.9 min CN=73 Runoff=9.15 cfs 0.502 af

Subcatchment 035: Runoff Area=0.790 ac Runoff Depth>3.65"
Flow Length=340' Tc=25.1 min CN=73 Runoff=2.81 cfs 0.241 af

Subcatchment 036: Runoff Area=0.140 ac Runoff Depth>3.68"
Flow Length=130' Tc=1.8 min CN=73 Runoff=0.98 cfs 0.043 af

Subcatchment ROAD12: Runoff Area=0.230 ac Runoff Depth>6.22"
Flow Length=480' Tc=3.1 min CN=98 Runoff=2.34 cfs 0.119 af

Reach C2: culvert Peak Depth=1.28' Max Vel=8.8 fps Inflow=25.38 cfs 1.623 af
D=36.0" n=0.013 L=69.8' S=0.0100 '/' Capacity=66.79 cfs Outflow=25.31 cfs 1.623 af

Reach C3: culvert Peak Depth=1.59' Max Vel=14.8 fps Inflow=56.11 cfs 4.184 af
D=36.0" n=0.013 L=69.8' S=0.0234 '/' Capacity=101.93 cfs Outflow=56.03 cfs 4.184 af

Reach C4: culvert Peak Depth=1.46' Max Vel=9.3 fps Inflow=31.89 cfs 2.133 af
D=36.0" n=0.013 L=63.5' S=0.0099 '/' Capacity=66.44 cfs Outflow=31.79 cfs 2.133 af

Reach C5: culvert Peak Depth=2.66' Max Vel=12.6 fps Inflow=112.30 cfs 7.470 af
D=48.0" n=0.013 L=80.0' S=0.0100 '/' Capacity=143.64 cfs Outflow=111.95 cfs 7.469 af

Reach C6: culvert Peak Depth=2.14' Max Vel=12.1 fps Inflow=165.23 cfs 14.773 af
D=48.0" n=0.013 L=80.4' S=0.0106 '/' Capacity=295.39 cfs Outflow=165.16 cfs 14.771 af

Reach C7: culvert Peak Depth=1.46' Max Vel=15.3 fps Inflow=189.56 cfs 16.822 af
D=48.0" n=0.013 L=160.0' S=0.0241 '/' Capacity=669.33 cfs Outflow=189.29 cfs 16.818 af

Reach C8: culvert Peak Depth=1.43' Max Vel=15.6 fps Inflow=189.13 cfs 16.857 af
D=48.0" n=0.013 L=60.0' S=0.0257 '/' Capacity=690.38 cfs Outflow=189.01 cfs 16.856 af

Reach RN1: Peak Depth=0.62' Max Vel=9.8 fps Inflow=26.07 cfs 1.626 af
n=0.030 L=528.7' S=0.1133 '/' Capacity=259.53 cfs Outflow=25.38 cfs 1.623 af

Reach RN10: Peak Depth=1.02' Max Vel=9.5 fps Inflow=49.44 cfs 3.191 af
n=0.030 L=627.6' S=0.0625 '/' Capacity=192.74 cfs Outflow=48.15 cfs 3.186 af

Reach RN11: Peak Depth=1.06' Max Vel=10.7 fps Inflow=58.11 cfs 3.908 af
n=0.030 L=378.5' S=0.0760 '/' Capacity=212.47 cfs Outflow=57.18 cfs 3.905 af

Reach RN12: Peak Depth=2.18' Max Vel=9.0 fps Inflow=165.16 cfs 14.771 af
n=0.030 L=430.0' S=0.0229 '/' Capacity=1,005.31 cfs Outflow=164.12 cfs 14.756 af

Reach RN13: Peak Depth=2.00' Max Vel=7.6 fps Inflow=122.83 cfs 10.876 af
n=0.030 L=246.6' S=0.0179 '/' Capacity=890.17 cfs Outflow=122.13 cfs 10.868 af

Reach RN14: Peak Depth=2.08' Max Vel=7.3 fps Inflow=124.10 cfs 10.604 af
n=0.030 L=712.3' S=0.0155 '/' Capacity=1,031.01 cfs Outflow=122.00 cfs 10.582 af

Reach RN15: Peak Depth=1.52' Max Vel=8.7 fps Inflow=121.75 cfs 9.337 af
n=0.030 L=1,158.2' S=0.0282 '/' Capacity=451.72 cfs Outflow=118.29 cfs 9.307 af

Reach RN16: Peak Depth=1.98' Max Vel=6.1 fps Inflow=120.22 cfs 8.217 af
n=0.030 L=311.5' S=0.0104 '/' Capacity=274.05 cfs Outflow=117.93 cfs 8.207 af

Reach RN17: Peak Depth=1.15' Max Vel=3.4 fps Inflow=9.58 cfs 0.502 af
n=0.030 L=416.6' S=0.0117 '/' Capacity=117.14 cfs Outflow=8.90 cfs 0.501 af

Reach RN18: Peak Depth=0.63' Max Vel=3.6 fps Inflow=9.96 cfs 0.514 af
n=0.030 L=392.0' S=0.0149 '/' Capacity=735.37 cfs Outflow=9.30 cfs 0.513 af

Reach RN19: Peak Depth=0.58' Max Vel=7.2 fps Inflow=17.38 cfs 1.009 af
n=0.030 L=391.7' S=0.0639 '/' Capacity=2,352.84 cfs Outflow=16.88 cfs 1.007 af

Reach RN2: Peak Depth=0.85' Max Vel=5.3 fps Inflow=21.39 cfs 1.338 af
n=0.030 L=432.3' S=0.0231 '/' Capacity=117.25 cfs Outflow=20.66 cfs 1.335 af

Reach RN20: Peak Depth=2.68' Max Vel=5.0 fps Inflow=112.83 cfs 9.019 af
n=0.030 L=229.0' S=0.0060 '/' Capacity=38,244.53 cfs Outflow=111.72 cfs 9.011 af

Reach RN21: Peak Depth=2.12' Max Vel=8.6 fps Inflow=132.96 cfs 11.029 af
n=0.030 L=872.8' S=0.0231 '/' Capacity=2,841.91 cfs Outflow=130.65 cfs 11.006 af

Reach RN22: Peak Depth=1.27' Max Vel=6.0 fps Inflow=156.55 cfs 13.129 af
n=0.030 L=465.1' S=0.0129 '/' Capacity=704.13 cfs Outflow=154.60 cfs 13.102 af

Reach RN23: Peak Depth=1.02' Max Vel=6.2 fps Inflow=25.31 cfs 1.623 af
n=0.030 L=116.9' S=0.0289 '/' Capacity=271.53 cfs Outflow=25.11 cfs 1.622 af

Reach RN24: Peak Depth=2.34' Max Vel=9.3 fps Inflow=189.29 cfs 16.818 af
n=0.030 L=91.5' S=0.0224 '/' Capacity=995.23 cfs Outflow=189.01 cfs 16.815 af

Reach RN3: Peak Depth=1.43' Max Vel=6.7 fps Inflow=57.06 cfs 4.189 af
n=0.030 L=371.4' S=0.0215 '/' Capacity=113.14 cfs Outflow=56.11 cfs 4.184 af

Reach RN4: Peak Depth=0.79' Max Vel=9.0 fps Inflow=32.85 cfs 2.138 af
n=0.030 L=731.1' S=0.0727 '/' Capacity=207.86 cfs Outflow=31.89 cfs 2.133 af

Reach RN5: Peak Depth=1.76' Max Vel=8.6 fps Inflow=99.38 cfs 7.503 af
n=0.030 L=591.7' S=0.0281 '/' Capacity=312.31 cfs Outflow=97.74 cfs 7.492 af

Reach RN6: Peak Depth=1.27' Max Vel=7.9 fps Inflow=56.93 cfs 3.456 af
n=0.030 L=947.6' S=0.0337 '/' Capacity=141.62 cfs Outflow=54.25 cfs 3.446 af

Reach RN7: Peak Depth=1.28' Max Vel=8.3 fps Inflow=59.39 cfs 4.030 af
n=0.030 L=490.9' S=0.0368 '/' Capacity=147.95 cfs Outflow=58.12 cfs 4.024 af

Reach RN8: downchute Peak Depth=1.56' Max Vel=11.7 fps Inflow=111.95 cfs 7.469 af
n=0.050 L=69.0' S=0.1664 '/' Capacity=188.67 cfs Outflow=111.63 cfs 7.468 af

Reach RN9: Peak Depth=1.06' Max Vel=5.0 fps Inflow=28.40 cfs 1.645 af
n=0.030 L=855.7' S=0.0162 '/' Capacity=98.04 cfs Outflow=26.82 cfs 1.638 af

Total Runoff Area = 98.600 ac Runoff Volume = 30.175 af Average Runoff Depth = 3.67"

Subcatchment 010:

Runoff = 26.07 cfs @ 12.06 hrs, Volume= 1.625 af, Depth> 3.67"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 Y 24 H Rainfall=6.70"

Area (ac)	CN	Description
5.320	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.9					Direct Entry,

Subcatchment 011:

Runoff = 21.39 cfs @ 12.06 hrs, Volume= 1.338 af, Depth> 3.67"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 Y 24 H Rainfall=6.70"

Area (ac)	CN	Description
4.380	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.0					Direct Entry,

Subcatchment 012:

Runoff = 36.96 cfs @ 12.14 hrs, Volume= 2.854 af, Depth> 3.66"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 Y 24 H Rainfall=6.70"

Area (ac)	CN	Description
9.360	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
21.1					Direct Entry,

Subcatchment 013:

Runoff = 32.85 cfs @ 12.07 hrs, Volume= 2.138 af, Depth> 3.66"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 Y 24 H Rainfall=6.70"

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Area (ac)	CN	Description
7.000	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
15.2					Direct Entry,

Subcatchment 014:

Runoff = 56.93 cfs @ 12.05 hrs, Volume= 3.456 af, Depth> 3.67"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 Y 24 H Rainfall=6.70"

Area (ac)	CN	Description
11.310	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.1					Direct Entry,

Subcatchment 015:

Runoff = 59.39 cfs @ 12.09 hrs, Volume= 4.030 af, Depth> 3.66"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 Y 24 H Rainfall=6.70"

Area (ac)	CN	Description
13.200	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
16.6					Direct Entry,

Subcatchment 016:

Runoff = 28.40 cfs @ 12.03 hrs, Volume= 1.645 af, Depth> 3.67"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 Y 24 H Rainfall=6.70"

Area (ac)	CN	Description
5.380	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.6					Direct Entry,

Subcatchment 017:

Runoff = 27.82 cfs @ 12.02 hrs, Volume= 1.553 af, Depth> 3.67"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 Y 24 H Rainfall=6.70"

Area (ac)	CN	Description
5.080	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.4					Direct Entry,

Subcatchment 018:

Runoff = 13.63 cfs @ 12.00 hrs, Volume= 0.722 af, Depth> 3.67"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 Y 24 H Rainfall=6.70"

Area (ac)	CN	Description
2.360	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.0					Direct Entry,

Subcatchment 019:

Runoff = 23.85 cfs @ 12.11 hrs, Volume= 1.706 af, Depth> 3.66"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 Y 24 H Rainfall=6.70"

Area (ac)	CN	Description
5.590	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.4	300	0.0930	0.4		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.40"
1.4	180	0.0890	2.1		**Shallow Concentrated Flow, Shallow Flow** Short Grass Pasture Kv= 7.0 fps
3.3	590	0.1800	3.0		**Shallow Concentrated Flow, Shallow Flow segment 2** Short Grass Pasture Kv= 7.0 fps
1.3	140	0.0700	1.9		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
18.4	1,210	Total			

Subcatchment 020:

[49] Hint: Tc<2dt may require smaller dt

Runoff = 6.26 cfs @ 11.96 hrs, Volume= 0.294 af, Depth> 3.67"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 Y 24 H Rainfall=6.70"

Area (ac)	CN	Description
0.960	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.2					**Direct Entry,**

Subcatchment 021:

Runoff = 25.14 cfs @ 12.00 hrs, Volume= 1.297 af, Depth> 3.67"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 Y 24 H Rainfall=6.70"

Area (ac)	CN	Description
4.240	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.3					**Direct Entry,**

Subcatchment 022:

[49] Hint: Tc<2dt may require smaller dt

Runoff = 25.01 cfs @ 11.95 hrs, Volume= 1.130 af, Depth> 3.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 Y 24 H Rainfall=6.70"

Area (ac)	CN	Description
3.690	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.3					**Direct Entry,**

Subcatchment 023:

[49] Hint: Tc<2dt may require smaller dt

Runoff = 5.53 cfs @ 11.95 hrs, Volume= 0.248 af, Depth> 3.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 Y 24 H Rainfall=6.70"

Area (ac)	CN	Description
0.810	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.1					**Direct Entry,**

Subcatchment 024:

Runoff = 9.58 cfs @ 12.00 hrs, Volume= 0.502 af, Depth> 3.67"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 Y 24 H Rainfall=6.70"

Area (ac)	CN	Description
1.640	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.7					**Direct Entry,**

Subcatchment 025:

Runoff = 9.96 cfs @ 12.00 hrs, Volume= 0.514 af, Depth> 3.67"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 Y 24 H Rainfall=6.70"

Area (ac)	CN	Description
1.680	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.3					Direct Entry,

Subcatchment 026:

Runoff = 7.75 cfs @ 11.98 hrs, Volume= 0.377 af, Depth> 3.67"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 Y 24 H Rainfall=6.70"

Area (ac)	CN	Description
1.230	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.3					Direct Entry,

Subcatchment 027:

Runoff = 11.95 cfs @ 12.00 hrs, Volume= 0.630 af, Depth> 3.67"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 Y 24 H Rainfall=6.70"

Area (ac)	CN	Description
2.060	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.9					Direct Entry,

Subcatchment 028:

[49] Hint: Tc<2dt may require smaller dt

Runoff = 2.75 cfs @ 11.93 hrs, Volume= 0.119 af, Depth> 3.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 Y 24 H Rainfall=6.70"

Area (ac)	CN	Description
0.390	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.8					Direct Entry,

Subcatchment 029:

Runoff = 9.43 cfs @ 12.04 hrs, Volume= 0.556 af, Depth> 3.67"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 Y 24 H Rainfall=6.70"

Area (ac)	CN	Description
1.820	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.2					Direct Entry,

Subcatchment 030:

Runoff = 6.62 cfs @ 12.03 hrs, Volume= 0.382 af, Depth> 3.67"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 Y 24 H Rainfall=6.70"

Area (ac)	CN	Description
1.250	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.5					Direct Entry,

Subcatchment 031:

[49] Hint: Tc<2dt may require smaller dt

Runoff = 3.17 cfs @ 11.93 hrs, Volume= 0.138 af, Depth> 3.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 Y 24 H Rainfall=6.70"

Area (ac)	CN	Description
0.450	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.8					Direct Entry,

Subcatchment 032:

Runoff = 23.48 cfs @ 12.06 hrs, Volume= 1.478 af, Depth> 3.67"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 Y 24 H Rainfall=6.70"

Area (ac)	CN	Description
4.840	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.2					Direct Entry,

Subcatchment 033:

[49] Hint: Tc<2dt may require smaller dt

Runoff = 12.26 cfs @ 11.94 hrs, Volume= 0.539 af, Depth> 3.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 Y 24 H Rainfall=6.70"

Area (ac)	CN	Description
1.760	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.5					Direct Entry,

Subcatchment 034:

Runoff = 9.15 cfs @ 12.01 hrs, Volume= 0.502 af, Depth> 3.67"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 Y 24 H Rainfall=6.70"

Area (ac)	CN	Description
1.640	73	Woods/grass comb., Poor, HSG B

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.9					Direct Entry,

Subcatchment 035:

Runoff = 2.81 cfs @ 12.19 hrs, Volume= 0.241 af, Depth> 3.65"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 Y 24 H Rainfall=6.70"

Area (ac)	CN	Description
0.790	73	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
24.4	300	0.0170	0.2		Sheet Flow, Grass: Short n= 0.150 P2= 3.40"
0.7	40	0.0170	0.9		Shallow Concentrated Flow, Short Grass Pasture Kv= 7.0 fps
25.1	340	Total			

Subcatchment 036:

[49] Hint: Tc<2dt may require smaller dt

Runoff = 0.98 cfs @ 11.92 hrs, Volume= 0.043 af, Depth> 3.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 Y 24 H Rainfall=6.70"

Area (ac)	CN	Description
0.140	73	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.7	40	0.2500	0.4		Sheet Flow, Grass: Short n= 0.150 P2= 3.40"
0.1	90	0.0440	12.9	905.39	Channel Flow, channel Area= 70.0 sf Perim= 50.4' r= 1.39' n= 0.030
1.8	130	Total			

Subcatchment ROAD12:

[49] Hint: Tc<2dt may require smaller dt

Runoff = 2.34 cfs @ 11.93 hrs, Volume= 0.119 af, Depth> 6.22"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 Y 24 H Rainfall=6.70"

Area (ac)	CN	Description
0.230	98	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.2	10	0.0100	0.7		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.40"
2.9	470	0.0170	2.7	0.54	**Channel Flow,** Area= 0.2 sf Perim= 2.6' r= 0.08' n= 0.013
3.1	480	Total			

Reach C2: culvert

[52] Hint: Inlet conditions not evaluated
[61] Hint: Submerged 2% of Reach RN1 bottom

Inflow Area = 5.320 ac, Inflow Depth > 3.66" for 100 Y 24 H event
Inflow = 25.38 cfs @ 12.09 hrs, Volume= 1.623 af
Outflow = 25.31 cfs @ 12.09 hrs, Volume= 1.623 af, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 8.8 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 3.0 fps, Avg. Travel Time= 0.4 min

Peak Depth= 1.28' @ 12.09 hrs
Capacity at bank full= 66.79 cfs
Inlet Invert= 768.08', Outlet Invert= 767.38'
36.0" Diameter Pipe, n= 0.013 Concrete pipe, straight & clean
Length= 69.8' Slope= 0.0100 '/'

Reach C3: culvert

[52] Hint: Inlet conditions not evaluated
[61] Hint: Submerged 20% of Reach RN3 bottom

Inflow Area = 13.740 ac, Inflow Depth > 3.65" for 100 Y 24 H event
Inflow = 56.11 cfs @ 12.15 hrs, Volume= 4.184 af
Outflow = 56.03 cfs @ 12.15 hrs, Volume= 4.184 af, Atten= 0%, Lag= 0.1 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 14.8 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 5.3 fps, Avg. Travel Time= 0.2 min

Peak Depth= 1.59' @ 12.15 hrs
Capacity at bank full= 101.93 cfs
Inlet Invert= 810.00', Outlet Invert= 808.37'
36.0" Diameter Pipe, n= 0.013 Concrete pipe, straight & clean
Length= 69.8' Slope= 0.0234 '/'

Reach C4: culvert

[52] Hint: Inlet conditions not evaluated
[61] Hint: Submerged 3% of Reach RN4 bottom

Inflow Area = 7.000 ac, Inflow Depth > 3.66" for 100 Y 24 H event
Inflow = 31.89 cfs @ 12.11 hrs, Volume= 2.133 af
Outflow = 31.79 cfs @ 12.12 hrs, Volume= 2.133 af, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 9.3 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 3.2 fps, Avg. Travel Time= 0.3 min

Peak Depth= 1.46' @ 12.12 hrs
Capacity at bank full= 66.44 cfs
Inlet Invert= 808.75', Outlet Invert= 808.12'
36.0" Diameter Pipe, n= 0.013 Concrete pipe, straight & clean
Length= 63.5' Slope= 0.0099 '/'

Reach C5: culvert

[52] Hint: Inlet conditions not evaluated
[61] Hint: Submerged 8% of Reach RN6 bottom
[61] Hint: Submerged 15% of Reach RN7 bottom

Inflow Area = 24.510 ac, Inflow Depth > 3.66" for 100 Y 24 H event
Inflow = 112.30 cfs @ 12.11 hrs, Volume= 7.470 af
Outflow = 111.95 cfs @ 12.12 hrs, Volume= 7.469 af, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 12.6 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 4.5 fps, Avg. Travel Time= 0.3 min

Peak Depth= 2.66' @ 12.12 hrs
Capacity at bank full= 143.64 cfs
Inlet Invert= 829.92', Outlet Invert= 829.12'
48.0" Diameter Pipe, n= 0.013 Concrete pipe, straight & clean
Length= 80.0' Slope= 0.0100 '/'

Reach C6: culvert

[52] Hint: Inlet conditions not evaluated
[61] Hint: Submerged 7% of Reach RN11 bottom
[61] Hint: Submerged 48% of Reach RN13 bottom

Inflow Area = 48.670 ac, Inflow Depth > 3.64" for 100 Y 24 H event
Inflow = 165.23 cfs @ 12.15 hrs, Volume= 14.773 af
Outflow = 165.16 cfs @ 12.16 hrs, Volume= 14.771 af, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 12.1 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 4.6 fps, Avg. Travel Time= 0.3 min

Peak Depth= 2.14' @ 12.15 hrs
Capacity at bank full= 295.39 cfs
Inlet Invert= 766.18', Outlet Invert= 765.33'
A factor of 2.00 has been applied to the supplied storage and discharge data
48.0" Diameter Pipe, n= 0.013 Concrete pipe, straight & clean
Length= 80.4' Slope= 0.0106 '/'

Reach C7: culvert

[52] Hint: Inlet conditions not evaluated
[61] Hint: Submerged 15% of Reach RN12 bottom

Inflow Area = 55.280 ac, Inflow Depth > 3.65" for 100 Y 24 H event
Inflow = 189.56 cfs @ 12.16 hrs, Volume= 16.822 af
Outflow = 189.29 cfs @ 12.17 hrs, Volume= 16.818 af, Atten= 0%, Lag= 0.3 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 15.3 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 5.1 fps, Avg. Travel Time= 0.5 min

Peak Depth= 1.46' @ 12.17 hrs
Capacity at bank full= 669.33 cfs
Inlet Invert= 755.50', Outlet Invert= 751.64'
A factor of 3.00 has been applied to the supplied storage and discharge data
48.0" Diameter Pipe, n= 0.013 Concrete pipe, straight & clean
Length= 160.0' Slope= 0.0241 '/'

Reach C8: culvert

[52] Hint: Inlet conditions not evaluated
[61] Hint: Submerged 70% of Reach RN24 bottom

Inflow Area = 55.420 ac, Inflow Depth > 3.65" for 100 Y 24 H event
Inflow = 189.13 cfs @ 12.17 hrs, Volume= 16.857 af
Outflow = 189.01 cfs @ 12.17 hrs, Volume= 16.856 af, Atten= 0%, Lag= 0.1 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 15.6 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 5.2 fps, Avg. Travel Time= 0.2 min

Peak Depth= 1.43' @ 12.17 hrs
Capacity at bank full= 690.38 cfs
Inlet Invert= 749.59', Outlet Invert= 748.05'
A factor of 3.00 has been applied to the supplied storage and discharge data
48.0" Diameter Pipe, n= 0.013
Length= 60.0' Slope= 0.0257 '/'

Reach RN1:

Inflow Area = 5.320 ac, Inflow Depth > 3.67" for 100 Y 24 H event
Inflow = 26.07 cfs @ 12.06 hrs, Volume= 1.625 af
Outflow = 25.38 cfs @ 12.09 hrs, Volume= 1.623 af, Atten= 3%, Lag= 1.6 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 9.8 fps, Min. Travel Time= 0.9 min
Avg. Velocity = 2.9 fps, Avg. Travel Time= 3.1 min

Peak Depth= 0.62' @ 12.07 hrs
Capacity at bank full= 259.53 cfs
Inlet Invert= 828.00', Outlet Invert= 768.08'
3.00' x 2.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 11.00'
Length= 528.7' Slope= 0.1133 '/'

Reach RN10:

[61] Hint: Submerged 7% of Reach RN9 bottom

Inflow Area = 10.460 ac, Inflow Depth > 3.66" for 100 Y 24 H event
Inflow = 49.44 cfs @ 12.06 hrs, Volume= 3.191 af
Outflow = 48.15 cfs @ 12.09 hrs, Volume= 3.186 af, Atten= 3%, Lag= 2.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 9.5 fps, Min. Travel Time= 1.1 min
Avg. Velocity = 3.0 fps, Avg. Travel Time= 3.5 min

Peak Depth= 1.02' @ 12.07 hrs
Capacity at bank full= 192.74 cfs
Inlet Invert= 834.16', Outlet Invert= 794.93'
3.00' x 2.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 11.00'
Length= 627.6' Slope= 0.0625 '/'

Reach RN11:

[61] Hint: Submerged 3% of Reach RN10 bottom

Inflow Area = 12.820 ac, Inflow Depth > 3.66" for 100 Y 24 H event
Inflow = 58.11 cfs @ 12.07 hrs, Volume= 3.908 af
Outflow = 57.18 cfs @ 12.09 hrs, Volume= 3.905 af, Atten= 2%, Lag= 1.1 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 10.7 fps, Min. Travel Time= 0.6 min
Avg. Velocity = 3.4 fps, Avg. Travel Time= 1.9 min

Peak Depth= 1.06' @ 12.07 hrs
Capacity at bank full= 212.47 cfs
Inlet Invert= 794.93', Outlet Invert= 766.18'
3.00' x 2.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 11.00'
Length= 378.5' Slope= 0.0760 '/'

Reach RN12:

[62] Warning: Submerged 33% of Reach C6 inlet

Inflow Area = 48.670 ac, Inflow Depth > 3.64" for 100 Y 24 H event
Inflow = 165.16 cfs @ 12.16 hrs, Volume= 14.771 af
Outflow = 164.12 cfs @ 12.18 hrs, Volume= 14.756 af, Atten= 1%, Lag= 1.4 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 9.0 fps, Min. Travel Time= 0.8 min
Avg. Velocity = 3.3 fps, Avg. Travel Time= 2.1 min

Peak Depth= 2.18' @ 12.16 hrs
Capacity at bank full= 1,005.31 cfs
Inlet Invert= 765.33', Outlet Invert= 755.50'
4.00' x 5.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 24.00'
Length= 430.0' Slope= 0.0229 '/'

Reach RN13:

[61] Hint: Submerged 18% of Reach RN14 bottom

Inflow Area = 35.850 ac, Inflow Depth > 3.64" for 100 Y 24 H event
Inflow = 122.83 cfs @ 12.23 hrs, Volume= 10.876 af
Outflow = 122.13 cfs @ 12.24 hrs, Volume= 10.868 af, Atten= 1%, Lag= 0.7 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 7.6 fps, Min. Travel Time= 0.5 min
Avg. Velocity = 2.8 fps, Avg. Travel Time= 1.5 min

Peak Depth= 2.00' @ 12.24 hrs
Capacity at bank full= 890.17 cfs
Inlet Invert= 770.60', Outlet Invert= 766.18'
4.00' x 5.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 24.00'
Length= 246.6' Slope= 0.0179 '/'

Reach RN14:

[61] Hint: Submerged 6% of Reach RN15 bottom

Inflow Area = 34.890 ac, Inflow Depth > 3.65" for 100 Y 24 H event
Inflow = 124.10 cfs @ 12.19 hrs, Volume= 10.604 af
Outflow = 122.00 cfs @ 12.23 hrs, Volume= 10.582 af, Atten= 2%, Lag= 2.5 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 7.3 fps, Min. Travel Time= 1.6 min
Avg. Velocity = 2.6 fps, Avg. Travel Time= 4.5 min

Peak Depth= 2.08' @ 12.20 hrs
Capacity at bank full= 1,031.01 cfs
Inlet Invert= 781.64', Outlet Invert= 770.60'
4.00' x 5.50' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 26.00'
Length= 712.3' Slope= 0.0155 '/'

Reach RN15:

[61] Hint: Submerged 47% of Reach RN16 bottom

Inflow Area = 30.650 ac, Inflow Depth > 3.66" for 100 Y 24 H event
Inflow = 121.75 cfs @ 12.14 hrs, Volume= 9.337 af
Outflow = 118.29 cfs @ 12.20 hrs, Volume= 9.307 af, Atten= 3%, Lag= 3.6 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 8.7 fps, Min. Travel Time= 2.2 min
Avg. Velocity = 2.8 fps, Avg. Travel Time= 7.0 min

Peak Depth= 1.52' @ 12.16 hrs
Capacity at bank full= 451.72 cfs
Inlet Invert= 814.27', Outlet Invert= 781.64'
6.00' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 18.00'
Length= 1,158.2' Slope= 0.0282 '/'

Reach RN16:

[61] Hint: Submerged 40% of Reach RN17 bottom
[61] Hint: Submerged 16% of Reach RN8 bottom

Inflow Area = 26.960 ac, Inflow Depth > 3.66" for 100 Y 24 H event
Inflow = 120.22 cfs @ 12.11 hrs, Volume= 8.217 af
Outflow = 117.93 cfs @ 12.14 hrs, Volume= 8.207 af, Atten= 2%, Lag= 1.6 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 6.1 fps, Min. Travel Time= 0.9 min
Avg. Velocity = 1.9 fps, Avg. Travel Time= 2.7 min

Peak Depth= 1.98' @ 12.12 hrs
Capacity at bank full= 274.05 cfs
Inlet Invert= 817.50', Outlet Invert= 814.27'
6.00' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 18.00'
Length= 311.5' Slope= 0.0104 '/'

Reach RN17:

Inflow Area = 1.640 ac, Inflow Depth > 3.67" for 100 Y 24 H event
Inflow = 9.58 cfs @ 12.00 hrs, Volume= 0.502 af
Outflow = 8.90 cfs @ 12.06 hrs, Volume= 0.501 af, Atten= 7%, Lag= 3.5 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.4 fps, Min. Travel Time= 2.0 min
Avg. Velocity = 1.3 fps, Avg. Travel Time= 5.3 min

Peak Depth= 1.15' @ 12.03 hrs
Capacity at bank full= 117.14 cfs
Inlet Invert= 822.36', Outlet Invert= 817.50'
0.00' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 12.00'
Length= 416.6' Slope= 0.0117 '/'

Reach RN18:

Inflow Area = 1.680 ac, Inflow Depth > 3.67" for 100 Y 24 H event
Inflow = 9.96 cfs @ 12.00 hrs, Volume= 0.514 af
Outflow = 9.30 cfs @ 12.05 hrs, Volume= 0.513 af, Atten= 7%, Lag= 3.1 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.6 fps, Min. Travel Time= 1.8 min
Avg. Velocity = 1.0 fps, Avg. Travel Time= 6.3 min

Peak Depth= 0.63' @ 12.02 hrs
Capacity at bank full= 735.37 cfs
Inlet Invert= 822.36', Outlet Invert= 816.53'
3.00' x 5.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 23.00'
Length= 392.0' Slope= 0.0149 '/'

Reach RN19:

[61] Hint: Submerged 10% of Reach RN18 bottom

Inflow Area = 3.300 ac, Inflow Depth > 3.67" for 100 Y 24 H event
Inflow = 17.38 cfs @ 11.99 hrs, Volume= 1.009 af
Outflow = 16.88 cfs @ 12.02 hrs, Volume= 1.007 af, Atten= 3%, Lag= 1.5 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 7.2 fps, Min. Travel Time= 0.9 min
Avg. Velocity = 2.2 fps, Avg. Travel Time= 2.9 min

Peak Depth= 0.58' @ 12.00 hrs
Capacity at bank full= 2,352.84 cfs
Inlet Invert= 816.53', Outlet Invert= 791.50'
3.00' x 6.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 27.00'
Length= 391.7' Slope= 0.0639 '/'

Reach RN2:

Inflow Area = 4.380 ac, Inflow Depth > 3.67" for 100 Y 24 H event
Inflow = 21.39 cfs @ 12.06 hrs, Volume= 1.338 af
Outflow = 20.66 cfs @ 12.10 hrs, Volume= 1.335 af, Atten= 3%, Lag= 2.5 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.3 fps, Min. Travel Time= 1.4 min
Avg. Velocity = 1.6 fps, Avg. Travel Time= 4.5 min

Peak Depth= 0.85' @ 12.08 hrs
Capacity at bank full= 117.25 cfs
Inlet Invert= 828.00', Outlet Invert= 818.00'
3.00' x 2.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 11.00'
Length= 432.3' Slope= 0.0231 '/'

Reach RN20:

[61] Hint: Submerged 11% of Reach RN19 bottom
[61] Hint: Submerged 16% of Reach RN5 bottom

Inflow Area = 29.620 ac, Inflow Depth > 3.65" for 100 Y 24 H event
Inflow = 112.83 cfs @ 12.12 hrs, Volume= 9.019 af
Outflow = 111.72 cfs @ 12.15 hrs, Volume= 9.011 af, Atten= 1%, Lag= 1.4 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.0 fps, Min. Travel Time= 0.8 min
Avg. Velocity = 2.0 fps, Avg. Travel Time= 1.9 min

Peak Depth= 2.68' @ 12.13 hrs
Capacity at bank full= 38,244.53 cfs
Inlet Invert= 791.50', Outlet Invert= 790.12'
3.00' x 29.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 119.00'
Length= 229.0' Slope= 0.0060 '/'

TVA-00021141

Reach RN21:

[62] Warning: Submerged 3% of Reach RN20 inlet

Inflow Area = 36.220 ac, Inflow Depth > 3.65" for 100 Y 24 H event
Inflow = 132.96 cfs @ 12.12 hrs, Volume= 11.029 af
Outflow = 130.65 cfs @ 12.17 hrs, Volume= 11.006 af, Atten= 2%, Lag= 3.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 8.6 fps, Min. Travel Time= 1.7 min
Avg. Velocity = 3.3 fps, Avg. Travel Time= 4.5 min

Peak Depth= 2.12' @ 12.15 hrs
Capacity at bank full= 2,841.91 cfs
Inlet Invert= 790.12', Outlet Invert= 770.00'
3.00' x 8.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 35.00'
Length= 872.8' Slope= 0.0231 '/'

Reach RN22:

[61] Hint: Submerged 6% of Reach RN21 bottom
[63] Warning: Exceeded Reach RN23 inflow depth by 3.09' @ 12.30 hrs

Inflow Area = 43.180 ac, Inflow Depth > 3.65" for 100 Y 24 H event
Inflow = 156.55 cfs @ 12.15 hrs, Volume= 13.129 af
Outflow = 154.60 cfs @ 12.18 hrs, Volume= 13.102 af, Atten= 1%, Lag= 2.2 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 6.0 fps, Min. Travel Time= 1.3 min
Avg. Velocity = 1.7 fps, Avg. Travel Time= 4.5 min

Peak Depth= 1.27' @ 12.16 hrs
Capacity at bank full= 704.13 cfs
Inlet Invert= 770.00', Outlet Invert= 764.00'
18.00' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 30.00'
Length= 465.1' Slope= 0.0129 '/'

Reach RN23:

[62] Warning: Submerged 11% of Reach C2 inlet

Inflow Area = 5.320 ac, Inflow Depth > 3.66" for 100 Y 24 H event
Inflow = 25.31 cfs @ 12.09 hrs, Volume= 1.623 af
Outflow = 25.11 cfs @ 12.10 hrs, Volume= 1.622 af, Atten= 1%, Lag= 0.5 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 6.2 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 2.0 fps, Avg. Travel Time= 1.0 min

Peak Depth= 1.02' @ 12.09 hrs
Capacity at bank full= 271.53 cfs
Inlet Invert= 767.38', Outlet Invert= 764.00'
2.00' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 14.00'
Length= 116.9' Slope= 0.0289 '/'

Reach RN24:

[61] Hint: Submerged 61% of Reach C7 bottom

Inflow Area = 55.280 ac, Inflow Depth > 3.65" for 100 Y 24 H event
Inflow = 189.29 cfs @ 12.17 hrs, Volume= 16.818 af
Outflow = 189.01 cfs @ 12.17 hrs, Volume= 16.815 af, Atten= 0%, Lag= 0.3 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 9.3 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 3.1 fps, Avg. Travel Time= 0.5 min

Peak Depth= 2.34' @ 12.17 hrs
Capacity at bank full= 995.23 cfs
Inlet Invert= 751.64', Outlet Invert= 749.59'
4.00' x 5.00' deep channel, n= 0.030
Side Slope Z-value= 2.0 '/' Top Width= 24.00'
Length= 91.5' Slope= 0.0224 '/'

Reach RN3:

[61] Hint: Submerged 14% of Reach RN2 bottom

Inflow Area = 13.740 ac, Inflow Depth > 3.66" for 100 Y 24 H event
Inflow = 57.06 cfs @ 12.12 hrs, Volume= 4.189 af
Outflow = 56.11 cfs @ 12.15 hrs, Volume= 4.184 af, Atten= 2%, Lag= 1.7 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 6.7 fps, Min. Travel Time= 0.9 min
Avg. Velocity = 2.3 fps, Avg. Travel Time= 2.7 min

Peak Depth= 1.43' @ 12.13 hrs
Capacity at bank full= 113.14 cfs
Inlet Invert= 818.00', Outlet Invert= 810.00'
3.00' x 2.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 11.00'
Length= 371.4' Slope= 0.0215 '/'

Reach RN4:

Inflow Area = 7.000 ac, Inflow Depth > 3.66" for 100 Y 24 H event
Inflow = 32.85 cfs @ 12.07 hrs, Volume= 2.138 af
Outflow = 31.89 cfs @ 12.11 hrs, Volume= 2.133 af, Atten= 3%, Lag= 2.4 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 9.0 fps, Min. Travel Time= 1.4 min
Avg. Velocity = 2.7 fps, Avg. Travel Time= 4.5 min

Peak Depth= 0.79' @ 12.09 hrs
Capacity at bank full= 207.86 cfs
Inlet Invert= 861.90', Outlet Invert= 808.75'
3.00' x 2.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 11.00'
Length= 731.1' Slope= 0.0727 '/'

Reach RN5:

[61] Hint: Submerged 92% of Reach C3 bottom
[62] Warning: Submerged 37% of Reach C4 inlet

Inflow Area = 24.620 ac, Inflow Depth > 3.66" for 100 Y 24 H event
Inflow = 99.38 cfs @ 12.12 hrs, Volume= 7.503 af
Outflow = 97.74 cfs @ 12.15 hrs, Volume= 7.492 af, Atten= 2%, Lag= 2.1 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 8.6 fps, Min. Travel Time= 1.1 min
Avg. Velocity = 3.0 fps, Avg. Travel Time= 3.2 min

Peak Depth= 1.76' @ 12.13 hrs
Capacity at bank full= 312.31 cfs
Inlet Invert= 808.12', Outlet Invert= 791.50'
3.00' x 3.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 15.00'
Length= 591.7' Slope= 0.0281 '/'

Reach RN6:

Inflow Area = 11.310 ac, Inflow Depth > 3.67" for 100 Y 24 H event
Inflow = 56.93 cfs @ 12.05 hrs, Volume= 3.456 af
Outflow = 54.25 cfs @ 12.11 hrs, Volume= 3.446 af, Atten= 5%, Lag= 3.5 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 7.9 fps, Min. Travel Time= 2.0 min
Avg. Velocity = 2.5 fps, Avg. Travel Time= 6.3 min

Peak Depth= 1.27' @ 12.08 hrs
Capacity at bank full= 141.82 cfs
Inlet Invert= 861.90', Outlet Invert= 829.92'
3.00' x 2.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 11.00'
Length= 947.6' Slope= 0.0337 '/'

Reach RN7:

Inflow Area = 13.200 ac, Inflow Depth > 3.66" for 100 Y 24 H event
Inflow = 59.39 cfs @ 12.09 hrs, Volume= 4.030 af
Outflow = 58.12 cfs @ 12.12 hrs, Volume= 4.024 af, Atten= 2%, Lag= 1.7 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 8.3 fps, Min. Travel Time= 1.0 min
Avg. Velocity = 2.7 fps, Avg. Travel Time= 3.0 min

Peak Depth= 1.28' @ 12.10 hrs
Capacity at bank full= 147.95 cfs
Inlet Invert= 848.00', Outlet Invert= 829.92'
3.00' x 2.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 11.00'
Length= 490.9' Slope= 0.0368 '/'

Reach RN8: downchute

[62] Warning: Submerged 19% of Reach C5 inlet

Inflow Area = 24.510 ac, Inflow Depth > 3.66" for 100 Y 24 H event
Inflow = 111.95 cfs @ 12.12 hrs, Volume= 7.469 af
Outflow = 111.63 cfs @ 12.12 hrs, Volume= 7.468 af, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 11.7 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 3.9 fps, Avg. Travel Time= 0.3 min

Peak Depth= 1.56' @ 12.12 hrs
Capacity at bank full= 188.67 cfs
Inlet Invert= 829.12', Outlet Invert= 817.64'
3.00' x 2.00' deep channel, n= 0.050 Earth, cobble bottom, clean sides
Side Slope Z-value= 2.0 '/' Top Width= 11.00'
Length= 69.0' Slope= 0.1664 '/'

Reach RN9:

Inflow Area = 5.380 ac, Inflow Depth > 3.67" for 100 Y 24 H event
Inflow = 28.40 cfs @ 12.03 hrs, Volume= 1.645 af
Outflow = 26.82 cfs @ 12.12 hrs, Volume= 1.638 af, Atten= 6%, Lag= 4.8 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.0 fps, Min. Travel Time= 2.9 min
Avg. Velocity = 1.5 fps, Avg. Travel Time= 9.4 min

Peak Depth= 1.06' @ 12.07 hrs
Capacity at bank full= 98.04 cfs
Inlet Invert= 848.00', Outlet Invert= 834.16'
3.00' x 2.00' deep channel, n= 0.030 Rubble masonry, cemented
Side Slope Z-value= 2.0 '/' Top Width= 11.00'
Length= 855.7' Slope= 0.0162 '/'

TVA-00021144

Attachment 9

Sediment Storage Volume

SEDIMENT STORAGE VOLUME

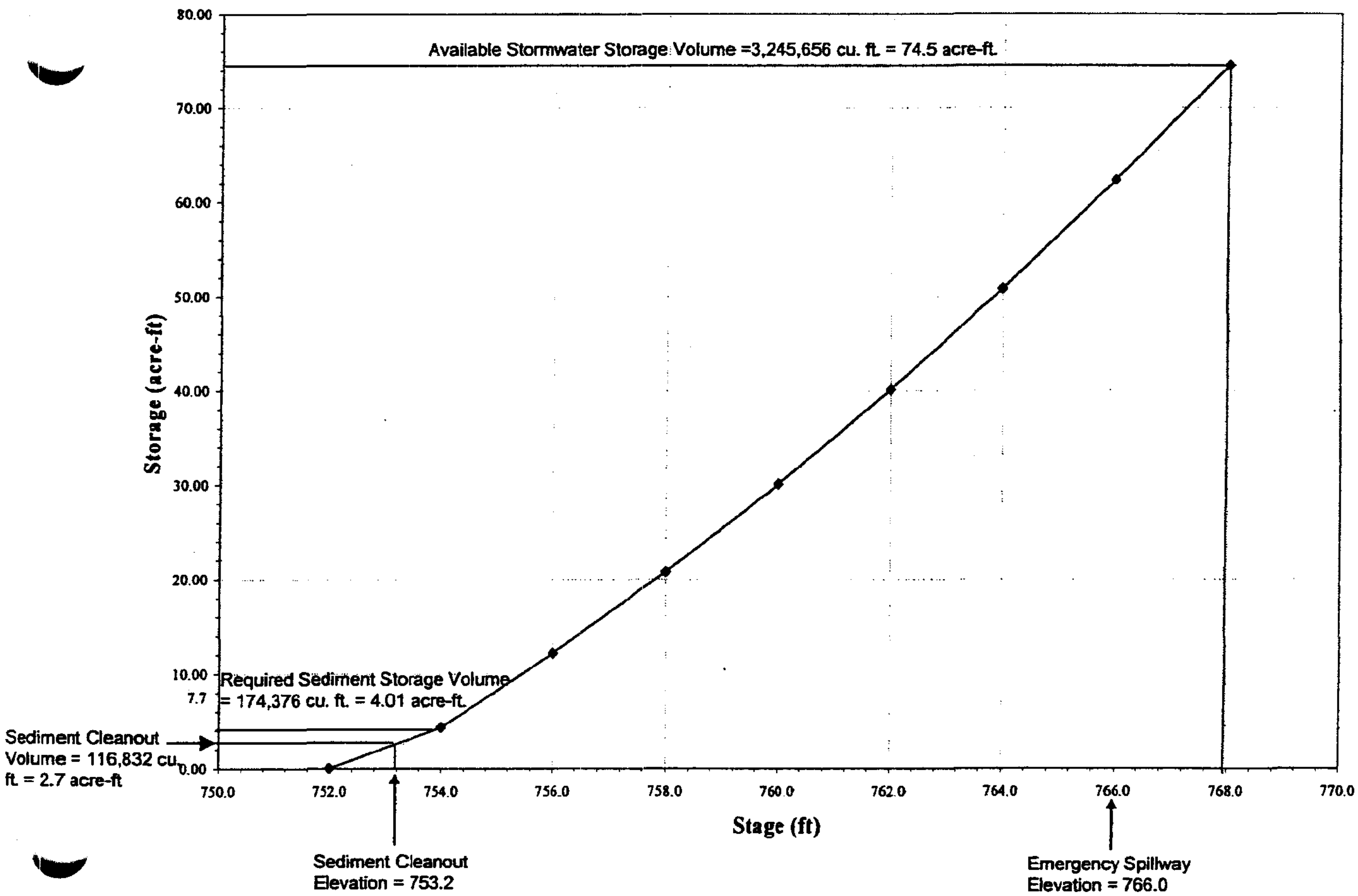
The stormwater pond is designed to hold 67 cubic yards per acre of drainage area (sediment storage volume) and the calculated runoff volume from a 25-year 24-hour design storm without the water elevation reaching the elevation of the emergency spillway. For the 100-year 24-hour storm event, the water elevation reaches the emergency spillway, and a small discharge (0.14 cfs) occurs through it.

Required Sediment Storage Volume = 67 cubic yards / acre of disturbed area

Stormwater Pond (SP):

Total disturbed area flowing to stormwater pond= 96.6 acres

∴ Required Sediment Storage Volume = 6472.2 cubic-yards
= 174,749 cubic-ft. = 4.01 acre-ft.
< Available Stormwater Storage Volume, OK



Based on the stage storage relationship shown above, for the Stormwater Pond:

Sediment Cleanout Volume = 0.67 * Required Sediment Storage Volume
= 0.67 x 174,376 cubic-ft
= 116,832 cubic-ft. = 2.68 acre-ft.

Sediment Cleanout Elevation = 753.2 ft.

Attachment 10

Design of Drainage Benches

DESIGN OF DRAINAGE BENCH

METHODOLOGY

The drainage bench design is checked for the critical bench (i.e., the drainage bench with the maximum discharge). In order to determine the location of the critical bench, the peak discharge from each Subarea located on the final cover during a 25-year 24-hour storm (computed using HydroCAD) is plotted against the plan area of the Subarea. As indicated in Figure 1, a linear relationship is observed between area and peak discharge.

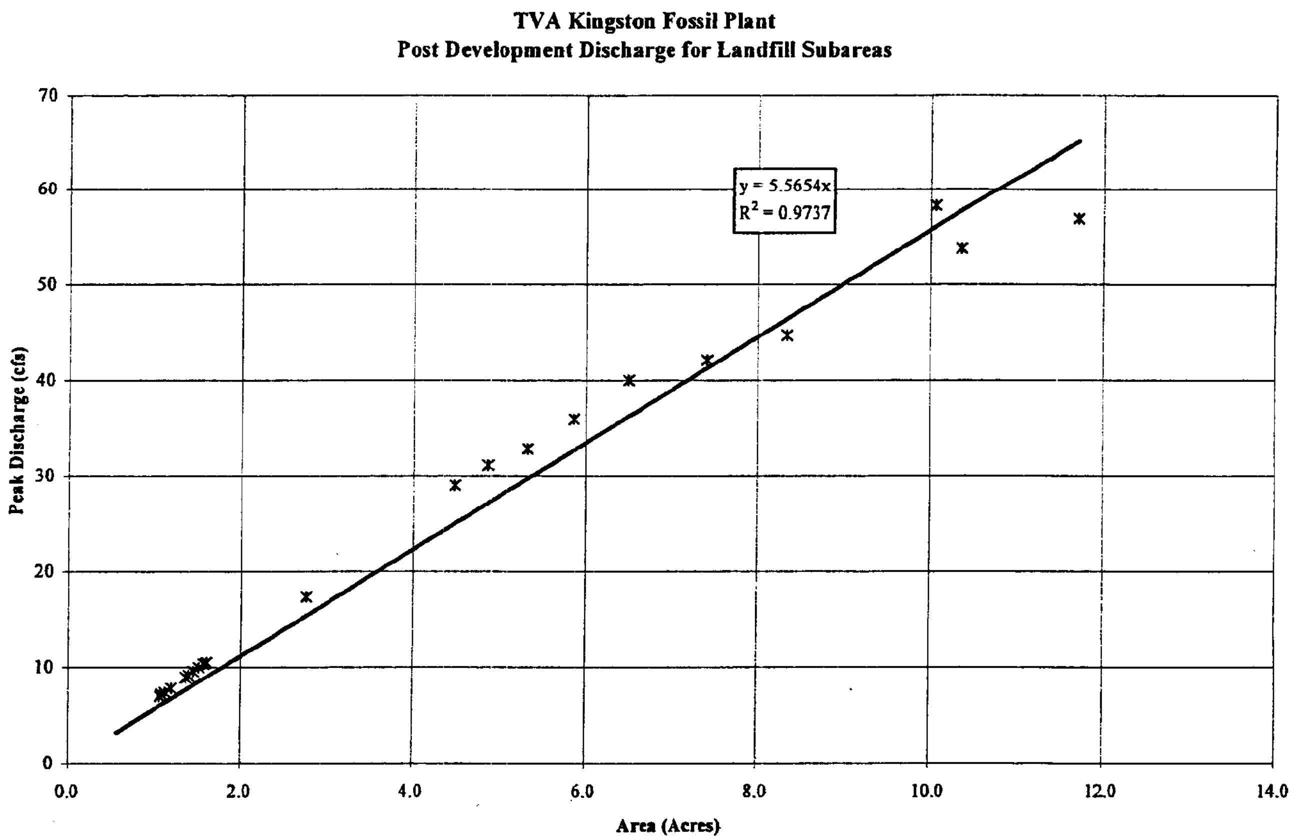


Figure 1. Post Development Discharge for Final Cover Subareas.

Based on the observed linear relationship, the location of the critical bench is estimated as the bench with the largest contributing cover area. The location is shown on the attached Figure 2. The linear relationship is used to estimate the peak discharge in the critical bench during a 25-year 24-hour storm.

Contributing final cover area for the critical bench = 2.33 acres

Based on the Relation Shown above:
During a 25-year 24-hour storm, peak bench flow = 2.33 acres * 5.57 cfs/acre = 12.98 cfs

The flow capacity of the bench is calculated using Manning's equation for open channel flow.
As indicated below:
Bench capacity at full flow depth = 83.9 cfs > 12.98 cfs ==> OK
At design discharge,
Flow depth = 0.75 ft ==> Freeboard = 1.5 – 0.75 = 0.75 ft. = 9 in.

Written by: Sowmya Bulusu / Alexander Maestre Date: 12/07/06 Reviewed by: Ganesh Gopalakrishnan Date: 12/13/06

Client: TVA Project: Kingston Fossil Plant Gypsum Disposal Facility Project/Proposal No.: GR3731 Task No.: 06

Design/Check: Trapezoidal/Triangular Channel

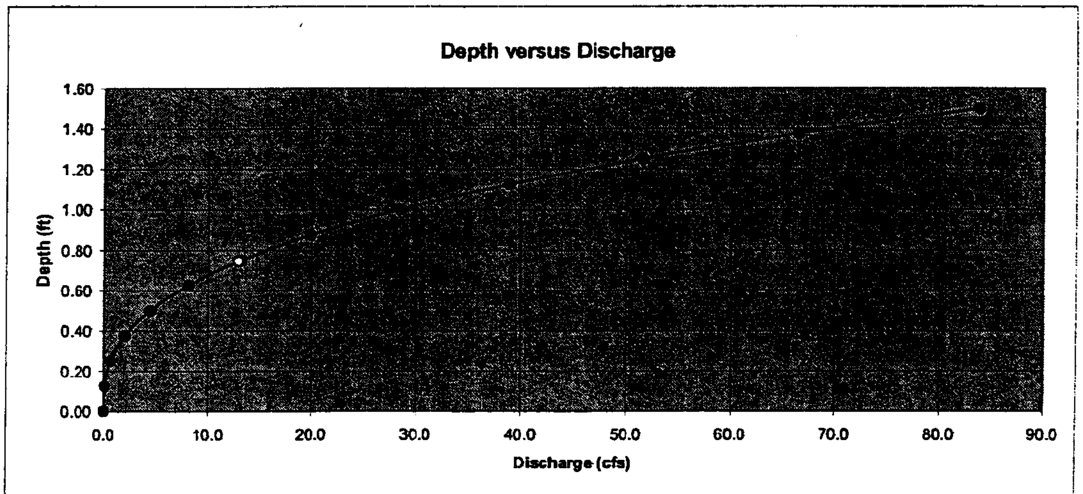
Methodology: Manning's Equation

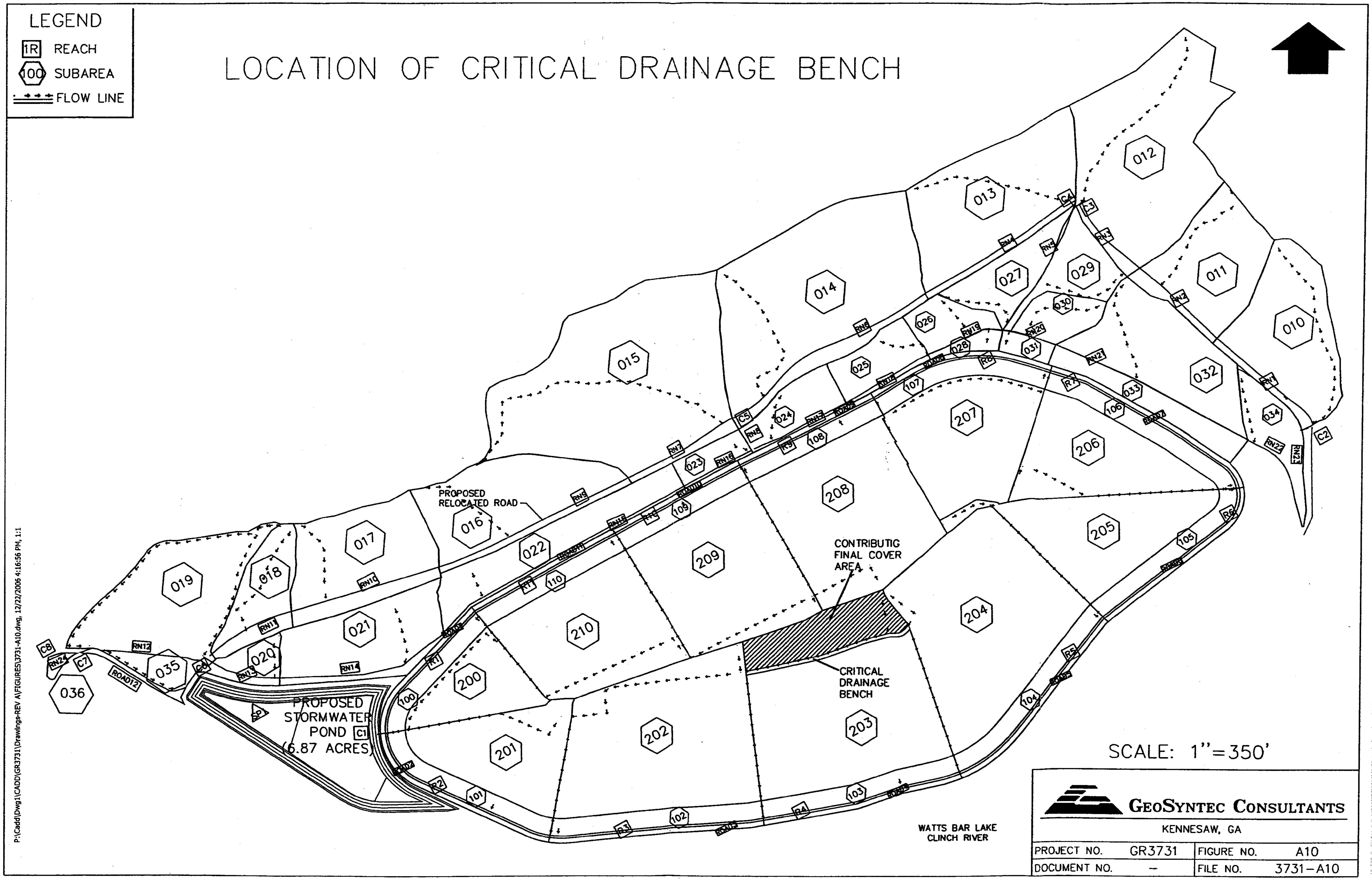
Project: TVA Kingston Fossil Plant

Ditch ID: Drainage Bench

Peak Discharge, Q_{max} =	12.98	cfs
Bottom Width, B =	0.00	ft
Left Side Slope, Z_1 =	10.00	horizontal :1 vertical
Right Side Slope, Z_2 =	3.00	horizontal :1 vertical
Manning's Roughness Coeff., n =	0.0300	
Longitudinal Channel Slope, S_o =	0.0200	ft/ft
Rip-Rap size needed, d_{50} =	2.0379	inches
mpirical Manning's Roughness Coeff., n =		

Depth of Flow Y ft	Area of Flow A ft²	Wetted Perimeter P ft	Hydraulic Radius R=A/P ft	Channel Slope ft/ft	Average Velocity V ft/s	Discharge (Flow Rate) Q=AV ft³/s	Avg. Tractive Stress τ_o lb/ft²	Comments
0.00	0.00	0.00	0.00	0.020	0.00	0.0	0.00	
0.13	0.10	1.65	0.06	0.020	1.09	0.1	0.08	
0.25	0.41	3.30	0.12	0.020	1.74	0.7	0.15	
0.38	0.91	4.95	0.18	0.020	2.28	2.1	0.23	
0.50	1.63	6.61	0.25	0.020	2.76	4.5	0.31	
0.63	2.54	8.26	0.31	0.020	3.20	8.1	0.38	
0.75	3.66	9.91	0.37	0.020	3.61	13.2	0.46	
0.88	4.98	11.56	0.43	0.020	4.00	19.9	0.54	
1.00	6.50	13.21	0.49	0.020	4.38	28.4	0.61	
1.13	8.23	14.86	0.55	0.020	4.73	38.9	0.69	
1.25	10.16	16.52	0.61	0.020	5.08	51.6	0.77	
1.38	12.29	18.17	0.68	0.020	5.41	66.5	0.84	
1.50	14.63	19.82	0.74	0.020	5.74	83.9	0.92	
0.75	3.61	9.84	0.37	0.020	3.60	12.98	0.46	DESIGN Q





TVA-00021152

Attachment 11

Design of Downdrains

DESIGN OF DOWNDRAINS

METHODOLOGY

For the design of the downdrains, the critical condition was identified as the downdrain with the mildest slope (4 percent at drainage bench), receiving the highest discharge from a subarea (Subarea 202) to a downdrain.

The highest flow from a subarea to a downdrain is obtained from HydroCAD post-development analysis for the 25-year, 24-hour storm event. The highest flow (58.20 cfs) to a downdrain is anticipated from Subarea 202 (Attachment 2). The capacity of a 24-inch downdrain with a longitudinal slope of 4 percent is 70.47 cfs.

$Q_{anticipated} = 58.20$,

$Q_{max} = 70.47$ cfs

$Q_{anticipated} < Q_{max}$ ==> OK

Written by: Sowmya Bulusu / Alexander Maestre Date: 12/07/06 Reviewed by: Ganesh Gopalakrishnan Date: 12/13/06

Client: TVA Project: Kingston Fossil Plant Gypsum Disposal Facility Project/Proposal No.: GR3731 Task No.: 06

Flow Through Circular Pipe

Diameter of pipe, D=	24	inches
Longitudinal Slope, So=	0.04	ft/ft
Manning's n=	0.009	
Density of flowing liquid, rho=	1.94	slugs/ft^3

Theta (radians)	Theta (degrees)	Depth of Flow (inches)	Area of Flow A (ft2)	Wetted Perimeter P (ft)	Hydraulic Radius R (ft)	Average Velocity V (ft/s)	Discharge Q=A*V (cfs)	Force F (lb)
0.00	0	0.0	0.000	0.00		0.0	0.00	0.0
0.25	14	0.1	0.001	0.25	0.01	1.0	0.00	0.0
0.50	29	0.4	0.010	0.50	0.02	2.5	0.03	0.1
0.75	43	0.8	0.034	0.75	0.05	4.2	0.14	1.2
1.00	57	1.5	0.079	1.00	0.08	6.1	0.48	5.7
1.25	72	2.3	0.151	1.25	0.12	8.1	1.21	19.0
1.50	86	3.2	0.251	1.50	0.17	10.1	2.53	49.3
1.75	100	4.3	0.383	1.75	0.22	12.0	4.60	107.3
2.00	115	5.5	0.545	2.00	0.27	13.9	7.59	204.9
2.25	129	6.8	0.736	2.25	0.33	15.7	11.56	352.5
2.50	143	8.2	0.951	2.50	0.38	17.4	16.52	556.8
2.75	158	9.7	1.184	2.75	0.43	18.9	22.35	818.5
3.00	172	11.2	1.429	3.00	0.48	20.2	28.87	1130.9
3.25	186	12.7	1.679	3.25	0.52	21.3	35.79	1479.9
3.50	201	14.1	1.925	3.50	0.55	22.2	42.79	1845.1
3.75	215	15.6	2.161	3.75	0.58	22.9	49.53	2202.8
4.00	229	17.0	2.378	4.00	0.59	23.4	55.68	2528.4
4.25	244	18.3	2.572	4.25	0.61	23.7	60.94	2800.6
4.50	258	19.5	2.739	4.50	0.61	23.8	65.12	3003.4
4.75	272	20.6	2.875	4.75	0.61	23.7	68.09	3128.8
5.00	286	21.6	2.979	5.00	0.60	23.4	69.85	3176.6
5.25	301	22.4	3.054	5.25	0.58	23.1	70.47	3154.3
5.50	315	23.1	3.103	5.50	0.56	22.6	70.13	3075.0
5.75	329	23.6	3.129	5.75	0.54	22.1	69.05	2955.8
6.00	344	23.9	3.140	6.00	0.52	21.5	67.49	2814.7
6.25	358	24.0	3.142	6.25	0.50	20.9	65.75	2669.3

Q

Attachment 12

Design of Drainage Channels

Written by: Sowmya Bulusu / Alexander Maestre Date: 12/07/06 Reviewed by: Ganesh Gopalakrishnan Date: 12/13/06

Client: TVA Project: Kingston Fossil Plant Gypsum Disposal Facility Project/Proposal No.: GR3731 Task No.: 06

TVA KINGSTON FOSSIL PLANT LANDFILL, ROANE COUNTY, TENNESSEE
SURFACE WATER MANAGEMENT SYSTEM CALCULATIONS
PERIMETER DRAINAGE CHANNELS

Reach No [1]	Length (ft)	Starting Elevation (ft)	Ending Elevation (ft)	Slope, S_o (ft/ft)	Width, B (ft)	Depth of channel, D (ft)	Left side slope H:1V	Right side slope H:1V	Post -Development Analysis results [3]			Average Traction Stress (psf)	Free Overboard (in)	Lining Type	Riprap d50 (inch)
									25 –year, 24 – hour Discharge (cfs)	Depth of flow (ft)	Maximum Velocity (ft/s)				
R1	617.6	786.58	759.39	0.0440	5.5	3.00	2.0	3.0	143.35	1.48	10.5	2.77	18.2	Riprap	12.41
R2	822.6	773.1	759.39	0.0167	5.5	3.00	3.0	2.0	216.31	2.32	8.2	1.52	8.2	Riprap	7.1
R3	870.4	781.2	773.1	0.0093	5.5	3.00	3.0	2.0	200.54	2.49	6.4	0.90	6.1	Grass	-
R4	828.1	789.05	781.2	0.0095	5.5	3.00	3.0	2.0	153.80	2.23	6	0.83	9.2	Grass	-
R5	869.2	800	789.05	0.0126	5.5	3.00	3.0	2.0	104.36	1.71	6	0.89	15.5	Grass	-
R6	777.2	805.92	797.85	0.0104	5.5	3.00	3.0	2.0	79.37	1.56	5.2	0.68	17.3	Grass	-
R7	908.9	815.32	805.92	0.0103	5.5	3.00	3.0	2.0	56.26	1.27	4.7	0.58	20.8	Grass	-
R8	767.1	823.23	815.32	0.0103	5.5	3.00	3.0	2.0	12.05	0.53	2.9	0.28	29.6	Grass	-
R9	611.2	823.23	816.31	0.0113	5.5	3.00	2.0	3.0	9.92	0.47	2.8	0.28	30.4	Grass	-
R10	578.9	816.31	809.39	0.0120	5.5	3.00	2.0	3.0	57.43	1.27	5	0.67	20.8	Grass	-
R11	655.3	809.39	786.59	0.0348	5.5	3.00	2.0	3.0	96.78	1.28	8.6	1.95	20.6	Riprap	9.59

Notes:

(1) Reach numbers as shown in the Schematic Surface Water Management Plan

(2) Maximum Allowable discharge computed using Manning's equation

(3) Summary of post-development analysis was obtained from HydroCAD output presented in Attachment 8

Written by: Sowmya Bulusu / Alexander Maestre Date: 12/07/06 Reviewed by: Ganesh Gopalakrishnan Date: 12/13/06

Client: TVA Project: Kingston Fossil Plant Gypsum Disposal Facility Project/Proposal No.: GR3731 Task No.: 06

TVA KINGSTON FOSSIL PLANT LANDFILL, ROANE COUNTY, TENNESSEE
SURFACE WATER MANAGEMENT SYSTEM CALCULATIONS
RUN-ON DRAINAGE CHANNELS

Reach No [1]	Length (ft)	Starting Elevation (ft)	Ending Elevation (ft)	Slope, S_o (ft/ft)	Width, B (ft)	Depth of channel, D (ft)	Left side slope H:1V	Right side slope H:1V	Post –Development Analysis results [3]			Average Traction Stress (psf)	Free Overboard (in)	Lining Type	Riprap d50 (inch)
									25 -year 24 hour Discharge (cfs)	Depth of flow (ft)	Maximum Velocity (ft/s)				
RN1	528.7	828	768.08	0.1133	3.0	2.00	2.0	2.0	26.07	0.62	9.8	3.22	16.6	Riprap	17.23
RN2	432.3	828	818	0.0231	3.0	2.00	2.0	2.0	16.53	0.74	4.9	0.76	15.1	Grass	-
RN3	371.4	818	810	0.0215	3.0	2.00	2.0	2.0	43.91	1.26	6.3	1.08	8.9	Riprap	5.14
RN4	731.1	861.9	808.75	0.0727	3.0	2.00	2.0	2.0	25.33	0.69	8.4	2.25	15.7	Riprap	11.15
RN5	591.7	808.12	791.5	0.0281	3.0	3.00	2.0	2.0	76.24	1.55	8.0	1.67	17.4	Riprap	7.60
RN6	947.6	861.9	829.92	0.0337	3.0	2.00	2.0	2.0	44.02	1.11	7.3	1.53	10.7	Riprap	7.48
RN7	490.9	848	829.92	0.0368	3.0	2.00	2.0	2.0	45.85	1.12	7.7	1.68	10.6	Riprap	8.21
RN8	69	829.12	817.64	0.1664	3.0	2.00	2.0	2.0	86.3	1.37	10.9	8.95	7.56	Riprap	36.11
RN9	855.7	848	834.16	0.0162	3.0	2.00	2.0	2.0	21.99	0.92	4.6	0.63	13.0	Grass	-
RN10	627.6	834.16	794.93	0.0625	3.0	2.00	2.0	2.0	37.64	0.88	8.8	2.36	13.4	Riprap	11.77
RN11	378.5	794.93	766.18	0.0760	3.0	2.00	2.0	2.0	44.06	0.91	9.9	2.94	13.1	Riprap	14.89
RN12	430	765.33	755.50	0.0229	4.0	5.00	2.0	2.0	123.66	1.89	8.4	1.69	53.5	Riprap	7.13
RN13	246.6	770.60	766.18	0.0179	4.0	5.00	2.0	2.0	93.86	1.75	7.1	1.24	39.0	Riprap	5.16
RN14	712.3	781.64	770.60	0.0155	4.0	5.00	2.0	2.0	95.09	1.82	6.7	1.11	38.2	Riprap	5.25
RN15	1158.2	814.27	781.64	0.0282	6.0	3.00	2.0	2.0	93.79	1.32	8.0	1.69	44.2	Riprap	8.61
RN16	311.5	817.5	814.27	0.0104	6.0	3.00	2.0	2.0	92.65	1.72	5.6	2.09	15.4	Riprap	8.44
RN17	416.6	822.36	817.5	0.0117	0.0	3.00	2.0	2.0	7.43	1.05	3.2	0.34	23.4	Grass	-
RN18	392.0	822.36	816.53	0.0149	3.0	5.00	2.0	2.0	7.73	0.54	3.3	0.38	53.5	Grass	-
RN19	391.7	816.53	791.5	0.0639	3.0	6.00	2.0	2.0	13.30	0.50	6.6	1.52	66.0	Riprap	7.46
RN20	229.0	791.5	790.12	0.0060	3.0	29.00	2.0	2.0	86.61	2.37	4.7	0.51	319.6	Grass	-
RN21	872.8	790.12	770	0.0231	3.0	8.00	2.0	2.0	101.66	1.86	8.0	1.59	73.7	Riprap	7.78
RN22	465.1	770	764	0.0129	18.0	3.00	2.0	2.0	120.56	1.09	5.5	0.77	22.9	Grass	-
RN23	154.8	767.38	764	0.0289	1.0	2.00	2.0	2.0	25.31	1.02	6.2	1.01	11.8	Riprap	5.46
RN24	91.5	751.64	749.59	0.0224	4.0	5.00	2.0	2.0	140.94	2.03	8.6	1.75	35.6	Riprap	8.47

NOTES:

(1) Reach numbers as shown in the Schematic Surface Water Management Plan

(2) Maximum Allowable discharge computed using Manning's equation

(3) Summary of post-development run-on analysis was obtained from HydroCAD output presented in Attachment 8

Attachment 13

Design of Culverts

DESIGN OF CULVERTS

TABLE 1. SURFACE WATER MANAGEMENT SYSTEM CALCULATIONS - CULVERTS

Pipe Designation in HydroCAD		Diameter (in)	Length (ft)	Starting Elevation (ft)	Ending Elevation (ft)	Slope (ft/ft)	Manning n	Maximum Flow Capacity (cfs)	25-year 24-hour Discharge (cfs)
ID	**Type**								
C1	Concrete	(3) x 48"	54.2	759.39	758.31	0.020	0.013	608.3	335.25
C2	Concrete	(1) x 36"	69.8	768.08	767.38	0.010	0.013	66.79	19.59
C3	Concrete	(1) x 36"	69.8	810.00	808.37	0.023	0.013	101.93	43.26
C4	Concrete	(1) x 36"	63.5	808.75	808.12	0.010	0.013	66.44	24.57
C5	Concrete	(1) x 48"	80	829.92	829.12	0.010	0.013	143.64	86.59
C6	Concrete	(2) x 48"	80.4	766.18	765.33	0.011	0.013	295.39	123.53
C7	Concrete	(3) x 48"	160	755.50	751.64	0.025	0.013	669.33	141.12
C8	Concrete	(3) x 48"	60	749.59	748.05	0.025	0.013	690.38	140.77

METHODOLOGY

The design of culverts is analyzed for the governing hydraulic condition (i.e., inlet control versus outlet control) using the computer program CulvertMaster, and the headwater depth (H_w) to diameter (D) ratio for the pipe under consideration is obtained from the output report generated by CulvertMaster, based on the 100-year, 24-hour peak discharge from culvert and culvert diameter (input parameters). Based on the headwater depth to diameter ratio the headwater depth at the culvert inlet is estimated. The headwater depths for culverts C1 to C8 are listed in table below. The CulvertMaster outputs for the culvert C1 through C8 are presented in this attachment.

TABLE 2. SUMMARY OF RESULTS FROM CulvertMaster® OUTPUTS.

Pipe Designation in HydroCAD ID	Diameter (in)	100-year, 24-hour Discharge (cfs)	Inlet Type	Ke	Control Type	H_w/ D	H_w (ft)
C1	(3) x 48"	431.12	Square edge w/headwall	0.5	Outlet	2.10	8.40
C2	(1) x 36"	25.38	Square edge w/headwall	0.5	Entrance	0.87	2.61
C3	(1) x 36"	56.11	Square edge w/headwall	0.5	Inlet	1.49	4.47
C4	(1) x 36"	31.90	Square edge w/headwall	0.5	Entrance	1.00	3.00
C5	(1) x 48"	112.3	Square edge w/headwall	0.5	Inlet	1.46	5.84
C6	(2) x 48"	165.45	Square edge w/headwall	0.5	Inlet	1.16	4.64
C7	(3) x 48"	189.69	Square edge w/headwall	0.5	Inlet	0.98	3.90
C8	(3) x 48"	189.25	Square edge w/headwall	0.5	Inlet	0.98	3.88

CULVERTMASTER - CULVERT CALCULATOR RESULTS

Culvert Calculator Report
TVA Kinston Fossil Plant - 100-yr 24-hr storm P=6.7 C1

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	0.00 ft	Headwater Depth/Height	2.10
Computed Headwater Elevi	767.80 ft	Discharge	431.12 cfs
Inlet Control HW Elev.	767.24 ft	Tailwater Elevation	764.21 ft
Outlet Control HW Elev.	767.80 ft	Control Type	Outlet Control

Grades

Upstream Invert	759.39 ft	Downstream Invert	758.31 ft
Length	54.20 ft	Constructed Slope	0.019926 ft/ft

Hydraulic Profile

Profile	PressureProfile	Depth, Downstream	5.90 ft
Slope Type	N/A	Normal Depth	2.49 ft
Flow Regime	N/A	Critical Depth	3.54 ft
Velocity Downstream	11.44 ft/s	Critical Slope	0.008942 ft/ft

Section

Section Shape	Circular	Mannings Coefficient	0.013
Section Material	Concrete	Span	4.00 ft
Section Size	48 inch	Rise	4.00 ft
Number Sections	3		

Outlet Control Properties

Outlet Control HW Elev.	767.80 ft	Upstream Velocity Head	2.03 ft
Ke	0.50	Entrance Loss	1.02 ft

Inlet Control Properties

Inlet Control HW Elev.	767.24 ft	Flow Control	Submerged
Inlet Type	Square edge w/headwall	Area Full	37.7 ft²
K	0.00980	HDS 5 Chart	1
M	2.00000	HDS 5 Scale	1
C	0.03980	Equation Form	1
Y	0.67000		

Culvert Calculator Report
TVA Kinston Fossil Plant - 100-yr 24-hr storm P=6.7 C2

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	0.00 ft	Headwater Depth/Height	0.87
Computed Headwater Elev:	770.69 ft	Discharge	25.38 cfs
Inlet Control HW Elev.	770.47 ft	Tailwater Elevation	0.00 ft
Outlet Control HW Elev.	770.69 ft	Control Type	Entrance Control

Grades

Upstream Invert	768.08 ft	Downstream Invert	767.38 ft
Length	69.80 ft	Constructed Slope	0.010029 ft/ft

Hydraulic Profile

Profile	S2	Depth, Downstream	1.32 ft
Slope Type	Steep	Normal Depth	1.28 ft
Flow Regime	Supercritical	Critical Depth	1.63 ft
Velocity Downstream	8.50 ft/s	Critical Slope	0.004429 ft/ft

Section

Section Shape	Circular	Mannings Coefficient	0.013
Section Material	Concrete	Span	3.00 ft
Section Size	36 inch	Rise	3.00 ft
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev.	770.69 ft	Upstream Velocity Head	0.65 ft
Ke	0.50	Entrance Loss	0.33 ft

Inlet Control Properties

Inlet Control HW Elev.	770.47 ft	Flow Control	Unsubmerged
Inlet Type	Square edge w/headwall	Area Full	7.1 ft²
K	0.00980	HDS 5 Chart	1
M	2.00000	HDS 5 Scale	1
C	0.03980	Equation Form	1
Y	0.67000		

Culvert Calculator Report
TVA Kinston Fossil Plant - 100-yr 24-hr storm P=6.7 C3

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	0.00 ft	Headwater Depth/Height	1.49
Computed Headwater Eleva	814.48 ft	Discharge	56.11 cfs
Inlet Control HW Elev.	814.48 ft	Tailwater Elevation	0.00 ft
Outlet Control HW Elev.	814.38 ft	Control Type	Inlet Control

Grades

Upstream Invert	810.00 ft	Downstream Invert	808.37 ft
Length	69.80 ft	Constructed Slope	0.023352 ft/ft

Hydraulic Profile

Profile	S2	Depth, Downstream	1.75 ft
Slope Type	Steep	Normal Depth	1.59 ft
Flow Regime	Supercritical	Critical Depth	2.43 ft
Velocity Downstream	13.12 ft/s	Critical Slope	0.007238 ft/ft

Section

Section Shape	Circular	Mannings Coefficient	0.013
Section Material	Concrete	Span	3.00 ft
Section Size	36 inch	Rise	3.00 ft
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev.	814.38 ft	Upstream Velocity Head	1.30 ft
Ke	0.50	Entrance Loss	0.65 ft

Inlet Control Properties

Inlet Control HW Elev.	814.48 ft	Flow Control	Submerged
Inlet Type	Square edge w/headwall	Area Full	7.1 ft²
K	0.00980	HDS 5 Chart	1
M	2.00000	HDS 5 Scale	1
C	0.03980	Equation Form	1
Y	0.67000		

Culvert Calculator Report
TVA Kinston Fossil Plant - 100-yr 24-hr storm P=6.7 C4

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	0.00 ft	Headwater Depth/Height	1.00
Computed Headwater Elev:	811.74 ft	Discharge	31.90 cfs
Inlet Control HW Elev.	811.54 ft	Tailwater Elevation	0.00 ft
Outlet Control HW Elev.	811.74 ft	Control Type	Entrance Control

Grades			
Upstream Invert	808.75 ft	Downstream Invert	808.12 ft
Length	63.50 ft	Constructed Slope	0.009921 ft/ft

Hydraulic Profile			
Profile	S2	Depth, Downstream	1.51 ft
Slope Type	Steep	Normal Depth	1.46 ft
Flow Regime	Supercritical	Critical Depth	1.83 ft
Velocity Downstream	8.92 ft/s	Critical Slope	0.004800 ft/ft

Section			
Section Shape	Circular	Mannings Coefficient	0.013
Section Material	Concrete	Span	3.00 ft
Section Size	36 inch	Rise	3.00 ft
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	811.74 ft	Upstream Velocity Head	0.77 ft
Ke	0.50	Entrance Loss	0.39 ft

Inlet Control Properties			
Inlet Control HW Elev.	811.54 ft	Flow Control	Unsubmerged
Inlet Type	Square edge w/headwall	Area Full	7.1 ft²
K	0.00980	HDS 5 Chart	1
M	2.00000	HDS 5 Scale	1
C	0.03980	Equation Form	1
Y	0.67000		

Culvert Calculator Report
TVA Kinston Fossil Plant - 100-yr 24-hr storm P=6.7 C5

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	0.00 ft	Headwater Depth/Height	1.46
Computed Headwater Elev:	835.76 ft	Discharge	112.30 cfs
Inlet Control HW Elev.	835.76 ft	Tailwater Elevation	0.00 ft
Outlet Control HW Elev.	835.65 ft	Control Type	Inlet Control

Grades

Upstream Invert	829.92 ft	Downstream Invert	829.12 ft
Length	80.00 ft	Constructed Slope	0.010000 ft/ft

Hydraulic Profile

Profile	S2	Depth, Downstream	2.78 ft
Slope Type	Steep	Normal Depth	2.66 ft
Flow Regime	Supercritical	Critical Depth	3.20 ft
Velocity Downstream	12.07 ft/s	Critical Slope	0.006392 ft/ft

Section

Section Shape	Circular	Mannings Coefficient	0.013
Section Material	Concrete	Span	4.00 ft
Section Size	48 inch	Rise	4.00 ft
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev.	835.65 ft	Upstream Velocity Head	1.69 ft
Ke	0.50	Entrance Loss	0.84 ft

Inlet Control Properties

Inlet Control HW Elev.	835.76 ft	Flow Control	Submerged
Inlet Type	Square edge w/headwall	Area Full	12.6 ft²
K	0.00980	HDS 5 Chart	1
M	2.00000	HDS 5 Scale	1
C	0.03980	Equation Form	1
Y	0.67000		

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Culvert Calculator Report
TVA Kinston Fossil Plant - 100-yr 24-hr storm P=6.7 C6

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	0.00 ft	Headwater Depth/Height	1.16
Computed Headwater Elev:	770.81 ft	Discharge	165.45 cfs
Inlet Control HW Elev.	770.59 ft	Tailwater Elevation	0.00 ft
Outlet Control HW Elev.	770.81 ft	Control Type	Entrance Control

Grades

Upstream Invert	766.18 ft	Downstream Invert	765.33 ft
Length	80.40 ft	Constructed Slope	0.010572 ft/ft

Hydraulic Profile

Profile	S2	Depth, Downstream	2.26 ft
Slope Type	Steep	Normal Depth	2.14 ft
Flow Regime	Supercritical	Critical Depth	2.76 ft
Velocity Downstream	11.30 ft/s	Critical Slope	0.004933 ft/ft

Section

Section Shape	Circular	Mannings Coefficient	0.013
Section Material	Concrete	Span	4.00 ft
Section Size	48 inch	Rise	4.00 ft
Number Sections	2		

Outlet Control Properties

Outlet Control HW Elev.	770.81 ft	Upstream Velocity Head	1.25 ft
Ke	0.50	Entrance Loss	0.62 ft

Inlet Control Properties

Inlet Control HW Elev.	770.59 ft	Flow Control	N/A
Inlet Type	Square edge w/headwall	Area Full	25.1 ft²
K	0.00980	HDS 5 Chart	1
M	2.00000	HDS 5 Scale	1
C	0.03980	Equation Form	1
Y	0.67000		

Culvert Calculator Report
TVA Kinston Fossil Plant - 100-yr 24-hr storm P=6.7 C7

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	0.00 ft	Headwater Depth/Height	0.98
Computed Headwater Elev:	759.40 ft	Discharge	189.69 cfs
Inlet Control HW Elev.	759.10 ft	Tailwater Elevation	0.00 ft
Outlet Control HW Elev.	759.40 ft	Control Type	Entrance Control

Grades

Upstream Invert	755.50 ft	Downstream Invert	751.64 ft
Length	160.00 ft	Constructed Slope	0.024125 ft/ft

Hydraulic Profile

Profile	S2	Depth, Downstream	1.51 ft
Slope Type	Steep	Normal Depth	1.46 ft
Flow Regime	Supercritical	Critical Depth	2.40 ft
Velocity Downstream	14.58 ft/s	Critical Slope	0.004300 ft/ft

Section

Section Shape	Circular	Mannings Coefficient	0.013
Section Material	Concrete	Span	4.00 ft
Section Size	48 inch	Rise	4.00 ft
Number Sections	3		

Outlet Control Properties

Outlet Control HW Elev.	759.40 ft	Upstream Velocity Head	1.00 ft
Ke	0.50	Entrance Loss	0.50 ft

Inlet Control Properties

Inlet Control HW Elev.	759.10 ft	Flow Control	N/A
Inlet Type	Square edge w/headwall	Area Full	37.7 ft²
K	0.00980	HDS 5 Chart	1
M	2.00000	HDS 5 Scale	1
C	0.03980	Equation Form	1
Y	0.67000		

Culvert Calculator Report
TVA Kinston Fossil Plant - 100-yr 24-hr storm P=6.7 C8

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	0.00 ft	Headwater Depth/Height	0.97
Computed Headwater Eleva	753.49 ft	Discharge	189.25 cfs
Inlet Control HW Elev.	753.18 ft	Tailwater Elevation	0.00 ft
Outlet Control HW Elev.	753.49 ft	Control Type	Entrance Control

Grades

Upstream Invert	749.59 ft	Downstream Invert	748.05 ft
Length	60.00 ft	Constructed Slope	0.025667 ft/ft

Hydraulic Profile

Profile	S2	Depth, Downstream	1.64 ft
Slope Type	Steep	Normal Depth	1.43 ft
Flow Regime	Supercritical	Critical Depth	2.40 ft
Velocity Downstream	13.01 ft/s	Critical Slope	0.004296 ft/ft

Section

Section Shape	Circular	Mannings Coefficient	0.013
Section Material	Concrete	Span	4.00 ft
Section Size	48 inch	Rise	4.00 ft
Number Sections	3		

Outlet Control Properties

Outlet Control HW Elev.	753.49 ft	Upstream Velocity Head	1.00 ft
Ke	0.50	Entrance Loss	0.50 ft

Inlet Control Properties

Inlet Control HW Elev.	753.18 ft	Flow Control	N/A
Inlet Type	Square edge w/headwall	Area Full	37.7 ft²
K	0.00980	HDS 5 Chart	1
M	2.00000	HDS 5 Scale	1
C	0.03980	Equation Form	1
Y	0.67000		

ALTERNATIVE FINAL COVER SYSTEM DEMONSTRATION

GEOSYNTEC CONSULTANTS

COMPUTATION COVER SHEET

Client: TVA **Project:** KIF Gypsum Disposal Facility **Project/Proposal #:** GR3731 **Task #:** 06

TITLE OF COMPUTATIONS ALTERNATIVE FINAL COVER SYSTEM DEMONSTRATION

COMPUTATIONS BY:
Signature [signature] DATE 04/11/06
Printed Name and Title: Sowmya Bulusu, Staff Engineer

ASSUMPTIONS AND PROCEDURES CHECKED BY: (Peer Reviewer)
Signature T. Elkady DATE 05/11/06
Printed Name and Title: Tamer Y. Elkady, Engineer

COMPUTATIONS CHECKED BY:
Signature Basak Gulec DATE 05/11/06
Printed Name and Title: Basak Gulec, Engineer

COMPUTATIONS BACKCHECKED BY: (Originator)
Signature [signature] DATE 05/10/06
Printed Name and Title: Sowmya Bulusu, Staff Engineer

APPROVED BY: (PM or Designate)
Signature R. Neil Davies DATE May 11, 2006
Printed Name and Title: Neil Davies, Principal/Vice President

APPROVAL NOTES:

REVISIONS (Number and initial all revisions)

NO.	SHEET	DATE	BY	CHECKED BY	APPROVAL

ALTERNATIVE FINAL COVER SYSTEM DEMONSTRATION

PURPOSE OF ANALYSES

The purpose of the analyses presented in this calculation package is to demonstrate the equivalency of an alternative final cover system for Kingston Fossil Plant Gypsum disposal facility (herein referred as KIF Gypsum disposal facility) to the prescribed final cover system meeting minimum technical requirements of Tennessee Department of Environment and Conservation (TDEC) Chapter 1200-1-7 [TDEC, 2005].

INTRODUCTION

Waste placement activities in the disposal area will be followed by the construction of a final cover system. The proposed alternative final cover consists of (from top to bottom):

- a 12-inch thick vegetative layer;
- a geocomposite drainage layer, consisting of a High-Density PolyEthylene (HDPE) geonet with geotextile filters heat bonded to both sides of the geonet;
- a 40-mil thick linear HDPE geomembrane; and
- a 12-inch thick compacted soil layer.

Regulations that describe the minimum technical requirements for final cover system at Class I and Class II facilities are included in Chapter 1200-1-7 of "*Rules of TDEC, Division of Solid Waste Management*" [TDEC, 2005]. According to this rule, the final cover system should consist of (from top to bottom):

- a vegetative layer at least 12 inches in thickness; and
- a compacted soil layer below it, at least 24 inches in thickness with permeability no greater than 1×10^{-7} cm/sec.

The details of the prescribed and proposed alternative final cover systems are shown in Figure 1.

DEMONSTRATION OF EQUIVALENCY OF THE PROPOSED FINAL COVER SYSTEM

According to Rule 1200-1-7, the Department may approve alternative final cover designs if determined by the staff to meet or exceed the minimum standards. The performances of the prescribed and alternative final cover systems are compared in terms of the infiltration through the final cover. The vegetative layer of the proposed final cover system (12-in thickness) is consistent with the Regulation 200-1-7 prescribed vegetative layer and therefore it will not be discussed further.

In the proposed alternative final cover system, the upper component of the composite infiltration barrier system is a geomembrane, below which is a 12-inch thick layer of compacted soil. In addition, the proposed alternative final cover has a geocomposite drainage layer that is placed above the geomembrane to reduce the hydraulic head on the infiltration barrier.

METHOD OF ANALYSIS

Comparison of hydraulic performances of the alternative and prescribed final cover systems is carried out using the Hydrologic Evaluation of Landfill Performance (HELP) model, Version 3.07, developed by the U.S. Environmental Protection Agency (USEPA) [Schroeder et al., 1994 a, b]. The HELP program is a quasi two-dimensional hydrologic model of water movement across, into, through, and out of landfills. The program accepts climatologic, soil, and design data, and uses a solution technique that accounts for the effects of surface storage, runoff, infiltration, percolation, evaporation, soil moisture storage, and lateral drainage.

PARAMETERS USED IN HELP MODEL ANALYSIS

Climatic Data

- The mean monthly precipitation data was obtained from the National Climatic Data Center CDROM "*NCDC SUMMARY OF THE DAY*" published by EarthInfo Inc. [EarthInfo, 2005]. Daily precipitation data between 1948 and 2005 for the closest weather station to the site (i.e., Kingston, Weather Station ID: 404871) were averaged to obtain the normal mean monthly precipitation data. The precipitation was modeled in the HELP program using the synthetic daily weather generation option for Knoxville, Tennessee (over a 100-year modelling period) in conjunction with the calculated normal mean monthly precipitation data.

- The temperature, relative humidity, and solar radiation were modeled for Knoxville, Tennessee using the synthetic daily weather generation over a 100-year modeling period.

- The evaporative zone depth was selected as 12 in. from HELP default values, since the thickness of the vegetative cover soil for the prescribed and alternative final cover systems is 12 in.

Layer Material Properties

Final Cover System Data

The material properties used to represent the different components of the final cover are presented in Table 1. The final cover system was assumed to be vegetated with good stand of grass and runoff was allowed.

The analyzed drainage path is the length between the drainage benches on the final cover, i.e., 90 feet, at a slope of 33.3% (3 horizontal: 1 vertical).

Table 1. Layer Material Properties for Prescriptive and Proposed Alternative Final Cover System

Cover	Component	Thickness	HELP Material Texture #	Type / Classification	Total Porosity	Field Capacity	Wilting Point	Saturated Hydraulic Conductivity, k (cm/s)
Prescribed	Vegetative Cover(1)	12-inch	12	CL	0.471	0.342	0.210	4.2×10^{-5}
	Compacted Clay Layer	24-inch	16	Barrier Soil	0.427	0.418	0.367	1×10^{-7}
Alternative	Vegetative Cover(1)	12-inch	12	CL	0.471	0.342	0.210	4.2×10^{-5}
	Geocomposite(3) Drainage Layer	200-mil	20	Drainage Net	0.850	0.01	0.005	4.17 (3)
	Geomembrane (2)	40-mil	35	GM	0.000	0.000	0.000	2×10^{-13}
	Compacted Soil Layer(1)	12-inch	26	CL	0.445	0.393	0.277	1.9×10^{-6}

Notes:

(1) It was assumed that soils obtained from the on-site borrow areas would be used as vegetative cover and compacted soil layers. Information on the on-site potential borrow soils was obtained from the report titled "*Report of Geotechnical Investigation*" prepared by MACTEC in April 2006 [MACTEC, 2006]. Three types of soil s were identified during MACTEC [2006] subsurface explorations and laboratory testing. These soils were classified as MH, CH, and CL based on the Unified Soil Classification System (USCS). In the HELP analysis, CL and compacted CL were used for the vegetative cover and the compacted soil layer, respectively. HELP's default hydraulic conductivities were used for these layers. The default hydraulic conductivities were within the range of hydraulic conductivities obtained from laboratory testing (i.e., 2.8×10^{-5} cm/s to 6.7×10^{-8} cm/s) for MH, CH, and CL soil samples [MACTEC, 2006].

(2) Geomembrane was assumed to contain one hole per acre assuming good placement quality can be achieved through third-party CQA testing. The hole size was assumed to be 0.16 in^2, as recommended for these types of calculations by Giroud and Bonaparte [1989].

(3) The geocomposite drainage layer hydraulic conductivity value was estimated using a procedure described in the Attachment 1 of this calculation package.

RESULTS

The results of the HELP Model analyses are summarized in Table 2. The HELP model output files are included in Attachment 2.

Table 2. Infiltration rate comparison for the prescribed and alternative final cover systems.

Final Cover System	Average Annual Infiltration (in/day)	Peak Daily Infiltration (in/day)	Head on the top of the geomembrane (in) (peak daily)	
			Average	Maximum
Prescribed	3.20×10^{-3}	5.10×10^{-3}	12	12
Alternative	6.03×10^{-9}	9.09×10^{-8}	0.021	0.040

The results of these analyses (Attachment 2) show that less infiltration would occur through the proposed alternative final cover system than through the prescribed (i.e., compacted clay) final cover system.

In order to ensure that the synthetic component of the proposed final cover system will perform as analyzed, it is presented that, the synthetic component of the final cover will be constructed in accordance with the Material Specifications and Construction Quality Assurance and Quality Control (QA/QC) plan presented as part of this permit application.

CONCLUSION

Based on the analyses above, less infiltration would occur through the proposed alternative final cover system than for the prescribed (i.e., compacted clay) final cover system. The head in the final cover protection layer will also be less for the alternative final cover system compared to the prescribed one. Therefore, the alternative final cover system is considered superior to the prescribed final cover system.

REFERENCES

EarthInfo Inc., *NCDC Summary of the Day, Reference Manual*, EarthInfo Inc., 2005.

Giroud, J.P., Zornberg, J.G., and Zhao, A. "Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers", *Geosynthetics International*, Vol. 7, Nos. 4-6, 2000.

Giroud, J.P. and Bonaparte, R. "Leakage Through Liners Constructed with Geomembranes, Part I: Geomembrane Liners", *Geotextiles and Geomembranes,* Vol. 8, No. 1, pp. 27-67, 1989.

GRI-GC8, "*Determination of the Allowable Flow Rate of a Drainage Geocomposite*", Standard Guide, Geosynthetic Research Institute, April, 2001.

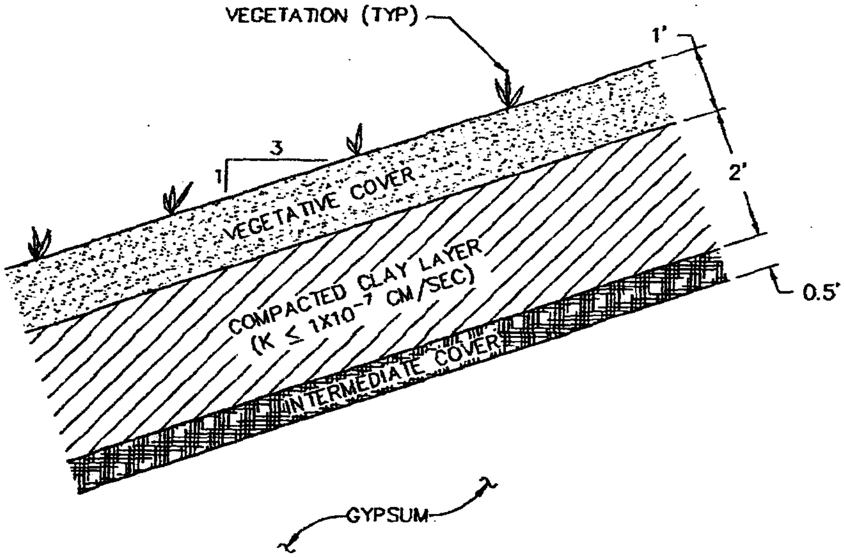
Koerner, R.M., "*Designing with Geosynthetics*", Third Edition, Prentice Hall, pp. 302 – 304, 1998.

MACTEC, "*Report of Geotechnical Investigation*", Prepared for Tennessee Valley Authority by MACTEC Engineering and Consulting, Inc., Project 3043051064.02, April 2006.

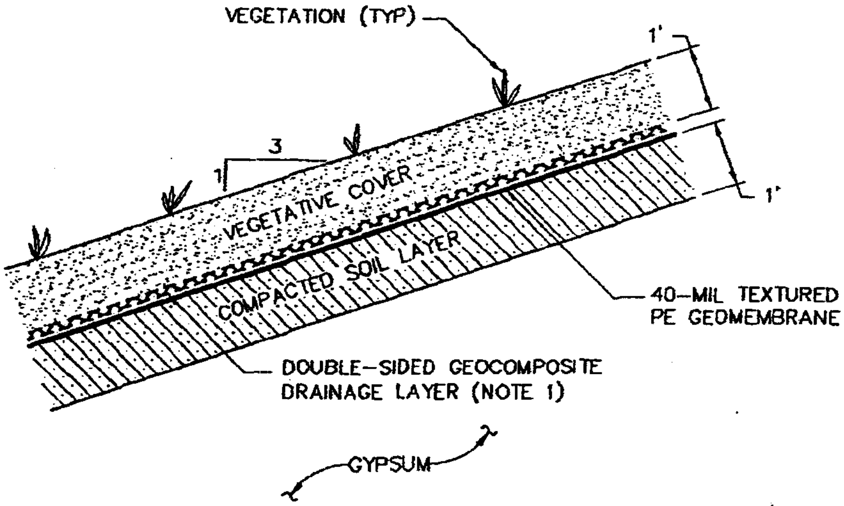
Schroeder, P. R., Lloyd, C. M., and Zappi, P. A., "*The Hydraulic Evaluation of Landfill Performance (HELP) Model, User's Guide for Version 3*", U.S. Environmental Protection Agency, Office of Research .d Development Washington, D.C., Report No. EPA/600/R094/168a, 1994 a.

Schroeder, P. R., Dozier, T. S., Zappi, P. A., McEnroe, B. M., Sjostrom, J. W., and Peyton, R. L., "*The Hydraulic Evaluation of Landfill Performance (HELP) Model, Engineering documentation for Version 3*", U.S. Environmental Protection Agency, Office of Research and Development Washington, D.C., Report No. EPA/600/R094/168b, 1994 b.

TDEC, "*Rules of Tennessee Department of Environment and Conservation, Chapter 1200-1-7 – Solid Waste Processing and Disposal*", Division of Solid Waste Management, January 2005.



(a) Prescribed Final Cover System



(b) Proposed Alternative Final Cover System

Figure 1. Details of Prescribed and Alternative Final Cover Systems

ATTACHMENT 1

DRAINAGE LAYER HYDRAULIC CONDUCTIVITY DESIGN VALUES

Drainage Layer Hydraulic Conductivity Design Values

For geocomposite drainage layer (Alternative Final Cover System)

The hydraulic conductivity of a geocomposite drainage layer is related to the hydraulic transmissivity (θ) and the thickness of the geocomposite drainage layer (t) as follows:

$$k = \frac{\theta}{t} \qquad (1)$$

where:

k	=	hydraulic conductivity (cm/sec);
θ	=	hydraulic transmissivity (cm^2/sec); and
t	=	drainage layer thickness (cm).

The following equations proposed by Giroud et al. [2000] are used to estimate an appropriate transmissivity design value for the geocomposite drainage layer.

$$\theta_{LTIS} = \frac{\theta_{measured}}{\prod(RF)} = \frac{\theta_{measured}}{RF_{IMCO} \times RF_{IMIN} \times RF_{CR} \times RF_{IN} \times RF_{CD} \times RF_{PC} \times RF_{CC} \times RF_{BC}} \qquad (2)$$

where:

θ_{LTIS}	=	long-term-in-soil hydraulic transmissivity of the geocomposite;
$\theta_{measured}$	=	value of hydraulic transmissivity measured in laboratory tests;
$\prod(RF)$	=	product of all reduction factors;
RF_{IMCO}	=	reduction factor for immediate compression, i.e. decrease of hydraulic transmissivity due to compression of the transmissive core immediately following the application of stress;
RF_{IMIN}	=	reduction factor for immediate intrusion, i.e. decrease of hydraulic transmissivity due to geotextile intrusion into the transmissive core immediately following the application of stress;
RF_{CR}	=	reduction factor for creep, i.e. time-dependent hydraulic transmissivity reduction due to creep of the transmissive core under the applied stress;
RF_{IN}	=	reduction factor for delayed intrusion, i.e. decrease of hydraulic transmissivity over time due to geotextile intrusion into the transmissive core resulting from time-dependent deformation of the

		geotextile;
RF_{CD}	=	reduction factor for chemical degradation, i.e. decrease of hydraulic transmissivity due to chemical degradation of the polymeric compound(s) used to make the geocomposite;
RF_{PC}	=	reduction factor for particulate clogging, i.e. decrease of hydraulic transmissivity due to clogging by particles migrating into the transmissive core;
RF_{CC}	=	reduction factor for chemical clogging, i.e. decrease of hydraulic transmissivity due to chemical clogging of the transmissive core;
RF_{BC}	=	reduction factor for biological clogging, i.e. decrease of hydraulic transmissivity due to biological clogging of the transmissive core;
θ_{design}	=	geocomposite transmissivity appropriate for use in design; and
FS	=	factor of safety to account for all possible uncertainties.

An overall factor of safety 1.5 is applied to the drainage layer transmissivity value. Therefore, θ_{design} can be calculated as follows:

$$\theta_{design} = \frac{\theta_{LTIS}}{FS} \quad (3)$$

where:

θ_{design}	=	geocomposite transmissivity appropriate for use in design; and
FS	=	overall factor of safety to account for all possible uncertainties.

The selection of each reduction factor was based on certain mechanisms that reduce the flow capacity of the geocomposite layer due to thickness reduction caused by applied stresses, and hydraulic conductivity reduction caused by clogging. Recommendations on the selection of these reduction factors were obtained from several sources available in the technical literature [Giroud et al, 2000; GRI-GC8, 2001; and Koerner, 1998]. Reduction factors incorporated for the alternative final cover are discussed as follows:

The final cover system experiences a low confining pressure and is designed to function for a long time. Immediate compression, immediate intrusion, chemical degradation, and chemical clogging will be negligible for the proposed final cover and therefore a RF of 1 was assumed for these factors. Creep, delayed intrusion, and particulate clogging were assumed to happen to a small degree (RF_{CR} = RF_{IN} = RF_{PC} = 1.1); some biological clogging were also assumed to occur (RF_{BC} = 1.2). The overall factor of safety was assumed equal to 1.5.

Table 1. Reduction Factors for Geocomposite Drainage Layer

Reduction Factors			
		Range of Values	Alternative Final Cover
RF_{IMCO} =	Reduction factor for immediate compression	1.0 (1)	1.0
RF_{IMIN} =	Reduction factor for immediate intrusion	1.0 (1)	1.0
RF_{CD} =	Reduction factor for chemical degradation	1.2	1.0
RF_{CC} =	Reduction factor for chemical clogging	1.0-1.2 (1)	1.0
RF_{CR} =	Reduction factor for creep	1.1-1.4 (1)	1.1
RF_{IN} =	Reduction factor for delayed intrusion	1.0-1.2 (1)	1.1
RF_{PC} =	Reduction factor for particulate clogging	1.2	1.1
RF_{BC} =	Reduction factor for biological clogging	1.2-1.5 (1)	1.2
	Overall Reduction Factors =	Π (RF)	**1.6**
FS =	Factor of safety to account for all possible uncertainties		1.5

Range of published values.

For this project, a bi-planar geocomposite drainage layer with an assumed thickness of 200 mils (i.e., 0.20 inches) and a measured hydraulic transmissivity ($\theta_{measured}$) of 5.08 x 10^{-4} m^2/sec was considered. A geocomposite product with these properties is a standard commercially available product. Based on the reduction factors described above, θ_{design} and k_{design} values were calculated based on the $\theta_{measured}$ using Equations (1) through (3). The corresponding k_{design} values are presented in Table 2.

Table 2. Design Hydraulic Conductivity for Geocomposite Drainage Layer

Operation Condition	$\theta_{measured}$ (m^2/s)	Π (RF)	θ_{LTIS} (m^2/s)	FS	θ_{design} (m^2/s)	t (mm)	k_{design} (cm/s)
Alternative Final Cover	5.08E-04	1.6	3.18E-04	1.5	2.12E-04	5.08	4.17

ATTACHMENT 2

HELP RUNS

PRESCRIBED FINAL COVER SYSTEM

Written by: Sowmya Bulusu Date: 04/11/06 Reviewed by: Basak Gulec Date: 04/27/06

Client: TVA Project: TVA Kingston Fossil Plant Landfill Project/Proposal No.: GR3731 Task No.: 06

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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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SOLAR RADIATION DATA FILE:    C:\HELP\TVA_1.D13
EVAPOTRANSPIRATION DATA:      C:\HELP\TVA_1.D11
SOIL AND DESIGN DATA FILE:    C:\HELP\TVA.D10
OUTPUT DATA FILE:             C:\HELP\TVA.OUT


TIME:  12:21      DATE:    5/ 5/2006


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     TITLE:  TVA Kingston Fossil Plant Landfill

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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  12
          THICKNESS                    =     12.00    INCHES
          POROSITY                     =      0.4710 VOL/VOL
          FIELD CAPACITY               =      0.3420 VOL/VOL
          WILTING POINT                =      0.2100 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.4209 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.419999997000E-04 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 3 -- BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #12 WITH A GOOD STAND OF GRASS, A SURFACE SLOPE OF 33.% AND A SLOPE LENGTH OF 90. FEET.

SCS RUNOFF CURVE NUMBER	=	85.30	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.050	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	5.652	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.520	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	15.298	INCHES
TOTAL INITIAL WATER	=	15.298	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM KNOXVILLE TENNESSEE

STATION LATITUDE	=	35.49	DEGREES
MAXIMUM LEAF AREA INDEX	=	4.50	
START OF GROWING SEASON (JULIAN DATE)	=	85	
END OF GROWING SEASON (JULIAN DATE)	=	307	
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	69.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	76.00	%

AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 72.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR KNOXVILLE TENNESSEE

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
5.28	4.94	5.67	4.32	4.56	4.00
4.72	3.50	3.78	2.88	4.55	5.48

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR KNOXVILLE TENNESSEE

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
35.40	40.30	49.80	59.10	67.10	73.50
77.20	76.50	70.30	60.20	50.30	38.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR KNOXVILLE TENNESSEE AND STATION LATITUDE = 35.49 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.90	5.10	5.40	4.25	4.94	3.89
	4.90	3.64	4.24	2.86	4.49	5.63
STD. DEVIATIONS	2.19	2.35	2.54	2.05	2.10	1.80
	2.25	1.51	2.29	1.75	2.33	3.09
RUNOFF						
TOTALS	3.659	4.094	2.718	0.999	0.563	0.223
	0.295	0.124	0.570	0.606	2.492	4.138
STD. DEVIATIONS	2.455	2.374	2.353	1.350	1.086	0.531
	0.536	0.357	0.995	1.023	2.170	2.888

EVAPOTRANSPIRATION

TOTALS	1.009	1.415	2.937	3.819	5.148	4.070
	4.243	3.787	2.764	1.440	1.083	0.874
STD. DEVIATIONS	0.261	0.349	0.277	0.667	1.035	1.493
	1.549	1.231	0.957	0.334	0.150	0.173

PERCOLATION/LEAKAGE THROUGH LAYER 2

TOTALS	0.1499	0.1347	0.1467	0.1314	0.0897	0.0331
	0.0367	0.0307	0.0425	0.0928	0.1282	0.1518
STD. DEVIATIONS	0.0083	0.0084	0.0057	0.0077	0.0374	0.0377
	0.0379	0.0367	0.0437	0.0578	0.0383	0.0115

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2

AVERAGES	10.1261	9.6411	9.3980	6.9105	3.3748	1.1266
	1.1828	0.8844	1.9264	4.9000	8.7509	10.8001
STD. DEVIATIONS	1.8815	2.0931	1.2863	1.8024	2.4958	1.7182
	1.6779	1.4301	2.4567	3.8209	3.3481	1.4147

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES		CU. FEET	PERCENT
PRECIPITATION	54.24	(7.873)	196891.6	100.00
RUNOFF	20.479	(6.4228)	74340.14	37.757
EVAPOTRANSPIRATION	32.588	(3.0575)	118293.12	60.080
PERCOLATION/LEAKAGE THROUGH LAYER 2	1.16835	(0.15528)	4241.115	2.15404
AVERAGE HEAD ON TOP OF LAYER 2	5.752	(0.939)		
CHANGE IN WATER STORAGE	0.005	(1.2363)	17.20	0.009

****

****

Written by: Sowmya Bulusu Date: 04/11/06 Reviewed by: Basak Gulec Date: 04/27/06

Client: TVA Project: TVA Kingston Fossil Plant Landfill Project/Proposal No.: GR3731 Task No.: 06

PEAK DAILY VALUES FOR YEARS 1 THROUGH 100

	(INCHES)	(CU. FT.)
PRECIPITATION	5.13	18621.900
RUNOFF	5.047	18321.5332
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.005102	18.52133
AVERAGE HEAD ON TOP OF LAYER 2	12.000	
SNOW WATER	7.25	26300.9785

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4710

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.2100

****

****

FINAL WATER STORAGE AT END OF YEAR 100

LAYER	(INCHES)	(VOL/VOL)
1	5.5243	0.4604
2	10.2480	0.4270
SNOW WATER	0.000	

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ALTERNATIVE FINAL COVER SYSTEM

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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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EVAPOTRANSPIRATION DATA:      C:\HELP\TVA_1.D11
SOIL AND DESIGN DATA FILE:    C:\HELP\TVA-ALT.D10
OUTPUT DATA FILE:             C:\HELP\TVA-ALT.OUT


TIME:  12:33     DATE:   5/ 5/2006


******************************************************************************

     TITLE:  TVA Kingston Fossil Plant Landfill - Alternative final cover

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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  12
          THICKNESS                    =     12.00   INCHES
          POROSITY                     =      0.4710 VOL/VOL
          FIELD CAPACITY               =      0.3420 VOL/VOL
          WILTING POINT                =      0.2100 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.3008 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.419999997000E-04 CM/SEC
       NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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                         LAYER  2
                         --------

              TYPE 2 - LATERAL DRAINAGE LAYER
               MATERIAL TEXTURE NUMBER 200
THICKNESS                  =       0.20    INCHES
POROSITY                   =       0.8500 VOL/VOL
FIELD CAPACITY             =       0.0100 VOL/VOL
WILTING POINT              =       0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT =       0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =    4.17000008000      CM/SEC
SLOPE                      =      33.30    PERCENT
DRAINAGE LENGTH            =      90.0     FEET


                         LAYER  3
                         --------

              TYPE 4 - FLEXIBLE MEMBRANE LINER
               MATERIAL TEXTURE NUMBER  35
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.  =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY        =       0.00    HOLES/ACRE
FML INSTALLATION DEFECTS   =       1.00    HOLES/ACRE
FML PLACEMENT QUALITY      =  3 - GOOD


                         LAYER  4
                         --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER  26
THICKNESS                  =      12.00    INCHES
POROSITY                   =       0.4450 VOL/VOL
FIELD CAPACITY             =       0.3930 VOL/VOL
WILTING POINT              =       0.2770 VOL/VOL
INITIAL SOIL WATER CONTENT =       0.4450 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.190000003000E-05 CM/SEC


          GENERAL DESIGN AND EVAPORATIVE ZONE DATA
          ----------------------------------------

NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
         SOIL DATA BASE USING SOIL TEXTURE #12 WITH A
         FAIR STAND OF GRASS, A SURFACE SLOPE OF 33.%
         AND A SLOPE LENGTH OF    90. FEET.
```

Written by: Sowmya Bulusu Date: 04/11/06 Reviewed by: Basak Gulec Date: 04/27/06

Client: TVA Project: TVA Kingston Fossil Plant Landfill Project/Proposal No.: GR3731 Task No.: 06

```
SCS RUNOFF CURVE NUMBER                  =    89.30
FRACTION OF AREA ALLOWING RUNOFF         =   100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE       =     1.000  ACRES
EVAPORATIVE ZONE DEPTH                   =    12.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE        =     3.609  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE       =     5.652  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE       =     2.520  INCHES
INITIAL SNOW WATER                       =     0.000  INCHES
INITIAL WATER IN LAYER MATERIALS         =     8.951  INCHES
TOTAL INITIAL WATER                      =     8.951  INCHES
TOTAL SUBSURFACE INFLOW                  =     0.00   INCHES/YEAR
```

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
KNOXVILLE TENNESSEE

```
STATION LATITUDE                              =  35.49 DEGREES
MAXIMUM LEAF AREA INDEX                       =   4.50
START OF GROWING SEASON (JULIAN DATE)         =    85
END OF GROWING SEASON (JULIAN DATE)           =   307
EVAPORATIVE ZONE DEPTH                        =  12.0  INCHES
AVERAGE ANNUAL WIND SPEED                     =   7.10 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY         =  68.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY         =  69.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY         =  76.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY         =  72.00 %
```

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR KNOXVILLE TENNESSEE

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
5.28	4.94	5.67	4.32	4.56	4.00
4.72	3.50	3.78	2.88	4.55	5.48

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR KNOXVILLE TENNESSEE

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
35.40	40.30	49.80	59.10	67.10	73.50
77.20	76.50	70.30	60.20	50.30	38.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING

Written by: Sowmya Bulusu Date: 04/11/06 Reviewed by: Basak Gulec Date: 04/27/06

Client: TVA Project: TVA Kingston Fossil Plant Landfill Project/Proposal No.: GR3731 Task No.: 06

COEFFICIENTS FOR KNOXVILLE TENNESSEE
AND STATION LATITUDE = 35.49 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.90	5.10	5.40	4.25	4.94	3.89
	4.90	3.64	4.24	2.86	4.49	5.63
STD. DEVIATIONS	2.19	2.35	2.54	2.05	2.10	1.80
	2.25	1.51	2.29	1.75	2.33	3.09
RUNOFF						
TOTALS	1.117	1.550	0.766	0.364	0.497	0.326
	0.495	0.222	0.599	0.285	0.713	1.168
STD. DEVIATIONS	1.294	1.655	0.925	0.564	0.647	0.413
	0.562	0.304	0.717	0.461	0.770	1.390
EVAPOTRANSPIRATION						
TOTALS	1.018	1.423	2.945	3.598	4.200	3.642
	3.933	3.474	2.653	1.438	1.131	0.893
STD. DEVIATIONS	0.265	0.351	0.281	0.833	1.191	1.301
	1.398	1.092	0.951	0.377	0.152	0.183
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	2.6383	2.6616	2.1160	0.7999	0.4166	0.1633
	0.2278	0.1278	0.5230	0.7721	2.1893	3.1477
STD. DEVIATIONS	1.5492	1.3948	1.5094	0.9652	0.6595	0.3879
	0.4102	0.3223	0.8198	0.8974	1.4411	1.7064
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Written by: Sowmya Bulusu	Date: 04/11/06	Reviewed by: Basak Gulec	Date: 04/27/06
Client: TVA	Project: TVA Kingston Fossil Plant Landfill	Project/Proposal No.: GR3731	Task No.: 06

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0015	0.0016	0.0012	0.0005	0.0002	0.0001
	0.0001	0.0001	0.0003	0.0004	0.0013	0.0018
STD. DEVIATIONS	0.0009	0.0009	0.0009	0.0006	0.0004	0.0002
	0.0002	0.0002	0.0005	0.0005	0.0009	0.0010

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES		CU. FEET	PERCENT
PRECIPITATION	54.24	(7.873)	196891.6	100.00
RUNOFF	8.103	(3.0361)	29414.05	14.939
EVAPOTRANSPIRATION	30.348	(2.7853)	110161.85	55.951
LATERAL DRAINAGE COLLECTED FROM LAYER 2	15.78332	(4.15610)	57293.441	29.09898
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00000	(0.00000)	0.008	0.00000
AVERAGE HEAD ON TOP OF LAYER 3	0.001	(0.000)		
CHANGE IN WATER STORAGE	0.006	(1.3447)	22.24	0.011

PEAK DAILY VALUES FOR YEARS 1 THROUGH 100

	(INCHES)	(CU. FT.)
PRECIPITATION	5.13	18621.900
RUNOFF	3.817	13856.2451
DRAINAGE COLLECTED FROM LAYER 2	0.97077	3523.87769
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000000	0.00033
AVERAGE HEAD ON TOP OF LAYER 3	0.021	

MAXIMUM HEAD ON TOP OF LAYER 3	0.040	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	7.25	26300.9785
MAXIMUM VEG. SOIL WATER (VOL/VOL)		0.4567
MINIMUM VEG. SOIL WATER (VOL/VOL)		0.2100

*** 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 100

LAYER	(INCHES)	(VOL/VOL)
1	4.2219	0.3518
2	0.0020	0.0100
3	0.0000	0.0000
4	5.3400	0.4450
SNOW WATER	0.000	

****
****

FINAL COVER SYSTEM STABILITY ANALYSIS – VENEER MODE

GEOSYNTEC CONSULTANTS

COMPUTATION COVER SHEET

Client: TVA **Project:** KIF Gypsum Disposal Facility **Project/Proposal #:** GR3731 **Task #:** 06

TITLE OF COMPUTATIONS FINAL COVER SYSTEM STABILITY ANALYSIS - VENEER MODE

COMPUTATIONS BY:
Signature Basak Gulec
DATE 05/11/06
Printed Name and Title: Basak Gulec, Engineer

ASSUMPTIONS AND PROCEDURES CHECKED BY: (Peer Reviewer)
Signature T. Elkady
DATE 05/11/06
Printed Name and Title: Tamer Y. Elkady, Engineer

COMPUTATIONS CHECKED BY:
Signature T. Elkady
DATE 05/11/06
Printed Name and Title: Tamer Y. Elkady, Engineer

COMPUTATIONS BACKCHECKED BY: (Originator)
Signature Basak Gulec
DATE 05/11/06
Printed Name and Title: Basak Gulec, Engineer

APPROVED BY: (PM or Designate)
Signature R. Neil Davies
DATE May 12, 2006
Printed Name and Title: Neil Davies, Principal/Vice President

APPROVAL NOTES:

REVISIONS (Number and initial all revisions)

NO.	SHEET	DATE	BY	CHECKED BY	APPROVAL

calc-cover-veneer.doc 5/11/2006

Written by: Basak Gulec Date: 04/27/06 Reviewed by: Tamer Elkady Date: 05/01/06

Client: TVA Project: TVA Kingston Fossil Plant Project/Proposal No.: GR3731 Task No.: 06

FINAL COVER SYSTEM STABILITY ANALYSIS VENEER MODE

PURPOSE

The purpose of the analyses described in this calculation package is to evaluate static and seismic stability of the final cover system in a veneer failure mode for the proposed Kingston Fossil Plant Gypsum disposal facility (hereinafter referred to as KIF Gypsum disposal facility) located at Peninsula site.

METHOD OF ANALYSIS

Slope stability of a landfill final cover system can be analyzed assuming infinite slope conditions or finite slope conditions. The infinite slope method considers a slope of infinite length whereby driving and resisting forces occur only along or parallel to an interface (i.e., slip plane). The finite slope method considers a slope of finite length and additionally takes into account soil strength above a slip plane, primarily as a toe-buttressing effect. Due to the buttressing effect provided by graded-in benches of the final cover system, the finite slope method is used for analysis of the final cover system for the KIF Gypsum disposal facility (Figure 1).

The finite slope stability factor of safety equation, as formulated by Giroud, et. al. [1995], is:

$$FS=\left[\frac{\gamma_t(t-t_w)+\gamma_b t_w}{\gamma_t(t-t_w)+\gamma_{sat}t_w}\right]\frac{\tan\delta}{\tan\beta}+\frac{a/\sin\beta}{\gamma_t(t-t_w)+\gamma_{sat}t_w}$$

$$+\left[\frac{\gamma_t(t-t^*_w)+\gamma_b t^*_w}{\gamma_t(t-t_w)+\gamma_{sat}t_w}\right]\left[\frac{\tan\phi/(2\sin\beta\cos^2\beta)}{1-\tan\beta\tan\phi}\right]\frac{t}{h}$$

$$+\left[\frac{1}{\gamma_t(t-t_w)+\gamma_{sat}t_w}\right]\left[\frac{1/(\sin\beta\cos\beta)}{1-\tan\beta\tan\phi}\right]\frac{ct}{h} \qquad (1)$$

where: FS = factor of safety;
- δ = interface friction angle;
- a = apparent interface adhesion;
- ϕ = soil internal friction angle;
- c = apparent soil cohesion;
- γ_t = moist soil unit weight;
- γ_b = buoyant soil unit weight;
- γ_{sat} = saturated soil unit weight;
- t = depth of cover soil above critical interface;
- t_w = water depth above critical interface;

t_w* = water depth at slope toe;
β = slope inclination; and
h = vertical height of slope.

It should be noted that while the above equation is specifically for an interface above a geomembrane, or similar layers, it can also be applied to interfaces below the geomembrane by changing the coefficient of the first term, (i.e., the coefficient of $\tan\delta / \tan\beta$) to 1.0. The slope geometry, which is used to derive the above equation, is shown in Figure 2. The above Equations used to calculate the FS above and below a geomembrane are coded in a spreadsheet presented herein as Tables 1 and 2, for peak and residual final cover shear strength parameters, respectively.

The water depth (t_w) in the drainage layer above the geomembrane was calculated using the HELP model [Schroeder, 1994] as presented in the calculation package titled "*Alternative Final Cover System Demonstration*". Based on this analysis, the average head in the drainage layer was estimated to be 0.021 in.

The final cover system static stability analyses were performed by solving the finite slope stability equation, presented above, for various combinations of peak and residual internal/interface shear strength parameters (i.e., "δ" and "a" for above and below a geomembrane) based on the target ctors of safety.

Seismic Stability:

A pseudo-static slope stability analysis is performed for the final cover system. The pseudo-static factor of safety is estimated by performing an infinite slope analysis using Equation 2 [Matasović, 1991]:

$$FS = \frac{c/(\gamma z \cos^2\beta) + \tan\phi\,[1 - \gamma_w (z - d_w)/(\gamma z)] - k_s \tan\beta \tan\phi}{k_s + \tan\beta} \quad (2)$$

where: FS = factor of safety;
k_s = peak average horizontal acceleration as a fraction of gravity;
γ = unit weight of slope material(s) in pcf;
γ_w = unit weight of water in pcf;
c = cohesion in psf;
β = slope angle in degrees;
ϕ = angle of internal friction on the assumed failure surface in degrees;
z = depth to the assumed failure surface in ft; and
d_w = depth to the water table (assumed parallel to the slope) in ft.

The peak average horizontal acceleration (k_s) is estimated using the mean horizontal acceleration (MHA) at the site and a chart (Figure 3) developed by Idriss [1990], as presented by Kavazanjian and Matasović [1995].

A calculated factor of safety greater than 1.0 suggests that no permanent seismic deformation is expected. A factor of safety less than 1.0, however, suggests permanent deformation can occur. The amount of seismic displacement can be computed based on k_s and the yield acceleration, K_y. The yield acceleration is the horizontal acceleration which results in a pseudo-static factor of safety of 1.0. The yield acceleration may be calculated using Equation 3 [Matasović, 1991]:

$$K_y = \frac{c/(\gamma \bullet z \bullet \cos^2\beta) + \tan\phi\,[1 - \gamma_w(z - d_w)/(\gamma \bullet z)] - \tan\beta}{1 + \tan\beta\tan\phi} \qquad (3)$$

The seismic displacement, corresponding to the computed K_y/k_s ratio, is estimated using the results presented by Hynes and Franklin [1984] and the "modified mean + one standard deviation curve" developed by GeoSyntec as presented in Figure 4. The "modified mean + one standard deviation curve" considers data associated with only large earthquakes and therefore is more conservative to use. This procedure is consistent with those given in the USEPA guidance document [USEPA; 1995].

The seismic stability analysis, described above, was performed assuming the final cover interfaces have the minimum shear strength values required to achieve a static factor of safety of 1.5 (i.e., peak shear strength parameters), as presented in Table 3.

PERFORMANCE CRITERIA

For the static stability analysis, the target FS for peak and residual internal/interface shear strength is 1.5 and 1.2, respectively. Based on the recommendations of Seed and Bonaparte [1992] and Anderson and Kavazanjian [1995], the performance criterion for seismic analysis is permanent deformation. The permanent deformation is considered acceptable if it is less than 6 to 12 in.

GEOMETRY AND MATERIAL PROPERTIES

The KIF Gypsum disposal facility will be constructed on outer slopes of the facility that has an inclination of 3 horizontal to 1 vertical with graded-in benches that are spaced vertically every 30 ft. The graded-in benches are expected to provide a buttressing effect. Therefore, analysis is performed considering the height of the final cover to be 30 ft.

Details of the proposed final cover system are shown in Figure 1. For the purpose of this analysis, the vegetative soil was conservatively assumed to have a unit weight of 120 pcf and shear strength parameters of $\phi = 30°$ and c = 0 psf.

DESIGN PEAK GROUND ACCELERATION

The MHA at the site was assumed to be the maximum expected horizontal acceleration, depicted on a seismic hazard map, with a 90% or greater probability that the acceleration will not be exceeded in 250 years. Therefore, the MHA was estimated to be 0.25g based on the 2002 United States Geological Survey (USGS) Seismic Hazard Map. Based on this value, the corresponding peak horizontal acceleration (k_s) at the top of the KIF Gypsum disposal facility was estimated using the chart developed by Idriss [1990] presented in Figure 3. According to Figure 3, k_s is estimated as 0.32g.

RESULTS AND CONCLUSIONS

Results of the final cover system static stability analyses are presented in Figures 5 and 6. These figures represent various combinations of peak and residual internal/interface shear strength parameters (i.e., δ and a) required for a target static FS of 1.5 and 1.2, respectively. It is noted that the minimum requirements for internal/interface shear strength parameters are typical of many commercially available products. Prior to construction, the peak and residual interface/internal strength properties of the soil and geosynthetic materials selected for use shall be measured by performing site-specific testing to verify that they exceed the envelopes shown in Figures 5 and 6.

Calculated pseudo-static factor of safety for the final cover system using peak internal/interface shear strength parameters was less than one, indicating permanent deformation can occur when subjected to the design earthquake event. However, the maximum calculated seismic deformation (illustrated in Figure 4) was 3.2 in., which is considered acceptable (i.e., less than 6 to 12 in.).

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Hynes, M. E., and Franklin, A. G., "Rationalizing the Seismic Coefficient Method," *Miscellaneous Paper GL - 84 - 13,* U.S. Army Engineer Waterways Experiment Station, Vickburg, MS, 1984, pp. 34.

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Seed, R. B., and Bonaparte, R., "Seismic Analysis and Design of Lined Waste Fills: Current Practice," Proceedings, Stability and Performance of Slopes and Embankments-II, Vol. 2, *ASCE Geotechnical Special Publication No. 31*, Berkeley, California, 1992, pp. 1521-1545.

Schroeder, P. R., N. M., Lloyd, C. M. and Zappi, P. A. *"The Hydrologic Evaluation of Landfill Performance (HELP) Model: User's Guide for Version 3,"* EPA/600/R-94/168a, September 1994, U. S. Environmental Protection Agency Office of Research and Development, Washington, D.C, 1994.

USEPA, *"RCRA Subtitle D (258) Seismic Design Guidance for Municipal Solid Waste Landfill Facilities"*, Office of Research and Development, EPA/600/R-95/051, April 1995.

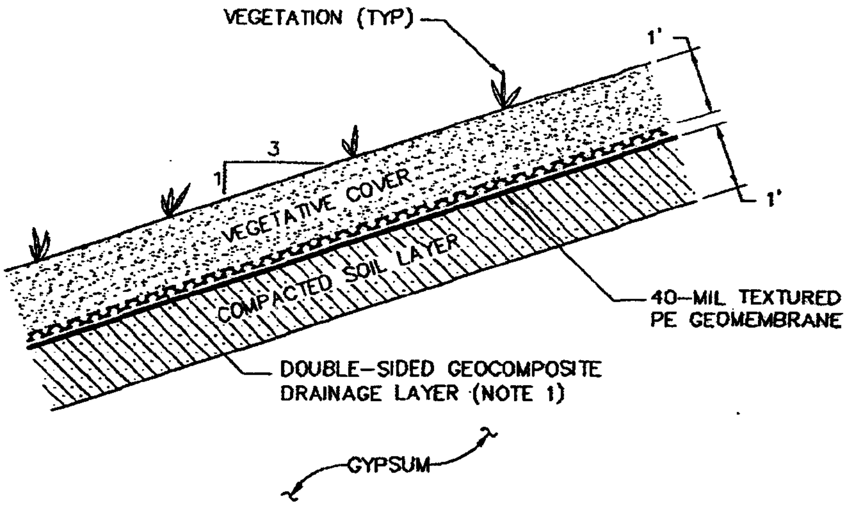

Figure 1. Final Cover System

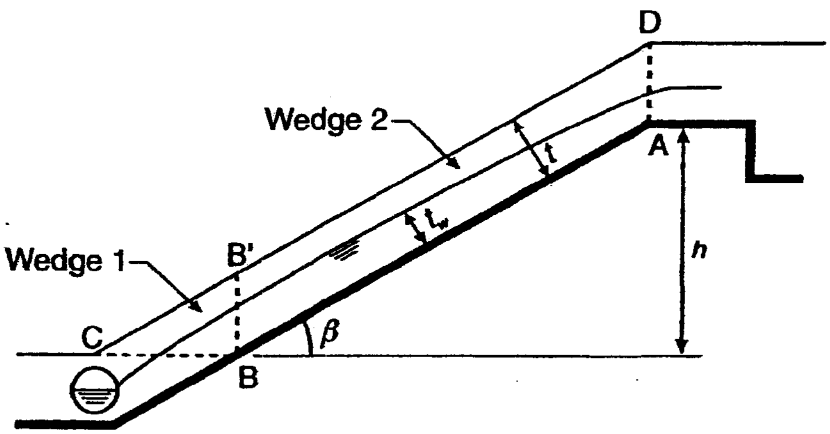

Figure 2. Slope Geometry Used to Derive Finite Slope Stability Equation

Written by: Basak Gulec Date: 04/27/06 Reviewed by: Tamer Elkady Date: 05/01/06

Client: TVA Project: TVA Kingston Fossil Plant Project/Proposal No.: GR3731 Task No.: 06

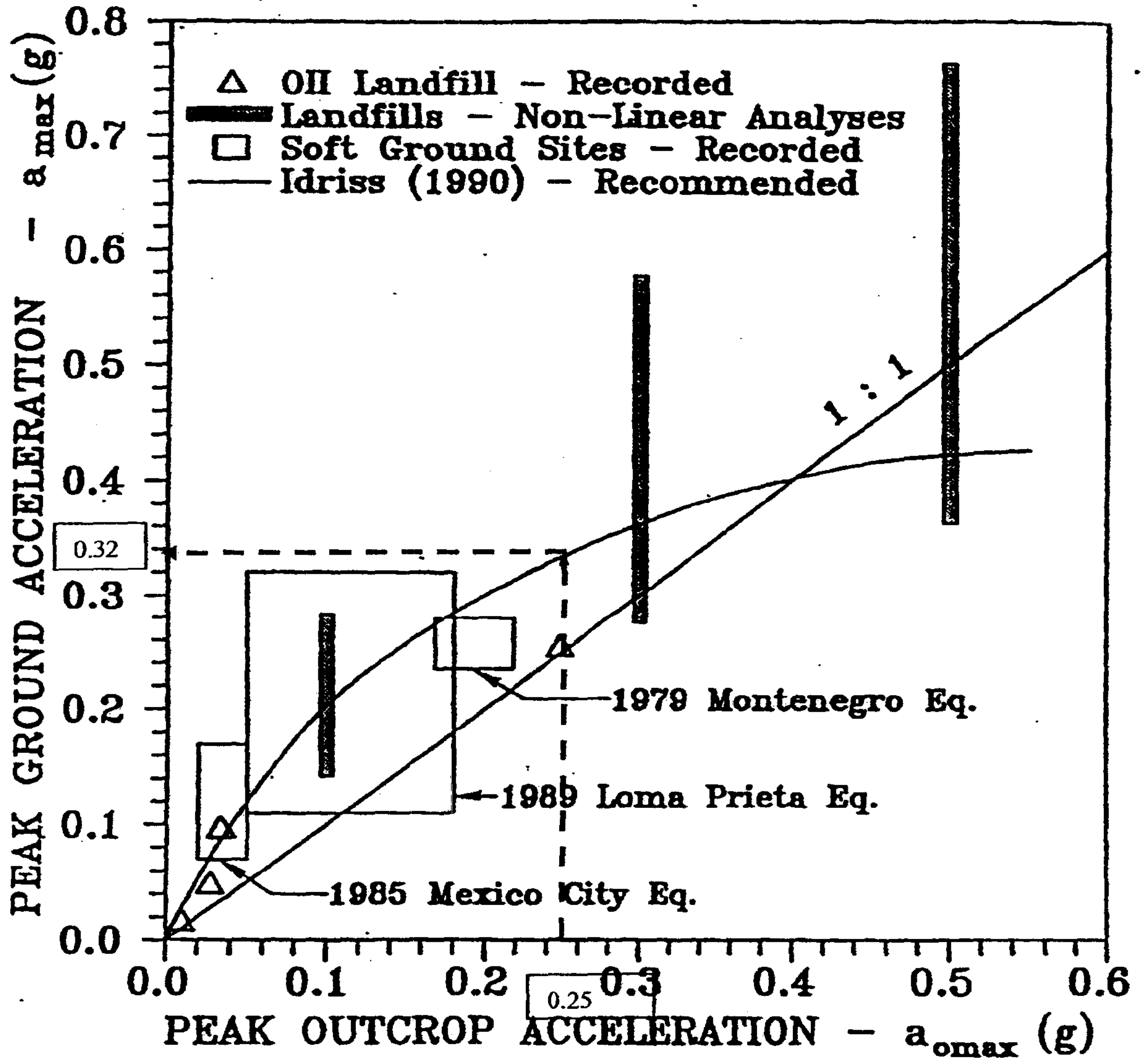

Figure 3. **Observed Variations of Peak Horizontal Accelerations on Soft Soil and MSW Sites in Comparison to Rock Sites (Kavazanjian and Matasović, 1994).**

Written by: Basak Gulec Date: 04/27/06 Reviewed by: Tamer Elkady Date: 05/01/06

Client: TVA Project: TVA Kingston Fossil Plant Project/Proposal No.: GR3731 Task No.: 06

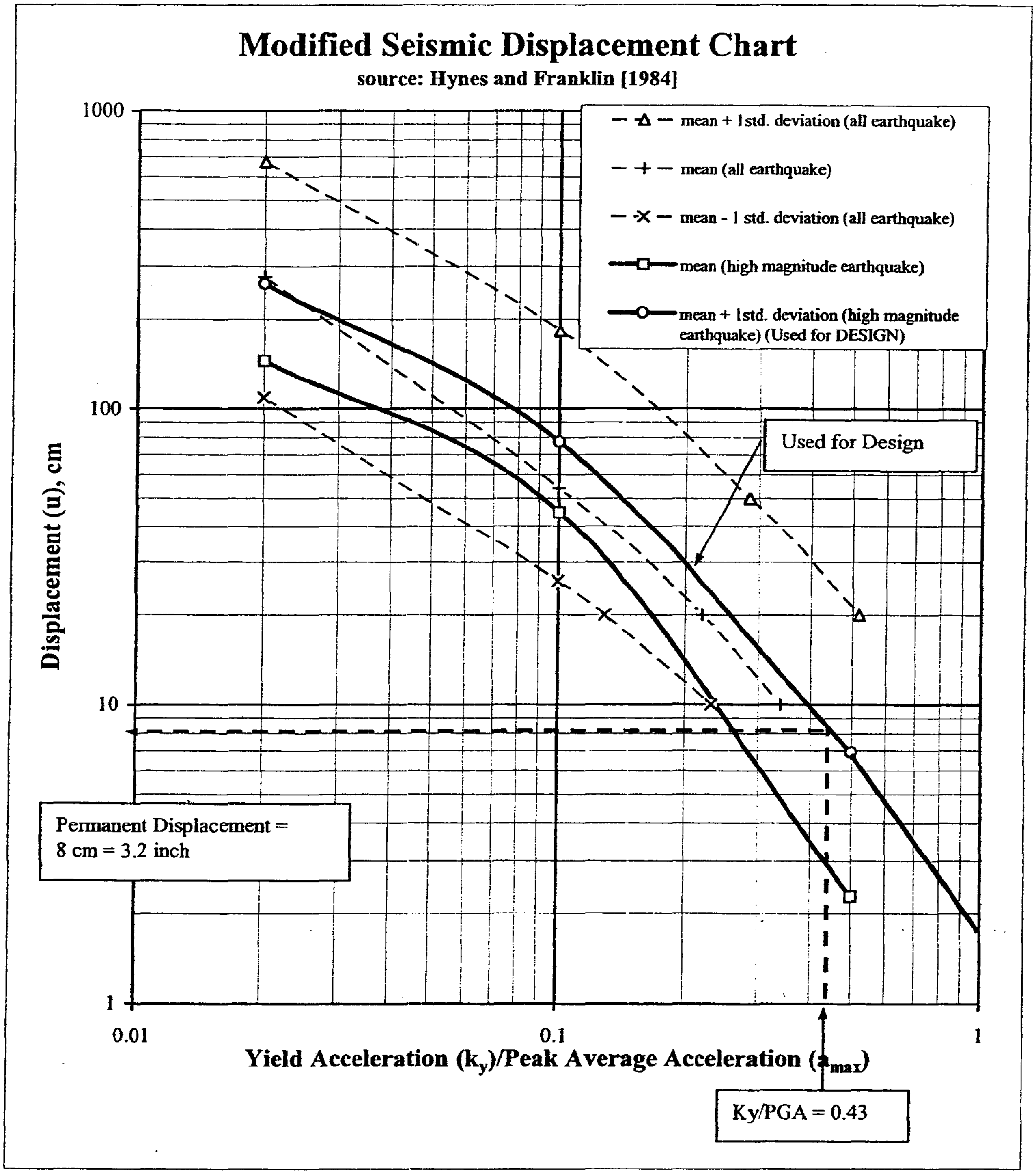

Figure 4. Seismic Displacement versus Yield Acceleration/Peak Average Acceleration Ratio.

Written by: Basak Gulec Date: 04/27/06 Reviewed by: Tamer Elkady Date: 05/01/06

Client: TVA Project: TVA Kingston Fossil Plant Project/Proposal No.: GR3731 Task No.: 06

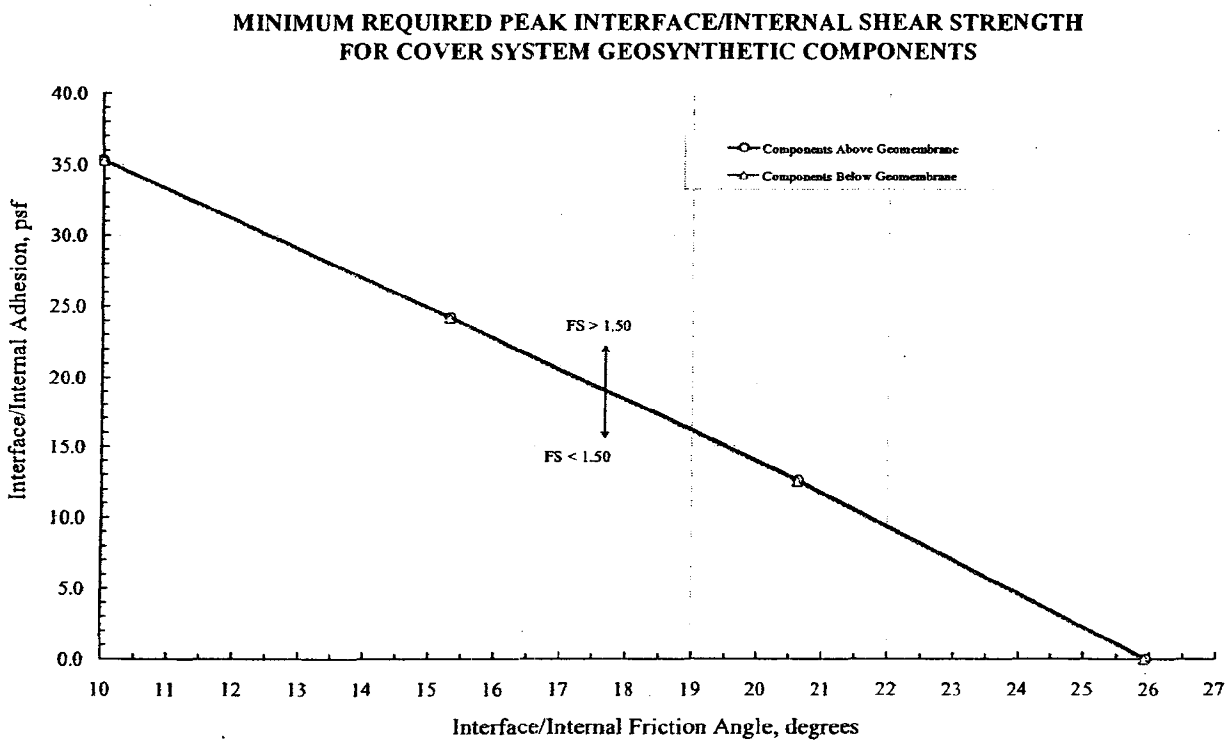

Figure 5. Peak Interface/Internal Shear Strength Graph

Written by: Basak Gulec Date: 04/27/06 Reviewed by: Tamer Elkady Date: 05/01/06

Client: TVA Project: TVA Kingston Fossil Plant Project/Proposal No.: GR3731 Task No.: 06

Table 1. Peak Interface/Internal Shear Strength

FS Above GEOMEMBRANE		
Input Parameters:		
γ_t (Unit wt of soil):	120	pcf
γ_{sat} (Saturated unit wt of soil):	120	pcf
γ_w (Unit wt of water):	62.4	pcf
γ_b (Buoyant unit wt of soil):	57.6	pcf
t_w (water thickness):	0.002	ft
t* (water thickness at slope toe):	0.002	ft
δ (weakest interface friction angle):	10.00	deg
ϕ (friction angle of soil):	30	deg
a (interface adhesion)	35.28	psf
c (cohesion of soil above geomembrane)	0	psf
T (Tension in Geosynthetics)	0	psf
h (height of slope):	30	ft
t (thickness of soil layer)	1.0	ft
β (slope angle)	18.4	deg
FS	[redacted]	

FS Below GEOMEMBRANE		
Input Parameters:		
γ_t (Unit wt of soil):	120	pcf
γ_{sat} (Saturated unit wt of soil):	120	pcf
γ_w (Unit wt of water):	62.4	pcf
γ_b (Buoyant unit wt of soil):	57.6	pcf
t_w (water thickness):	0.002	ft
t* (water thickness at slope toe):	0.002	ft
δ (weakest interface friction angle):	10.00	deg
ϕ (friction angle of soil):	30	deg
a (interface adhesion)	35.25	psf
c (cohesion of soil above geomembrane)	0	psf
T (Tension in Geosynthetics)	0	psf
h (height of slope):	30	ft
t (thickness of soil layer)	1.0	ft
β (slope angle)	18.4	deg
FS	[redacted]	

Written by: Basak Gulec Date: 04/27/06 Reviewed by: Tamer Elkady Date: 05/01/06

Client: TVA Project: TVA Kingston Fossil Plant Project/Proposal No.: GR3731 Task No.: 06

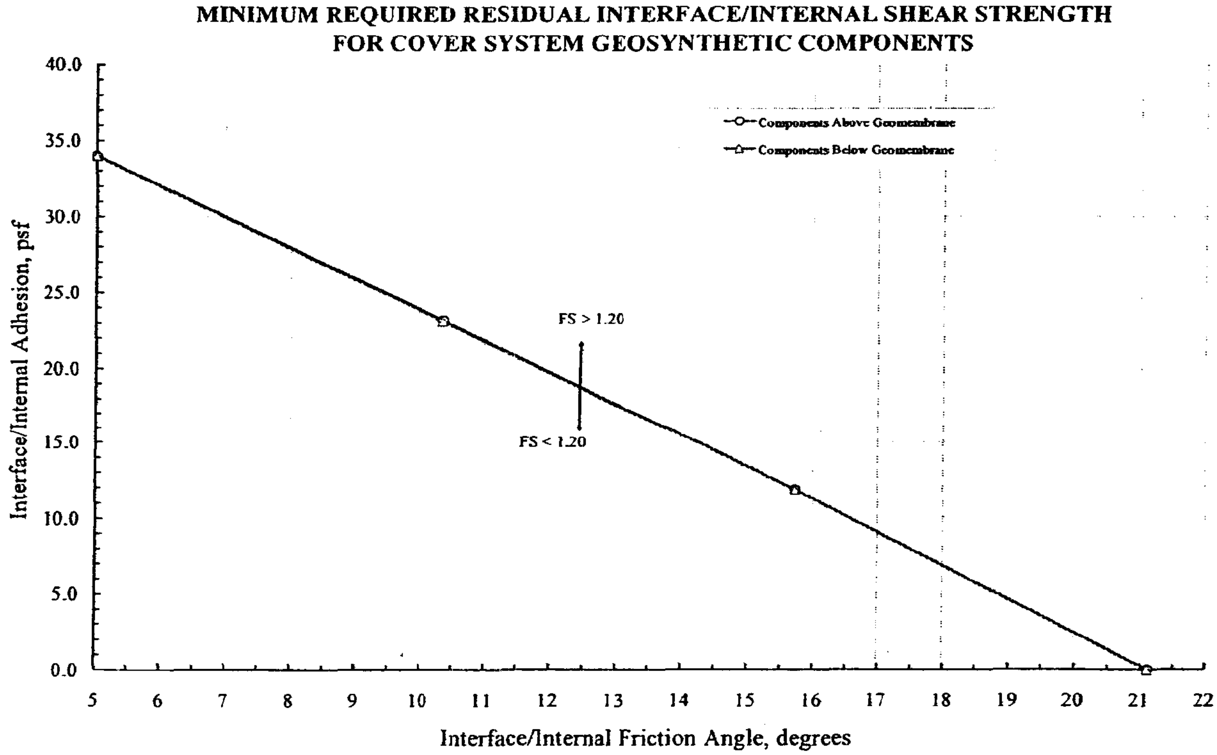

Figure 6. Residual Interface/Internal Shear Strength Graph.

Written by: Basak Gulec	Date: 04/27/06	Reviewed by: Tamer Elkady	Date: 05/01/06
Client: TVA	Project: TVA Kingston Fossil Plant	Project/Proposal No.: GR3731	Task No.: 06

Table 2. Residual Interface/Internal Shear Strength.

FS Above GEOMEMBRANE		
Input Parameters:		
γ_t (Unit wt of soil):	120	pcf
γ_{sat} (Saturated unit wt of soil):	120	pcf
γ_w (Unit wt of water):	62.4	pcf
γ_b (Buoyant unit wt of soil):	57.6	pcf
t_w (water thickness):	0.002	ft
t* (water thickness at slope toe):	0.002	ft
δ (weakest interface friction angle):	5.00	deg
ϕ (friction angle of soil):	30	deg
a (interface adhesion)	34.00	psf
c (cohesion of soil above geomembrane)	0	psf
T (Tension in Geosynthetics)	0	psf
h (height of slope):	30	ft
t (thickness of soil layer)	1.0	ft
β (slope angle)	18.4	deg
FS	[redacted]	

FS Below GEOMEMBRANE		
Input Parameters:		
γ_t (Unit wt of soil):	120	pcf
γ_{sat} (Saturated unit wt of soil):	120	pcf
γ_w (Unit wt of water):	62.4	pcf
γ_b (Buoyant unit wt of soil):	57.6	pcf
t_w (water thickness):	0.002	ft
t* (water thickness at slope toe):	0.002	ft
δ (weakest interface friction angle):	5.00	deg
ϕ (friction angle of soil):	30	deg
a (interface adhesion)	33.98	psf
c (cohesion of soil above geomembrane)	0	psf
T (Tension in Geosynthetics)	0	psf
h (height of slope):	30	ft
t (thickness of soil layer)	1.0	ft
β (slope angle)	18.4	deg
FS	[redacted]	

Table 3. Seismic Analysis Using Peak Interface/Internal Shear Strength.

Calculation of Factor of Safety and Yield Acceleration For Infinite Slope Conditions Using Equation from Matasovic [1991]

$$k_y = \frac{\left(\frac{c}{\gamma z \cos^2\beta} + \tan\delta\left(1 - \frac{\gamma_w (z - d_w)}{\gamma z}\right) - \tan\beta\right)}{1 + \tan\beta\tan\delta}$$

Where:

k_y = yield acceleration, g.;
γ = unit weight of soil cover, pcf;
γ_w = unit weight of water, pcf;
c = cohesion along the assumed failure surface, psf;
δ = friction angle along the assumed failure surface, degrees;
β = slope angle, degrees;
z = depth of the assumed failure surface, ft; and
d_w = depth of water surface (assumed parallel to the slope), ft.
k_s = peak average horizontal acceleration for potential slide mass, g. = a_{max}

Input parameters:	
γ, pcf	120
z, ft	1
β, degrees	18.43
γ_w, pcf	62.4
d_w, ft	0.996
ks, g	0.32

δ (degrees)	c (psf)	FS	k_y (g)	k_y/a_{max}	
26.4	0	0.677	0.139	0.43	<== minimum
20.9	12.96	0.705	0.149	0.47	
15.5	24.85	0.730	0.158	0.49	
10	36.34	0.756	0.169	0.53	

DRAINAGE SYSTEM PIPE DESIGN

GEOSYNTEC CONSULTANTS

COMPUTATION COVER SHEET

Client: TVA **Project:** KIF Gypsum Disposal Facility **Project/Proposal #:** GR3731 **Task #:** 06

TITLE OF COMPUTATIONS DRAINAGE SYSTEM PIPE DESIGN

COMPUTATIONS BY: Signature [signature] DATE 04/12/06

Printed Name and Title: Sowmya Bulusu, Staff Engineer

ASSUMPTIONS AND PROCEDURES CHECKED BY: (Peer Reviewer) Signature T. Elkady DATE 05/11/06

Printed Name and Title: Tamer Y. Elkady, Engineer

COMPUTATIONS CHECKED BY: Signature Basak Gulec DATE 05/11/06

Printed Name and Title: Basak Gulec, Engineer

COMPUTATIONS BACKCHECKED BY: (Originator) Signature [signature] DATE 05/10/06

Printed Name and Title: Sowmya Bulusu, Staff Engineer

APPROVED BY: (PM or Designate) Signature R. Neil Davies DATE May 12, 2006

Printed Name and Title: Neil Davies, Principal/Vice President

APPROVAL NOTES:

REVISIONS (Number and initial all revisions)

NO.	SHEET	DATE	BY	CHECKED BY	APPROVAL

Written by: Sowmya Bulusu Date: 06 /04 /12 (YY MM DD) Reviewed by: Basak Gulec Date: 06 /05 /03 (YY MM DD)

Client: TVA Project: Kingston Fossil Plant Gypsum Disposal Facility Project/Proposal No.: GR3731 Task No: 06

DRAINAGE SYSTEM PIPE DESIGN

PURPOSE OF ANALYSES

The purpose of this calculation package is to evaluate the performance of the drainage corridor pipes used in the proposed gypsum disposal facility located at the Kingston Fossil Plant - peninsula site (herein referred to as KIF Gypsum disposal facility). Analyses were preformed to verify that the proposed pipes have adequate structural resistance to withstand applied loads.

DESCRIPTION OF THE DRAINAGE CORRIDOR SYSTEM

The proposed drainage system for the KIF Gypsum disposal facility is a gravity flow system, which consists of six perforated high density polyethylene (HDPE) pipes (herein referenced as drainage corridor (DC) pipes), 12-in. in diameter, running along the length (northeast to southwest) of the disposal facility. The DC pipes are embedded within a gravel media that is wrapped with a geotextile filter. Plan layouts of the proposed drainage system for Phases 1 and 2 of the disposal facility are shown on Engineering Drawing 10W427-5 and 10W427-9 respectively, included as part of this permit application. Gypsum slurry will be sluiced from the dewatering facility to disposal facility and then allowed to settle. The purpose of the DC pipes is to facilitate dewatering of the gypsum in the disposal area in order to minimize the potential buildup of hydraulic head on the liner system. Water collected by the DC pipes will be conveyed to an underdrain lift station, which will in turn pump the water into the stormwater pond.

In addition to the DC pipes, a 24-in diameter decant outlet (DO) pipe is embedded in the gravel media of the central corridor. The purpose of this pipe is to convey decant water collected from Phases 1 and 2 to the underdrain lift station.

METHOD OF ANALYSIS

Pipe Structural Stability:

Calculations are performed to verify the proposed DC pipes and DO pipe are able to withstand the loads applied on it with an adequate factor of safety. Failure mechanisms that will be checked are: (i) wall crushing; (ii) wall buckling; (iii) excessive ring deflection; and (iv) excessive bending strain. Plastic pipe can be designed to resist failure by the above mechanisms using design methods presented in the technical literature [Chevron Phillips, 2003].

Stresses applied on the proposed DC and DO pipes will be estimated for two conditions: (i) the active operation condition and (ii) the post-closure condition. The active operation condition assumes that in areas where truck traffic is anticipated, 3 ft of soil/aggregate cover will be maintained on top of the pipe. The stresses due to traffic are assumed to be applied by a loaded truck with a total wheel load of 40,000 lb when full. The total stress on the pipe is then the sum of the stresses applied by the gravel layer and the stresses applied by the loaded truck, which can be calculated as described by Chevron Phillips [2003] as follows:

$$P_L = \gamma_p \cdot H + C_H \cdot \frac{I_I \cdot W_L}{L \cdot D} \quad (1)$$

where:

- P_L = stress on the pipe (psf);
- γ_p = average unit weight of the overburden materials (pcf);
- H = thickness of the overburden materials (ft.);
- D = pipe outer diameter (ft.);
- C_H = load coefficient [Chevron Phillips, 2003; Table 1], which is a function of D/(2H) and L/(2H);
- W_L = wheel load (lb);
- I_I = impact factor accounting for dynamic loads; and
- L = effective length of pipe, which is arbitrarily defined as follows by Chevron Phillips [2003]: L = 3 ft if pipe is longer than 3 ft, and L = actual pipe length if pipe is shorter than 3-ft.

During the post-closure condition, the stress applied to the pipe is due to the overburden materials above the pipe (i.e., gravel, gypsum, and final cover soils). This stress is calculated as follows:

$$P_L = \sum \gamma_p H \quad (2)$$

where:

- P_L = stress on the collector pipe (psf);
- γ_p = average unit weight of the overburden materials (pcf); and
- H = thickness of the overburden materials (ft.).

Wall Crushing: Wall crushing can occur when the stress in the pipe wall, due to external vertical pressure, exceeds the compressive strength of the pipe material. The compressive stress on the pipe wall can be calculated by the following equation [Chevron Phillips, 2003]:

$$S = \frac{P_t \cdot D}{288 \cdot t} \qquad (3)$$

where:

- S = pipe wall compressive stress (psi);
- P_t = vertical load applied to the pipe (psf);
- D = pipe outside diameter (in.); and
- t = pipe wall thickness (in.).

The pipe wall compressive stress is compared to an allowable material stress value. The recommended, long-term compressive strength design value for a HDPE pipe is 800 psi as reported in the Chevron Phillips Manual [2003].

Wall Buckling: Wall buckling, a longitudinal wrinkling in the pipe wall can occur when the external vertical pressure exceeds the critical buckling pressure of the pipe/bedding aggregate system. The allowable wall buckling may be calculated using the following equation:

$$P_{WC} = \frac{5.65}{SF}\sqrt{R\ B'\ E'\frac{E}{12(SDR-1)^3}} \qquad (4)$$

where:

- P_{WC} = allowable wall buckling pressure (psf);
- SF = safety factor;
- R = buoyancy reduction factor; $R = 1 - \left(0.33\frac{H_w}{H}\right)$
- H_w = groundwater height above pipe (ft.);
- H = cover above pipe (ft.);
- B′ = elastic support factor; $B' = \frac{1}{1+4e^{-0.065H}}$
- E′ = modulus of soil reaction for pipe bedding (psf);
- E = modulus of elasticity of the pipe material (psf); and
- SDR = standard dimension ratio of the pipe.

Based on recommendation presented in Chevron Phillips [2003], a minimum factor of safety of 2 is applied. If the total vertical stress on the pipe (P_t) is less than the critical buckling pressure calculated, no buckling of pipe wall is anticipated.

Excessive Ring Deflection: Excessive ring deflection, a horizontal over-deflection of the pipe causing a reversal of curvature of the pipe wall, can occur where large external vertical pressures are applied to the pipe/bedding aggregate system. In addition, excessive ring deflection can lead to substantial loss in flow capacity. Ring deflection is calculated using the Spangler's Modified Iowa Formula [Chevron Phillips, 2003]:

$$\Delta X\% = \frac{\Delta X}{D_i}100 = \left[\frac{P_t}{144} \cdot \frac{KL}{\frac{2E}{3}\left(\frac{1}{SDR-1}\right)^3 + (0.061E')}\right].100 \qquad (5)$$

where:

ΔX%	=	ring deflection, (%);
ΔX	=	horizontal deflection or change in diameter, (in);
L	=	deflection lag factor (assume 1.5) [Chevron Phillips, 2003];
K	=	bedding constant (assume 0.1) [Chevron Phillips, 2003];
D_i	=	inside pipe diameter, (in);
P_t	=	pipe crown vertical pressure, (psf);
E	=	short-term modulus of elasticity of the pipe material, (psi);
E'	=	modulus of soil reaction for pipe bedding material, (psi); and
SDR	=	standard dimension ratio.

An allowable ring deflection of 7.5 % is assumed based on guidance from Chevron Phillips [2003].

Excessive Bending Strain: When a pipe deflects under load, bending strains are induced in the pipe wall. Bending strain occurs in the pipe wall as external pressures are applied to the pipe/bedding aggregate system. Bending strain is calculated using the following equation [Chevron Phillips, 2003]:

$$\varepsilon_b = f_d \frac{\Delta X}{D_m}\frac{2C}{D_m} \qquad (6)$$

where:

ε_b = bending strain, (%);
ΔX = vertical deflection or change in diameter, (in);
C = distance from outer fiber to wall centroid, (in);
= 0.5 * (1.06 * pipe wall thickness), [Chevron Phillips, 2003];
f_d = deformation shape factor; and
D_m = mean pipe diameter, (in);
= D – (1.06 * pipe wall thickness), [Chevron Phillips, 2003];
D = pipe outer diameter, (in).

The following are recommendations for allowable bending strain from the literature and plastic pipes manufacturers:

- An allowable bending strain of 5% is recommended by Wilson-Fahmy and Koerner [1994], based on ASSHTO guidelines.
- An allowable bending strain of 4.2% is recommended as conservative in Chevron Phillips [2003], where it is noted that strains up to 8% are reported in the literature as acceptable for a design period of 50 years.
- An allowable strain from 1 to 1.5% is recommended as conservative in Phillips 66, [1991]. This range is based on Equation 6 where $f_d = 4$. Chevron [1994] recommends an allowable bending strain between 1.5 to 2.25% for $f_d = 6$. This range incorporates a factor of safety varying with stress intensity and time duration of applied stresses.

Based on the above information and recognizing that Δy (assumed equal to the ring deflection, ΔX) is calculated very conservatively (neglecting the effect of arching), an allowable strain of 5 % is selected. A deformation factor (f_d) of 6 was also selected.

PARAMETERS USED IN ANALYSES

The characteristics of the DC and DO pipes to be used in structural stability calculations, as estimated from manufacturers' literature [Chevron Phillips, 2003], are as follows:

For DC pipes:

12-in. nominal diameter HDPE, SDR-7.3

- nominal outer diameter, D = 12.75 in.;
- minimum wall thickness, t = 1.747 in.;
- average inner diameter, D_i = 9.046 in; and
- mean diameter, D_m = 10.898 in.

For proposed DO pipe:

24-in. nominal diameter HDPE, SDR-9

- nominal outer diameter, D = 24 in.;
- minimum wall thickness, t = 2.667 in.;
- average inner diameter, D_i = 18.346 in; and
- mean diameter, D_m = 21.173 in.

Pipe Perforation Sizing:

For proposed DC pipe:

- d_{85} = particle size of the pipe bedding material for which 85 percent by weight of the particles are finer; assuming #57 gravel, d_{85} =16 to 22 mm as shown in Figure 1. Conservatively assume d_{85} = 16 mm (0.630 in.); and
- F = factor varying from 1.2 to 2 (assume 1.2).

Structural Stability:

- Unit weight of overburden materials
  - bedding (gravel) layer = 120 pcf;
  - final cover system = 120 pcf; and
  - waste (gypsum) = 100 pcf.

Information on the unit weight of gypsum in these analyses is obtained from MACTEC [2004], and MACTEC [1995]. The overburden material on the pipe will consist of dry stack gypsum and fine gypsum. Dry stack gypsum, which will be dewatered at the plant before it is transported to the disposal facility, will be placed above an elevation of approximately 900 feet. The unit weight of dry stack gypsum is approximately 107 pcf as indicated in MACTEC [1995]. Fine grained gypsum is a by-product of the rim-ditch method of sluiced material placement. The unit weight of 100 pcf is reported for fine grained gypsum [MACTEC, 2004]. Since a majority of the gypsum on the pipes (upto an elevation of approximately 900 ft) will be fine grained gypsum, a unit weight of 100 pcf is used in the analyses for overburden gypsum.

- Stresses on DC and DO pipes

<u>*active-operation condition:*</u>

- H = 3.0 ft;

- W_L = wheel load = 40,000 lb (assumed based on a standard loaded truck) [Chevron Phillips, 2003];
- I_I = impact factor accounting for dynamic loads = 2.5 [Chevron Phillips, 2003];
- L = effective length of pipe = 3 ft;
- C_H = load coefficient (Table 1) = 0.140 (*for proposed DC pipe)*,
  = 0.242 (*for proposed DO pipe)*; and
- D = outer pipe diameter
  = 1.061 ft = 12.75 in. *(for proposed DC pipe)*,
  = 2.0 ft = 24.0 in. *(for proposed DO pipe)*.

post-closure condition:

- bedding layer (gravel) = 3.0 ft
- final cover system = 3.0 ft;
- waste = 218 ft (thickness of waste only, excluding final cover and gravel thicknesses, i.e., 221–3 = 218 ft., see Figures 2 and 3); and
- σ_{max} = 3.0 * 120 + 218 * 100 + 3.0 * 120
  = 22, 520 psf = 156.39 psi

Wall Crushing:

- P_t = vertical pressure applied to the pipe (psi);
- σ_y = allowable pipe wall compressive stress = 115200 psf = 800 psi [Chevron Phillips, 2003];

Wall Buckling:

- SF = safety factor = 2;
- H_w = groundwater height above pipe = 0 ft;
  (Due to the relative high permeability of the gravel layer, it is anticipated that the central drainage corridor will facilitate drainage of water during facility operations and therefore reduce head on top of the pipe. Therefore, for the purpose of the analysis presented herein, the height of water above the pipe (H_w) is assumed to be zero.)

- H = cover above pipe = 224 ft (height of gypsum + final cover + gravel; see Figures 2 and 3);
- E′ = modulus of soil reaction for pipe bedding = 4.32 x10^5 psf (3,000 psi) (Table 2);
- E = modulus of elasticity of the pipe material (Table 3) = 4.06 x 10^6 psf (28,200 psi) *(for 50 years @ 73° F)*; and
- SDR = 7.3 *(for proposed DC pipe),* = 9.0 *(for proposed DO pipe).*

Excessive Ring Deflection:

- L = deflection lag factor (assume 1.5) [Chevron Phillips, 2003];
- K = bedding constant (assume 0.1) [Chevron Phillips, 2003];
- D_i = inside pipe diameter = 9.046 in. *(for proposed DC pipe),* = 18.346 in. *(for proposed DO pipe)*;
- E = short-term modulus of elasticity of pipe material *((@ 73° F)* = 1.58 x 10^7 psf = 110,000 psi, [Chevron Phillips, 2003];
- E' = modulus of soil reaction for pipe bedding material = 3,000 psi, [Chevron Phillips, 2003];

Excessive Bending Strain:

- C = distance from outer fiber to wall centroid = 0.5 * (1.06* pipe wall thickness);
- f_d = deformation shape factor = 6; and
- D_m = mean diameter = pipe outer diameter D – (1.06 * pipe wall thickness) = 10.898 in. *(for proposed DC pipe),* = 21.173 in. *(for proposed DO pipe).*

CALCULATIONS

See following pages for calculations.

Written by: Sowmya Bulusu Date: 06 /04 /12 (YY MM DD) Reviewed by: Basak Gulec Date: 06 /05 /03 (YY MM DD)

Client: TVA Project: Kingston Fossil Plant Gypsum Disposal Facility Project/Proposal No.: GR3731 Task No: 06

CALCULATIONS FOR STRUCTURAL PERFORMANCE (PROPOSED DC PIPE)

Written by: Sowmya Bulusu Date: 06 /04 /12 (YY MM DD) Reviewed by: Basak Gulec Date: 06 /05 /03 (YY MM DD)

Client: TVA Project: Kingston Fossil Plant Gypsum Disposal Facility Project/Proposal No.: GR3731 Task No: 06

PROPOSED DC PIPE DESIGN

Pipe Type:

Name: 12-in nominal diameter HDPE Pipe

Nominal Outer Diameter	D =	12.75	in
Minimum wall thickness	t =	1.747	in
Average inner diameter	D_i =	9.046	in
Standard Dimension Ratio of pipe	SDR =	7.3	

Pipe Perforation Sizing

Material : assuming #57 gravel, d85 =16~22mm

d_{85} = 16 mm

Factor varying from 1.2 ~ 2.0 F = 1.2

$d_{hmax} = d_{85} / F$

= 16 / 1.2

= 13.3 mm

= 0.52 inch Use 0.50 inch

Stress on collector pipe

Active Operation Condition

Wheel Load	W_L =	40000	lbs	From Chevron Phillips, 2003
Impact Factor	I_I =	2.5		From Chevron Phillips, 2003
Length of pipe	L =	3.0	ft	Note: L = 3-ft if pipe > 3-ft, L = actual length If pipe < 3-ft
Unit weight of overburden soil	γ_p =	120	pcf	
Thickness of overburden soil	H =	3	ft	L / (2*H) = 0.50 D/ (2*H) = 0.18
Load coefficient	C_H =	0.140		[Chevron Phillips, 2003], Table 1

$$P_L = \gamma_p \cdot H + C_H \cdot \frac{I_I \cdot W_L}{L \cdot D}$$

= 4752 psf

Post Closure Condition

Post Closure Condition

Layer No.	γ_p (pcf)	H (ft)	γ_p x H (psf)
1 (Final Cover)	120	3.0	360
2 (Waste)	100	218.0	21800
3 (Liner System)	120	3.0	360
4			
5			
6			

Total = 22520 psf = 156.39 psi

Maximum Vertical Stress = P_t = 22520 psf = 156.39 psi

Wall Crushing

Allowable Compressive Stress	σ_y =	115200	psf =	800 psi	From Chevron Phillips, 2003

Actual Wall compressive stress $S = \dfrac{P_t \cdot D}{288 \cdot t}$ From Chevron Phillips, 2003

= **570.68** psi ≤ 800 psi <= OK

Wall Buckling

Height of water table above Pipe	H_w =	0	ft		
Height of Waste+Final Cover above Pipe	H =	224	ft		From Chevron Phillips, 2003
modulus of elasticity of pipe	E =	4060800.0	psf =	28200 psi	For 50 years @ 73°F
modulus of soil reaction	E' =	432000.0	psf =	3000 psi	From Chevron Phillips, 2003

$$P_{WC} = \frac{5.65}{SF} \cdot \sqrt{R \cdot B' \cdot E' \cdot \frac{E}{12 \cdot (SDR - 1)^3}}$$

From Chevron Phillips, 2003

where

$$R = 1 - \left(0.33 \cdot \frac{H_w}{H}\right) \quad \text{and} \quad B' = \frac{1}{1 + 4 \cdot e^{-0.065 \cdot H}}$$

From Chevron Phillips, 2003

Water Buoyancy Factor	R =	1.0000
Coefficient of Elastic Support	B' =	1.0000
Factor of Safety	SF	2

Allowable Critical Buckling Pressure P_{WC} = **68307** psf

$P_t < P_{WC}$? **Yes** <= OK

Written by: Sowmya Bulusu Date: 06 /04 /12 (YY MM DD) Reviewed by: Basak Gulec Date: 06 /05 /03 (YY MM DD)

Client: TVA Project: Kingston Fossil Plant Gypsum Disposal Facility Project/Proposal No.: GR3731 Task No: 06

MAXIMUM RING DEFLECTION AND RING BENDING STRAIN

Ring Deflection Using the Modified Spangler Equation:

$$\frac{\Delta X}{D_i} = \frac{P_t}{144} \cdot \frac{K \cdot L}{\left(\frac{2 \cdot E}{3} \cdot \frac{1}{(SDR-1)^3}\right) + (0.061 \cdot E')}$$

L	1.5	
K	0.1	
P_t	22520.00	psf
D_i	9.046	in.
E	110000	psi
E'	3000	psi
SDR	7.3	

ΔX = maximum horizontal deflection or change in diameter, in;
L = deflection lag factor (assume 1.5) [Chevron Phillips, 2003];
K = bedding constant (assume 0.1) [Chevron Phillips, 2003];
P_t = pipe Crown Vertical Pressure, psf;
E = short-term modulus of elasticity of the pipe material @ 73° F, [Chevron Phillips, 2003], psi;
E' = the modulus of soil reaction for pipe bedding material [Chevron Phillips, 2003], psi;
SDR = standard dimension ratio [Chevron Phillips, 2003]
ΔX% = ring deflection, %,
= 100 ($\Delta X/D_i$).
Di = inside pipe diameter, in.

Change in diameter, ΔX = 0.45 in.

$$\Delta X\% = \frac{\Delta X}{D_i} . 100$$

= 4.93 % <= Ring Deflection < 7.5%, OK

Ring Bending Strain

$$\varepsilon_b = f_d \cdot \frac{\Delta X}{D_m} \cdot \frac{2 \cdot C}{D_m}$$

D_m	10.898	
f_d	6	
C	0.926	in

ε_b = bending strain, %;
ΔX = maximum vertical deflection or change in diameter, in;
Dm = mean pipe diameter, in,
= D - (1.06* pipe wall thickness); [Chevron Phillips, 2003]
f_d = deformation shape factor
C = distance from outer fiber to wall centroid, in.
= 0.5 * (1.06* pipe wall thickness); [Chevron Phillips, 2003].

Bending strain, ε_b = 4.17 % <= Bending Strain < 5.0%, OK

CALCULATIONS FOR STRUCTURAL PERFORMANCE (PROPOSED DO PIPE)

Written by: Sowmya Bulusu Date: 06 /04 /12 (YY MM DD) Reviewed by: Basak Gulec Date: 06 /05 /03 (YY MM DD)

Client: TVA Project: Kingston Fossil Plant Gypsum Disposal Facility Project/Proposal No.: GR3731 Task No: 06

PROPOSED DO PIPE DESIGN

Pipe Type:

Name: 12-in nominal diameter HDPE Pipe

Norminal Outer Diameter	D =	24	in
Minimum wall thickness	t =	2.667	in
Average inner diameter	D_i =	18.346	in
Standard Dimension Ratio of pipe	SDR =	9	

Stress on collector pipe

Active Operation Condition

Wheel Load	W_L =	40000	lbs	From Chevron Phillips, 2003
Impact Factor	I_I =	2.5		From Chevron Phillips, 2003
Length of pipe	L =	3.0	ft	Note: L = 3-ft if pipe > 3-ft, L = actual length If pipe < 3-ft
Unit weight of overburden soil	γ_p =	120	pcf	
Thickness of overburden soil	H =	3	ft	L / (2*H) = 0.50 D/ (2*H) = 0.33
Load coefficient	C_H =	0.242		[Chevron Phillips, 2003], Table 1

$$P_L = \gamma_p \cdot H + C_H \cdot \frac{I_I \cdot W_L}{L \cdot D}$$

= 4393 psf

Post Closure Condition

Post Closure Condition

Layer No.	γ_p (pcf)	H (ft)	γ_p x H (psf)
1 (Final Cover)	120	3.0	360
2 (Waste)	100	218.0	21800
3 (Liner System)	120	3.0	360
4			
5			
6			

Total = 22520 psf = 156.39 psi

Maximum Vertical Stress = P_t = 22520 psf = 156.39 psi

Written by: Sowmya Bulusu Date: 06 /04 /12 (YY MM DD) Reviewed by: Basak Gulec Date: 06 /05 /03 (YY MM DD)

Client: TVA Project: Kingston Fossil Plant Gypsum Disposal Facility Project/Proposal No.: GR3731 Task No: 06

Wall Crushing

Allowable Compressive Stress	σ_y =	115200	psf =	800 psi	From Chevron Phillips, 2003

Actual Wall compressive stress $$S = \frac{P_t \cdot D}{288 \cdot t}$$ From Chevron Phillips, 2003

= 703.66 psi ≤ 800 psi <= OK

703.6620422

Wall Buckling

Height of water table above Pipe	H_w =	0	ft		
Height of Waste+Final Cover above Pipe	H =	224	ft		From Chevron Phillips, 2003
modulus of elasticity of pipe	E =	4060800.0	psf =	28200 psi	For 50 years @ 73°F
modulus of soil reaction	E' =	432000.0	psf =	3000 psi	From Chevron Phillips, 2003

$$P_{WC} = \frac{5.65}{SF} \cdot \sqrt{R \cdot B' \cdot E' \cdot \frac{E}{12 \cdot (SDR - 1)^3}}$$ From Chevron Phillips, 2003

where

$$R = 1 - \left(0.33 \cdot \frac{H_w}{H}\right) \quad \text{and} \quad B' = \frac{1}{1 + 4 \cdot e^{-0.065 \cdot H}}$$ From Chevron Phillips, 2003

Water Buoyancy Factor	R =	1.0000
Coefficient of Elastic Support	B' =	1.0000
Factor of Safety	SF	2

Allowable Critical Buckling Pressure P_{WC} = 47735 psf

$P_t < P_{WC}$? Yes <= OK

Written by: Sowmya Bulusu Date: 06 /04 /12 (YY MM DD) Reviewed by: Basak Gulec Date: 06 /05 /03 (YY MM DD)

Client: TVA Project: Kingston Fossil Plant Gypsum Disposal Facility Project/Proposal No.: GR3731 Task No: 06

MAXIMUM RING DEFLECTION AND RING BENDING STRAIN

Ring Deflection Using the Modified Spangler Equation:

$$\frac{\Delta X}{D_i} = \frac{P_t}{144} \cdot \frac{K \cdot L}{\left(\frac{2 \cdot E}{3} \frac{1}{(SDR-1)^3}\right) + (0.061 \cdot E')}$$

L	1.5	
K	0.1	
P_t	22520.00	psf
D_i	18.346	in.
E	110000	psi
E'	3000	psi
SDR	9	

ΔX = maximum horizontal deflection or change in diameter, in;
L = deflection lag factor (assume 1.5) [Chevron Phillips, 2003];
K = bedding constant (assume 0.1) [Chevron Phillips, 2003];
P_t = pipe Crown Vertical Pressure, psf;
E = short-term modulus of elasticity of the pipe material @ 73° F, [Chevron Phillips, 2003], psi;
E' = the modulus of soil reaction for pipe bedding material [Chevron Phillips, 2003], psi;
SDR = standard dimension ratio [Chevron Phillips, 2003]
ΔX% = ring deflection, %,
= 100 ($\Delta X/D_i$).
Di = inside pipe diameter, in.

Change in diameter, ΔX = 1.32 in.

$$\Delta X\,\% = \frac{\Delta X}{D_i} . 100$$

= 7.19 % <= Ring Deflection < 7.5%, OK

Ring Bending Strain

$$\varepsilon_b = f_d \cdot \frac{\Delta X}{D_m} \cdot \frac{2 \cdot C}{D_m}$$

D_m	21.173	
f_d	6	
C	1.414	in

ε_b = bending strain, %;
ΔX = maximum vertical deflection or change in diameter, in ;
Dm = mean pipe diameter, in,
= D - (1.06* pipe wall thickness); [Chevron Phillips, 2003]
f_d = deformation shape factor
C = distance from outer fiber to wall centroid, in.
= 0.5 * (1.06* pipe wall thickness); [Chevron Phillips, 2003].

Bending strain, ε_b = 4.99 % <= Bending Strain < 5.0%, OK

SUMMARY AND CONCLUSIONS

Assumptions:

Proposed DC pipes:

- 12-inch HDPE SDR-7.3 perforated pipe

Proposed DO pipes:

- 24-inch HDPE SDR-9.0 solid pipe

Installation of proposed pipes:

- Pipe bedding consists of # 57 stone (crushed)
- Minimum 2.5-ft of drainage gravel and cover soil placed before construction vehicles are permitted to pass over the pipes.

Analysis summary and conclusions:

Structural Stability:

For proposed DC pipe

- **Wall crushing**
  Pipe wall compressive stress = 570.68 psi < Allowable compressive stress (800 psi) → OK
- **Wall buckling**
  Allowable critical buckling pressure = 68,307 psf > Total vertical stress on pipe (22,520 psf) → OK
- **Ring deflection** = 4.93 % < allowable ring deflection (7.5 %) → OK
- **Bending strain** = 4.17 % < allowable strain (5%) → OK

For proposed DO pipe

- **Wall crushing**
  Pipe wall compressive stress = 703.66 psi < Allowable compressive stress (800 psi) → OK
- **Wall buckling**
  Allowable critical buckling pressure = 47,735 psf > Total vertical stress on pipe (22,520 psf) → OK
- **Ring deflection** = 7.19 % < allowable ring deflection (7.5 %) → OK

- **Bending strain** = 4.99 % < allowable strain (5%) → OK

Based on the above results, the specified pipes are anticipated to perform satisfactorily under the active and post-closure conditions for the KIF Gypsum Disposal Facility.

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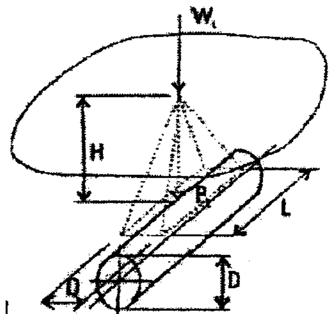
Written by: Sowmya Bulusu Date: 06 /04 /12 (YY MM DD) Reviewed by: Basak Gulec Date: 06 /05 /03 (YY MM DD)

Client: TVA Project: Kingston Fossil Plant Gypsum Disposal Facility Project/Proposal No.: GR3731 Task No: 06

Table 1. Load Coefficient, C_H [Chevron Phillips, 2003]



D/2H	L/2H													
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.5	2.0	20.0
0.1	0.019	0.037	0.053	0.067	0.079	0.089	0.097	0.103	0.108	0.112	0.117	0.121	0.124	0.127
0.2	0.037	0.072	0.103	0.131	0.155	0.174	0.189	0.202	0.211	0.219	0.229	0.238	0.244	0.248
0.3	0.053	0.103	0.149	0.190	0.224	0.252	0.274	0.292	0.306	0.318	0.333	0.346	0.355	0.361
0.4	0.067	0.131	0.190	0.241	0.284	0.320	0.349	0.373	0.391	0.405	0.425	0.442	0.454	0.462
0.5	0.079	0.155	0.224	0.284	0.336	0.379	0.414	0.441	0.463	0.481	0.505	0.525	0.540	0.550
0.6	0.089	0.174	0.252	0.320	0.379	0.428	0.467	0.499	0.524	0.544	0.572	0.596	0.613	0.625
0.7	0.097	0.189	0.274	0.349	0.414	0.467	0.511	0.546	0.574	0.597	0.628	0.655	0.674	0.688
0.8	0.103	0.202	0.292	0.373	0.441	0.499	0.546	0.584	0.615	0.639	0.674	0.703	0.725	0.740
0.9	0.108	0.211	0.306	0.391	0.463	0.524	0.574	0.615	0.647	0.673	0.711	0.743	0.766	0.783
1.0	0.112	0.219	0.318	0.405	0.481	0.544	0.597	0.639	0.673	0.701	0.740	0.775	0.800	0.818
1.2	0.117	0.229	0.333	0.425	0.505	0.572	0.628	0.674	0.711	0.740	0.783	0.821	0.849	0.871
1.5	0.121	0.238	0.346	0.422	0.525	0.596	0.655	0.703	0.743	0.775	0.821	0.863	0.895	0.920
2.0	0.124	0.244	0.355	0.454	0.540	0.613	0.674	0.725	0.766	0.800	0.849	0.895	0.930	0.960
20.0	0.127	0.248	0.361	0.462	0.550	0.625	0.688	0.740	0.783	0.818	0.871	0.920	0.960	1.000

Annotations: 0.18 → 0.14; 0.33 → 0.242

Written by: Sowmya Bulusu Date: 06 /04 /12 (YY MM DD) Reviewed by: Basak Gulec Date: 06 /05 /03 (YY MM DD)

Client: TVA Project: Kingston Fossil Plant Gypsum Disposal Facility Project/Proposal No.: GR3731 Task No: 06

Table 2. Bureau of Reclamation Average Values of E' for Iowa Formula (Initial Deflection [Chevron Phillips, 2003]

Soil type – pipe bedding material (Unified Classification)†	*E' for Degree of Bedding Compaction, lb/in²*			
	Dumped	*Slight (<85% Proctor <40% relative density)*	*Moderate (48%-95% Proctor 40%-70% relative density)*	*High (>95% Proctor >70% relative density)*
Fine-grained soils (LL>50)‡ Soils with medium to high plasticity CH, MH, CH-MH	No data available; consult a competent soils engineer; otherwise, use E' = 0.			
Fine-grained soils (LL<50) Soils with medium to no plasticity CL, ML, CL-ML, with <25% coarse grained particles	50	200	400	1000
Fine-grained soils (LL<50) Soils with medium to no plasticity CL, ML, CL-ML, with >25% coarse grained particles Coarse-grained soils with fines GM, GC, SM, SC◊ contains >12% fines	100	400	1000	2000
Coarse-grained soils with little or no fines GW, GP, SW, SP◊ contains <12% fines	200	1000	2000	3000
Crushed rock	1000	3000	3000	3000
Accuracy in terms of percentage deflection▼	±2%	±2%	±1%	±0.5%

† ASTM D 2487; USBR Designation E-3. ‡ LL = Liquid limit. ◊ Or any borderline soil beginning with one of these symbols, i.e., GM-GC, GC-SC. ▼For ±1% accuracy and predicted deflection of 3%, actual deflection would be between 2% and 4%.

Note – Values applicable only for fills less than 50 ft (15 m). No safety factor included in table values. For use in predicting initial deflections only; appropriate Deflection Lag Factor must be applied for long-term deflections. If bedding falls on the borderline between two compaction categories, select the lower E' value or average the two values. Percentage Proctor based on laboratory maximum dry density from test standards using 12,500 ft-lb/ft³ (598,000 J/m²) (ASTM D 698, AASHTO T-99, USBR Designation E-11). 1 lb/in² = 6.895 kPa.

Table 3. Typical Elastic Modulus for DriscoPlex® [Chevron Phillips, 2003]

Load Duration	*Elastic Modulus†, 1000 psi (MPa), at Temperature, °F (°C)*							
	-20 (-29)	*0 (-18)*	*40 (4)*	*60 (16)*	*73 (23)*	*100 (38)*	*120 (49)*	*140 (60)*
Short-Term	300.0 (2069)	260.0 (1793)	170.0 (1172)	130.0 (896)	110.0 (758)	100.0 (690)	65.0 (448)	50.0 (345)
10 h	140.8 (971)	122.0 (841)	79.8 (550)	61.0 (421)	57.5 (396)	46.9 (323)	30.5 (210)	23.5 (162)
100 h	125.4 (865)	108.7 (749)	71.0 (490)	54.3 (374)	51.2 (353)	41.8 (288)	27.2 (188)	20.9 (144)
1000 h	107.0 (738)	92.8 (640)	60.7 (419)	46.4 (320)	43.7 (301)	35.7 (246)	23.2 (160)	17.8 (123)
1 y	93.0 (641)	80.6 (556)	52.7 (363)	40.3 (278)	38.0 (262)	31.0 (214)	20.2 (139)	15.5 (107)
10 y	77.4 (534)	67.1 (463)	43.9 (303)	33.5 (231)	31.6 (218)	25.8 (178)	16.8 (116)	12.9 (89)
50 y	69.1 (476)	59.9 (413)	39.1 (270)	29.9 (206)	28.2 (194)	23.0 (159)	15.0 (103)	11.5 (79)

† Typical values based on ASTM D 638 testing of molded plaque material specimens.

Written by: Sowmya Bulusu Date: 06 /04 /12 (YY MM DD) Reviewed by: Basak Gulec Date: 06 /05 /03 (YY MM DD)

Client: TVA Project: Kingston Fossil Plant Gypsum Disposal Facility Project/Proposal No.: GR3731 Task No: 06

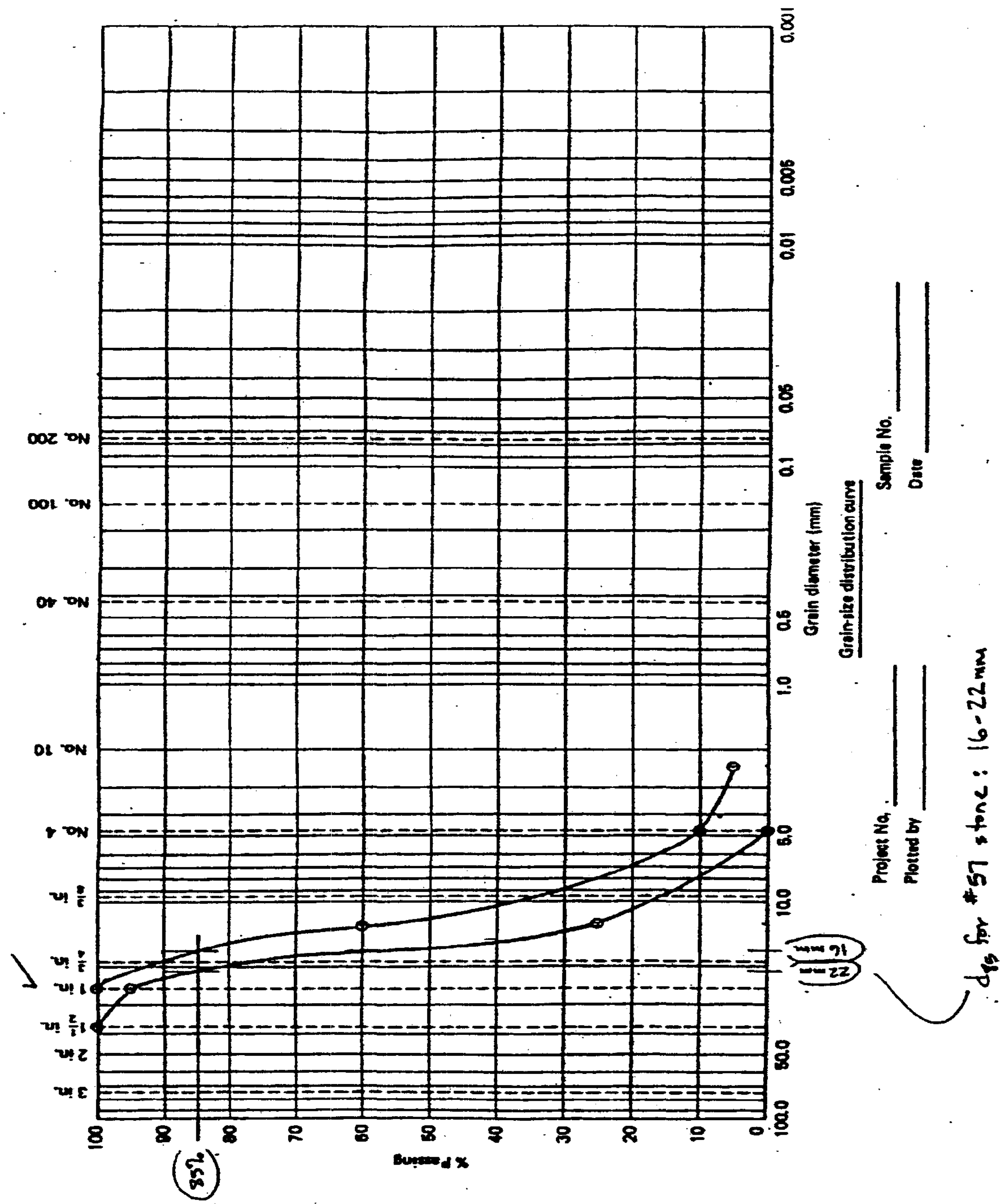
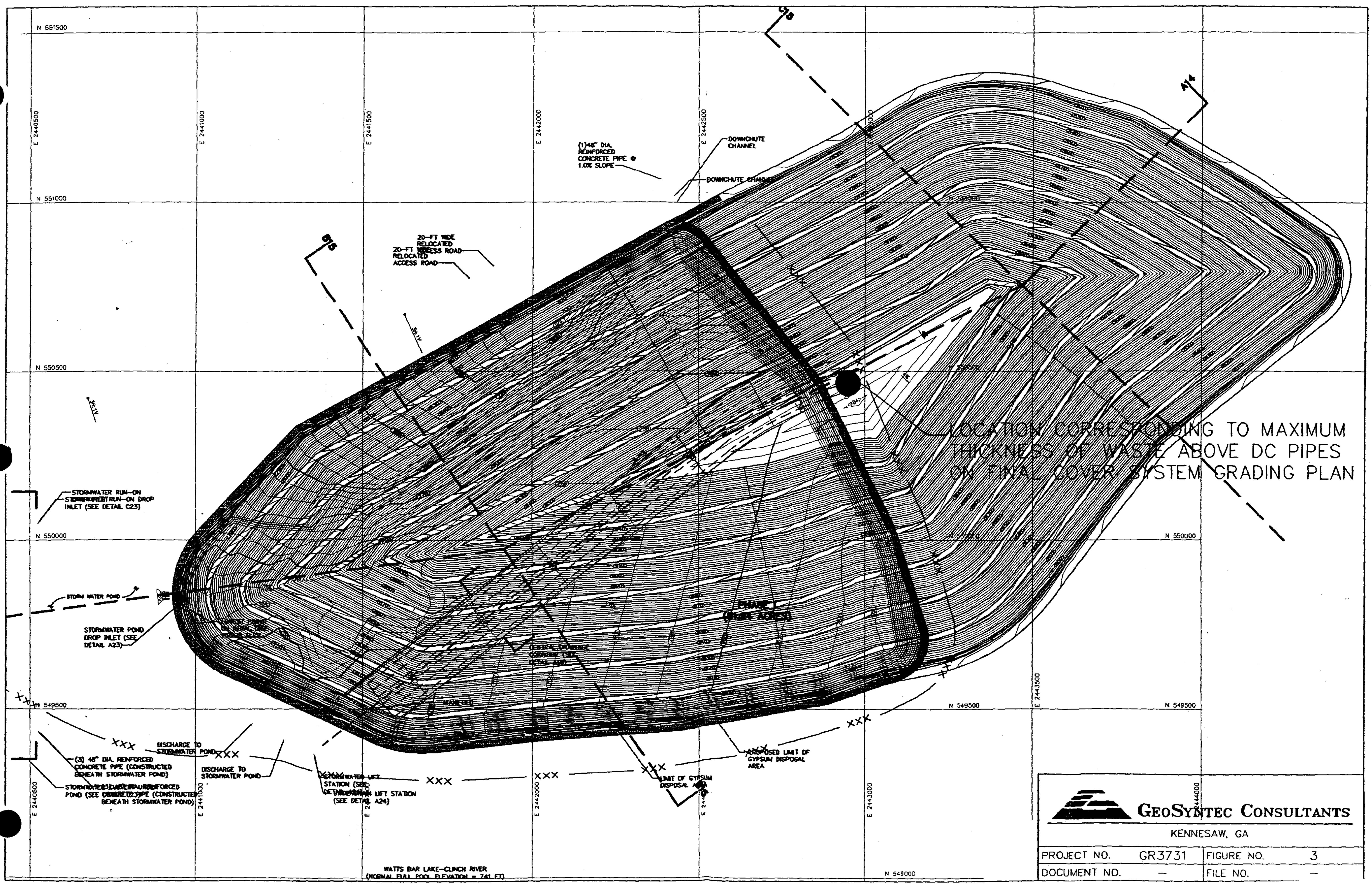


Figure 1. Grain Size Distribution Curve for # 57 Stone

25|25



LOCATION CORRESPONDING TO MAXIMUM THICKNESS OF WASTE ABOVE DC PIPES ON FINAL COVER SYSTEM GRADING PLAN
(1)48" DIA. REINFORCED CONCRETE PIPE @ 1.0% SLOPE
DOWNCHUTE CHANNEL
DOWNCHUTE CHANNEL
20-FT WIDE RELOCATED ACCESS ROAD
20-FT WIDE RELOCATED ACCESS ROAD
STORMWATER RUN-ON DROP INLET (SEE DETAIL C23)
STORM WATER POND
STORMWATER POND DROP INLET (SEE DETAIL A23)
DISCHARGE TO STORMWATER POND
(3) 48" DIA. REINFORCED CONCRETE PIPE (CONSTRUCTED BENEATH STORMWATER POND)
STORMWATER POND (SEE DETAIL C23)
DISCHARGE TO STORMWATER POND
STORMWATER LIFT STATION (SEE DETAIL A24)
LIMIT OF GYPSUM DISPOSAL AREA
PROPOSED LIMIT OF GYPSUM DISPOSAL AREA
WATTS BAR LAKE-CLINCH RIVER (NORMAL FULL POOL ELEVATION = 741 FT)
N 551500
N 551000
N 550500
N 550000
N 549500
N 549000
E 2440500
E 2441000
E 2441500
E 2442000
E 2442500
E 2443000
E 2443500
E 2444000
B15
C15
A14
GEOSYNTEC CONSULTANTS
KENNESAW, GA
PROJECT NO. GR3731
FIGURE NO. 3
DOCUMENT NO. —
FILE NO. —

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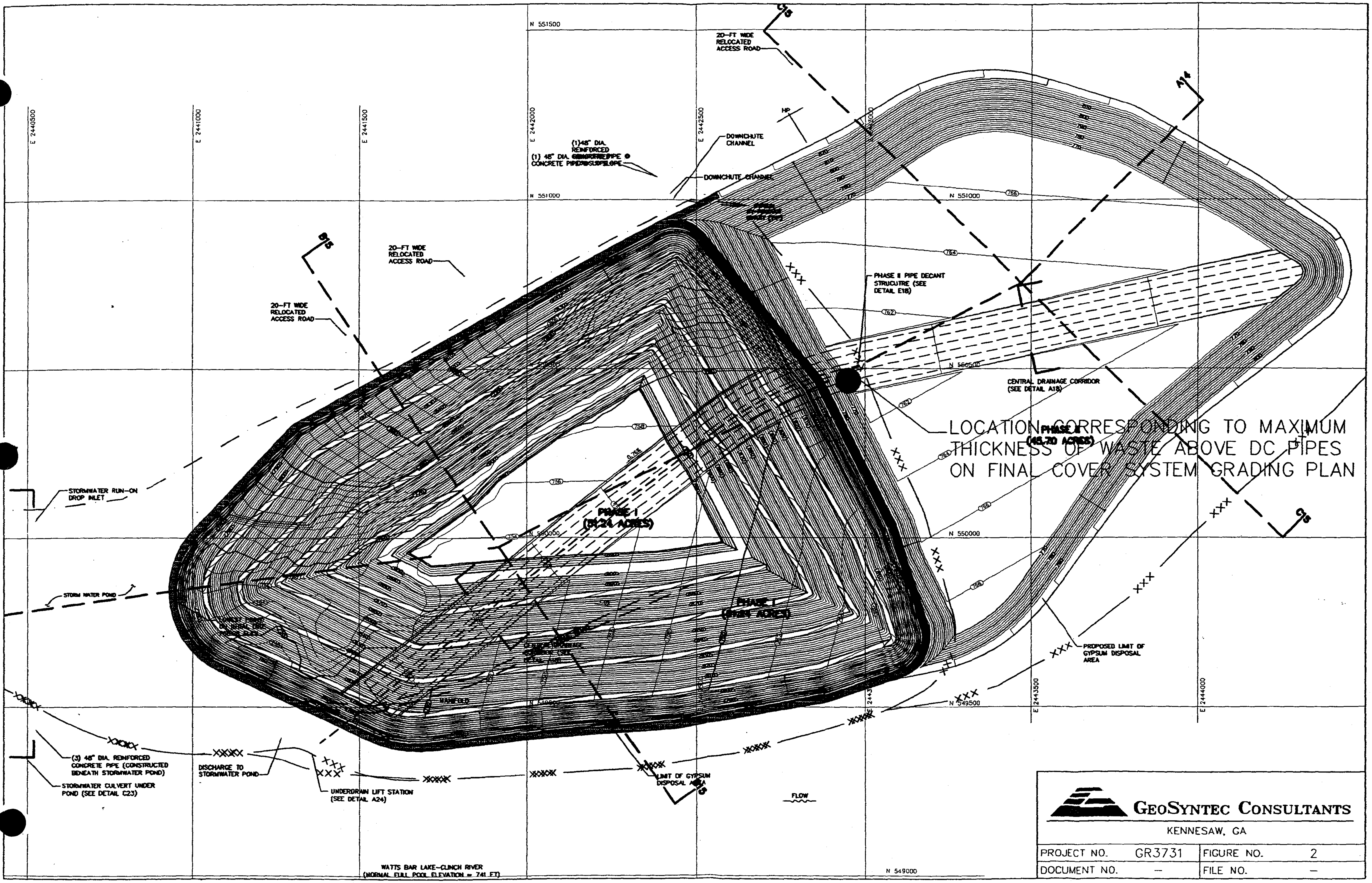

TVA-00021238

LIQUEFACTION ANALYSIS

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Tennessee Valley Authority (TVA)

Project: Kingston Fossil Plant Gypsum Disposal Facility **Project/Proposal #:** GR3731 **Task #:** 06

Title of Computations: *Liquefaction Analysis*

Computation Package: ______________________

Computations By:

[signature] SIGNATURE — May 4, 2006 DATE

Jill F. Roboski/Engineer
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Assumptions and Procedures Checked By (Peer Reviewer):

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Paul Sabatini, Ph.D., P.E. / Senior Engineer
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Approved By (PM or Designate):

R Neil Davies SIGNATURE — May 6, 2006 DATE

R. Neil Davies, C. Eng., MICE, P.E./Principal
PRINTED NAME AND TITLE

Approval Notes: ______________________

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

LIQUEFACTION ANALYSIS

PURPOSE

This analysis was performed to evaluate the liquefaction potential of foundation soils during the design earthquake event and the potential effect of liquefaction on the integrity of the gypsum disposal facility located at the Kingston Fossil Plant-Peninsula Site (hereafter referenced as the KIF gypsum disposal facility).

METHOD OF ANALYSIS

Guidelines for the evaluation of the liquefaction potential of cohesionless soils in Tennessee is provided in the Tennessee Division of Solid Waste Management (a division of the Tennessee Department of Environment and Conservation (TDEC)) guidance document [TDEC, 1993]. The native material present within the footprint of the KIF gypsum disposal facility is generally classified as a fine-grained soil, herefore, the TDEC guidelines may not apply. The liquefaction analysis presented herein is based on procedures recommended in the Southern California Earthquake Center (SCEC) guidance document [SCEC, 1999] which can be applied to fine-grained soils. Specifically, the SCEC guidance states:

> *"If clayey soil materials are encountered during site exploration, those materials may be considered non-liquefiable. For purposes of this screening, clayey soils are those that have a clay content (particle size <0.005 mm) greater than 15 percent. However, based on the "Chinese Criteria," [Seed and Idriss, 1982] clayey soils having all of the following characteristics may be susceptible to severe strength loss:*
>
> - *Percent finer than 0.005 mm less than 15 percent*
> - *Liquid Limit less than 35*
> - *Water Content greater than 0.9 x Liquid Limit"*

ANALYSIS RESULTS

Grain size distributions from 25 samples taken from the foundation soils at the KIF gypsum disposal facility are summarized in Figure 1. As illustrated in this figure, the range of percentages of material finer than 0.005 mm is 45 to 95 percent (which is greater than 15 percent). Results from 68 index property tests indicate that only one sample has a liquid limit of less than 35 and a water content greater than 0.9 x the liquid limit. Grain size information for another sample from this same borehole indicate that the percent finer than 0.005 mm is greater than 15 percent. Based on this, no native soils below the KIF gypsum disposal facility meet all of the "Chinese Criteria" and therefore these soils are not anticipated to experience severe strength loss (or liquefaction) during the deisgn earthquake event.

An additional screening method suggested by Tsuchida (1970) is also illustrated in Figure 1. The bold lines indicate the grain size distribution for the lower boundary for potentially liquefiable soils and the lower boundary for most liquefiable soils. The grain size distributions for all samples from the KIF gypsum disposal facility do not fit within these boundaries due to the appreciable amounts of silt and clay-size particles.

Based on the above analyses, no potentially liquefiable soils were identified in any of the borings.

¯ONCLUSIONS

Based on the soil stratigraphy, sample grain size distribution, and index property information, it is concluded that no potentially liquefiable zones exist within the native soils below the KIF gypsum gypsum disposal facility.

REFERENCES

Southern California Earthquake Center (SCEC), "*Recommended Procedures for Implementation of DMG Special Publication 117: Guidelines for Analyzing and Mitigating Liquefaction Hazards in California*," University of Southern California, March 1999, 70 p.

Seed, H.B. and Idriss, I.M., "Ground Motions and Soil Liquefaction During Earthquakes," *Earthquake Engineering Research Institute Monograph Series*, Berkley, California, 1982, 134 p.

Tennessee Division of Solid Waste Management, a Division of the Tennessee Department of Environment and Conservation (TDEC), "*Technical Guidance Document: Earthquake Evaluation Guidance Policy*," 1993, 41 p.

Tsuchida, H. "Prediction and Countermeasure Against the Liquefaction in Sand Deposits", (in Japanese) in abstract of the *Seminar in the Port and Harbor Research Institute*, 1970, pp 3.1-3.33.

Written by: JFR Date: 5/11/2006 Reviewed by: PJS Date: 5/4/2006

Client: TVA Project: Kingston Fossil Plant Project/Proposal No.: GR3731 Task No.: 06

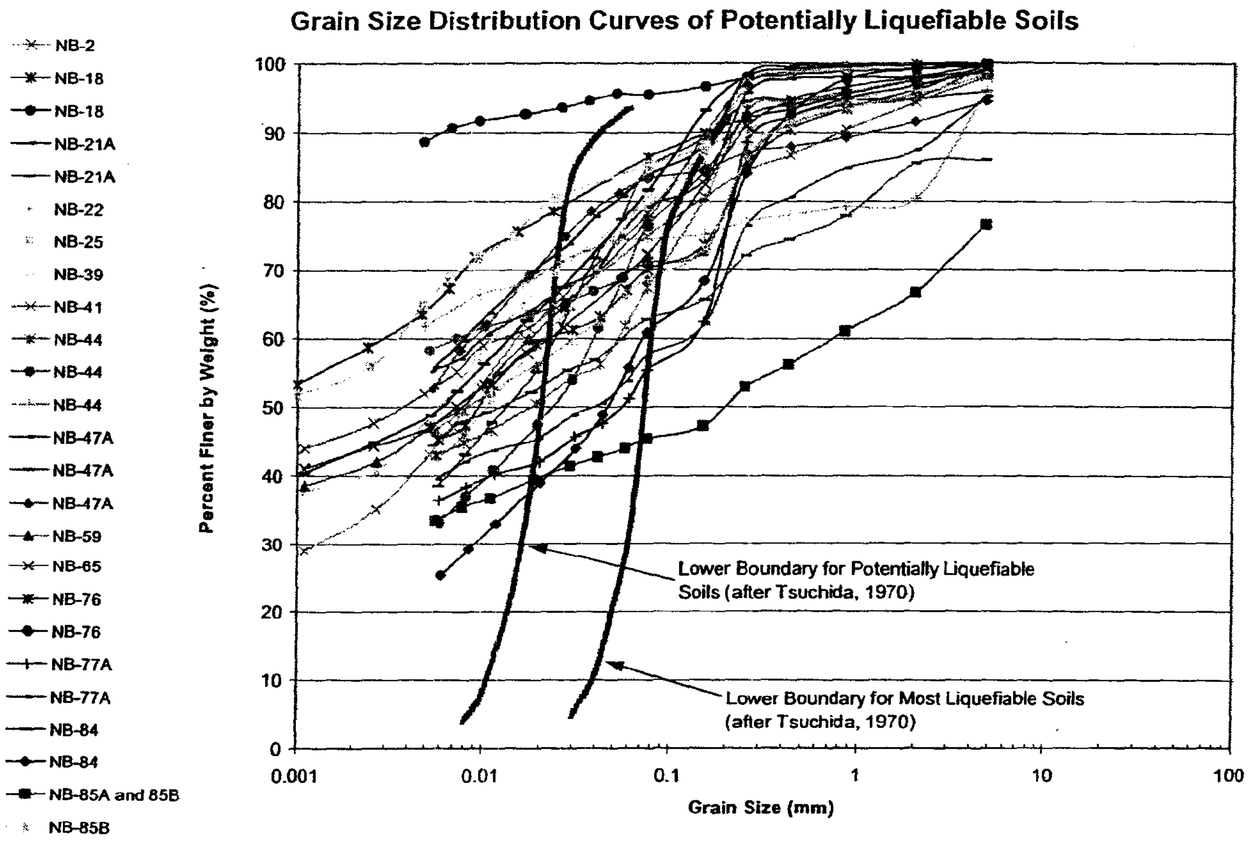

Figure 1. Summary of Grain Size Distribution for Native Material.

GEOTEXTILE DESIGN ANALYSIS

GeoSyntec Consultants
COMPUTATION COVER SHEET

Client: Tennessee Valley Authority (TVA)

Project: Kingston Fossil Plant Gypsum Disposal Facility **Project/Proposal #:** GR3731 **Task #:** 06

Title of Computations: *Geotextile Design Analysis*

Computation Package:

Computations By: [signature] SIGNATURE — 5/8/06 DATE
Jill F. Roboski/Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer): [signature] SIGNATURE — 5/8/06 DATE
for Beth Gross, Ph.D., P.E. / Senior Engineer
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Computations Checked By: [signature] SIGNATURE — 5/8/06 DATE
for Beth Gross, Ph.D., P.E. / Senior Engineer
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Computations Backchecked By (Originator): [signature] SIGNATURE — 5/8/06 DATE
Jill F. Roboski/Engineer
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Approved By (PM or Designate): [signature] SIGNATURE — May 12, 2006 DATE
R. Neil Davies, C. Eng., MICE, P.E./Principal
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Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by:	JFR	Date:	06 /04 /12 (YY MM DD)	Reviewed by:	B. Gross	Date:	06 04 19 (YY MM DD)
Client:	TVA	Project:	Kingston Fossil Plant	Project/Proposal No.:	GR3731	Task No:	06

GEOTEXTILE DESIGN ANALYSIS

PURPOSE

The purpose of this calculation package is to evaluate the minimum requirements of the geotextile filter to be used for the internal drainage system of the gypsum disposal facility at Kingston Fossil Plant-Peninsula Site. The filter will be located around the gravel material of the central drainage corridor and perimeter drainage trenches to separate the sluiced gypsum from the drainage gravel material. The geotextile filter will be specified as needlepunched and non-woven.

This design evaluates the filtration and survivability requirements for the geotextile, and minimum specifications to meet these requirements are provided.

METHODOLOGY

Geotextile Filtration

The filtration characteristics of the geotextile will be evaluated using a retention criterion, a permeability criterion, and an anti-clogging criterion, based on methods presented in the technical literature (Christopher and Holtz 1984, Giroud 1982, Koerner et al. 1994, USEPA 1987).

Geotextile Survivability

Survivability requirements (grab, tear, puncture, and burst strengths) will also be considered so that the geotextile will have adequate resistance to stresses applied on the geotextile during construction (i.e., when concentrated stresses should be the highest), using the method presented in GRI-GT13 (2004).

As each criterion is evaluated and specifications are derived, characteristics of geotextile products on the current market will be checked to make sure the specification is reasonable and that products are available that can meet the specification.

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Client: TVA Project: Kingston Fossil Plant Project/Proposal No.: GR3731 Task No: 06

FILTRATION EVALUATION RESULTS

The filtration criteria used for the geotextile filter design are presented below in Table 1, followed by a description justifying selection of the required design values.

Table 1. Filtration Criteria for Geotextile (adapted From Christopher and Holtz, 1984; Giroud, 1982; and USEPA, 1987)

1. Retention Criterion

1.1. Soils with less than 50% particles < 0.075 mm (US Sieve No. 200)

Density index of the soil (Relative density)		Linear coefficient of uniformity of the soil	
		$1 < C'_u < 3$	$C'_u > 3$
loose soil	$I_D < 35\%$	$O_{95} < C'_u\, d_{50}$	$O_{95} < \frac{9}{C'_u} d_{50}$
medium dense soil	$35\% < I_D < 65\%$	$O_{95} < 1.5\, C'_u\, d_{50}$	$O_{95} < \frac{13.5}{C'_u} d_{50}$
dense soil	$I_D > 65\%$	$O_{95} < 2\, C'_u\, d_{50}$	$O_{95} < \frac{18}{C'_u} d_{50}$

1.2. Soils with more than 50% particles < 0.075 mm (US Sieve No. 200)
$O_{95} \leq 210\ \mu m$ (US Sieve No. 70)

2. Permeability Criterion

2.1. Critical and/or Severe Applications
$k_{geotextile} > 10\, k_{soil}$

2.2. Noncritical and Nonsevere Applications
$k_{geotextile} > k_{soil}$

3. Anti-Clogging Criterion

Nonwoven geotextiles: porosity, $n_g > 30\%$

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Client: TVA Project: Kingston Fossil Plant Project/Proposal No.: GR3731 Task No: 06

Table 1 (Continued). Filtration Criteria

Notes: - O_{95} is the apparent opening size (AOS) of the geotextile

-C'_u = linear coefficient of uniformity = $\sqrt{d'_{100}/d'_0}$

where d'_{100} and d'_0 are the top and bottom extremities, respectively, of a line drawn through the central portion of a soil particle-size distribution curve

- d_{50} and d_{85} are soil particle sizes for which 50% and 85%, respectively, of particles are finer by weight

- I_D = relative density or density index = $(e - e_{min})/(e_{max} - e_{min})$, where e = soil void ratio; e_{min} = soil minimum void ratio, and e_{max} = soil maximum void ratio

- $k_{geotextile}$ = geotextile hydraulic conductivity; k_{soil} = soil hydraulic conductivity

- porosity, n_g (dimensionless) is calculated as follows: $n_g = 1 - \mu_g/(\rho_g\ t_g)$, where: μ_g = geotextile mass per unit area, ρ_g = polymer density, and t_g = geotextile thickness.

Geotextile Retention (Filter Design)

The geotextile must have openings that are small enough to retain fine-grained soil particles to avoid clogging or flow capacity reduction of the gravel in the drainage corridor. Therefore, the apparent opening size (AOS, hereafter referred to as O_{95}) of the geotextile must be less than a required minimum value. The retention criterion is given in Table 1.

The gravel drainage material will be wrapped by the geotextile which in turn will be overlain by sedimented gypsum with primarily silt-sized particles. A copy of a typical grain size distribution curve for fine grained gypsum material obtained from a similar TVA gypsum disposal facility is shown in Figure 1. According to this grain size distribution curve, the gypsum material is characterized as having more than 50% particles finer than 0.075 mm (i.e., U.S. Sieve No. 200). As shown in Table 1, for this type of soil, the geotextile retention criterion is as follows:

$O_{95} \leq 210\ \mu m$ (U.S. Sieve No. 70) [USE AS PRODUCT SPECIFICATION]

Geotextile Permeability

The geotextile must have openings that are large enough to allow gypsum drainage water to pass through the gypsum/geotextile interface without significant flow impedance. Thus, the hydraulic conductivity or permeability of the geotextile must be greater than a minimum required value. The permeability criterion is given in Table 1. For severe or critical applications, the hydraulic conductivity of the geotextile $k_{geotextile}$ should be at least ten times greater than the hydraulic conductivity of the retained soil k_{soil}. Given the importance of long-term function of the drainage layer, the geotextile is designed so that:

$$k_{geotextile} > 10\ k_{soil}$$

As discussed previously, the upgradient side of the geotextile will be in contact with gypsum. A typical hydraulic conductivity evaluated for gypsum material from a similar disposal facility [MACTEC, 2004] is approximately $k_{soil} = 5 \times 10^{-4}$ cm/s (Figure 2). Therefore the geotextile permeability criterion is as follows:

$k_{geotextile} > 10 \times (5.0 \times 10^{-4}$ cm/s$) = 5.0 \times 10^{-3}$ cm/s. [USE AS PRODUCT SPECIFICATION]

Note that some manufacturers report the permeability property as "permittivity" (Ψ), which is defined as Ψ=k/t. Based on the range of geotextile mass per unit areas and thicknesses anticipated for the project (6 to 16 oz/yd^2 (200 to 540 g/m^2) and 1.3 to 5.7 mm, respectively), typical $k_{geotextile}$ values (calculated from typical permittivities and thicknesses) for needlepunched non-woven geotextiles are 0.2 to 0.4 cm/sec. Therefore, needlepunched non-woven geotextiles for this project are anticipated to have permeabilities well above the minimum required permeability value recommended to prevent flow impedance.

Geotextile Anti-Clogging

The geotextile filter must have enough openings so that blocking some of them will not significantly clog the geotextile and inhibit flow into the granular drainage layer. Thus, the porosity of the geotextile must be greater than a required minimum value. The clogging criterion is given in Table 1. As shown in Table 1, for non-woven geotextiles, the geotextile porosity n_g is required to be:

$$n_g > 30\%$$

Geotextile porosity is not a property that is directly measured or reported by manufacturers, however it can be calculated as indicated in Table 1 above (i.e., $n_g = 1 - \mu_g/(\rho_g\ t_g)$). Typical resulting n_g values for non-woven geotextiles are 50 to 95%. Based on the geotextile density of polypropylene or polyethylene and the range of mass per unit areas and thicknesses anticipated for the project (6 to 16 oz/yd^2 (200 to 540 g/m^2)

Written by: JFR	Date: 06 /04 /12 (YY MM DD)	Reviewed by: B. Gross	Date: 06 04 19 (YY MM DD)
Client: TVA	Project: Kingston Fossil Plant	Project/Proposal No.: GR3731	Task No: 06

and 1.3 to 5.7 mm, respectively), the calculated n_g values range from approximately 80% to 90%, which is well in excess of the minimum required porosity required to prevent clogging.

SURVIVABILITY EVALUATION RESULTS

Survivability refers to the ability of the geotextile to withstand the stresses during installation and handling in the field. The survivability criteria used for the geotextile filter design are presented below in Tables 2 and 3 using a two-step method outlined by GRI-GT13 (2004), followed by a discussion on the assumptions used to select the required design values.

Table 2. Required Degree of Survivability as a Function of Subgrade Conditions and Construction Equipment (GRI-GT13)*

Subgrade Conditions	Low ground-pressure equipment (≤ 25 kPa)	Medium ground-pressure equipment (> 25 kPa, ≤ 50 kPa)	High ground-pressure equipment (> 50 kPa)
Subgrade has been cleared of all obstacles except grass, leaves, and fine wood debris. Surface is smooth and level so that any shallow depressions and humps do not exceed 450 mm in depth or height. All larger depressions are filled. Alternatively, a smooth working table may be placed.	Low	Moderate	High
Subgrade has been cleared of obstacles larger than small to moderate-sized tree limbs and rocks. Tree trunks and stumps should be removed or covered with a partial working table. Depressions and humps should not exceed 450 mm in depth or height. Larger depressions should be filled.	Moderate	High	Very High
Minimal site preparation is required. Trees may be felled, delimbed, and left in place. Stumps should be cut to project not more than ± 150 mm above subgrade. Fabric may be draped directly over the tree trunks, stumps, large depressions and humps, holes, stream channels, and large boulders. Items should be removed only if placing the fabric and cover material over them will distort the finished road surface.	High	Very High	Not Recommended

* Recommendations are for 150 to 300 mm initial lift thickness. For other initial lift thicknesses:
300 to 450 mm: reduce survivability requirement one level;
450 to 600 mm: reduce survivability requirement two levels;
> 600 mm: reduce survivability requirement three levels
For special construction techniques such as prerutting, increase the fabric survivability requirement one level. Placement of excessive initial cover material thickness may cause bearing failure of the soft subgrade.

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Client: TVA Project: Kingston Fossil Plant Project/Proposal No.: GR3731 Task No: 06

Table 3. GRI-GT13 Geotextile Strength Property Requirements

			Geotextile Classification (1)						
			Class 1 (high)		Class 2 (moderate)		[redacted]		
Tests	Test Methods	Units	Elongation < 50%	Elongation ≥ 50%	Elongation < 50%	Elongation ≥ 50%	Elongation < 50%	[redacted]
Grab strength	ASTM D 4632	N	1400	900	1100	700	800	[redacted]
Trapezoid Tear strength	ASTM D 4533	N	500	350	400	250	300	[redacted]
CBR Puncture strength	ASTM D 6241	N	2800	2000	2250	1400	1700	[redacted]
Permittivity	ASTM D 4491	s^{-1}	0.02	0.02	0.02	0.02	0.02	[redacted]
Apparent opening size	ASTM D 4751	mm	0.6	0.6	0.6	0.6	0.6	[redacted]
Ultraviolet stability (2)	ASTM D 4355	% Ret. @ 500 hrs	50	50	50	50	50	[redacted]

Notes: (1) All values are MARV except UV stability (which is a minimum value) and AOS which is a maximum value).
(2) Evaluation to be on 50 mm strip tensile specimens after 500 hours exposure.

As shown above, the degree of survivability is first evaluated using Table 2 with the anticipated installation conditions. The following conditions are assumed to apply: (i) smooth and level subgrade condition; and (ii) maximum equipment ground pressure of less than 3.6 psi (25 kPa) (i.e., low ground-pressure due to equipment use considering the material is sluiced into place). Using Table 2, a "low" degree of survivability is used.

In the second step, the minimum required values for the mechanical properties of the geotextile are established from Table 3 based on the "low" or "Class 3" survivability requirement. The chart provides minimum required values for two ranges of geotextile extensibility. Values were selected for the more extensible range because this range is applicable to non-woven materials that are proposed for the geotextile filter.

CONCLUSIONS

Based on the evaluations herein, the following minimum specifications are recommended for the geotextile filter.

- Retention and Filtration:
  - Apparent Opening Size, $O_{95} \leq 210$ μm (U.S. Sieve No. 70)
  - Water Permeability, $k_{geotextile} \geq 5.0 \times 10^{-3}$ cm/s
- Survivability, Mechanical Properties:
  - Grab Strength = 500 N (113 lbs)
  - Trapezoid Tear Strength = 180 N (41 lbs)
  - CBR Puncture Strength = 1,000 N (225 lbs)

REFERENCES

Christopher, B.R., and Holtz, R.D., "*Geotextile Engineering Manual*", FHWA-DTFH61-80-C-00094, 1984.

Geosynthetic Research Institute (GRI), "Standard Specification for Test Methods and Properties for Geotextiles Used as Separation Between Subgrade Soil and Aggregate", *GRI Standard GT-13,* 2004.

Giroud, J.P., "Filter Criteria for Geotextiles", *Proceedings, Second International Conference on Geotextiles,* Vol. 1, Las Vegas, NV, August 1982, pp. 37-42.

Koerner, G.R., Koerner, R.M., and Martin, J.P., "Design of Landfill Leachate-Collection Filters", *ASCE Journal of Geotechnical Engineering*, Vol. 120, No.10, October 1994, pp. 1792-1803.

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USEPA, "*Background Document: Proposed Liner and Leak Detection Rule*", EPA\530-SW-87-015, Prepared by GeoServices Inc., May 1987, 526 p.

Written by:	JFR	Date:	06 /04 /12 (YY MM DD)	Reviewed by:	B. Gross	Date:	06 04 19 (YY MM DD)
Client:	TVA	Project:	Kingston Fossil Plant	Project/Proposal No.:	GR3731	Task No:	06

Figure 1. TYPICAL GRAIN SIZE DISTRIBUTION CURVE FOR CUMBERLAND GYPSUM (Unpublished Data)

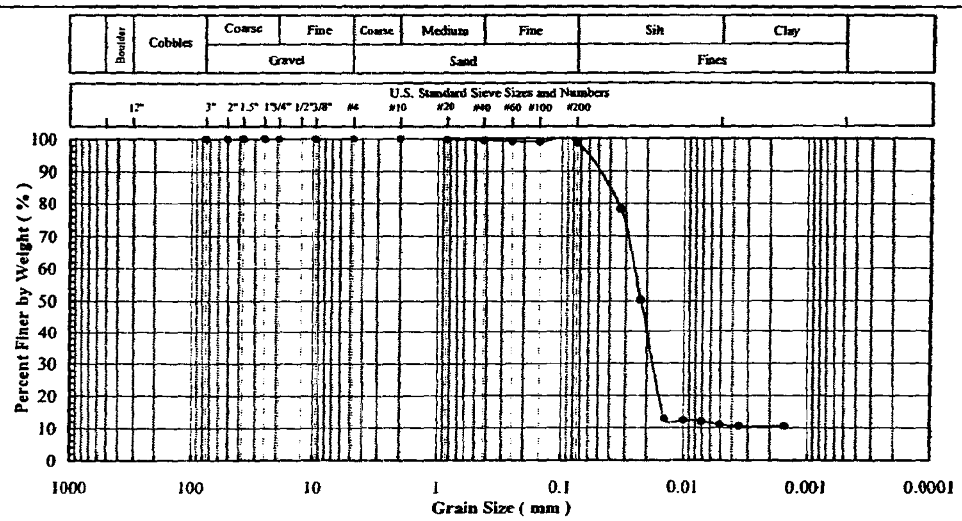
Excel Geotechnical Testing, Inc.
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name:	KIF-Peninsula Site
Project No:	182
Client Sample ID:	Sample-01
Lab Sample No:	D017

ASTM C 136, D 2216
D 1140, D 422, D 854

SOIL INDEX PROPERTIES

Moisture Content, Grain Size, Atterberg Limits, Classification



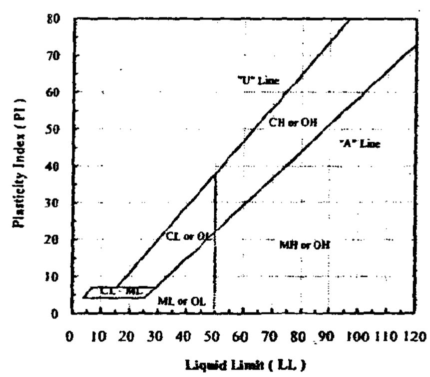
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	100.0
#10	2.00	100.0
#20	0.850	99.7
#40	0.425	99.4
#60	0.250	99.1
#100	0.150	98.9
#200	0.075	98.7

Specific Gravity (-):	2.45

Hydrometer Particle Diameter (mm)	% Finer
0.0332	78.3
0.0142	12.8
0.0071	11.9
0.0035	10.5
0.0015	10.5

Gravel (%):	
Sand (%):	1.3
Fines (%):	98.7
Silt (%):	87.7
Clay (%):	11.0

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
Sample-01	D017	34.6	98.7	NP	NP	NP	ML - Silt

Note(s):

Some of the tests may not be applicable for the material (gypsum) tested.

An assumed specific gravity of 2.45 was used when analysing the hydrometer test results.

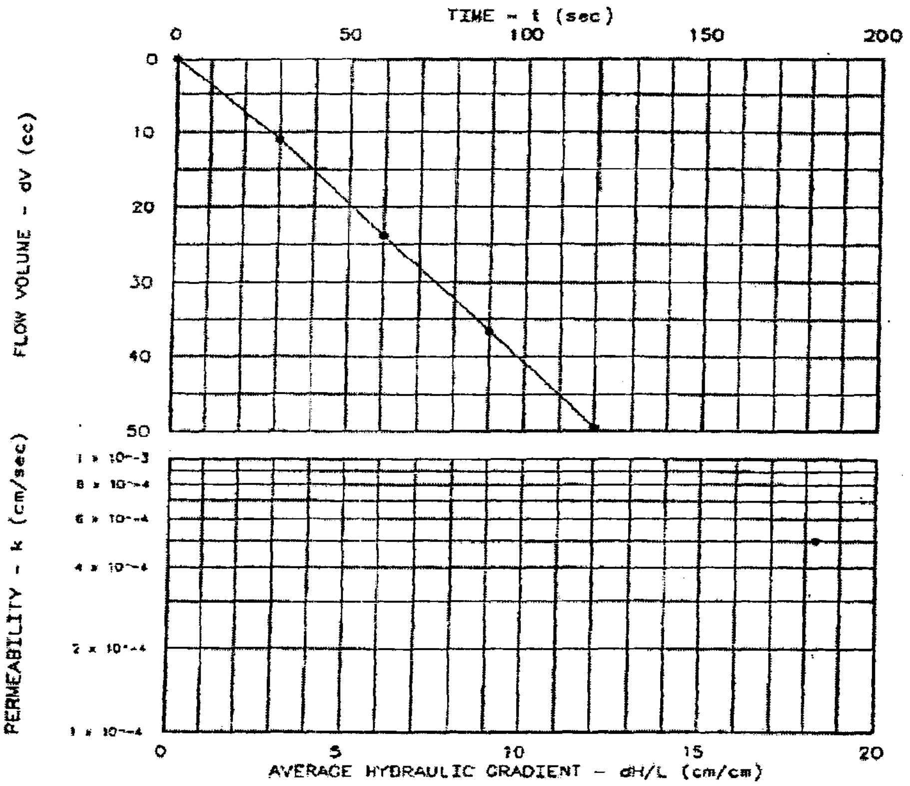
Written by:	JFR	Date:	06 /04 /12 (YY MM DD)	Reviewed by:	B. Gross	Date:	06 04 19 (YY MM DD)
Client:	TVA	Project:	Kingston Fossil Plant	Project/Proposal No.:	GR3731	Task No:	06

Figure 2. TYPICAL PERMEABILITY
FOR CUMBERLAND GYPSUM (MACTEC, 2004)

PERMEABILITY TEST REPORT

TEST DATA:
Specimen Height (cm): 5.04
Specimen Diameter (cm): 7.33
Dry Unit Weight (pcf): 69.0
Moisture Before Test (%): 29.0
Moisture After Test (%): 48.8
Run Number: 1 ● 2 ▲
Cell Pressure (psi): 57.0
Test Pressure(psi): 52.0
Back Pressure(psi): 50.7
Diff Head (psi): 1.3
Flow Rate (cc/sec): 4.14 x 10--1
Perm. (cm/sec): 5.02 x 10--4

SAMPLE DATA:
Sample Identification: Hole #3
Visual Description: Gypsum
Remarks:
Maximum Dry Density (pcf):
Optimum Moisture Content (%):
Percent Compaction:
Permeometer type: Flexible Wall
Sample type: Shelby Tube



Project: TVA Kingston Fossil Plant - CUF Gypsum	Project No.: 3043041009
Location:	File No.: As# 2651
Date: 05-04-04	Lab No.: 6226
PERMEABILITY TEST REPORT	Tested by: JA
	Checked by: MH
	Test: CH - Constant head

FOUNDATION SETTLEMENT ANALYSIS

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Tennessee Valley Authority (TVA)

Project: Kingston Fossil Plant Gypsum Disposal Facility **Project/Proposal #:** GR3731 **Task #:** 06

Title of Computations: *Foundation Settlement Analysis*

Computation Package: ______________________

Computations By:

SIGNATURE: [signature] DATE: May 4, 2006

Jill F. Roboski/Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):

SIGNATURE: [signature] DATE: May 4, 2006

Paul Sabatini, Ph.D., P.E. / Senior Engineer
PRINTED NAME AND TITLE

Computations Checked By:

SIGNATURE: [signature] DATE: May 4, 2006

Paul Sabatini, Ph.D., P.E. / Senior Engineer
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):

SIGNATURE: [signature] DATE: May 4, 2006

Jill F. Roboski/Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):

SIGNATURE: [signature] DATE: May 8, 2006

R. Neil Davies, C. Eng., MICE, P.E./Principal
PRINTED NAME AND TITLE

Approval Notes: ______________________

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: JFR **Date:** 5/23/2006 **Reviewed by:** PJS **Date:** 5/4/2006

Client: TVA **Project:** Kingston Fossil Plant Gypsum Stack **Project/Proposal No.:** GR3731 **Task No.:** 06

FOUNDATION SETTLEMENT ANALYSIS

PURPOSE

The purpose of this calculation package is to evaluate the foundation settlements below the proposed gypsum disposal facility at the Kingston Fossil Plant-Peninsula Site. The gypsum will be placed using the rim ditch method to approximately Elevation 900 ft MSL, and placed using the dry stack method to approximately Elevation 985 ft MSL. A subgrade layer comprising relocated/recompacted native soils will be placed on top of the existing ground, followed by a 3-ft thick layer of compacted clay comprising the geologic buffer.

The calculated settlements were used to evaluate the post-settlement grades of the subgrade and geologic buffer and tensile strains in the geologic buffer.

METHOD OF ANALYSIS

Settlements of the foundation material were calculated using equations for conventional one-dimensional compression settlement. It was assumed that the settlements are caused by primary consolidation of the foundation soil layers due to overburden stresses resulting from the gypsum load.

Settlement calculations were performed using a spreadsheet created in Microsoft EXCEL®. The spreadsheet calculates the magnitude of settlement due to one-dimensional consolidation at sections taken at horizontal locations approximately every 100 ft along a selected cross-section. Calculation layers in the foundation material for each vertical section were at most 10 ft thick. This calculation method allows for the geometry of the bedrock and subsurface soil layers to be modeled.

In the EXCEL® spreadsheets, settlements resulting from primary consolidation of soil layers are calculated using the following equations for one-dimensional compression [Lambe, 1969]:

$$S_p = \frac{C_r}{1+e_o} H \log\left(\frac{\sigma'_{vo} + \Delta\sigma}{\sigma'_{vo}}\right) \; for \; \sigma'_{vo} + \Delta\sigma_v < \sigma'_p \qquad (1)$$

$$S_p = \frac{C_c}{1+e_o} H \log\left(\frac{\sigma'_{vo} + \Delta\sigma}{\sigma'_p}\right) + \frac{C_r}{1+e_o} H \log\left(\frac{\sigma'_p}{\sigma'_{vo}}\right) \; for \; \sigma'_{vo} + \Delta\sigma_v > \sigma'_p \qquad (2)$$

where: S_p = primary settlement (ft);

C_c = compression index;
C_r = recompression index;
e_o = initial void ratio;
H = initial thickness of compressible layer (ft);
σ'_{vo} = initial vertical effective stress in the ground before waste placement (psf);
σ'_p = preconsolidation stress (psf); and
$\Delta\sigma$ = increment of vertical stress (psf).

Alternatively, the modified compression index, $C_{c\varepsilon}$, and the modified recompression index, $C_{r\varepsilon}$, can be used in Equations 1 and 2. These parameters are defined below:

$$C_{c\varepsilon} = \frac{C_c}{1 + e_o} \quad (3)$$

$$C_{r\varepsilon} = \frac{C_r}{1 + e_o} \quad (4)$$

Tensile Strains in Geologic Buffer Layer

Foundation settlements due to gypsum loading have the potential to induce tensile strains in the geologic buffer. Tensile strain was calculated using the following formula:

$$\varepsilon = (L_f - L_o) / L_o \quad (5)$$

where:
ε = strain in the geologic buffer (tension is positive)
L_o = initial (pre-settlement) length between calculation points
L_f = final (post-settlement) length between calculation points

Calculated tensile strains were compared to allowable values. Typical allowable tensile strains for compacted clays are on the order of 0.1 to greater than 1 percent [La Gatta et al., 1997].

SUBSURFACE STRATIGRAPHY

Information on the site stratigraphy used in these analyses is summarized in MACTEC [2005], MACTEC [2006], and TVA [2005]. The top of bedrock elevations were obtained from a contour map developed from a series of site investigations that included soil borings, CPT soundings, and GeoProbe soundings performed at the site as presented in TVA [2005]. Current ground elevations were obtained from the Kingston Fossil Plant topographic map provided by TVA. Nearby borings were projected to the cross section to develop the thicknesses of the compressible native material along the cross section.

This native material was subdivided into two groups based on the Standard Penetration Test (SPT) blow count and water content of the material. A description of the subsurface stratigraphy is presented below.

Native Material

The onsite native material is primarily classified as a medium stiff to stiff silty clay. The blow count of the material onsite ranges from 6 to 20 blows per foot (bpf). "Soft" material, classified by Standard Penetration Test (SPT) N values less than or equal to 4 bpf was found in several borings. This soft material ranged in thickness from 0 to 20 ft along the cross sections selected for the settlement analyses and occurred just above the bedrock material. For the analyses performed herein, compression properties were selected for two layers of foundation material (i.e., N>4 and N≤4).

- N>4: Three one-dimensional consolidation tests were performed on samples representative of material with SPT blow counts greater than 4. The maximum past pressure of the native material was determined using the Casagrande construction method [Holtz and Kovacs, 1981]. According to the consolidation test results, the preconsolidation stress ranges from 7,350 psf to 10,850 psf. The average calculated preconsolidation stress is 9,121 psf (see Casagrande selection of preconsolidation stress on test result curves in Attachment A).

- N≤4: A single one-dimensional consolidation test was performed on a sample representative of material with SPT blow count less than 4. The calculated preconsolidation stress of this native material is 5,650 psf (See Attachment A).

Geologic Buffer/Subgrade Fill

A preconsolidation stress was selected for the geologic buffer and subgrade fill assuming that the material is placed at 95 percent of the maximum dry density, at or near optimum water content. The selected preconsolidation stress is 1,000 psf.

Ground Water Table

The groundwater table was found to be directly related to the surface water elevation of the Watts Bar Reservoir adjacent to the site. Based on the normal operating zone for the reservoir, the maximum reservoir elevation is 741 ft MSL during the months of May through October and is decreased to a low elevation of 737 ft MSL during the remainder of the year. The design ground water table was selected as approximately Elevation 741 ft MSL near the sump, based on the July 2005 potentiometric map presented in TVA [2005]. The July 2005 potentiometric map was used in this design to represent the historical high groundwater table because: (i) the July 2005 data were obtained during the maximum reservoir elevation and (ii) the recently obtained March 2006 elevations were lower than the July 2005 elevations. For the purposes of this analysis, the constant ground water table of Elevation 741 ft MSL was used.

ANALYSIS CROSS SECTION

Foundation settlements were calculated along the central drainage corridor (see stratigraphy in Figure 1 and Figure 2). The location of the cross section is provided on Figure 3. This cross section is selected to demonstrate that positive drainage will be maintained through the corridor after placement of the dry stack material.

The central drainage corridor is designed with a pre-settlement compound grade. From the eastern most limit of waste to horizontal location 1600 ft near the boundary between the Phase I and Phase II footprints, the corridor is designed at a 0.3 percent grade; and from horizontal location 1600 ft to the west towards the sump, the corridor is constructed at a 0.76 percent grade. These design grades were selected based on preliminary settlement calculations.

MATERIAL PARAMETERS

Input parameters for the EXCEL® spreadsheet calculations include the surface and subsurface topography profiles, unit weights, modified compression and recompression indices, and ground water surface. Unit weights and compressibility parameters were interpreted from consolidation test results provided in the *Report of Geotechnical Exploration* prepared by MACTEC [2005]. A discussion regarding the material parameters used in this analysis are presented below. A summary of the foundation material parameters is presented in Table 1.

Native Material (N>4)

For the modified compression index, $C_{c\varepsilon}$, a value of 0.14 was selected as the average value from three consolidation tests (as summarized in MACTEC [2005]) performed on foundation material samples at an average loading interval equal to 16,000 to 64,000 psf. The maximum load expected on the foundation material due to gypsum is approximately 25,000 psf. For the modified recompression index, $C_{r\varepsilon}$, a value of 0.0037 was calculated as the average of the unload cycle (i.e., from 4,000 psf to 1,000 psf) from three consolidation tests performed on foundation material samples as summarized in MACTEC [2005]. A total unit weight of 120 lb/ft^3 for the foundation material was selected based on dry unit weights and natural moisture content of the tested samples.

Native Material (N≤4)

A modified compression index, $C_{c\varepsilon}$, of 0.24 was selected from one consolidation test performed on a sample of low blow count material identified by the high moisture content of the material (i.e., moisture content of 54 percent). This modified compression index was selected for an average loading interval of 16,000 to 64,000 psf. For the modified recompression index, $C_{r\varepsilon}$, a value of 0.01 was calculated as the average of the unload cycle from 4,000 to 1,000 psf. A summary of the consolidation test performed on this material is in MACTEC [2005]. A total unit weight of 105 lb/ft^3 was used based on the laboratory results.

Geologic Buffer/Subgrade and Soil Fill

On site material will be used to construct the subgrade, the initial soil berm around the gypsum pond, and the geologic buffer. Standard Proctor tests were run on 17 samples of native material from depths ranging from 6 to 12.5 ft. The unit weight of the soil fill material was selected as 95 percent of the average of the maximum dry unit weights resulting from the Standard Proctor tests. A total unit weight of 117 lb/ft^3 was selected. In the absence of data, the compression and recompression indices chosen to represent the compressibility of the geologic buffer and soil fill materials were a $C_{c\varepsilon}$ value of 0.14 and a $C_{r\varepsilon}$ value of 0.0037.

RESULTS

Calculated settlements along the central drainage corridor under final configuration (i.e., end of dry stack operations) are presented in Table 2. As mentioned above, the calculated settlements account for the compressibility of the native material, subgrade layer, and geologic buffer. The initial (i.e., 0.3 to 0.76 percent) and calculated final post-settlement grade along the gravel drainage corridor are illustrated in Figure 4

Tensile strains in the geologic buffer were calculated along the gravel drainage corridor and are summarized in Table 3. The maximum calculated tensile strain is 0.01 percent.

Details of the consolidation settlement calculations for the native material, subgrade layer, and geologic buffer due to final waste loading along the gravel drainage corridor are provided in Attachment B.

SUMMARY AND CONCLUSIONS

Foundation settlements under final configuration of the gypsum disposal facility were calculated for a cross section along the centerline of the central drainage corridor. Based on settlement results, the maximum calculated settlement is 5.9 ft occurring at horizontal location of 1500 ft. Results indicate that the minimum calculated post-settlement grade is 0.03%, indicating that positive drainage will be maintained along the central drainage corridor.

Maximum tensile strains in the geologic buffer were calculated to be 0.01 percent. Typical allowable tensile strains for compacted clays are on the order of 0.1 to greater than 1 percent [La Gatta et al., 1997]. Therefore tensile strains in the geologic buffer are considered to be acceptable.

REFERENCES

Holtz, R.D., and W.D. Kovacs, "*An Introduction to Geotechnical Engineering*", Prentice Hall, New Jersey, 1981, 733 p.

LaGatta, M. D., Boardman, B.T., Cooley, B.H., and Daniel, D.E., "Geosynthetic Clay Liners Subjected to Differential Settlement", *Journal of Geotechnical and Geoenvironmental Engineering*, ASCE, Vol. 123, No. 5, 1997, pp. 402-410.

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MACTEC, "*Report of Additional Geotechnical Exploration: Proposed Gypsum Disposal Area at Kingston Fossil Plant, Kingston, Tennessee*," MACTEC Project 3043051064.01, prepared for TVA, February 2006.

Tennessee Valley Authority (TVA), "*Kingston Fossil Plant – Peninsula Site Hydrogeologic Evaluation of Coal-Combustion Byproduct Disposal Facility*", WR2005-1-36-133. Prepared by Mr. Hank E. Julian and Mr. J. Mark Boggs for TVA, October 2005.

TABLES

TABLE 1
SUMMARY OF COMPRESSION PARAMETERS

Material	Unit Weight	Compression Properties		
	(pcf)	$C_{c\varepsilon}$	$C_{r\varepsilon}$	σ_p' (psf)
Dry Stack Gypsum	107	-	-	-
Coarse Gypsum	90	-	-	-
Fine Gypsum	100	-	-	-
Subgrade Fill	117	0.14	0.0037	1,000
Geologic Buffer	117	0.14	0.0037	1,000
Native Soil (N>4)	120	0.14	0.0037	9,121
Native Soil (N<4)	105	0.24	0.01	5,650
Bedrock	155	-	-	-

Written by: JFR Date: 5/23/2006 Reviewed by: PJS Date: 5/4/2006

Client: TVA Project: Kingston Fossil Plant Gypsum Stack Project/Proposal No.: GR3731 Task No.: 06

TABLE 2
SUMMARY OF CALCULATED SETTLEMENT ALONG CENTERLINE OF DRAINAGE CORRIDOR

Horizontal Location, (ft)	Initial Grade (%)	Settlement (ft)	Grade Changes[1] (%)	Final Grade[1] (%)
3450	0.3	0.1	-0.02	0.32
3400	0.3	0.1	-0.58	0.88
3300	0.3	0.7	-0.69	0.99
3200	0.3	1.4	-1.12	1.42
3100	0.3	2.5	0.00	0.30
3000	0.3	2.5	-0.11	0.41
2900	0.3	2.6	-0.25	0.55
2800	0.3	2.8	-0.33	0.63
2700	0.3	3.2	0.13	0.17
2600	0.3	3.0	0.15	0.15
2500	0.3	2.9	0.04	0.26
2400	0.3	2.8	-0.32	0.62
2300	0.3	3.2	-0.55	0.85
2200	0.3	3.7	-0.29	0.59
2100	0.3	4.0	-0.40	0.70
2000	0.3	4.4	-0.10	0.40
1900	0.3	4.5	-0.67	0.97
1800	0.3	5.2	0.19	0.11
1700	0.3	5.0	-0.53	0.83
1600	0.76	5.5	-0.41	1.17
1500	0.76	5.9	0.43	0.33
1400	0.76	5.5	0.12	0.64
1300	0.76	5.4	0.06	0.70
1200	0.76	5.3	-0.40	1.16
1100	0.76	5.7	0.62	0.14
1000	0.76	5.1	0.73	0.03
900	0.76	4.4	0.66	0.10
800	0.76	3.7	0.66	0.10
700	0.76	3.0	0.40	0.36
600	0.76	2.6	0.64	0.12
500	0.76	2.0	0.56	0.20
400	0.76	1.4	0.45	0.31
300	0.76	1.0	0.20	0.56
200	0.76	0.8	0.69	0.07
100	0.76	0.1	-	-

Note: (1) The reported value is calculated between the horizontal location where the value is presented and the adjacent horizontal location (i.e. between 1500 and 1400 ft, a grade change of 0.43 percent occurs).

Written by: JFR Date: 5/23/2006 Reviewed by: PJS Date: 5/4/2006

Client: TVA Project: Kingston Fossil Plant Gypsum Stack Project/Proposal No.: GR3731 Task No.: 06

TABLE 3
SUMMARY OF CALCULATED STRAINS DUE TO GYPSUM LOADING

Horizontal Location, (ft)	L_o, (ft)	L_f, (ft)	Strains $\varepsilon^{(1)}$, (%)
3450	**50.0025**	**50.00242**	**-0.0002**
3400	**100.005**	**100.0009**	**-0.0041**
3300	**100.005**	**100.0005**	**-0.0045**
3200	**100.005**	**100.0001**	**-0.0049**
3100	**100.005**	**100.005**	**0.0000**
3000	**100.005**	**100.004**	**-0.0010**
2900	**100.005**	**100.0028**	**-0.0022**
2800	**100.005**	**100.0023**	**-0.0027**
2700	**100.005**	**100.0064**	**0.0014**
2600	**100.005**	**100.0066**	**0.0016**
2500	**100.005**	**100.0054**	**0.0004**
2400	**100.005**	**100.0023**	**-0.0027**
2300	**100.005**	**100.001**	**-0.0040**
2200	**100.005**	**100.0025**	**-0.0025**
2100	**100.005**	**100.0018**	**-0.0032**
2000	**100.005**	**100.004**	**-0.0010**
1900	**100.005**	**100.0006**	**-0.0044**
1800	**100.005**	**100.0071**	**0.0021**
1700	**100.005**	**100.0011**	**-0.0039**
1600	**100.005**	**100.0017**	**-0.0033**
1500	**100.005**	**100.0103**	**0.0053**
1400	**100.005**	**100.0063**	**0.0013**
1300	**100.005**	**100.0056**	**0.0006**
1200	**100.005**	**100.0018**	**-0.0032**
1100	**100.005**	**100.0132**	**0.0082**
1000	**100.005**	**100.0149**	**0.0099**
900	**100.005**	**100.0137**	**0.0087**
800	**100.005**	**100.0139**	**0.0089**
700	**100.005**	**100.0098**	**0.0048**
600	**100.005**	**100.0134**	**0.0084**
500	**100.005**	**100.0122**	**0.0072**
400	**100.005**	**100.0105**	**0.0055**
300	**100.005**	**100.0072**	**0.0022**
200	**100.005**	**100.0144**	**0.0094**
100	-	-	-

Notes: (1) Positive strains are considered tensile. The reported value is calculated between the horizontal location where the value is presented and the adjacent horizontal location (i.e. between 1500 and 1400 ft, a strain of 0.0053 percent occurs).

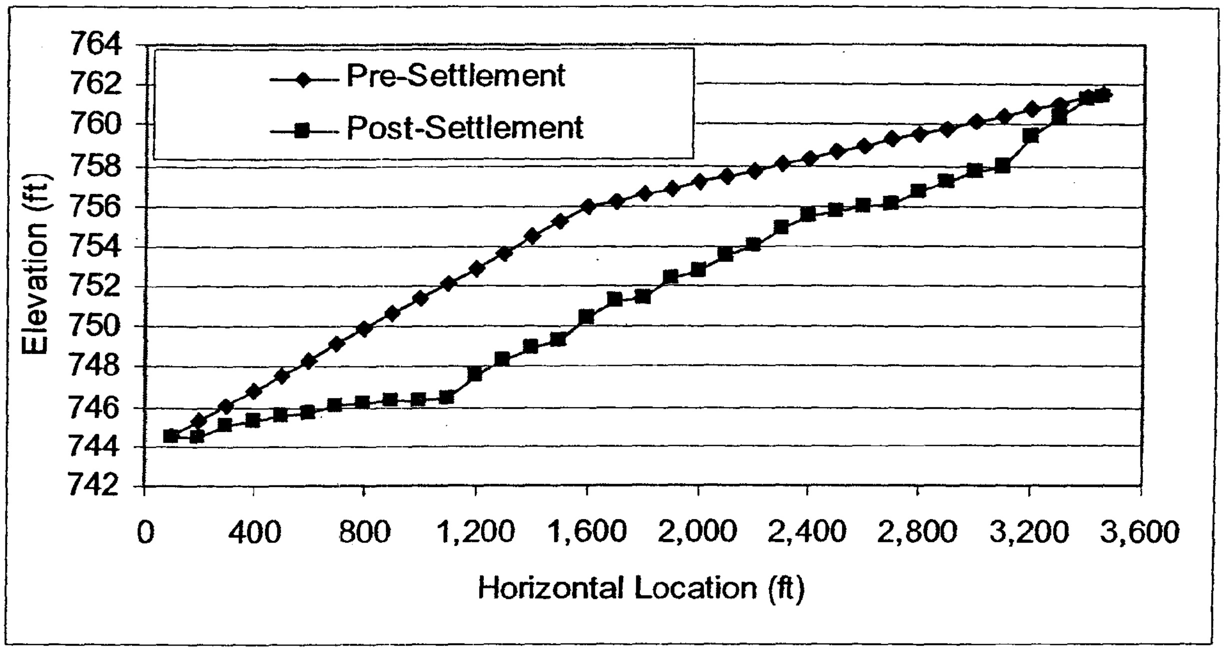
FIGURES

Written by: JFR	Date: 5/23/2006	Reviewed by: PJS	Date: 5/4/2006
Client: TVA	Project: Kingston Fossil Plant Gypsum Stack	Project/Proposal No.: GR3731	Task No.: 06

FIGURE 4

PRE- AND POST-SETTLEMENT GRADES

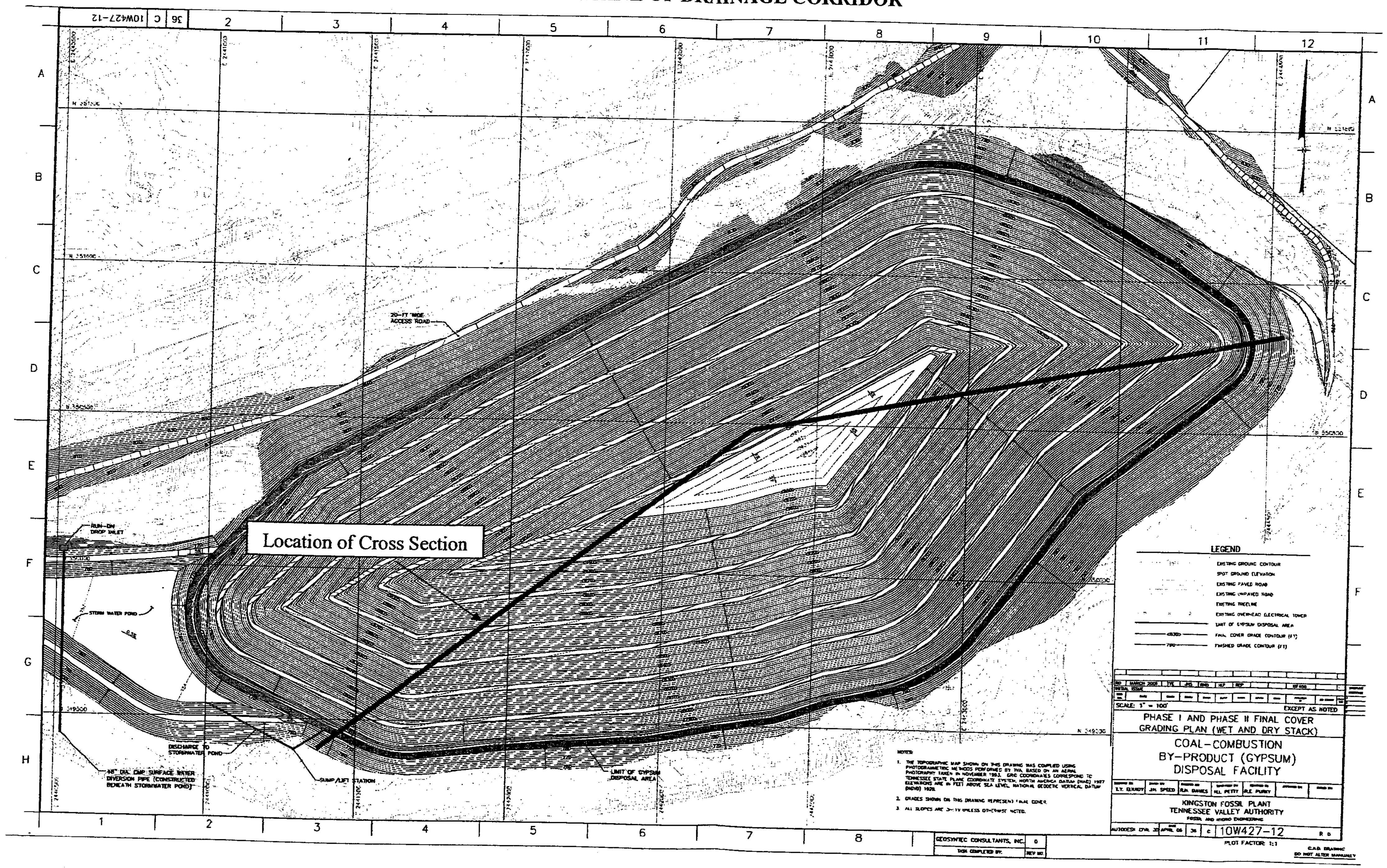
CENTERLINE OF DRAINAGE CORRIDOR



by: JFR Date: 5/23/2006 Reviewed by: PJS Date: 5/4/2006

TVA Project: Kingston Fossil Plant Gypsum Stack Project/Proposal No.: GR3731 Task No.: 06

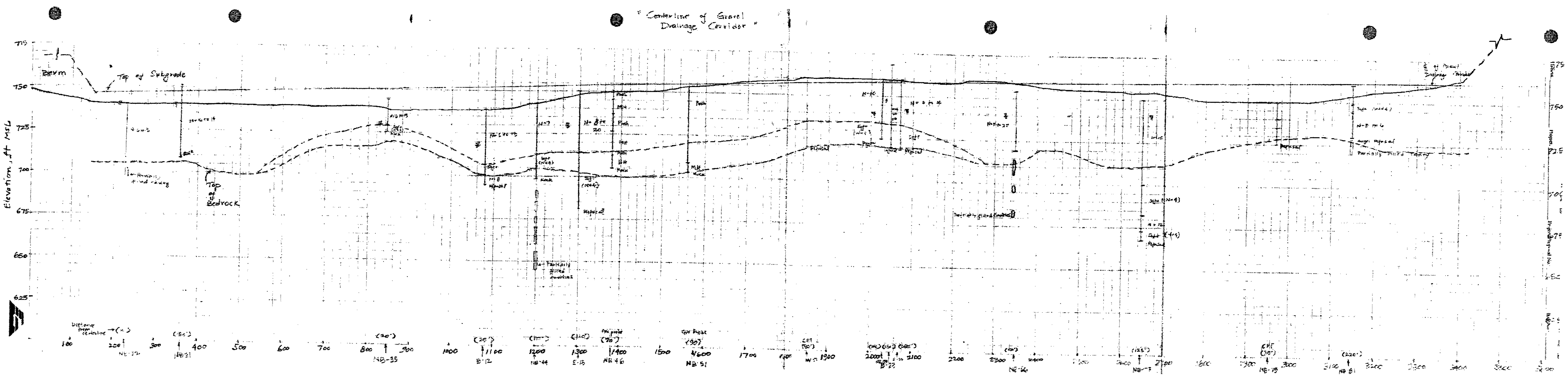
FIGURE 3
LOCATION OF CRITICAL CROSS SECTION:
CENTERLINE OF DRAINAGE CORRIDOR



by: JFR Date: 5/23/2006 Reviewed by: PJS Date: 5/4/2006

TVA Project: Kingston Fossil Plant Gypsum Stack Project/Proposal No.: GR3731 Task No.: 06

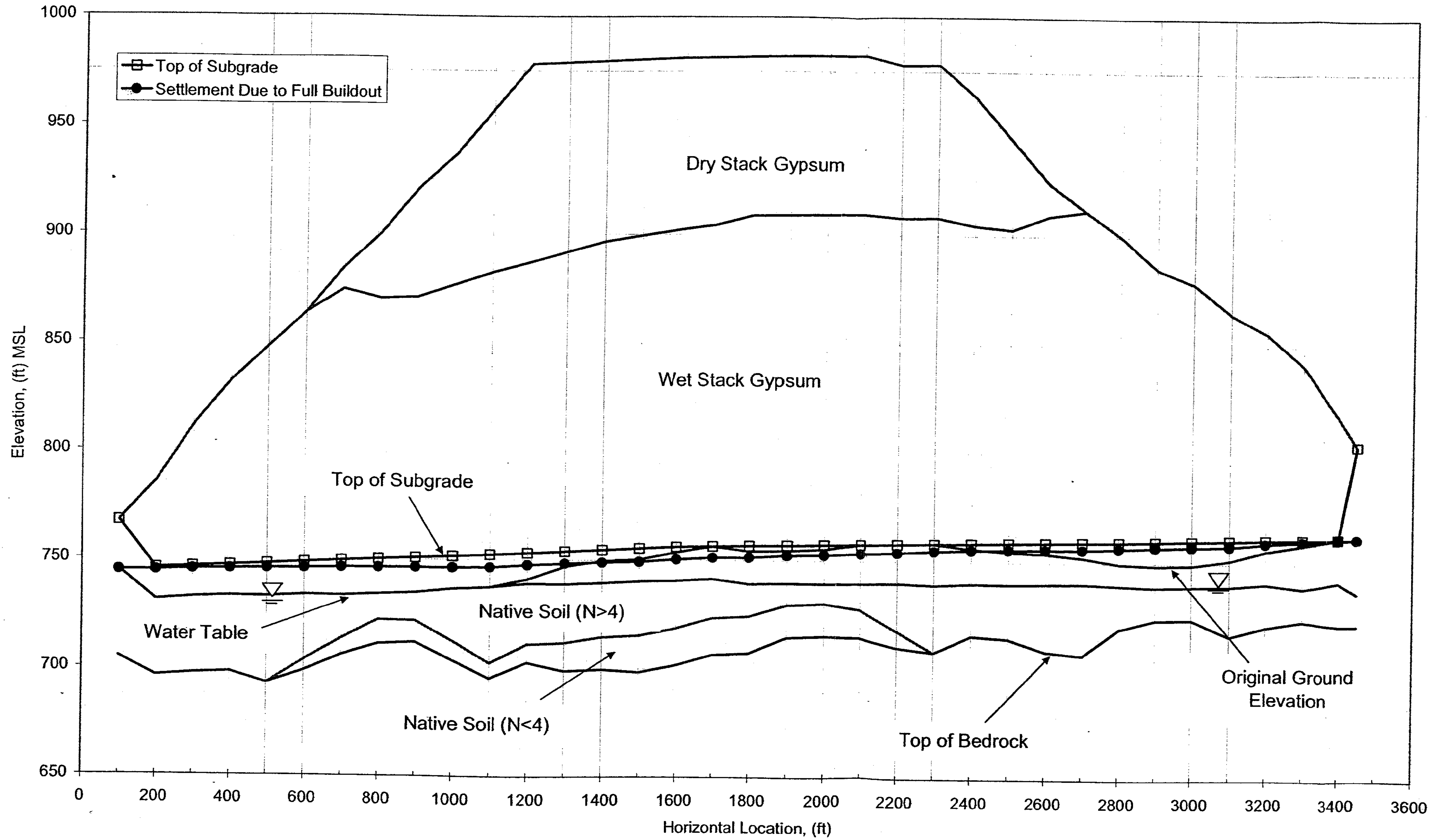
FIGURE 1
SUBSURFACE STRATIGRAPHY BENEATH CENTERLINE OF DRAINAGE CORRIDOR



· JFR Date: 5/23/2006 Reviewed by: PJS Date: 5/4/2006

[illegible] TVA Project: Kingston Fossil Plant Gypsum Stack Project/Proposal No.: GR3731 Task No.: 06

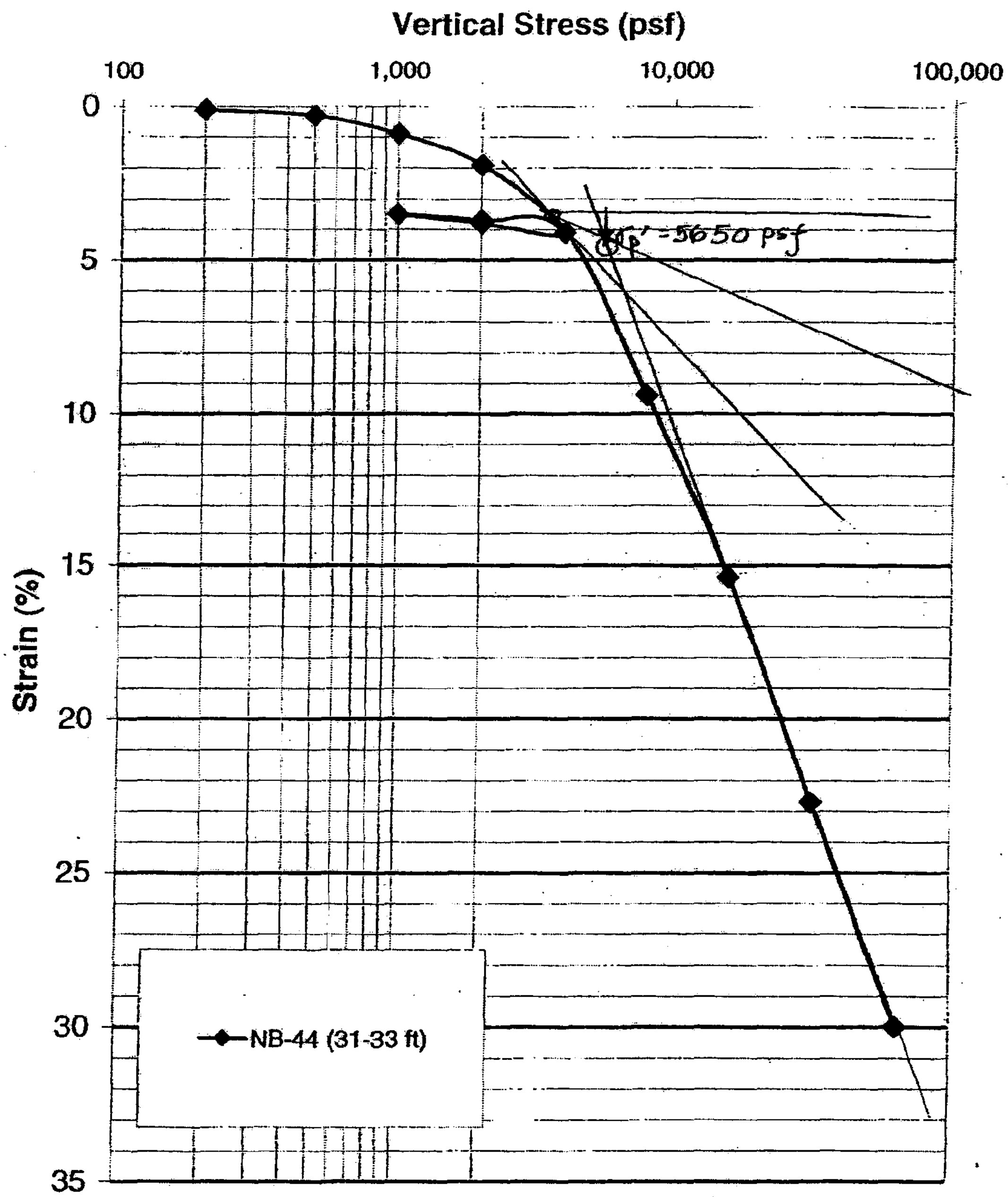
FIGURE 2
SUBSURFACE STRATIGRAPHY AND GYPSUM LOADING ALONG CENTERLINE OF DRAINAGE CORRIDOR



ATTACHMENT A
PRECONSOLIDATION STRESS CALCULATIONS
CASAGRANDE CONSTRUCTION

Written by: JFR Date: 5/23/2006 Reviewed by: PJS Date: 5/4/2006

Client: TVA Project: Kingston Fossil Plant Gypsum Stack Project/Proposal No.: GR3731 Task No.: 06

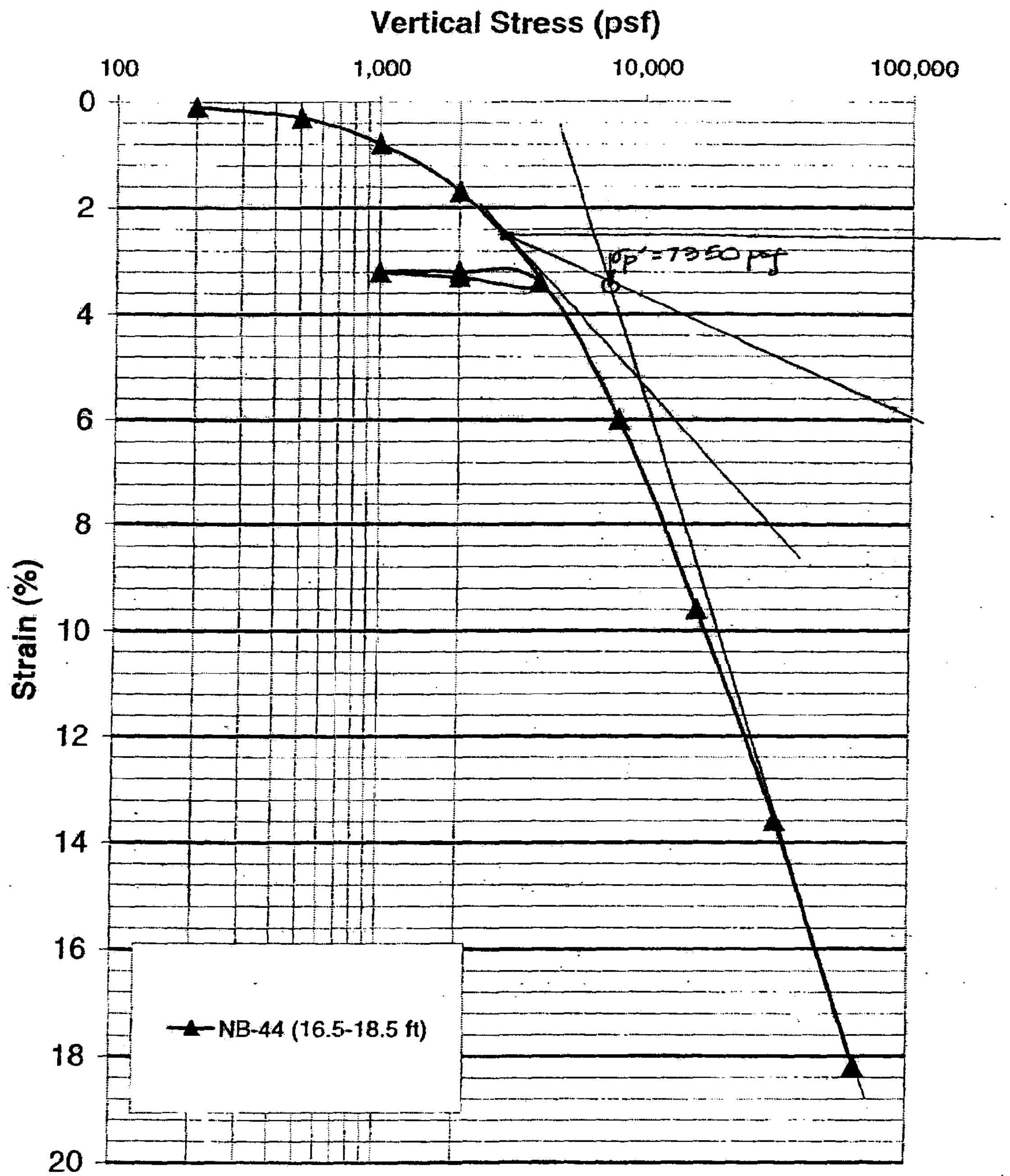


$$C_{r\varepsilon} = \frac{(4.1-3.5)/100}{\log\left(\frac{4000}{1000}\right)} = 0.01$$

$$C_{c\varepsilon} = \frac{(30-15.4)/100}{\log\left(\frac{64000}{16000}\right)} = 0.24$$

Written by: JFR Date: 5/23/2006 Reviewed by: PJS Date: 5/4/2006

Client: TVA Project: Kingston Fossil Plant Gypsum Stack Project/Proposal No.: GR3731 Task No.: 06

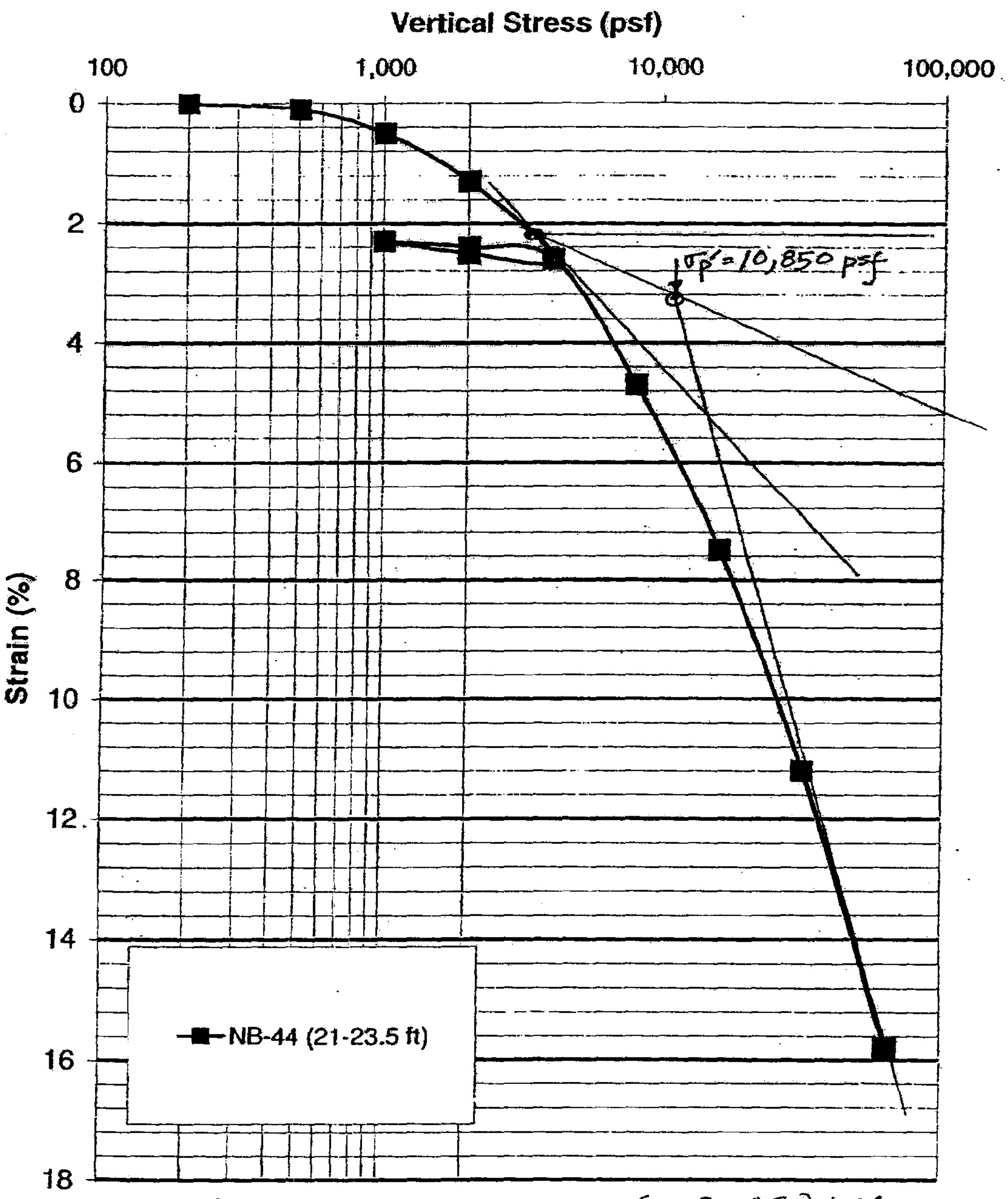


$$C_{r\varepsilon} = \frac{(3.4-3.2)/100}{\log(4000/1000)} = 0.003$$

$$C_{c\varepsilon} = \frac{(18.2-9.6)/100}{\log\left(\frac{64000}{16000}\right)} = 0.14$$

Written by: JFR Date: 5/23/2006 Reviewed by: PJS Date: 5/4/2006

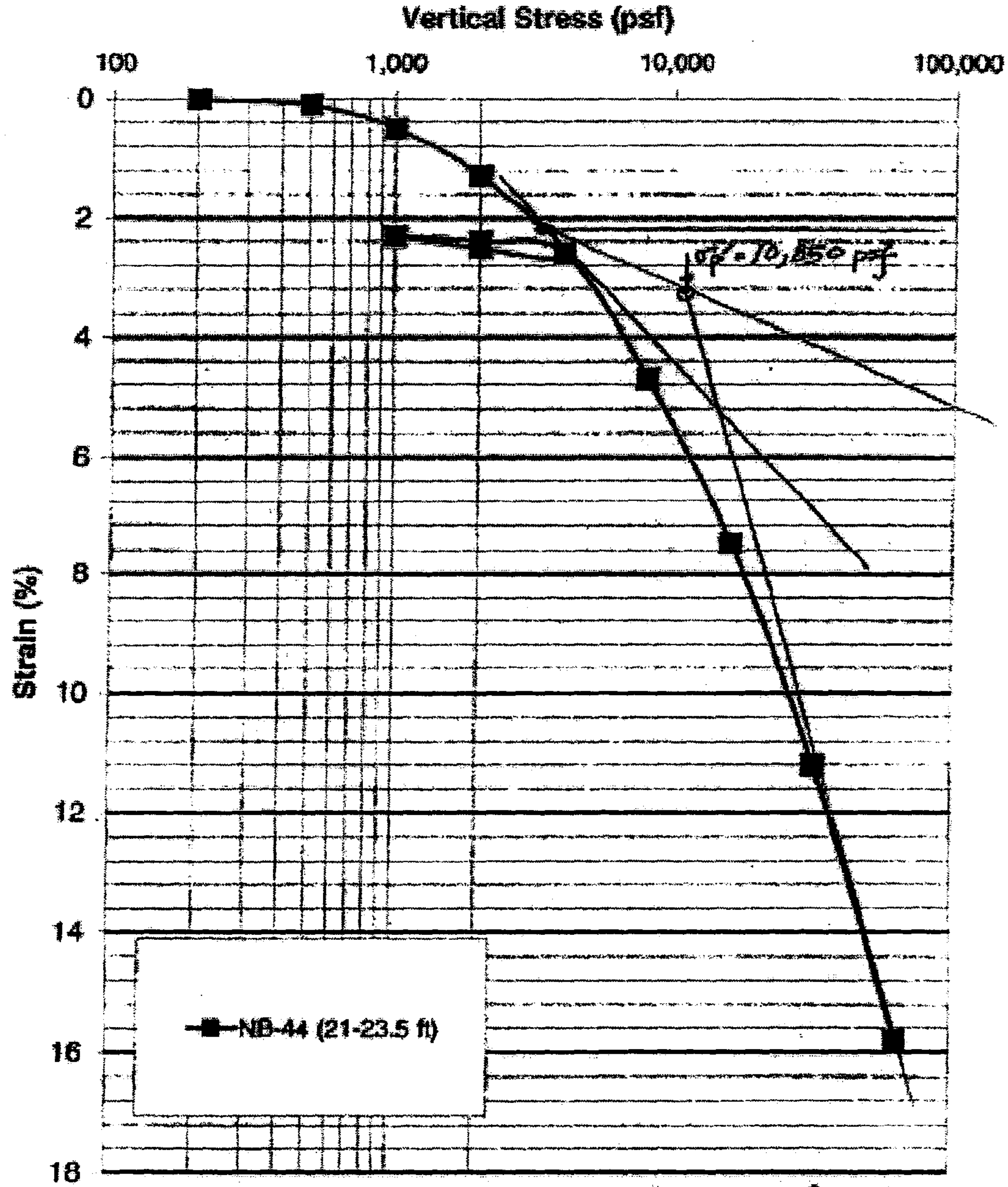
Client: TVA Project: Kingston Fossil Plant Gypsum Stack Project/Proposal No.: GR3731 Task No.: 06



$$C_{r\varepsilon} = \frac{(2.6-2.3)/100}{\log(4000/1000)} = 0.005 \qquad C_{c\varepsilon} = \frac{(15.8-7.5)/100}{\log\left(\frac{64000}{16000}\right)} = 0.14$$

Written by: JFR Date: 5/23/2006 Reviewed by: PJS Date: 5/4/2006

Client: TVA Project: Kingston Fossil Plant Gypsum Stack Project/Proposal No.: GR3731 Task No.: 06



$$C_{r\varepsilon} = \frac{(2.6 - 2.3)/100}{\log(4000/1000)} = 0.005 \qquad C_{c\varepsilon} = \frac{(15.8 - 7.5)/100}{\log\left(\frac{64000}{16000}\right)} = 0.14$$

ATTACHMENT B
SETTLEMENT CALCULATIONS

Fill Material						
γ	117 pcf					
Residual Soil (N>4)		Thickness of Calculation Layers				
γ	120 pcf		10 ft			
Residual Soil (N<4)			Fill	N>4	N<4	
γ	105 pcf	$C_{\epsilon c}$	0.14	0.14	0.24	
		$C_{r\epsilon}$	0.0037	0.0037	0.01	
Gypsum		σ_p'	1000	9121	5650	psf
γwet	100 pcf					
γdry	107 pcf					

Calculation of Settlement in the Geologic Buffer

Horizontal Location (ft)	Point	Thickness of Geologic Buffer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	$C_{\epsilon c}$	$C_{r\epsilon}$	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
3450	1	3	0	0	0	0.14	0.0037	3	1.5	175.5	1000	0
												0

Horizontal Location (ft)	Point	Thickness of Geologic Buffer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	$C_{\epsilon c}$	$C_{r\epsilon}$	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
3400	1	3	56	0	5600	0.14	0.0037	3	1.5	175.5	1000	0.328256
												0.328256

Horizontal Location (ft)	Point	Thickness of Geologic Buffer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	$C_{\epsilon c}$	$C_{r\epsilon}$	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
3300	1	3	80	0	8000	0.14	0.0037	3	1.5	175.5	1000	0.391646
												0.391646

Horizontal Location (ft)	Point	Thickness of Geologic Buffer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	$C_{\epsilon c}$	$C_{r\epsilon}$	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
3200	1	3	96	0	9600	0.14	0.0037	3	1.5	175.5	1000	0.422371
												0.422371

Calculation of Settlement in the Fill Layer

Horizontal Location (ft)	Point	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	$C_{\epsilon c}$	$C_{r\epsilon}$	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
3450	1	42.5	0	0	351	0.14	0.0037	42.5	21.25	2486.25	1000	0
												0

Horizontal Location (ft)	Point	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	$C_{\epsilon c}$	$C_{r\epsilon}$	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
3400	1	0	56	0	5951	0.14	0.0037	0	0	0	1000	0
												0

Horizontal Location (ft)	Point	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	$C_{\epsilon c}$	$C_{r\epsilon}$	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
3300	1	2.5	80	0	8351	0.14	0.0037	2.5	1.25	146.25	1000	0.33297
												0.33297

Horizontal Location (ft)	Point	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	$C_{\epsilon c}$	$C_{r\epsilon}$	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
3200	1	5	96	0	9951	0.14	0.0037	5	2.5	292.5	1000	0.714206
												0.714206

Drainage Corridor

Horizontal Location (ft)	Point	Thickness of Geologic Buffer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{sc}	C_{rc}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
3100	1	3	104	0	10400	0.14	0.0037	3	1.5	175.5	1000	0.438596
												0.438595

Horizontal Location (ft)	Point	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{sc}	C_{rc}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
3100	1	9	104	0	10751	0.14	0.0037	9	4.5	526.5	1000	1.335066
												1.335066

Horizontal Location (ft)	Point	Thickness of Geologic Buffer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{sc}	C_{rc}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
3000	1	3	118	0	11800	0.14	0.0037	3	1.5	175.5	1000	0.461272
												0.461272

Horizontal Location (ft)	Point	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{sc}	C_{rc}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
3000	1	11	118	0	12151	0.14	0.0037	11	5.5	643.5	1000	1.712608
												1.712608

Horizontal Location (ft)	Point	Thickness of Geologic Buffer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{sc}	C_{rc}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
2900	1	3	125	0	12500	0.14	0.0037	3	1.5	175.5	1000	0.471634
												0.471634

Horizontal Location (ft)	Point	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{sc}	C_{rc}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
2900	1	11	125	0	12851	0.14	0.0037	11	5.5	643.5	1000	1.749234
												1.749234

Horizontal Location (ft)	Point	Thickness of Geologic Buffer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{sc}	C_{rc}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
2800	1	3	140	0	14000	0.14	0.0037	3	1.5	175.5	1000	0.492035
												0.492035

Horizontal Location (ft)	Point	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{sc}	C_{rc}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
2800	1	10	140	0	14361	0.14	0.0037	10	5	585	1000	1.682643
												1.682643

Centerline of Gravel Drainage Corridor

Horizontal Location (ft)	Point	Thickness of Geologic Buffer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_r	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
2700	1	3	152	0	15200	0.14	0.0037	3	1.5	175.5	1000	0.506857
												0.506857
2600	1	3	150	15	16605	0.14	0.0037	3	1.5	175.5	1000	0.522807
												0.522807
2500	1	3	144	41	18787	0.14	0.0037	3	1.5	175.5	1000	0.546105
												0.546105
2400	1	3	148	58	20813	0.14	0.0037	3	1.5	175.5	1000	0.564488
												0.564488
2300	1	3	150	70	22480	0.14	0.0037	3	1.5	175.5	1000	0.577642
												0.577642

Horizontal Location (ft)	Point	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_r	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
2700	1	7	152	0	15551	0.14	0.0037	7	3.5	409.5	1000	1.189028
												1.189028
2600	1	5	150	15	16956	0.14	0.0037	5	2.5	292.5	1000	0.875803
												0.875803
2500	1	4	144	41	19138	0.14	0.0037	4	2	234	1000	0.730153
												0.730153
2400	1	2.5	149	58	21204	0.14	0.0037	2.5	1.25	146.25	1000	0.47344
												0.47344
2300	1	0	150	70	22841	0.14	0.0037	0	0	0	1000	0
												0

Horizontal Location (ft)	Point	Thickness of Geologic Buffer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{ve}'$ (psf)	C_{ec}	C_{rc}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
2200	1	3	150	70	22480	0.14	0.0037	3	1.5	175.5	1000	0.577642
												0.577642
2100	1	3	152	73	23011	0.14	0.0037	3	1.5	175.5	1000	0.581787
												0.581787
2000	1	3	152	73	23011	0.14	0.0037	3	1.5	175.5	1000	0.581787
												0.581787
1900	1	3	152	73	23011	0.14	0.0037	3	1.5	175.5	1000	0.581787
												0.581787
1800	1	3	152	73	23011	0.14	0.0037	3	1.5	175.5	1000	0.581787
												0.581787

Horizontal Location (ft)	Point	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{ve}'$ (psf)	C_{ec}	C_{rc}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
2200	1	0	150	70	22841	0.14	0.0037	0	0	0	1000	0
												0
2100	1	0	152	73	23362	0.14	0.0037	0	0	0	1000	0
												0
2000	1	2	152	73	23362	0.14	0.0037	2	1	117	1000	0.390686
												0.390686
1900	1	2.5	152	73	23362	0.14	0.0037	2.5	1.25	146.25	1000	0.48765
												0.48765
1800	1	2.5	152	73	23362	0.14	0.0037	2.5	1.25	146.25	1000	0.48765
												0.48765

Horizontal Location (ft)	Point	Thickness of Geologic Buffer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_{c}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
1700	1	3	148	77	23039	0.14	0.0037	3	1.5	175.5	1000	0.582007
												0.582007

Horizontal Location (ft)	Point	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_{c}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
1700	1	0	148	77	23380	0.14	0.0037	0	0	0	1000	0
												0

Horizontal Location (ft)	Point	Thickness of Geologic Buffer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_{c}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
1600	1	3	146	79	23053	0.14	0.0037	3	1.5	175.5	1000	0.582117
												0.582117

Horizontal Location (ft)	Point	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_{c}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
1600	1	2.5	146	79	23404	0.14	0.0037	2.5	1.25	146.25	1000	0.487921
												0.487921

Horizontal Location (ft)	Point	Thickness of Geologic Buffer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_{c}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
1500	1	3	144	81	23067	0.14	0.0037	3	1.5	175.5	1000	0.582227
												0.582227

Horizontal Location (ft)	Point	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_{c}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
1500	1	4.5	144	81	23418	0.14	0.0037	4.5	2.25	263.25	1000	0.875526
												0.875526

Horizontal Location (ft)	Point	Thickness of Geologic Buffer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_{c}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
1400	1	3	142	83	23081	0.14	0.0037	3	1.5	175.5	1000	0.582337
												0.582337

Horizontal Location (ft)	Point	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_{c}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
1400	1	4	142	83	23432	0.14	0.0037	4	2	234	1000	0.778846
												0.778846

Horizontal Location (ft)	Point	Thickness of Geologic Buffer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_{c}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
1300	1	3	138	87	23109	0.14	0.0037	3	1.5	175.5	1000	0.582557
												0.582557

Horizontal Location (ft)	Point	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_{c}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
1300	1	5	138	87	23460	0.14	0.0037	5	2.5	292.5	1000	0.972873
												0.972873

Horizontal Location (ft)	Point	Thickness of Geologic Buffer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{ec}	C_{re}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
1200	1	3	134	91	23137	0.14	0.0037	3	1.5	175.5	1000	0.582776

0.582776

Horizontal Location (ft)	Point	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{ec}	C_{re}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
1200	1	10	134	91	23488	0.14	0.0037	10	5	585	1000	1.942758

1.942758

Horizontal Location (ft)	Point	Thickness of Geologic Buffer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{ec}	C_{re}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
1100	1	3	130	75	21025	0.14	0.0037	3	1.5	175.5	1000	0.565464

0.565464

Horizontal Location (ft)	Point	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{ec}	C_{re}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
1100	1	13	130	75	21376	0.14	0.0037	13	6.5	760.5	1000	2.453517

2.453517

Horizontal Location (ft)	Point	Thickness of Geologic Buffer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{ec}	C_{re}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
1000	1	3	125	60	18920	0.14	0.0037	3	1.5	175.5	1000	0.54638

0.54638

Horizontal Location (ft)	Point	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{ec}	C_{re}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
1000	1	13	125	60	19271	0.14	0.0037	13	6.5	760.5	1000	2.374838

2.374838

Horizontal Location (ft)	Point	Thickness of Geologic Buffer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{ec}	C_{re}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
900	1	3	120	50	17350	0.14	0.0037	3	1.5	175.5	1000	0.53073

0.53073

Horizontal Location (ft)	Point	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{ec}	C_{re}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
900	1	12.5	120	50	17701	0.14	0.0037	12.5	6.25	731.25	1000	2.221049

2.221049

Horizontal Location (ft)	Point	Thickness of Geologic Buffer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{ec}	C_{re}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
800	1	3	120	30	15210	0.14	0.0037	3	1.5	175.5	1000	0.506975

0.506975

Horizontal Location (ft)	Point	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{ec}	C_{re}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
800	1	10	120	30	15561	0.14	0.0037	10	5	585	1000	1.689906

1.689906

Gravel Drainage Corridor

Horizontal Location (ft)	Point	Thickness of Geologic Buffer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{ec}	C_{re}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
700	1	3	125	10	13570	0.14	0.0037	3	1.5	175.5	1000	0.486416

0.486416

Horizontal Location (ft)	Point	Thickness of Geologic Buffer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{ec}	C_{re}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
600	1	3	115	0	11600	0.14	0.0037	3	1.5	175.5	1000	0.456044

0.456044

Horizontal Location (ft)	Point	Thickness of Geologic Buffer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{ec}	C_{re}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
500	1	3	100	0	10000	0.14	0.0037	3	1.5	175.5	1000	0.431562

0.431562

Horizontal Location (ft)	Point	Thickness of Geologic Buffer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{ec}	C_{re}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
400	1	3	85	0	8500	0.14	0.0037	3	1.5	175.5	1000	0.402472

0.402472

Horizontal Location (ft)	Point	Thickness of Geologic Buffer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{ec}	C_{re}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
300	1	3	65	0	8500	0.14	0.0037	3	1.5	175.5	1000	0.354672

0.354672

Horizontal Location (ft)	Point	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{ec}	C_{re}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
700	1	10	125	10	13921	0.14	0.0037	10	5	586	1000	1.634782

1.634782

Horizontal Location (ft)	Point	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{ec}	C_{re}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
600	1	8.5	115	0	11851	0.14	0.0037	8.5	4.25	497.25	1000	1.308553

1.308553

Horizontal Location (ft)	Point	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{ec}	C_{re}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
500	1	8	100	0	10351	0.14	0.0037	8	4	468	1000	1.16805

1.16805

Horizontal Location (ft)	Point	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{ec}	C_{re}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
400	1	7.5	85	0	8851	0.14	0.0037	7.5	3.75	436.75	1000	1.028333

1.028333

Horizontal Location (ft)	Point	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{ec}	C_{re}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
300	1	7	65	0	8651	0.14	0.0037	7	3.5	409.5	1000	0.85379

0.85379

Horizontal Location (ft)	Point	Thickness of Geologic Buffer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{ve}'$ (psf)	C_{cc}	C_{rc}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
200	1	3	40	0	4000	0.14	0.0037	3	1.5	175.5	1000	0.289086

0.289086

Horizontal Location (ft)	Point	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{ve}'$ (psf)	C_{cc}	C_{rc}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
200	1	7	40	0	4351	0.14	0.0037	7	3.5	409.5	1000	0.674142

0.674142

Horizontal Location (ft)	Point	Thickness of Geologic Buffer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{ve}'$ (psf)	C_{cc}	C_{rc}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
100	1	3	0	0	0	0.14	0.0037	3	1.5	175.5	1000	0

0

Horizontal Location (ft)	Point	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{ve}'$ (psf)	C_{cc}	C_{rc}	H_o (ft)	Depth to Point (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
100	1	22.5	0	0	0	0.14	0.0037	22.5	11.25	1316.25	1000	0

0

Calculation of Settlement in the Residual Soil (N>4)

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_r	H_c (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
3450	1	40	42.5	0	0	4972.5	0.14	0.0037	10	5	25	600	9121	0.035612
3450	2	40	42.5	0	0	4972.5	0.14	0.0037	10	15	25	1800	9121	0.021293
3450	3	40	42.5	0	0	4972.5	0.14	0.0037	10	25	25	3000	9121	0.016706
3450	4	40	42.5	0	0	4972.5	0.14	0.0037	10	35	25	3576	9121	0.014004
3450	5	40	42.5	0	0	4972.5	0.14	0.0037	10	35	25	3576	#N/A	0
3450	6	40	42.5	0	0	4972.5	0.14	0.0037	10	35	25	3576	#N/A	0
3450	7	40	42.5	0	0	4972.5	0.14	0.0037	10	35	25	3576	#N/A	0
3450	8	40	42.5	0	0	4972.5	0.14	0.0037	10	35	25	3576	#N/A	0
														0.086615

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_r	H_c (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
3400	1	40	0	56	0	5600	0.14	0.0037	10	5	20	600	9121	0.037527
3400	2	40	0	56	0	5600	0.14	0.0037	10	15	20	1800	9121	0.022718
3400	3	40	0	56	0	5600	0.14	0.0037	10	25	20	2868	9121	0.018094
3400	4	40	0	56	0	5600	0.14	0.0037	10	35	20	3264	9121	0.016054
3400	5	40	0	56	0	5600	0.14	0.0037	10	35	20	3264	#N/A	0
3400	6	40	0	56	0	5600	0.14	0.0037	10	35	20	3264	#N/A	0
3400	7	40	0	56	0	5600	0.14	0.0037	10	35	20	3264	#N/A	0
3400	8	40	0	56	0	5600	0.14	0.0037	10	35	20	3264	#N/A	0
														0.094391

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_r	H_c (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
3300	1	35	2.5	80	0	8292.5	0.14	0.0037	10	5	20	600	9121	0.043322
3300	2	35	2.5	80	0	8292.5	0.14	0.0037	10	15	20	1800	9121	0.087615
3300	3	35	2.5	80	0	8292.5	0.14	0.0037	10	25	20	2868	9121	0.132444
3300	4	35	2.5	80	0	8292.5	0.14	0.0037	5	32.5	20	3120	9121	0.076756
3300	5	35	2.5	80	0	8292.5	0.14	0.0037	5	32.5	20	3120	#N/A	0
3300	6	35	2.5	80	0	8292.5	0.14	0.0037	5	32.5	20	3120	#N/A	0
3300	7	35	2.5	80	0	8292.5	0.14	0.0037	5	32.5	20	3120	#N/A	0
3300	8	35	2.5	80	0	8292.5	0.14	0.0037	5	32.5	20	3120	#N/A	0
														0.340138

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_r	H_c (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
3200	1	35	5	95	0	10065	0.14	0.0037	10	5	15	600	9121	0.139958
3200	2	35	5	95	0	10065	0.14	0.0037	10	15	15	1800	9121	0.187016
3200	3	35	5	95	0	10065	0.14	0.0037	10	25	15	2376	9121	0.21133
3200	4	35	5	95	0	10065	0.14	0.0037	5	32.5	15	2808	9121	0.114684
3200	5	35	5	95	0	10065	0.14	0.0037	5	32.5	15	2808	#N/A	0
3200	6	35	5	95	0	10065	0.14	0.0037	5	32.5	15	2808	#N/A	0
3200	7	35	5	95	0	10065	0.14	0.0037	5	32.5	15	2808	#N/A	0
3200	8	35	5	95	0	10065	0.14	0.0037	5	32.5	15	2808	#N/A	0
														0.652988

Calculation of Settlement in the Residual Soil (N<4)

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_r	H_c (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
3450	1	0	42.5	0	0	4972.5	0.24	0.01	0	#N/A	25	#N/A	#N/A	0
3450	2	0	42.5	0	0	4972.5	0.24	0.01	0	#N/A	25	#N/A	#N/A	0
3450	3	0	42.5	0	0	4972.5	0.24	0.01	0	#N/A	25	#N/A	#N/A	0
3450	4	0	42.5	0	0	4972.5	0.24	0.01	0	#N/A	25	#N/A	#N/A	0
3450	5	0	42.5	0	0	4972.5	0.24	0.01	0	#N/A	25	#N/A	#N/A	0
3450	6	0	42.5	0	0	4972.5	0.24	0.01	0	#N/A	25	#N/A	#N/A	0
3450	7	0	42.5	0	0	4972.5	0.24	0.01	0	#N/A	25	#N/A	#N/A	0
3450	8	0	42.5	0	0	4972.5	0.24	0.01	0	#N/A	25	#N/A	#N/A	0
														0

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_r	H_c (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
3400	1	0	0	56	0	5600	0.24	0.01	0	#N/A	20	#N/A	#N/A	0
3400	2	0	0	56	0	5600	0.24	0.01	0	#N/A	20	#N/A	#N/A	0
3400	3	0	0	56	0	5600	0.24	0.01	0	#N/A	20	#N/A	#N/A	0
3400	4	0	0	56	0	5600	0.24	0.01	0	#N/A	20	#N/A	#N/A	0
3400	5	0	0	56	0	5600	0.24	0.01	0	#N/A	20	#N/A	#N/A	0
3400	6	0	0	56	0	5600	0.24	0.01	0	#N/A	20	#N/A	#N/A	0
3400	7	0	0	56	0	5600	0.24	0.01	0	#N/A	20	#N/A	#N/A	0
3400	8	0	0	56	0	5600	0.24	0.01	0	#N/A	20	#N/A	#N/A	0
														0

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_r	H_c (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
3300	1	0	2.5	80	0	8292.5	0.24	0.01	0	#N/A	20	#N/A	#N/A	0
3300	2	0	2.5	80	0	8292.5	0.24	0.01	0	#N/A	20	#N/A	#N/A	0
3300	3	0	2.5	80	0	8292.5	0.24	0.01	0	#N/A	20	#N/A	#N/A	0
3300	4	0	2.5	80	0	8292.5	0.24	0.01	0	#N/A	20	#N/A	#N/A	0
3300	5	0	2.5	80	0	8292.5	0.24	0.01	0	#N/A	20	#N/A	#N/A	0
3300	6	0	2.5	80	0	8292.5	0.24	0.01	0	#N/A	20	#N/A	#N/A	0
3300	7	0	2.5	80	0	8292.5	0.24	0.01	0	#N/A	20	#N/A	#N/A	0
3300	8	0	2.5	80	0	8292.5	0.24	0.01	0	#N/A	20	#N/A	#N/A	0
														0

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_r	H_c (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
3200	1	0	5	95	0	10065	0.24	0.01	0	#N/A	15	#N/A	#N/A	0
3200	2	0	5	95	0	10065	0.24	0.01	0	#N/A	15	#N/A	#N/A	0
3200	3	0	5	95	0	10065	0.24	0.01	0	#N/A	15	#N/A	#N/A	0
3200	4	0	5	95	0	10065	0.24	0.01	0	#N/A	15	#N/A	#N/A	0
3200	5	0	5	95	0	10065	0.24	0.01	0	#N/A	15	#N/A	#N/A	0
3200	6	0	5	95	0	10065	0.24	0.01	0	#N/A	15	#N/A	#N/A	0
3200	7	0	5	95	0	10065	0.24	0.01	0	#N/A	15	#N/A	#N/A	0
3200	8	0	5	95	0	10065	0.24	0.01	0	#N/A	15	#N/A	#N/A	0
														0

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_c	C_r	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
3100	1	35	9	104	0	11453	0.14	0.0037	10	5	12	600	9121	0.213204
3100	2	35	9	104	0	11453	0.14	0.0037	10	15	12	1612.8	9121	0.246372
3100	3	35	9	104	0	11453	0.14	0.0037	10	25	12	2169.8	9121	0.267695
3100	4	35	9	104	0	11453	0.14	0.0037	10	30	12	2476.8	9121	0.278411
3100	5	35	9	104	0	11453	0.14	0.0037	5	32.5	12	2620.8	9121	0.141876
3100	6	35	9	104	0	11453	0.14	0.0037	5	32.5	12	2620.8	#N/A	0
3100	7	35	9	104	0	11453	0.14	0.0037	5	32.5	12	2620.8	#N/A	0
3100	8	35	9	104	0	11453	0.14	0.0037	5	32.5	12	2620.8	#N/A	0
														1.14756

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_c	C_r	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
3100	1	0	9	104	0	11453	0.24	0.01	0	#N/A	12	#N/A	#N/A	0
3100	2	0	9	104	0	11453	0.24	0.01	0	#N/A	12	#N/A	#N/A	0
3100	3	0	9	104	0	11453	0.24	0.01	0	#N/A	12	#N/A	#N/A	0
3100	4	0	9	104	0	11453	0.24	0.01	0	#N/A	12	#N/A	#N/A	0
3100	5	0	9	104	0	11453	0.24	0.01	0	#N/A	12	#N/A	#N/A	0
3100	6	0	9	104	0	11453	0.24	0.01	0	#N/A	12	#N/A	#N/A	0
3100	7	0	9	104	0	11453	0.24	0.01	0	#N/A	12	#N/A	#N/A	0
3100	8	0	9	104	0	11453	0.24	0.01	0	#N/A	12	#N/A	#N/A	0
														0

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_c	C_r	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
3000	1	25	11	118	0	13087	0.14	0.0037	10	5	10	600	9121	0.290502
3000	2	25	11	118	0	13087	0.14	0.0037	10	15	10	1488	9121	0.314128
3000	3	25	11	118	0	13087	0.14	0.0037	5	22.5	10	1920	9121	0.163896
3000	4	25	11	118	0	13087	0.14	0.0037	5	22.5	10	1920	#N/A	0
3000	5	25	11	118	0	13087	0.14	0.0037	5	22.5	10	1920	#N/A	0
3000	6	25	11	118	0	13087	0.14	0.0037	5	22.5	10	1920	#N/A	0
3000	7	25	11	118	0	13087	0.14	0.0037	5	22.5	10	1920	#N/A	0
3000	8	25	11	118	0	13087	0.14	0.0037	5	22.5	10	1920	#N/A	0
														0.768526

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_c	C_r	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
3000	1	0	11	118	0	13087	0.24	0.01	0	#N/A	10	#N/A	#N/A	0
3000	2	0	11	118	0	13087	0.24	0.01	0	#N/A	10	#N/A	#N/A	0
3000	3	0	11	118	0	13087	0.24	0.01	0	#N/A	10	#N/A	#N/A	0
3000	4	0	11	118	0	13087	0.24	0.01	0	#N/A	10	#N/A	#N/A	0
3000	5	0	11	118	0	13087	0.24	0.01	0	#N/A	10	#N/A	#N/A	0
3000	6	0	11	118	0	13087	0.24	0.01	0	#N/A	10	#N/A	#N/A	0
3000	7	0	11	118	0	13087	0.24	0.01	0	#N/A	10	#N/A	#N/A	0
3000	8	0	11	118	0	13087	0.24	0.01	0	#N/A	10	#N/A	#N/A	0
														0

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_c	C_r	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
2900	1	25	11	125	0	13787	0.14	0.0037	10	5	10	600	9121	0.320829
2900	2	25	11	125	0	13787	0.14	0.0037	10	15	10	1488	9121	0.34265
2900	3	25	11	125	0	13787	0.14	0.0037	5	22.5	10	1920	9121	0.177755
2900	4	25	11	125	0	13787	0.14	0.0037	5	22.5	10	1920	#N/A	0
2900	5	25	11	125	0	13787	0.14	0.0037	5	22.5	10	1920	#N/A	0
2900	6	25	11	125	0	13787	0.14	0.0037	5	22.5	10	1920	#N/A	0
2900	7	25	11	125	0	13787	0.14	0.0037	5	22.5	10	1920	#N/A	0
2900	8	25	11	125	0	13787	0.14	0.0037	5	22.5	10	1920	#N/A	0
														0.841234

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_c	C_r	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
2900	1	0	11	125	0	13787	0.24	0.01	0	#N/A	10	#N/A	#N/A	0
2900	2	0	11	125	0	13787	0.24	0.01	0	#N/A	10	#N/A	#N/A	0
2900	3	0	11	125	0	13787	0.24	0.01	0	#N/A	10	#N/A	#N/A	0
2900	4	0	11	125	0	13787	0.24	0.01	0	#N/A	10	#N/A	#N/A	0
2900	5	0	11	125	0	13787	0.24	0.01	0	#N/A	10	#N/A	#N/A	0
2900	6	0	11	125	0	13787	0.24	0.01	0	#N/A	10	#N/A	#N/A	0
2900	7	0	11	125	0	13787	0.24	0.01	0	#N/A	10	#N/A	#N/A	0
2900	8	0	11	125	0	13787	0.24	0.01	0	#N/A	10	#N/A	#N/A	0
														0

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_c	C_r	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
2800	1	30	10	140	0	15170	0.14	0.0037	10	5	10	600	9121	0.376635
2800	2	30	10	140	0	15170	0.14	0.0037	10	15	10	1488	9121	0.395348
2800	3	30	10	140	0	15170	0.14	0.0037	10	25	10	2064	9121	0.410758
2800	4	30	10	140	0	15170	0.14	0.0037	10	25	10	2064	#N/A	0
2800	5	30	10	140	0	15170	0.14	0.0037	10	25	10	2064	#N/A	0
2800	6	30	10	140	0	15170	0.14	0.0037	10	25	10	2064	#N/A	0
2800	7	30	10	140	0	15170	0.14	0.0037	10	25	10	2064	#N/A	0
2800	8	30	10	140	0	15170	0.14	0.0037	10	25	10	2064	#N/A	0
														1.182741

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_c	C_r	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
2800	1	0	10	140	0	15170	0.24	0.01	0	#N/A	10	#N/A	#N/A	0
2800	2	0	10	140	0	15170	0.24	0.01	0	#N/A	10	#N/A	#N/A	0
2800	3	0	10	140	0	15170	0.24	0.01	0	#N/A	10	#N/A	#N/A	0
2800	4	0	10	140	0	15170	0.24	0.01	0	#N/A	10	#N/A	#N/A	0
2800	5	0	10	140	0	15170	0.24	0.01	0	#N/A	10	#N/A	#N/A	0
2800	6	0	10	140	0	15170	0.24	0.01	0	#N/A	10	#N/A	#N/A	0
2800	7	0	10	140	0	15170	0.24	0.01	0	#N/A	10	#N/A	#N/A	0
2800	8	0	10	140	0	15170	0.24	0.01	0	#N/A	10	#N/A	#N/A	0
														0

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_c	H_c (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
2700	1	45	7	152	0	16019	0.14	0.0037	10	5	12	600	9121	0.408617
2700	2	45	7	152	0	16019	0.14	0.0037	10	15	12	1612.8	9121	0.428597
2700	3	45	7	152	0	16019	0.14	0.0037	10	25	12	2188.8	9121	0.443235
2700	4	45	7	152	0	16019	0.14	0.0037	10	35	12	2764.8	9121	0.458417
2700	5	45	7	152	0	16019	0.14	0.0037	5	42.5	12	3196.8	9121	0.234956
2700	6	45	7	152	0	16019	0.14	0.0037	5	42.5	12	3196.8	#N/A	0
2700	7	45	7	152	0	16019	0.14	0.0037	5	42.5	12	3196.8	#N/A	0
2700	8	45	7	152	0	16019	0.14	0.0037	5	42.5	12	3196.8	#N/A	0
														1.973721

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_c	H_c (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
2700	1	0	7	152	0	16019	0.24	0.01	0	#N/A	12	#N/A	#N/A	0
2700	2	0	7	152	0	16019	0.24	0.01	0	#N/A	12	#N/A	#N/A	0
2700	3	0	7	152	0	16019	0.24	0.01	0	#N/A	12	#N/A	#N/A	0
2700	4	0	7	152	0	16019	0.24	0.01	0	#N/A	12	#N/A	#N/A	0
2700	5	0	7	152	0	16019	0.24	0.01	0	#N/A	12	#N/A	#N/A	0
2700	6	0	7	152	0	16019	0.24	0.01	0	#N/A	12	#N/A	#N/A	0
2700	7	0	7	152	0	16019	0.24	0.01	0	#N/A	12	#N/A	#N/A	0
2700	8	0	7	152	0	16019	0.24	0.01	0	#N/A	12	#N/A	#N/A	0
														0

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_c	H_c (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
2600	1	45	5	150	15	17190	0.14	0.0037	10	5	14	600	9121	0.449917
2600	2	45	5	150	15	17190	0.14	0.0037	10	15	14	1737.6	9121	0.470518
2600	3	45	5	150	15	17190	0.14	0.0037	10	25	14	2313.6	9121	0.484144
2600	4	45	5	150	15	17190	0.14	0.0037	10	35	14	2889.6	9121	0.498268
2600	5	45	5	150	15	17190	0.14	0.0037	5	42.5	14	3321.6	9121	0.264486
2600	6	45	5	150	15	17190	0.14	0.0037	5	42.5	14	3321.6	#N/A	0
2600	7	45	5	150	15	17190	0.14	0.0037	5	42.5	14	3321.6	#N/A	0
2600	8	45	5	150	15	17190	0.14	0.0037	5	42.5	14	3321.6	#N/A	0
														2.167333

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_c	H_c (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
2600	1	0	5	150	15	17190	0.24	0.01	0	#N/A	14	#N/A	#N/A	0
2600	2	0	5	150	15	17190	0.24	0.01	0	#N/A	14	#N/A	#N/A	0
2600	3	0	5	150	15	17190	0.24	0.01	0	#N/A	14	#N/A	#N/A	0
2600	4	0	5	150	15	17190	0.24	0.01	0	#N/A	14	#N/A	#N/A	0
2600	5	0	5	150	15	17190	0.24	0.01	0	#N/A	14	#N/A	#N/A	0
2600	6	0	5	150	15	17190	0.24	0.01	0	#N/A	14	#N/A	#N/A	0
2600	7	0	5	150	15	17190	0.24	0.01	0	#N/A	14	#N/A	#N/A	0
2600	8	0	5	150	15	17190	0.24	0.01	0	#N/A	14	#N/A	#N/A	0
														0

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_c	H_c (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
2500	1	40	4	144	41	19255	0.14	0.0037	10	5	15	600	9121	0.516688
2500	2	40	4	144	41	19255	0.14	0.0037	10	15	15	1800	9121	0.534714
2500	3	40	4	144	41	19255	0.14	0.0037	10	25	15	2376	9121	0.546663
2500	4	40	4	144	41	19255	0.14	0.0037	10	35	15	2952	9121	0.559154
2500	5	40	4	144	41	19255	0.14	0.0037	10	35	15	2952	#N/A	0
2500	6	40	4	144	41	19255	0.14	0.0037	10	35	15	2952	#N/A	0
2500	7	40	4	144	41	19255	0.14	0.0037	10	35	15	2952	#N/A	0
2500	8	40	4	144	41	19255	0.14	0.0037	10	35	15	2952	#N/A	0
														2.15722

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_c	H_c (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
2500	1	0	4	144	41	19255	0.24	0.01	0	#N/A	15	#N/A	#N/A	0
2500	2	0	4	144	41	19255	0.24	0.01	0	#N/A	15	#N/A	#N/A	0
2500	3	0	4	144	41	19255	0.24	0.01	0	#N/A	15	#N/A	#N/A	0
2500	4	0	4	144	41	19255	0.24	0.01	0	#N/A	15	#N/A	#N/A	0
2500	5	0	4	144	41	19255	0.24	0.01	0	#N/A	15	#N/A	#N/A	0
2500	6	0	4	144	41	19255	0.24	0.01	0	#N/A	15	#N/A	#N/A	0
2500	7	0	4	144	41	19255	0.24	0.01	0	#N/A	15	#N/A	#N/A	0
2500	8	0	4	144	41	19255	0.24	0.01	0	#N/A	15	#N/A	#N/A	0
														0

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_c	H_c (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
2400	1	40	2.5	146	59	21205.5	0.14	0.0037	10	5	16	600	9121	0.573663
2400	2	40	2.5	146	59	21205.5	0.14	0.0037	10	15	16	1800	9121	0.588561
2400	3	40	2.5	146	59	21205.5	0.14	0.0037	10	25	16	2438.4	9121	0.600346
2400	4	40	2.5	146	59	21205.5	0.14	0.0037	10	35	16	3014.4	9121	0.611673
2400	5	40	2.5	146	59	21205.5	0.14	0.0037	10	35	16	3014.4	#N/A	0
2400	6	40	2.5	146	59	21205.5	0.14	0.0037	10	35	16	3014.4	#N/A	0
2400	7	40	2.5	146	59	21205.5	0.14	0.0037	10	35	16	3014.4	#N/A	0
2400	8	40	2.5	146	59	21205.5	0.14	0.0037	10	35	16	3014.4	#N/A	0
														2.374163

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_c	H_c (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
2400	1	0	2.5	146	59	21205.5	0.24	0.01	0	#N/A	16	#N/A	#N/A	0
2400	2	0	2.5	146	59	21205.5	0.24	0.01	0	#N/A	16	#N/A	#N/A	0
2400	3	0	2.5	146	59	21205.5	0.24	0.01	0	#N/A	16	#N/A	#N/A	0
2400	4	0	2.5	146	59	21205.5	0.24	0.01	0	#N/A	16	#N/A	#N/A	0
2400	5	0	2.5	146	59	21205.5	0.24	0.01	0	#N/A	16	#N/A	#N/A	0
2400	6	0	2.5	146	59	21205.5	0.24	0.01	0	#N/A	16	#N/A	#N/A	0
2400	7	0	2.5	146	59	21205.5	0.24	0.01	0	#N/A	16	#N/A	#N/A	0
2400	8	0	2.5	146	59	21205.5	0.24	0.01	0	#N/A	16	#N/A	#N/A	0
														0

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_c	H_c (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
2300	1	50	0	150	70	22490	0.14	0.0037	10	5	19	600	9121	0.608464
2300	2	50	0	150	70	22490	0.14	0.0037	10	15	19	1800	9121	0.621616
2300	3	50	0	150	70	22490	0.14	0.0037	10	25	19	2625.6	9121	0.635872
2300	4	50	0	150	70	22490	0.14	0.0037	10	35	19	3201.6	9121	0.646471
2300	5	50	0	150	70	22490	0.14	0.0037	10	45	19	3777.6	9121	0.657294
2300	6	50	0	150	70	22490	0.14	0.0037	10	45	19	3777.6	#N/A	0
2300	7	50	0	150	70	22490	0.14	0.0037	10	45	19	3777.6	#N/A	0
2300	8	50	0	150	70	22490	0.14	0.0037	10	45	19	3777.6	#N/A	0
														3.169718

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_c	H_c (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
2300	1	0	0	150	70	22490	0.24	0.01	0	#N/A	19	#N/A	#N/A	0
2300	2	0	0	150	70	22490	0.24	0.01	0	#N/A	19	#N/A	#N/A	0
2300	3	0	0	150	70	22490	0.24	0.01	0	#N/A	19	#N/A	#N/A	0
2300	4	0	0	150	70	22490	0.24	0.01	0	#N/A	19	#N/A	#N/A	0
2300	5	0	0	150	70	22490	0.24	0.01	0	#N/A	19	#N/A	#N/A	0
2300	6	0	0	150	70	22490	0.24	0.01	0	#N/A	19	#N/A	#N/A	0
2300	7	0	0	150	70	22490	0.24	0.01	0	#N/A	19	#N/A	#N/A	0
2300	8	0	0	150	70	22490	0.24	0.01	0	#N/A	19	#N/A	#N/A	0
														0

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	$C_{c\varepsilon}$	$C_{r\varepsilon}$	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
2200	1	40	0	150	70	22490	0.14	0.0037	10	5	18	600	9121	0.608464
2200	2	40	0	150	70	22490	0.14	0.0037	10	15	18	1800	9121	0.621616
2200	3	40	0	150	70	22490	0.14	0.0037	10	25	18	2563.2	9121	0.634746
2200	4	40	0	150	70	22490	0.14	0.0037	10	35	18	3139.2	9121	0.645309
2200	5	40	0	150	70	22490	0.14	0.0037	10	35	18	3139.2	#N/A	0
2200	6	40	0	150	70	22490	0.14	0.0037	10	35	18	3139.2	#N/A	0
2200	7	40	0	150	70	22490	0.14	0.0037	10	35	18	3139.2	#N/A	0
2200	8	40	0	150	70	22490	0.14	0.0037	10	35	18	3139.2	#N/A	0
														2.510134

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	$C_{c\varepsilon}$	$C_{r\varepsilon}$	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
2200	1	7.5	0	150	70	22490	0.24	0.01	7.5	3.75	18	3586.95	5650	1.210374
2200	2	7.5	0	150	70	22490	0.24	0.01	7.5	3.75	18	3586.95	#N/A	0
2200	3	7.5	0	150	70	22490	0.24	0.01	7.5	3.75	18	3586.95	#N/A	0
2200	4	7.5	0	150	70	22490	0.24	0.01	7.5	3.75	18	3586.95	#N/A	0
2200	5	7.5	0	150	70	22490	0.24	0.01	7.5	3.75	18	3586.95	#N/A	0
2200	6	7.5	0	150	70	22490	0.24	0.01	7.5	3.75	18	3586.95	#N/A	0
2200	7	7.5	0	150	70	22490	0.24	0.01	7.5	3.75	18	3586.95	#N/A	0
2200	8	7.5	0	150	70	22490	0.24	0.01	7.5	3.75	18	3586.95	#N/A	0
														1.210374

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	$C_{c\varepsilon}$	$C_{r\varepsilon}$	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
2100	1	30	0	152	73	23011	0.14	0.0037	10	5	18	600	9121	0.622031
2100	2	30	0	152	73	23011	0.14	0.0037	10	15	18	1800	9121	0.634519
2100	3	30	0	152	73	23011	0.14	0.0037	10	25	18	2563.2	9121	0.64726
2100	4	30	0	152	73	23011	0.14	0.0037	10	25	18	2563.2	#N/A	0
2100	5	30	0	152	73	23011	0.14	0.0037	10	25	18	2563.2	#N/A	0
2100	6	30	0	152	73	23011	0.14	0.0037	10	25	18	2563.2	#N/A	0
2100	7	30	0	152	73	23011	0.14	0.0037	10	25	18	2563.2	#N/A	0
2100	8	30	0	152	73	23011	0.14	0.0037	10	25	18	2563.2	#N/A	0
														1.90381

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	$C_{c\varepsilon}$	$C_{r\varepsilon}$	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
2100	1	13	0	152	73	23011	0.24	0.01	13	6.5	18	3128.1	5650	2.108935
2100	2	13	0	152	73	23011	0.24	0.01	13	6.5	18	3128.1	#N/A	0
2100	3	13	0	152	73	23011	0.24	0.01	13	6.5	18	3128.1	#N/A	0
2100	4	13	0	152	73	23011	0.24	0.01	13	6.5	18	3128.1	#N/A	0
2100	5	13	0	152	73	23011	0.24	0.01	13	6.5	18	3128.1	#N/A	0
2100	6	13	0	152	73	23011	0.24	0.01	13	6.5	18	3128.1	#N/A	0
2100	7	13	0	152	73	23011	0.24	0.01	13	6.5	18	3128.1	#N/A	0
2100	8	13	0	152	73	23011	0.24	0.01	13	6.5	18	3128.1	#N/A	0
														2.108935

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	$C_{c\varepsilon}$	$C_{r\varepsilon}$	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
2000	1	25	2	152	73	23245	0.14	0.0037	10	5	16	600	9121	0.628027
2000	2	25	2	152	73	23245	0.14	0.0037	10	15	16	1800	9121	0.640227
2000	3	25	2	152	73	23245	0.14	0.0037	5	22.5	16	2294.4	9121	0.324106
2000	4	25	2	152	73	23245	0.14	0.0037	5	22.5	16	2294.4	#N/A	0
2000	5	25	2	152	73	23245	0.14	0.0037	5	22.5	16	2294.4	#N/A	0
2000	6	25	2	152	73	23245	0.14	0.0037	5	22.5	16	2294.4	#N/A	0
2000	7	25	2	152	73	23245	0.14	0.0037	5	22.5	16	2294.4	#N/A	0
2000	8	25	2	152	73	23245	0.14	0.0037	5	22.5	16	2294.4	#N/A	0
														1.592359

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	$C_{c\varepsilon}$	$C_{r\varepsilon}$	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
2000	1	15	2	152	73	23245	0.24	0.01	15	7.5	16	2757.9	5650	2.433425
2000	2	15	2	152	73	23245	0.24	0.01	15	7.5	16	2757.9	#N/A	0
2000	3	15	2	152	73	23245	0.24	0.01	15	7.5	16	2757.9	#N/A	0
2000	4	15	2	152	73	23245	0.24	0.01	15	7.5	16	2757.9	#N/A	0
2000	5	15	2	152	73	23245	0.24	0.01	15	7.5	16	2757.9	#N/A	0
2000	6	15	2	152	73	23245	0.24	0.01	15	7.5	16	2757.9	#N/A	0
2000	7	15	2	152	73	23245	0.24	0.01	15	7.5	16	2757.9	#N/A	0
2000	8	15	2	152	73	23245	0.24	0.01	15	7.5	16	2757.9	#N/A	0
														2.433425

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	$C_{c\varepsilon}$	$C_{r\varepsilon}$	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
1900	1	25	2.5	152	73	23303.5	0.14	0.0037	10	5	15	600	9121	0.629617
1900	2	25	2.5	152	73	23303.5	0.14	0.0037	10	15	15	1800	9121	0.641645
1900	3	25	2.5	152	73	23303.5	0.14	0.0037	5	22.5	15	2232	9121	0.324281
1900	4	25	2.5	152	73	23303.5	0.14	0.0037	5	22.5	15	2232	#N/A	0
1900	5	25	2.5	152	73	23303.5	0.14	0.0037	5	22.5	15	2232	#N/A	0
1900	6	25	2.5	152	73	23303.5	0.14	0.0037	5	22.5	15	2232	#N/A	0
1900	7	25	2.5	152	73	23303.5	0.14	0.0037	5	22.5	15	2232	#N/A	0
1900	8	25	2.5	152	73	23303.5	0.14	0.0037	5	22.5	15	2232	#N/A	0
														1.595443

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	$C_{c\varepsilon}$	$C_{r\varepsilon}$	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
1900	1	15	2.5	152	73	23303.5	0.24	0.01	15	7.5	15	2695.5	5650	2.434681
1900	2	15	2.5	152	73	23303.5	0.24	0.01	15	7.5	15	2695.5	#N/A	0
1900	3	15	2.5	152	73	23303.5	0.24	0.01	15	7.5	15	2695.5	#N/A	0
1900	4	15	2.5	152	73	23303.5	0.24	0.01	15	7.5	15	2695.5	#N/A	0
1900	5	15	2.5	152	73	23303.5	0.24	0.01	15	7.5	15	2695.5	#N/A	0
1900	6	15	2.5	152	73	23303.5	0.24	0.01	15	7.5	15	2695.5	#N/A	0
1900	7	15	2.5	152	73	23303.5	0.24	0.01	15	7.5	15	2695.5	#N/A	0
1900	8	15	2.5	152	73	23303.5	0.24	0.01	15	7.5	15	2695.5	#N/A	0
														2.434681

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	$C_{c\varepsilon}$	$C_{r\varepsilon}$	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
1800	1	30	2.5	152	73	23303.5	0.14	0.0037	10	5	15	600	9121	0.629617
1800	2	30	2.5	152	73	23303.5	0.14	0.0037	10	15	15	1800	9121	0.641645
1800	3	30	2.5	152	73	23303.5	0.14	0.0037	10	25	15	2376	9121	0.650877
1800	4	30	2.5	152	73	23303.5	0.14	0.0037	10	25	15	2376	#N/A	0
1800	5	30	2.5	152	73	23303.5	0.14	0.0037	10	25	15	2376	#N/A	0
1800	6	30	2.5	152	73	23303.5	0.14	0.0037	10	25	15	2376	#N/A	0
1800	7	30	2.5	152	73	23303.5	0.14	0.0037	10	25	15	2376	#N/A	0
1800	8	30	2.5	152	73	23303.5	0.14	0.0037	10	25	15	2376	#N/A	0
														1.922139

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	$C_{c\varepsilon}$	$C_{r\varepsilon}$	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
1800	1	17	2.5	152	73	23303.5	0.24	0.01	17	8.5	15	3026.1	5650	2.773153
1800	2	17	2.5	152	73	23303.5	0.24	0.01	17	8.5	15	3026.1	#N/A	0
1800	3	17	2.5	152	73	23303.5	0.24	0.01	17	8.5	15	3026.1	#N/A	0
1800	4	17	2.5	152	73	23303.5	0.24	0.01	17	8.5	15	3026.1	#N/A	0
1800	5	17	2.5	152	73	23303.5	0.24	0.01	17	8.5	15	3026.1	#N/A	0
1800	6	17	2.5	152	73	23303.5	0.24	0.01	17	8.5	15	3026.1	#N/A	0
1800	7	17	2.5	152	73	23303.5	0.24	0.01	17	8.5	15	3026.1	#N/A	0
1800	8	17	2.5	152	73	23303.5	0.24	0.01	17	8.5	15	3026.1	#N/A	0
														2.773153

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Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{ec}	C_{re}	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
1700	1	33	0	148	77	23039	0.14	0.0037	10	5	15	600	9121	0.622761
1700	2	33	0	148	77	23039	0.14	0.0037	10	15	15	1800	9121	0.635205
1700	3	33	0	148	77	23039	0.14	0.0037	10	25	15	2376	9121	0.644682
1700	4	33	0	148	77	23039	0.14	0.0037	5	32.5	15	2808	9121	0.326123
1700	5	33	0	148	77	23039	0.14	0.0037	5	32.5	15	2808	#N/A	0
1700	6	33	0	148	77	23039	0.14	0.0037	5	32.5	15	2808	#N/A	0
1700	7	33	0	148	77	23039	0.14	0.0037	5	32.5	15	2808	#N/A	0
1700	8	33	0	148	77	23039	0.14	0.0037	5	32.5	15	2808	#N/A	0
														2.228761

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{ec}	C_{re}	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
1600	1	35	2.5	146	79	23345.5	0.14	0.0037	10	5	13	600	9121	0.630684
1600	2	35	2.5	146	79	23345.5	0.14	0.0037	10	15	13	1675.2	9121	0.640791
1600	3	35	2.5	146	79	23345.5	0.14	0.0037	10	25	13	2251.2	9121	0.64968
1600	4	35	2.5	146	79	23345.5	0.14	0.0037	5	32.5	13	2683.2	9121	0.328618
1600	5	35	2.5	146	79	23345.5	0.14	0.0037	5	32.5	13	2683.2	#N/A	0
1600	6	35	2.5	146	79	23345.5	0.14	0.0037	5	32.5	13	2683.2	#N/A	0
1600	7	35	2.5	146	79	23345.5	0.14	0.0037	5	32.5	13	2683.2	#N/A	0
1600	8	35	2.5	146	79	23345.5	0.14	0.0037	5	32.5	13	2683.2	#N/A	0
														2.249873

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{ec}	C_{re}	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
1500	1	35	4.5	144	81	23593.5	0.14	0.0037	10	5	10	600	9121	0.636849
1500	2	35	4.5	144	81	23593.5	0.14	0.0037	10	15	10	1488	9121	0.644171
1500	3	35	4.5	144	81	23593.5	0.14	0.0037	10	25	10	2064	9121	0.652718
1500	4	35	4.5	144	81	23593.5	0.14	0.0037	5	32.5	10	2496	9121	0.329906
1500	5	35	4.5	144	81	23593.5	0.14	0.0037	5	32.5	10	2496	#N/A	0
1500	6	35	4.5	144	81	23593.5	0.14	0.0037	5	32.5	10	2496	#N/A	0
1500	7	35	4.5	144	81	23593.5	0.14	0.0037	5	32.5	10	2496	#N/A	0
1500	8	35	4.5	144	81	23593.5	0.14	0.0037	5	32.5	10	2496	#N/A	0
														2.263645

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{ec}	C_{re}	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
1400	1	35	4	142	83	23549	0.14	0.0037	10	5	10	600	9121	0.635729
1400	2	35	4	142	83	23549	0.14	0.0037	10	15	10	1488	9121	0.643091
1400	3	35	4	142	83	23549	0.14	0.0037	10	25	10	2064	9121	0.651663
1400	4	35	4	142	83	23549	0.14	0.0037	5	32.5	10	2496	9121	0.329389
1400	5	35	4	142	83	23549	0.14	0.0037	5	32.5	10	2496	#N/A	0
1400	6	35	4	142	83	23549	0.14	0.0037	5	32.5	10	2496	#N/A	0
1400	7	35	4	142	83	23549	0.14	0.0037	5	32.5	10	2496	#N/A	0
1400	8	35	4	142	83	23549	0.14	0.0037	5	32.5	10	2496	#N/A	0
														2.259872

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{ec}	C_{re}	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
1300	1	35	5	138	87	23694	0.14	0.0037	10	5	8	600	9121	0.639369
1300	2	35	5	138	87	23694	0.14	0.0037	10	15	8	1363.2	9121	0.644089
1300	3	35	5	138	87	23694	0.14	0.0037	10	25	8	1939.2	9121	0.653144
1300	4	35	5	138	87	23694	0.14	0.0037	5	32.5	8	2371.2	9121	0.330037
1300	5	35	5	138	87	23694	0.14	0.0037	5	32.5	8	2371.2	#N/A	0
1300	6	35	5	138	87	23694	0.14	0.0037	5	32.5	8	2371.2	#N/A	0
1300	7	35	5	138	87	23694	0.14	0.0037	5	32.5	8	2371.2	#N/A	0
1300	8	35	5	138	87	23694	0.14	0.0037	5	32.5	8	2371.2	#N/A	0
														2.267536

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{ec}	C_{re}	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
1700	1	17	0	148	77	23039	0.24	0.01	17	8.5	15	3198.9	5650	2.782871
1700	2	17	0	148	77	23039	0.24	0.01	17	8.5	15	3198.9	#N/A	0
1700	3	17	0	148	77	23039	0.24	0.01	17	8.5	15	3198.9	#N/A	0
1700	4	17	0	148	77	23039	0.24	0.01	17	8.5	15	3198.9	#N/A	0
1700	5	17	0	148	77	23039	0.24	0.01	17	8.5	15	3198.9	#N/A	0
1700	6	17	0	148	77	23039	0.24	0.01	17	8.5	15	3198.9	#N/A	0
1700	7	17	0	148	77	23039	0.24	0.01	17	8.5	15	3198.9	#N/A	0
1700	8	17	0	148	77	23039	0.24	0.01	17	8.5	15	3198.9	#N/A	0
														2.782871

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{ec}	C_{re}	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
1600	1	17	2.5	146	79	23345.5	0.24	0.01	17	8.5	13	3189.3	5650	2.783031
1600	2	17	2.5	146	79	23345.5	0.24	0.01	17	8.5	13	3189.3	#N/A	0
1600	3	17	2.5	146	79	23345.5	0.24	0.01	17	8.5	13	3189.3	#N/A	0
1600	4	17	2.5	146	79	23345.5	0.24	0.01	17	8.5	13	3189.3	#N/A	0
1600	5	17	2.5	146	79	23345.5	0.24	0.01	17	8.5	13	3189.3	#N/A	0
1600	6	17	2.5	146	79	23345.5	0.24	0.01	17	8.5	13	3189.3	#N/A	0
1600	7	17	2.5	146	79	23345.5	0.24	0.01	17	8.5	13	3189.3	#N/A	0
1600	8	17	2.5	146	79	23345.5	0.24	0.01	17	8.5	13	3189.3	#N/A	0
														2.783031

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{ec}	C_{re}	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
1500	1	17	4.5	144	81	23593.5	0.24	0.01	17	8.5	10	3002.1	5650	2.791552
1500	2	17	4.5	144	81	23593.5	0.24	0.01	17	8.5	10	3002.1	#N/A	0
1500	3	17	4.5	144	81	23593.5	0.24	0.01	17	8.5	10	3002.1	#N/A	0
1500	4	17	4.5	144	81	23593.5	0.24	0.01	17	8.5	10	3002.1	#N/A	0
1500	5	17	4.5	144	81	23593.5	0.24	0.01	17	8.5	10	3002.1	#N/A	0
1500	6	17	4.5	144	81	23593.5	0.24	0.01	17	8.5	10	3002.1	#N/A	0
1500	7	17	4.5	144	81	23593.5	0.24	0.01	17	8.5	10	3002.1	#N/A	0
1500	8	17	4.5	144	81	23593.5	0.24	0.01	17	8.5	10	3002.1	#N/A	0
														2.791552

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{ec}	C_{re}	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
1400	1	15	4	142	83	23549	0.24	0.01	15	7.5	10	2959.5	5650	2.456937
1400	2	15	4	142	83	23549	0.24	0.01	15	7.5	10	2959.5	#N/A	0
1400	3	15	4	142	83	23549	0.24	0.01	15	7.5	10	2959.5	#N/A	0
1400	4	15	4	142	83	23549	0.24	0.01	15	7.5	10	2959.5	#N/A	0
1400	5	15	4	142	83	23549	0.24	0.01	15	7.5	10	2959.5	#N/A	0
1400	6	15	4	142	83	23549	0.24	0.01	15	7.5	10	2959.5	#N/A	0
1400	7	15	4	142	83	23549	0.24	0.01	15	7.5	10	2959.5	#N/A	0
1400	8	15	4	142	83	23549	0.24	0.01	15	7.5	10	2959.5	#N/A	0
														2.456937

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{ec}	C_{re}	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
1300	1	13	5	138	87	23694	0.24	0.01	13	6.5	8	2792.1	5650	2.13322
1300	2	13	5	138	87	23694	0.24	0.01	13	6.5	8	2792.1	#N/A	0
1300	3	13	5	138	87	23694	0.24	0.01	13	6.5	8	2792.1	#N/A	0
1300	4	13	5	138	87	23694	0.24	0.01	13	6.5	8	2792.1	#N/A	0
1300	5	13	5	138	87	23694	0.24	0.01	13	6.5	8	2792.1	#N/A	0
1300	6	13	5	138	87	23694	0.24	0.01	13	6.5	8	2792.1	#N/A	0
1300	7	13	5	138	87	23694	0.24	0.01	13	6.5	8	2792.1	#N/A	0
1300	8	13	5	138	87	23694	0.24	0.01	13	6.5	8	2792.1	#N/A	0
														2.13322

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_{c}	H_{o} (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_{p}' (psf)	S_{c} (ft)
1200	1	30	10	134	91	24307	0.14	0.0037	10	5	2	412.8	9121	0.655943
1200	2	30	10	134	91	24307	0.14	0.0037	10	15	2	988.8	9121	0.655611
1200	3	30	10	134	91	24307	0.14	0.0037	10	25	2	1564.8	9121	0.662224
1200	4	30	10	134	91	24307	0.14	0.0037	10	25	2	1564.8	#N/A	0
1200	5	30	10	134	91	24307	0.14	0.0037	10	25	2	1564.8	#N/A	0
1200	6	30	10	134	91	24307	0.14	0.0037	10	25	2	1564.8	#N/A	0
1200	7	30	10	134	91	24307	0.14	0.0037	10	25	2	1564.8	#N/A	0
1200	8	30	10	134	91	24307	0.14	0.0037	10	25	2	1564.8	#N/A	0
														1.974078

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_{c}	H_{o} (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_{p}' (psf)	S_{c} (ft)
1100	1	35	13	130	75	22546	0.14	0.0037	10	5	0	288	9121	0.613479
1100	2	35	13	130	75	22546	0.14	0.0037	10	15	0	864	9121	0.610973
1100	3	35	13	130	75	22546	0.14	0.0037	10	25	0	1440	9121	0.617544
1100	4	35	13	130	75	22546	0.14	0.0037	5	32.5	0	1872	9121	0.31209
1100	5	35	13	130	75	22546	0.14	0.0037	5	32.5	0	1872	#N/A	0
1100	6	35	13	130	75	22546	0.14	0.0037	5	32.5	0	1872	#N/A	0
1100	7	35	13	130	75	22546	0.14	0.0037	5	32.5	0	1872	#N/A	0
1100	8	35	13	130	75	22546	0.14	0.0037	5	32.5	0	1872	#N/A	0
														2.154087

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_{c}	H_{o} (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_{p}' (psf)	S_{c} (ft)
1000	1	24	13	125	60	20441	0.14	0.0037	10	5	0	288	9121	0.554674
1000	2	24	13	125	60	20441	0.14	0.0037	10	15	0	864	9121	0.553685
1000	3	24	13	125	60	20441	0.14	0.0037	5	22.5	0	1296	9121	0.279688
1000	4	24	13	125	60	20441	0.14	0.0037	5	22.5	0	1296	#N/A	0
1000	5	24	13	125	60	20441	0.14	0.0037	5	22.5	0	1296	#N/A	0
1000	6	24	13	125	60	20441	0.14	0.0037	5	22.5	0	1296	#N/A	0
1000	7	24	13	125	60	20441	0.14	0.0037	5	22.5	0	1296	#N/A	0
1000	8	24	13	125	60	20441	0.14	0.0037	5	22.5	0	1296	#N/A	0
														1.388047

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_{c}	H_{o} (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_{p}' (psf)	S_{c} (ft)
900	1	13	12.5	120	50	18812.5	0.14	0.0037	10	5	0	288	9121	0.504927
900	2	13	12.5	120	50	18812.5	0.14	0.0037	5	12.5	0	720	9121	0.251901
900	3	13	12.5	120	50	18812.5	0.14	0.0037	5	12.5	0	720	#N/A	0
900	4	13	12.5	120	50	18812.5	0.14	0.0037	5	12.5	0	720	#N/A	0
900	5	13	12.5	120	50	18812.5	0.14	0.0037	5	12.5	0	720	#N/A	0
900	6	13	12.5	120	50	18812.5	0.14	0.0037	5	12.5	0	720	#N/A	0
900	7	13	12.5	120	50	18812.5	0.14	0.0037	5	12.5	0	720	#N/A	0
900	8	13	12.5	120	50	18812.5	0.14	0.0037	5	12.5	0	720	#N/A	0
														0.756828

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_{c}	H_{o} (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_{p}' (psf)	S_{c} (ft)
800	1	12	10	120	30	16380	0.14	0.0037	10	5	0	288	9121	0.422101
800	2	12	10	120	30	16380	0.14	0.0037	5	12.5	0	720	9121	0.211468
800	3	12	10	120	30	16380	0.14	0.0037	5	12.5	0	720	#N/A	0
800	4	12	10	120	30	16380	0.14	0.0037	5	12.5	0	720	#N/A	0
800	5	12	10	120	30	16380	0.14	0.0037	5	12.5	0	720	#N/A	0
800	6	12	10	120	30	16380	0.14	0.0037	5	12.5	0	720	#N/A	0
800	7	12	10	120	30	16380	0.14	0.0037	5	12.5	0	720	#N/A	0
800	8	12	10	120	30	16380	0.14	0.0037	5	12.5	0	720	#N/A	0
														0.633569

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_{c}	H_{o} (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_{p}' (psf)	S_{c} (ft)
1200	1	8.5	10	134	91	24307	0.24	0.01	8.5	4.25	2	2033.85	5650	1.401623
1200	2	8.5	10	134	91	24307	0.24	0.01	8.5	4.25	2	2033.85	#N/A	0
1200	3	8.5	10	134	91	24307	0.24	0.01	8.5	4.25	2	2033.85	#N/A	0
1200	4	8.5	10	134	91	24307	0.24	0.01	8.5	4.25	2	2033.85	#N/A	0
1200	5	8.5	10	134	91	24307	0.24	0.01	8.5	4.25	2	2033.85	#N/A	0
1200	6	8.5	10	134	91	24307	0.24	0.01	8.5	4.25	2	2033.85	#N/A	0
1200	7	8.5	10	134	91	24307	0.24	0.01	8.5	4.25	2	2033.85	#N/A	0
1200	8	8.5	10	134	91	24307	0.24	0.01	8.5	4.25	2	2033.85	#N/A	0
														1.401623

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_{c}	H_{o} (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_{p}' (psf)	S_{c} (ft)
1100	1	7	13	130	75	22546	0.24	0.01	7	3.5	0	2165.1	5650	1.105777
1100	2	7	13	130	75	22546	0.24	0.01	7	3.5	0	2165.1	#N/A	0
1100	3	7	13	130	75	22546	0.24	0.01	7	3.5	0	2165.1	#N/A	0
1100	4	7	13	130	75	22546	0.24	0.01	7	3.5	0	2165.1	#N/A	0
1100	5	7	13	130	75	22546	0.24	0.01	7	3.5	0	2165.1	#N/A	0
1100	6	7	13	130	75	22546	0.24	0.01	7	3.5	0	2165.1	#N/A	0
1100	7	7	13	130	75	22546	0.24	0.01	7	3.5	0	2165.1	#N/A	0
1100	8	7	13	130	75	22546	0.24	0.01	7	3.5	0	2165.1	#N/A	0
														1.105777

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_{c}	H_{o} (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_{p}' (psf)	S_{c} (ft)
1000	1	9	13	125	60	20441	0.24	0.01	9	4.5	0	1574.1	5650	1.325803
1000	2	9	13	125	60	20441	0.24	0.01	9	4.5	0	1574.1	#N/A	0
1000	3	9	13	125	60	20441	0.24	0.01	9	4.5	0	1574.1	#N/A	0
1000	4	9	13	125	60	20441	0.24	0.01	9	4.5	0	1574.1	#N/A	0
1000	5	9	13	125	60	20441	0.24	0.01	9	4.5	0	1574.1	#N/A	0
1000	6	9	13	125	60	20441	0.24	0.01	9	4.5	0	1574.1	#N/A	0
1000	7	9	13	125	60	20441	0.24	0.01	9	4.5	0	1574.1	#N/A	0
1000	8	9	13	125	60	20441	0.24	0.01	9	4.5	0	1574.1	#N/A	0
														1.325803

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_{c}	H_{o} (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_{p}' (psf)	S_{c} (ft)
900	1	10	12.5	120	50	18812.5	0.24	0.01	10	5	0	961.8	5650	1.382623
900	2	10	12.5	120	50	18812.5	0.24	0.01	10	5	0	961.8	#N/A	0
900	3	10	12.5	120	50	18812.5	0.24	0.01	10	5	0	961.8	#N/A	0
900	4	10	12.5	120	50	18812.5	0.24	0.01	10	5	0	961.8	#N/A	0
900	5	10	12.5	120	50	18812.5	0.24	0.01	10	5	0	961.8	#N/A	0
900	6	10	12.5	120	50	18812.5	0.24	0.01	10	5	0	961.8	#N/A	0
900	7	10	12.5	120	50	18812.5	0.24	0.01	10	5	0	961.8	#N/A	0
900	8	10	12.5	120	50	18812.5	0.24	0.01	10	5	0	961.8	#N/A	0
														1.382623

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{α}	C_{c}	H_{o} (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_{p}' (psf)	S_{c} (ft)
800	1	11	10	120	30	16380	0.24	0.01	11	5.5	0	925.5	5650	1.369622
800	2	11	10	120	30	16380	0.24	0.01	11	5.5	0	925.5	#N/A	0
800	3	11	10	120	30	16380	0.24	0.01	11	5.5	0	925.5	#N/A	0
800	4	11	10	120	30	16380	0.24	0.01	11	5.5	0	925.5	#N/A	0
800	5	11	10	120	30	16380	0.24	0.01	11	5.5	0	925.5	#N/A	0
800	6	11	10	120	30	16380	0.24	0.01	11	5.5	0	925.5	#N/A	0
800	7	11	10	120	30	16380	0.24	0.01	11	5.5	0	925.5	#N/A	0
800	8	11	10	120	30	16380	0.24	0.01	11	5.5	0	925.5	#N/A	0
														1.369622

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_c	C_r	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_t (ft)
700	1	20	10	125	10	14740	0.14	0.0037	10	5	0	288	9121	0.359126
700	2	20	10	125	10	14740	0.14	0.0037	5	12.5	0	720	9121	0.180817
700	3	20	10	125	10	14740	0.14	0.0037	5	12.5	0	720	#N/A	0
700	4	20	10	125	10	14740	0.14	0.0037	5	12.5	0	720	#N/A	0
700	5	20	10	125	10	14740	0.14	0.0037	5	12.5	0	720	#N/A	0
700	6	20	10	125	10	14740	0.14	0.0037	5	12.5	0	720	#N/A	0
700	7	20	10	125	10	14740	0.14	0.0037	5	12.5	0	720	#N/A	0
700	8	20	10	125	10	14740	0.14	0.0037	5	12.5	0	720	#N/A	0
														0.539943

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_c	C_r	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_t (ft)
600	1	30	8.5	115	0	12494.5	0.14	0.0037	10	5	0	288	9121	0.290727
600	2	30	8.5	115	0	12494.5	0.14	0.0037	10	15	0	864	9121	0.289872
600	3	30	8.5	115	0	12494.5	0.14	0.0037	10	25	0	1440	9121	0.237331
600	4	30	8.5	115	0	12494.5	0.14	0.0037	10	25	0	1440	#N/A	0
600	5	30	8.5	115	0	12494.5	0.14	0.0037	10	25	0	1440	#N/A	0
600	6	30	8.5	115	0	12494.5	0.14	0.0037	10	25	0	1440	#N/A	0
600	7	30	8.5	115	0	12494.5	0.14	0.0037	10	25	0	1440	#N/A	0
600	8	30	8.5	115	0	12494.5	0.14	0.0037	10	25	0	1440	#N/A	0
														0.817929

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_c	C_r	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_t (ft)
500	1	40	8	100	0	10936	0.14	0.0037	10	5	0	288	9121	0.181671
500	2	40	8	100	0	10936	0.14	0.0037	10	15	0	864	9121	0.194446
500	3	40	8	100	0	10936	0.14	0.0037	10	25	0	1440	9121	0.215215
500	4	40	8	100	0	10936	0.14	0.0037	10	35	0	2016	9121	0.237468
500	5	40	8	100	0	10936	0.14	0.0037	10	35	0	2016	#N/A	0
500	6	40	8	100	0	10936	0.14	0.0037	10	35	0	2016	#N/A	0
500	7	40	8	100	0	10936	0.14	0.0037	10	35	0	2016	#N/A	0
500	8	40	8	100	0	10936	0.14	0.0037	10	35	0	2016	#N/A	0
														0.8288

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_c	C_r	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_t (ft)
400	1	35	7.5	85	0	9377.5	0.14	0.0037	10	5	0	288	9121	0.090779
400	2	35	7.5	85	0	9377.5	0.14	0.0037	10	15	0	864	9121	0.10832
400	3	35	7.5	85	0	9377.5	0.14	0.0037	10	25	0	1440	9121	0.13338
400	4	35	7.5	85	0	9377.5	0.14	0.0037	5	32.5	0	1872	9121	0.076487
400	5	35	7.5	85	0	9377.5	0.14	0.0037	5	32.5	0	1872	#N/A	0
400	6	35	7.5	85	0	9377.5	0.14	0.0037	5	32.5	0	1872	#N/A	0
400	7	35	7.5	85	0	9377.5	0.14	0.0037	5	32.5	0	1872	#N/A	0
400	8	35	7.5	85	0	9377.5	0.14	0.0037	5	32.5	0	1872	#N/A	0
														0.408966

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_c	C_r	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_t (ft)
300	1	35	7	65	0	7319	0.14	0.0037	10	5	0	288	9121	0.052607
300	2	35	7	65	0	7319	0.14	0.0037	10	15	0	864	9121	0.036127
300	3	35	7	65	0	7319	0.14	0.0037	10	25	0	1440	9121	0.029011
300	4	35	7	65	0	7319	0.14	0.0037	5	32.5	0	1872	9121	0.015047
300	5	35	7	65	0	7319	0.14	0.0037	5	32.5	0	1872	#N/A	0
300	6	35	7	65	0	7319	0.14	0.0037	5	32.5	0	1872	#N/A	0
300	7	35	7	65	0	7319	0.14	0.0037	5	32.5	0	1872	#N/A	0
300	8	35	7	65	0	7319	0.14	0.0037	5	32.5	0	1872	#N/A	0
														0.132793

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_c	C_r	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_t (ft)
700	1	7.5	10	125	10	14740	0.24	0.01	7.5	3.75	0	1311.75	5650	0.563818
700	2	7.5	10	125	10	14740	0.24	0.01	7.5	3.75	0	1311.75	#N/A	0
700	3	7.5	10	125	10	14740	0.24	0.01	7.5	3.75	0	1311.75	#N/A	0
700	4	7.5	10	125	10	14740	0.24	0.01	7.5	3.75	0	1311.75	#N/A	0
700	5	7.5	10	125	10	14740	0.24	0.01	7.5	3.75	0	1311.75	#N/A	0
700	6	7.5	10	125	10	14740	0.24	0.01	7.5	3.75	0	1311.75	#N/A	0
700	7	7.5	10	125	10	14740	0.24	0.01	7.5	3.75	0	1311.75	#N/A	0
700	8	7.5	10	125	10	14740	0.24	0.01	7.5	3.75	0	1311.75	#N/A	0
														0.563818

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_c	C_r	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_t (ft)
600	1	5	8.5	115	0	12494.5	0.24	0.01	5	2.5	0	1834.5	5650	0.509427
600	2	5	8.5	115	0	12494.5	0.24	0.01	5	2.5	0	1834.5	#N/A	0
600	3	5	8.5	115	0	12494.5	0.24	0.01	5	2.5	0	1834.5	#N/A	0
600	4	5	8.5	115	0	12494.5	0.24	0.01	5	2.5	0	1834.5	#N/A	0
600	5	5	8.5	115	0	12494.5	0.24	0.01	5	2.5	0	1834.5	#N/A	0
600	6	5	8.5	115	0	12494.5	0.24	0.01	5	2.5	0	1834.5	#N/A	0
600	7	5	8.5	115	0	12494.5	0.24	0.01	5	2.5	0	1834.5	#N/A	0
600	8	5	8.5	115	0	12494.5	0.24	0.01	5	2.5	0	1834.5	#N/A	0
														0.509427

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_c	C_r	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_t (ft)
500	1	0	8	100	0	10936	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
500	2	0	8	100	0	10936	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
500	3	0	8	100	0	10936	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
500	4	0	8	100	0	10936	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
500	5	0	8	100	0	10936	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
500	6	0	8	100	0	10936	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
500	7	0	8	100	0	10936	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
500	8	0	8	100	0	10936	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
														0

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_c	C_r	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_t (ft)
400	1	0	7.5	85	0	9377.5	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
400	2	0	7.5	85	0	9377.5	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
400	3	0	7.5	85	0	9377.5	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
400	4	0	7.5	85	0	9377.5	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
400	5	0	7.5	85	0	9377.5	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
400	6	0	7.5	85	0	9377.5	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
400	7	0	7.5	85	0	9377.5	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
400	8	0	7.5	85	0	9377.5	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
														0

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_c	C_r	H_o (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_t (ft)
300	1	0	7	65	0	7319	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
300	2	0	7	65	0	7319	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
300	3	0	7	65	0	7319	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
300	4	0	7	65	0	7319	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
300	5	0	7	65	0	7319	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
300	6	0	7	65	0	7319	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
300	7	0	7	65	0	7319	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
300	8	0	7	65	0	7319	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
														0

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{sr}	C_{rr}	H_s (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
200	1	35	7	40	0	4819	0.14	0.0037	10	5	0	288	9121	0.046206
200	2	35	7	40	0	4819	0.14	0.0037	10	15	0	864	9121	0.030266
200	3	35	7	40	0	4819	0.14	0.0037	10	25	0	1440	9121	0.023611
200	4	35	7	40	0	4819	0.14	0.0037	5	32.5	0	1872	9121	0.010234
200	5	35	7	40	0	4819	0.14	0.0037	5	32.5	0	1872	#N/A	0
200	6	35	7	40	0	4819	0.14	0.0037	5	32.5	0	1872	#N/A	0
200	7	35	7	40	0	4819	0.14	0.0037	5	32.5	0	1872	#N/A	0
200	8	35	7	40	0	4819	0.14	0.0037	5	32.5	0	1872	#N/A	0
														0.110318

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{sr}	C_{rr}	H_s (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
200	1	0	7	40	0	4819	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
200	2	0	7	40	0	4819	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
200	3	0	7	40	0	4819	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
200	4	0	7	40	0	4819	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
200	5	0	7	40	0	4819	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
200	6	0	7	40	0	4819	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
200	7	0	7	40	0	4819	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
200	8	0	7	40	0	4819	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
														0

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{sr}	C_{rr}	H_s (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
100	1	40	22.5	0	0	2832.5	0.14	0.0037	10	5	0	288	9121	0.037224
100	2	40	22.5	0	0	2832.5	0.14	0.0037	10	15	0	864	9121	0.022463
100	3	40	22.5	0	0	2832.5	0.14	0.0037	10	25	0	1440	9121	0.016706
100	4	40	22.5	0	0	2832.5	0.14	0.0037	10	35	0	2016	9121	0.018424
100	5	40	22.5	0	0	2832.5	0.14	0.0037	10	35	0	2016	#N/A	0
100	6	40	22.5	0	0	2832.5	0.14	0.0037	10	35	0	2016	#N/A	0
100	7	40	22.5	0	0	2832.5	0.14	0.0037	10	35	0	2016	#N/A	0
100	8	40	22.5	0	0	2832.5	0.14	0.0037	10	35	0	2016	#N/A	0
														0.094818

Horizontal Location (ft)	Point	Thickness of Residual Soil (ft)	Thickness of Fill Layer (ft)	Height of Wet Waste (ft)	Height of Dry Waste (ft)	$\Delta\sigma_{vo}'$ (psf)	C_{sr}	C_{rr}	H_s (ft)	Depth to Point (ft)	Depth to Water Table (ft)	σ_{vo}' (psf)	σ_p' (psf)	S_c (ft)
100	1	0	22.5	0	0	2832.5	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
100	2	0	22.5	0	0	2832.5	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
100	3	0	22.5	0	0	2832.5	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
100	4	0	22.5	0	0	2832.5	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
100	5	0	22.5	0	0	2832.5	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
100	6	0	22.5	0	0	2832.5	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
100	7	0	22.5	0	0	2832.5	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
100	8	0	22.5	0	0	2832.5	0.24	0.01	0	#N/A	0	#N/A	#N/A	0
														0

FOUNDATION STABILITY ANALYSES

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Tennessee Valley Authority (TVA)

Project: Kingston Fossil Plant Gypsum Disposal Facility **Project/Proposal #:** GR3731 **Task #:** 06

Title of Computations: *Foundation Stability Analyses*

Computation Package: ______

Computations By:
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Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

FOUNDATION STABILITY ANALYSES

FOUNDATION STABILITY ANALYSES

PURPOSE

The purpose of this calculation package is to evaluate the static and seismic slope stability of the proposed gypsum disposal facility at the Kingston Fossil Plant (hereafter referenced as KIF gypsum disposal facility). For these analyses, potential slip surfaces passing through the gypsum material and underlying native foundation soils are considered.

METHOD OF ANALYSIS

Static Stability Analysis:

Slope stability analyses were performed using the simplified Bishop method [Bishop, 1955] for the circular search method for potential slip surfaces, and the Spencer method [Spencer, 1973] for block surfaces as implemented in the computer program SLIDE [2003]. The program was used to generate potential slip surfaces and calculate the factor of safety for each of these surfaces. SLIDE identifies the slip surface with the lowest factor of safety. Information required for the analyses include:

- the geometry of the gypsum disposal facility at the cross section location;
- the subsurface soil stratigraphy at the cross section location;
- the material properties for gypsum, subgrade fill, and subsurface materials;
- the water level within the gypsum stack; and
- the groundwater table elevation along the cross section location.

Analyses were performed for an interim construction phase representing the top elevation of the wet stack gypsum material (approximate Elevation 900 ft mean sea level (msl)); and for the final build out phase representing the top of dry stack gypsum material (approximate Elevation 985 ft msl). Both drained and undrained analyses were performed.

Seismic Stability Analysis:

Seismic slope stability analyses were performed using a procedure consistent with the guidance document prepared by the U.S. Environmental Protection Agency [USEPA, 1995]. The procedure is as follows:

- Estimate the maximum horizontal acceleration (MHA) in lithified earth material and the peak horizontal acceleration at the ground surface (PGA) for the site.
    - Based on the most recent current USGS seismic hazard map (2002), the MHA is 0.25g.
    - The PGA is conservatively assumed equal to the MHA (i.e., 0.25g).
- Estimate the peak horizontal acceleration of the potential sliding mass. This value is assumed to be equal to the PGA.
- Perform pseudo-static slope stability analyses of potentially critical cross sections to evaluate the yield acceleration. Yield acceleration is the acceleration value which produces a calculated pseudo-static factor of safety equal to one.
    - If the calculated yield acceleration exceeds the peak horizontal acceleration of the potential sliding mass (equal to PGA), it is concluded that permanent seismic deformations will not occur.
    - If the calculated yield acceleration is less than the PGA, it is concluded that permanent seismic deformations will occur and their magnitude is evaluated in the following step.
- Estimate the magnitude of the permanent seismic deformation using a seismic deformation analysis.
    - The ratio of yield acceleration to PGA is used with relationships presented by Hynes and Franklin [1984] and to estimate the magnitude of permanent seismic deformation. These relationships were based on analyses performed using the Newmark [1965] method of seismic deformation analysis and several hundred recorded time histories for earthquakes from around the world as well as six synthetic time histories, representing earthquakes up to 7.7 in magnitude. The "modified mean + one standard deviation curve" developed by GeoSyntec considers data associated with only large earthquakes, and therefore, is more conservative and is used herein.

For the pseudo-static slope stability analyses described, the computer program SLIDE [2003] was used. The analyses were performed using the simplified Bishop method [Bishop, 1955] for circular potential slip surfaces and the Spencer method [Spencer, 1973] for block surfaces.

Design Water Levels Within Disposal Facility

The gypsum material at the KIF gypsum disposal facility will be sluiced in up to Elevation 900 ft msl; therefore, the interim construction stability was evaluated assuming a water level within the gypsum stack to be at Elevation 900 ft msl (thus assuming no drainage has occurred). Under final configuration (i.e., wet and dry stack configuration), it is assumed that the water level within the gypsum stack will reduce as waters are removed via the internal drainage system. Analyses to estimate the water level within the KIF gypsum disposal facility at different time periods are presented in the calculation package titled "*Seepage Analysis*." According to this calculation package, and neglecting the effect of the central drainage corridor, the water level within the gypsum stack is calculated to drop by approximately 40 ft after five years. Considering that it will take more than 10 years to reach the maximum elevation of the dry stack material and since the beneficial effects of the central drainage corridor are neglected (i.e., assuming drainage only occurs through the perimeter drainage system), a 40 ft drop in the water level in the gypsum stack is considered to be a conservative assumption.

Target Factors of Safety:

The target calculated factor of safety for static stability analyses is 1.5.

The criterion for seismic stability is based on calculated permanent deformation. Based on the limiting seismic slope stability design criteria of the Tennessee Division of Solid Waste Management a division of the Tennessee Department of Environment and Conservation (TDEC) [TDEC, 1993], "*No landfill shall be acceptable if the predicted seismic induced deformations within the waste fill exceed one-half the thickness of the clay liner component of the liner system.*" Since there is no liner mandated for this facility, the 3-ft thick layer of geologic buffer (compacted clay) may be considered to be the clay liner component and therefore the maximum acceptable calculated permanent seismic deformation is 1.5 ft (18 inch).

CROSS SECTIONS ANALYZED

Two cross sections (i.e., Cross Section A and Cross Section B) were analyzed. The location of the cross sections with respect to the final cover system of the KIF gypsum disposal facility features is shown in Figure 1. The cross section geometries at each location (including dry stack and wet stack gypsum, coarse gypsum, soil stratigraphy, water table, and piezometric surface within the dry stack material) are shown in Figures 2 and 3. Each cross section is considered critical since the maximum waste height and grade is obtained at these locations.

SITE STRATIGRAPHY

Information on the site stratigraphy used in these analyses is summarized in MACTEC [2005], MACTEC [2006], and TVA [2005]. The top of bedrock elevations were obtained from a contour map developed from a series of site investigations that included soil borings, CPT soundings, and GeoProbe soundings performed at the site as presented in TVA [2005]. Current ground elevations were obtained from the Kingston Fossil Plant topographic map provided by TVA. Nearby borings were projected to the cross section to develop the thicknesses of the compressible native material along the cross section. This native material was subdivided into two groups based on the Standard Penetration Test (SPT) blow count and water content of the material. A description of the subsurface stratigraphy and the corresponding material properties are presented in the following section.

MATERIAL PARAMETERS

Information on the material parameters used in these analyses is obtained from MACTEC [2004], MACTEC [2005], and MACTEC [1995]. Material parameters used for the stability analyses are summarized in Table 1.

Gypsum

Samples of gypsum are not yet available from the Kingston Fossil Plant. Material from the Cumberland Fossil Plant is considered representative of the material that will be produced at the Kingston Fossil Plant once the scrubber is brought online. For design purposes, material properties of the Cumberland gypsum are used herein.

- *Dry Stack Gypsum*: The dry placed gypsum material will be dewatered at the plant before it is transported to the KIF gypsum disposal facility. This material will be placed at elevations above approximately 900 ft msl. Material properties for the dry stack gypsum are provided in the report titled *Use of Coal Combustion By-Products as Engineered Fills* prepared by MACTEC [1995]. According to this report, consolidated undrained (CU) triaxial tests were performed on specimens remolded to approximately 95 percent of the Standard Proctor maximum density at or near optimum moisture content. Based on these test results, an effective stress friction angle of 38 degrees was reported. For the stability analysis described herein, a friction angle of 35 degrees and a zero cohesion intercept was selected.

- *Coarse Gypsum*: Coarse grained gypsum is a by-product of the rim-ditch method of sluiced material placement. Coarser grained gypsum settles out in or near the rim ditch and is scooped out to form the perimeter dikes. Relatively undisturbed samples representing a coarser grained sluiced gypsum material at the Cumberland Fossil Plant were obtained by MACTEC [2004]. Based on a three-point consolidated undrained (CU) triaxial test a friction angle of 40 degrees was obtained and is used in the analyses presented herein.

- *Fine Gypsum*: Fine grained gypsum is also a by-product of the rim-ditch method of sluiced material placement, however the finer grained material travels further from the discharge point towards the center of the gypsum pond than the coarser material. Like the coarser grained gypsum, undisturbed samples representing the fine grained gypsum were obtained at the Cumberland Fossil Plant by MACTEC [2004]. Shear strength parameters were estimated based on a three-point CU triaxial test assuming failure occurs where the shear induced excess pore pressures are zero. Based on these results, the effective stress shear strength parameters used in the analyses presented herein are an effective stress friction angle of 30 degrees and a zero cohesion intercept. An undrained shear strength ratio (S_u/σ_{vo}') of 1.5 was selected.

Soil Fill/Subgrade

On site material will be used to construct the initial soil berm around the gypsum pond and the subgrade fill. Standard Proctor tests were run on 17 samples of native material from depths ranging from 6 to 12.5 ft. The unit weight of the soil fill material was selected as 95 percent of the average of the maximum dry unit weights resulting from the Standard Proctor tests. Effective stress properties for the soil berm and subgrade material are average values from three, three-point CU triaxial tests performed on remolded samples taken from depths ranging from 6 to 10 ft. Based on these results, the effective stress shear strength parameters used in the analyses presented herein are an effective stress friction angle of 30 degrees and a zero cohesion intercept.

Geologic Buffer

The geologic buffer effective stress properties for the geologic buffer have been estimated from averaging typical peak drained strengths for CL, MH, and CH soils as presented by Duncan and Wright [2005]. The effective stress shear strength parameters used in the analyses presented herein are estimated as an effective stress friction angle of 24 degrees and a zero cohesion intercept.

Native Soil

The onsite native material is primarily classified as a medium stiff to stiff silty clay. The average blow count of the material onsite ranges from 6 to 20 blows per foot (bpf). Approximately one-half of the borings encountered a "soft" material, classified by Standard Penetration Test (SPT) N values less than or equal to 4 bpf. This soft material ranged in thickness from 0 to 20 ft along the cross sections selected for the stability analyses and occurred just above the bedrock material. For the analyses performed herein, drained and undrained shear strength parameters were selected for two layers of foundation material (i.e., N>4 and N≤4). Triaxial tests summarized in MACTEC [2006] and CPT soundings summarized in TVA [2005] were used to develop the short and long term shear strength of the native material.

- N>4:
  - (*Undrained shear strength for analyses where gypsum disposal facility is at Elevation 900 ft msl*)

    CU and unconsolidated undrained (UU) triaxial tests were performed on eight samples obtained from depths ranging from 13 to 41 ft below ground surface. This triaxial data in combination with data from ten Cone Penetration Test (CPT) soundings performed across the site to depths of 42 ft were used to estimate native soil undrained shear strength. The undrained shear strength can be estimated from the measured tip resistance according to the following equation developed by Schmertmann [1978]:

$$S_u = \frac{q_c - \sigma_{vo}}{N_k}$$

where N_k is a normalizing factor that ranges from 12 to 19 and is related to the plasticity index of the in situ material. For the native soil at the KIF gypsum disposal facility, an N_k factor of 19 was chosen to calibrate the calculated CPT undrained shear strength data to the undrained shear strength developed from the triaxial test data.

The undrained shear strength data were plotted versus effective confining pressure to develop an undrained shear strength profile for the native material (i.e., a best fit linear trend line through the data as shown in Figure 4) resulting in the following equation:

$$S_u = 1{,}792 \text{ psf} + 0.27 \text{*Confining Pressure (psf)}$$

Conservatively assuming that the native soil is saturated, and a unit weight of 120 pcf, an undrained strength profile with depth can be estimated using the following equation:

$$S_u = 1{,}792 \text{ psf} + 15.6 \text{*depth}$$

where depth is measured in feet below the pre-construction ground surface (i.e. at the elevation of the top of the native material).

- *(Undrained shear strength for analyses where construction of gypsum disposal facility is above Elevation 900 ft msl up to Elevation 985 ft msl)*

  For analyses with gypsum placement above Elevation 900 ft msl (dry stack material placement), it was assumed that the native material would experience some improvement in undrained shear strength due to consolidation which will occur as a result of the weight of the previously place wet stack material. Based on a construction period of 14.5 years (i.e., assuming 10 ft of wet stack gypsum would be placed per year), the native soil will experience approximately 50 percent consolidation, and a corresponding increase in effective confining pressure at the approximate time when placement of the dry stack material is anticipated to commence. This improved undrained shear strength is evaluated in three zones under the wet stack loading: (i) beneath the maximum gypsum height of 900 ft msl; and (ii) two zones beneath the side slope. No shear strength improvement was assumed beneath the toe of the slope. Calculations to evaluate improvements in undrained strengths due to the consolidation of the native material under the weight of the wet stack gypsum are provided in Attachment A.

For the drained analyses, an average effective stress friction angle of 34 degrees was used based on triaxial testing results.

- N≤4: No triaxial tests were performed on native material with SPT blow counts of less than or equal to 4 bpf. Four of the ten CPT soundings performed at the site encountered the soft native material. The average undrained shear strength of this material was developed from these CPT soundings and is 800 psf for the analyses performed herein. The improved undrained shear strength of the "soft" native material was not developed.

For the drained analyses, an effective stress friction angle for the soft native material was estimated based on the plasticity index (PI) using the following relationship [Mitchell, 1976]:

$$\sin\phi'_{cv} \approx 0.8 - 0.094\ln(PI)$$

Considering an average PI of the soft native material to be 43, an effective stress friction angle of 26.5 degrees was calculated. A friction angle of 25 degrees was used for the analyses described herein.

Bedrock

Due to the anticipated high shear strength of the bedrock, the top of bedrock elevation is considered the lower limit for the potential critical slip surface therefore; reasonable cohesion, friction angle, and unit weight values were selected as required by the computer simulation.

RESULTS

Table 2 summarizes the results of the static slope stability analyses for both left and right potential slip surface directions (i.e., towards or away from the Clinch River). Analyses were performed for Cross Section A-A' at the interim wet stack material height of 900 ft msl and the final dry stack material height of 985 ft msl. As shown for Cross Section A-A', the critical geometry (i.e., the lowest calculated factor of safety) is the maximum height of dry stack gypsum of 985 ft msl. Therefore, for Cross Section B-B', the interim geometry of wet stack gypsum material height of 900 ft msl was not investigated. For Cross Section B-B', analyses were performed for the final dry stack gypsum material height of 980 ft msl.

Table 3 summarizes the results of the seismic slope stability analyses performed for the KIF gypsum disposal facility. Seismic slope stability analyses were performed for the final maximum height of gypsum of 985 ft msl. The calculated displacements were selected based on the modified Hynes and Franklin (1984) chart as shown in Figure 5, where the "modified mean + one standard deviation curve" developed by GeoSyntec was used for this analysis. Associated output files and figures from SLIDE are presented at the end of this package in Attachments B through E.

SUMMARY AND CONCLUSIONS

The stability of the KIF gypsum disposal facility was evaluated with respect to static and seismic foundation stability. The most critical cross sections with respect to foundation stability were analyzed. Results indicate that the minimum static stability factor of safety for a potential slip surface through the gypsum and foundation soils is 1.60, which is greater than the target factor of safety.

Results indicate that the minimum yield acceleration for slip surfaces through the waste and the foundation soils is 0.155 g. For the analyses considered herein, the maximum calculated permanent deformation evaluated by the modified Hynes and Franklin (1984) chart is 1.97 inch (as shown in Figure 5) which is less than half the clay liner thickness (18 inch) as prescribed by the TDEC Earthquake Evaluation Guidance document. Therefore, the calculated permanent seismic deformations are considered acceptable.

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TABLES

Table 1. Summary of Material Properties.

Material	Unit Weight	Effective Stress		Undrained Strength S_u	
	(pcf)	Cohesion (psf)	Friction Angle	For Placement of Gypsum *up to* Elevation 900 ft (psf)	For Placement of Gypsum *above* Elevation 900 ft (psf)
Dry Stack Gypsum	107	0	35	-	-
Coarse Gypsum	90	0	40	-	-
Fine Gypsum	100	0	30	$S_u/\sigma_{vo}'=1.5$	$S_u/\sigma_{vo}'=1.5$
Soil Fill	117	0	30	-	-
Geologic Buffer	117	0	24	-	-
Native Soil (N>4)	120	0	34	1,792+15.6* depth	Varies (See Attachment A)
Native Soil (N≤4)	105	0	25	800	800
Bedrock	155	10,000	30	-	-

Table 2. Summary of Static Foundation Stability Analyses.

Cross Section	Potential Slip Surface Direction	Search Method	Drained/ Undrained(1)	Maximum Height of Gypsum (ft msl)	Factor of Safety	Figure	File Name
A-A'	Left	Circle	Undrained	900	2.20	B-1	Cross Section A-A'_1a
A-A'	Left	Block	Undrained	900	1.93	B-2	Cross Section A-A'_1a_block
A-A'	Left	Circle	Undrained	985	1.98	B-3	Cross Section A-A'_2
A-A'	Left	Block	Undrained	985	1.67	B-4	Cross Section A-A'_2block
A-A'	Left	Circle	Drained	900	2.28	B-5	Cross Section A-A'_1a_drained
A-A'	Left	Circle	Drained	985	1.64	B-6	Cross Section A-A'_2_drained
A-A'	Right	Circle	Undrained	985	2.13	B-7	Cross Section A-A'_2_right
A-A'	Right	Block	Undrained	985	2.12	B-8	Cross Section A-A'_2_right_block
A-A'	Right	Circle	Drained	985	1.92	B-9	Cross Section A-A'_2_drained_right
B-B'	Left	Circle	Undrained	980	2.31	C-1	Cross Section B-B_1
B-B'	Left	Block	Undrained	980	1.88	C-2	Cross Section B-B_1_block
B-B'	Left	Circle	Drained	980	1.60	C-3	Cross Section B-B_1_drained
B-B'	Right	Circle	Undrained	980	2.70	C-4	Cross Section B-B_1_right
B-B'	Right	Block	Undrained	980	2.62	C-5	Cross Section B-B_1_right_block
B-B'	Right	Circle	Drained	980	2.05	C-6	Cross Section B-B_1_drained_right

Notes: (1) For all analyses, the coarse gypsum, soil fill, and dry stack gypsum were modeled as drained materials. For analyses indicated as "Undrained", only the fine gypsum and native material (foundation soils) were modeled as undrained materials.

Table 3. Summary of Seismic Foundation Stability Analyses.

Cross Section	Drained/ Undrained(1)	Minimum Yield Acceleration a_y	Design Peak Acceleration a_{max} (PGA)	$(a_y)/(a_{max})$	Calculated Displacement (inch)	Figure	File Name
A-A'	Undrained	0.175g	0.25g	0.7	1.67	D-1	Cross Section A-A'_2block_seis
A-A'	Drained	0.17g	0.25g	0.68	1.7	D-2	Cross Section A-A'_2_drained_seis
B-B'	Undrained	0.18g	0.25g	0.72	1.65	E-1	Cross Section B-B_1_block_seis
B-B'	Drained	0.155g	0.25g	0.62	1.97	E-2	Cross Section B-B_1_drained_seis

Notes: (1) For all analyses, the coarse gypsum, soil fill, and dry stack gypsum were modeled as drained materials. For analyses indicated as "Undrained", only the fine gypsum and native material (foundation soils) were modeled as undrained materials.

FIGURES

Written by: JFB Date: 5/5/2006 Reviewed by: PJS Date: 5/5/2006

Client: TVA Project: Kingston Fossil Plant Project/Proposal No.: GR3731 Task No.:

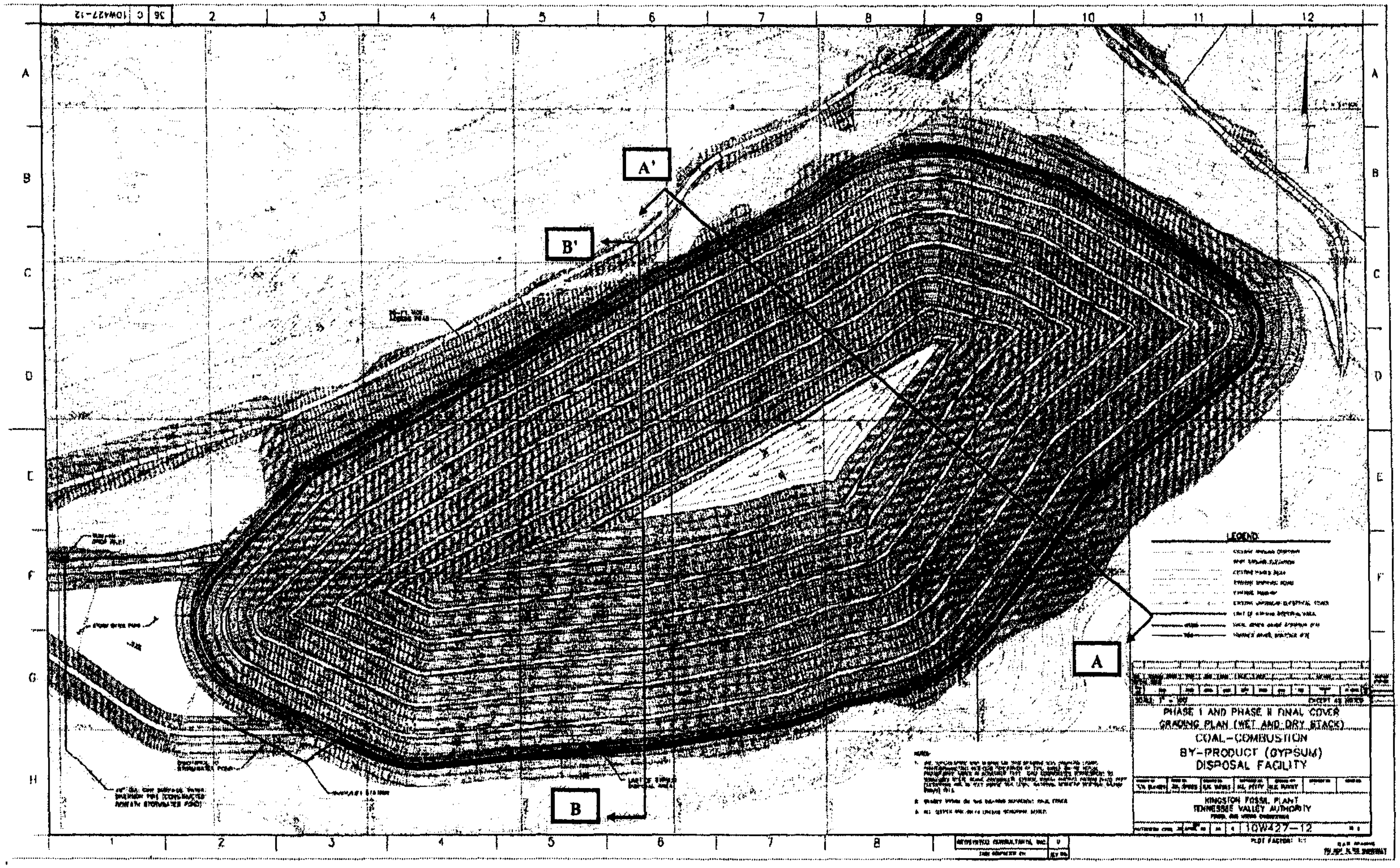


Figure 1: Location of the Analyzed Cross Sections on Final Cover Grading Plan.

Written by: JFR Date: 5/5/2006 Reviewed by: PJS Date: 5/5/2006

Client: TVA Project: Kingston Fossil Plant Project/Proposal No.: GR3731 Task No.:

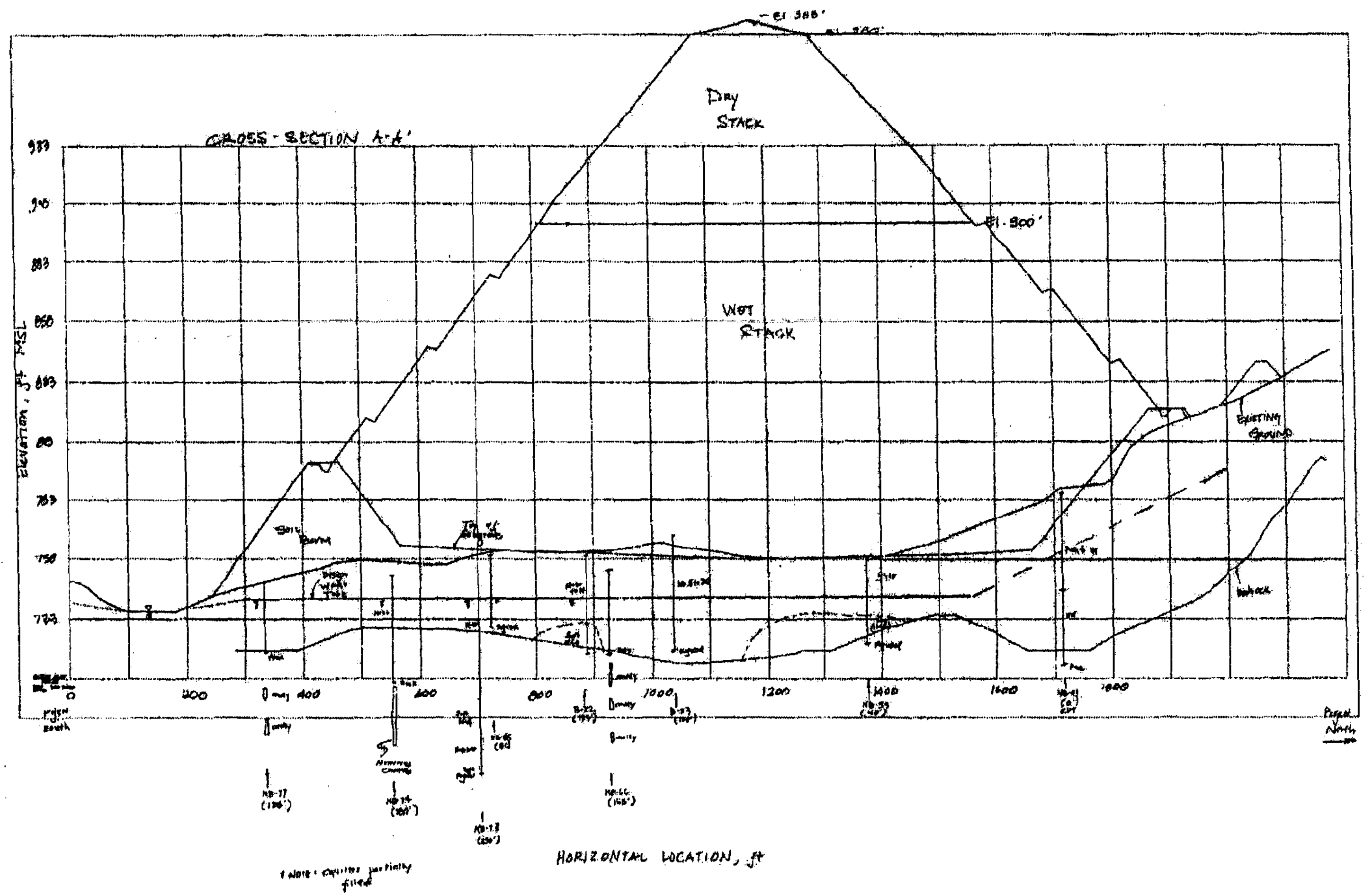


Figure 2: Stratigraphy of Analyzed Cross Section A-A'

TVA-00021314

Written by: JFR Date: 5/5/2006 Reviewed by: PJS Date: 5/5/2006

Client: TVA Project: Kingston Fossil Plant Project/Proposal No.: GR3731 Task No.:

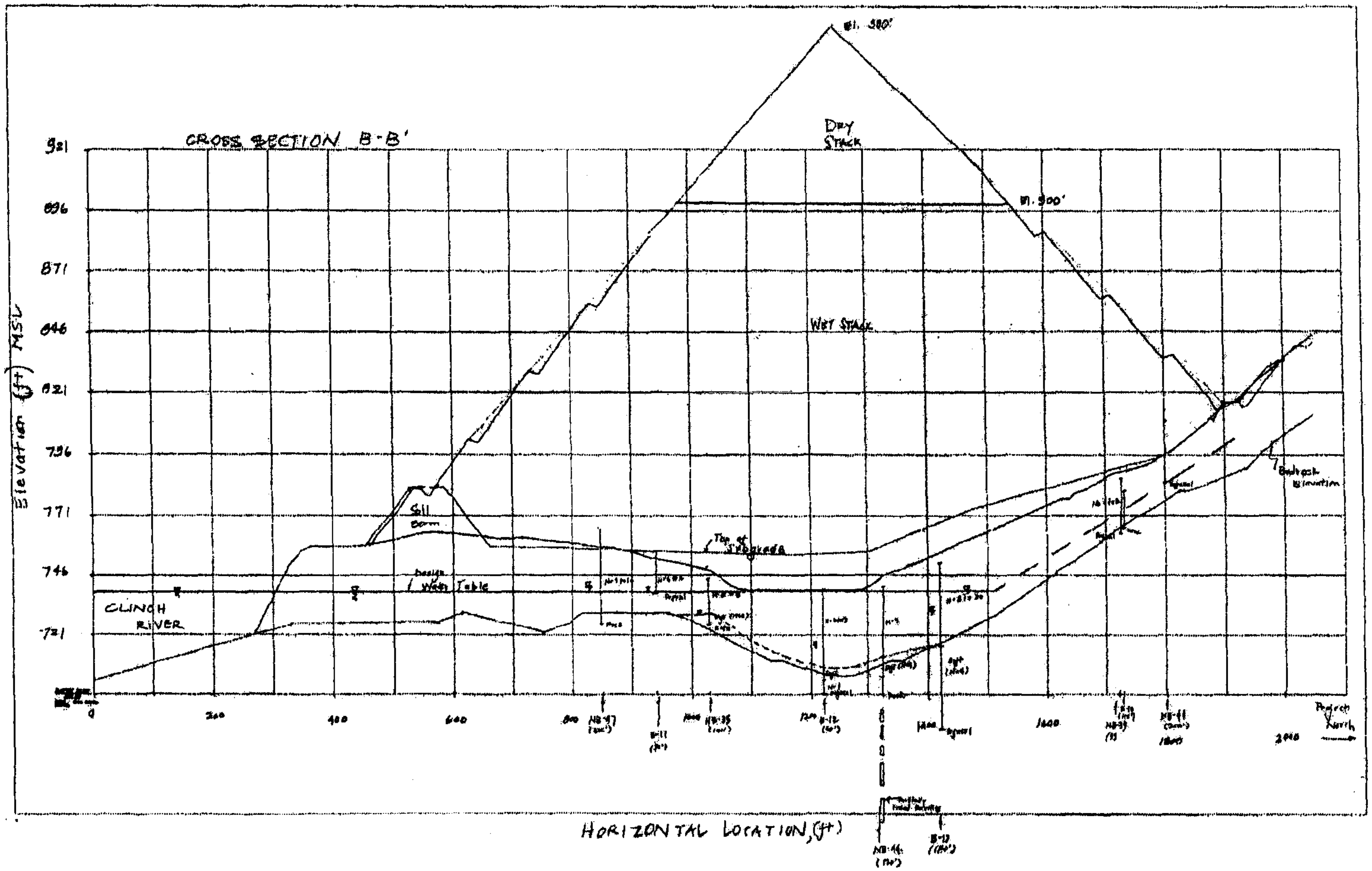
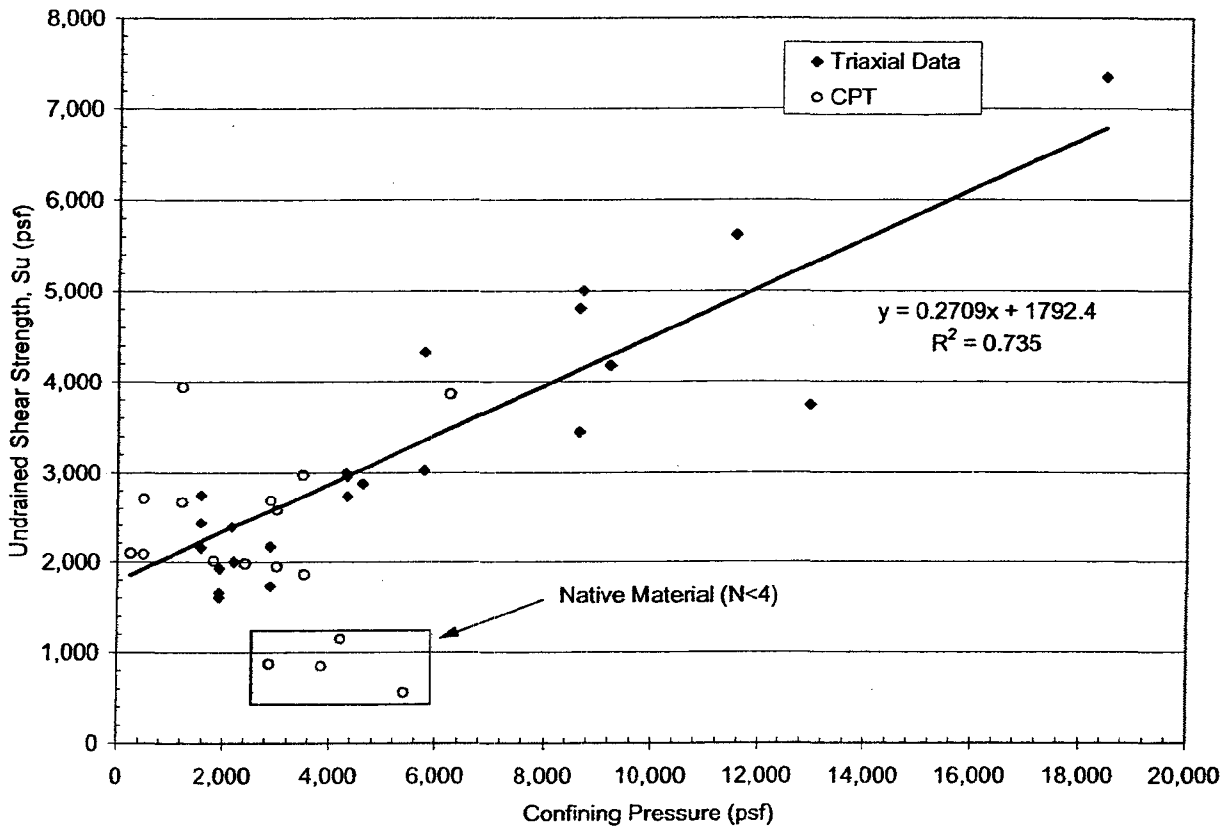


Figure 3: Stratigraphy of Analyzed Cross Section B-B'

Written by: JFR Date: 5/5/2006 Reviewed by: PJS Date: 5/5/2006

Client: TVA Project: Kingston Fossil Plant Project/Proposal No.: GR3731 Task No.:



Notes:

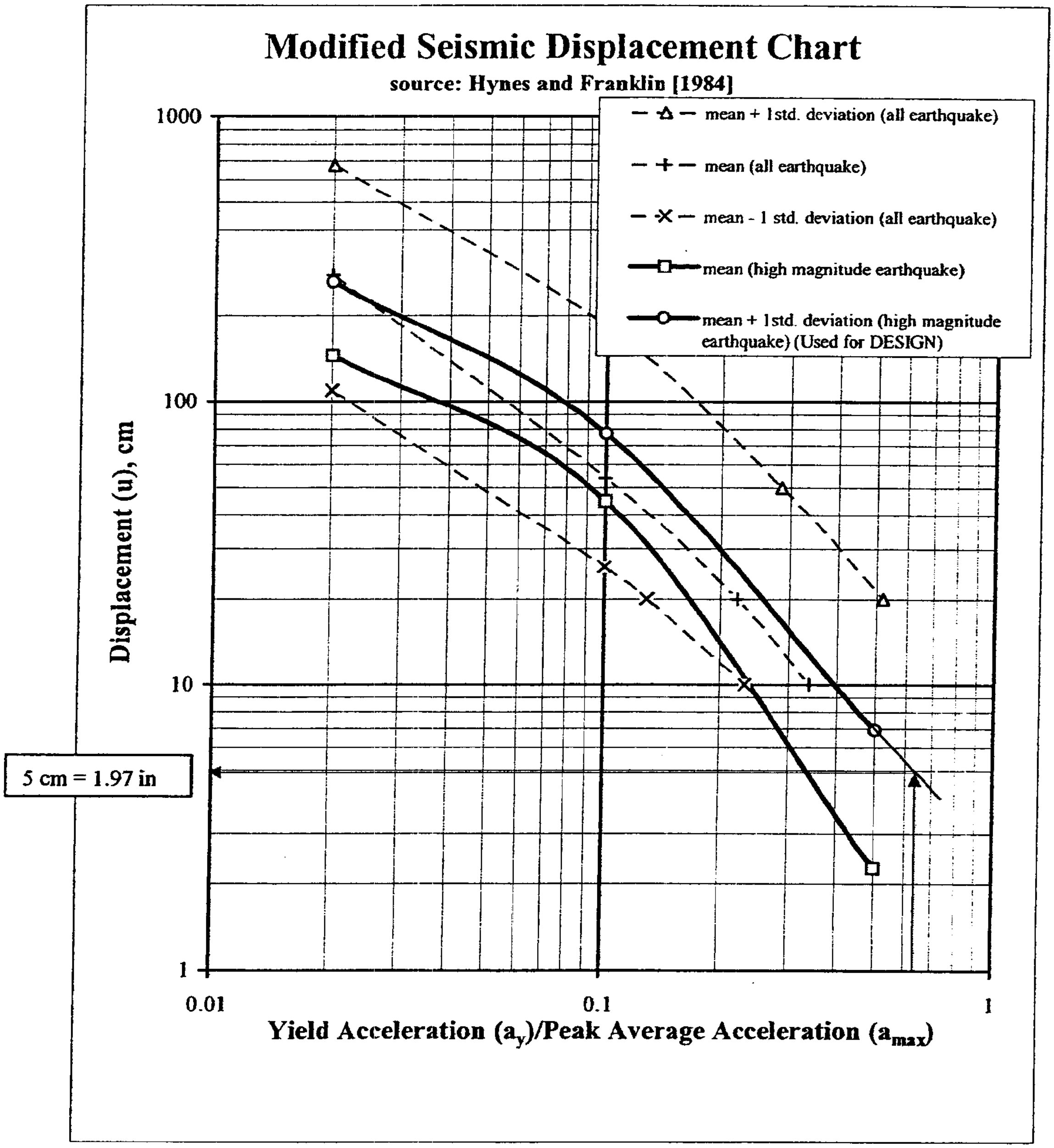
1-Undrained shear strengths were derived from the CPT soundings based on the method developed by Schmertmann [1978]. An N_k factor of 19 was chosen to calibrate the CPT data to the triaxial data.

2-Undrained shear strengths based on CPT soundings in the soft native material (N<4) are indicated. An average undrained shear strength of 800 psf was chosen based on these data.

Figure 4. Determination of Undrained Shear Strength Profile for Foundation Material.

Written by: JFR Date: 5/5/2006 Reviewed by: PJS Date: 5/5/2006

Client: TVA Project: Kingston Fossil Plant Project/Proposal No.: GR3731 Task No.:



Note: The example shown is for the Cross Section B-B' seismic stability analysis as shown in Figure E-2.

Figure 5. Selection of Calculated Displacement.

ATTACHMENT A

IMPROVEMENT IN UNDRAINED SHEAR STRENGTH IN NATIVE SOIL

Written by: JFR Date: 06/05/05 (YY MM DD) Reviewed by: ______ Date: __/__/__ (YY MM DD)

Client: TVA Project: KIF- Peninsula Project/Proposal No.: GR3731 Task No: 06

Improvement in Undrained Shear Strength Due to Wet Stack Loading and Consolidation of Native Material

Purpose: Evaluate the improvement in undrained shear strength of Native material after placement of wet stack gypsum.

Procedure: ① Verify that 145 ft (average height of wet stack material) can be placed instantaneously assuming the undrained shear strength of the native material is:

$$S_u = 1{,}792 + 15.6 * \text{depth}$$

② Calculate build rate and time to reach top of wet stack.

③ Determine % consolidation of native material after placement of full height of wet stack material.

④ Determine new in situ effective stress at middle of native material layer given % consolidation for each of four zones under wet stack gypsum.

⑤ Determine new undrained shear strength given updated confining pressure ($\sigma_{vo}'|_{new}$). and use this calculated undrained strength at the midheight of the layer for slope stability analyses.

Calculations:

① Filename: Cross Section A-A'_1a_block

Static foundation stability analysis for cross section A-A' demonstrates that 145 ft of wet gypsum load can be placed instantaneously. (See Table 2) Resulting FS = 2.18.

Written by: JFR Date: 06 / 05 / 05 (YY MM DD) Reviewed by: ________ Date: __/__/__ (YY MM DD)

Client: TVA Project: KIF-Peninsula Project/Proposal No.: GR3731 Task No: 06

(2) Assuming a production rate of 492,800 ton/yr and a dry unit weight of gypsum of 67 pcf, 544,831 cy of gypsum will be produced each year, or 337.6 ac·ft. Assuming an average footprint for Phase I of 34 ac, this is approximately 10 ft of gypsum per year. To place 145 ft of wet stack material will take 14.5 yr.

(3) Average Cv:

Given three consolidation tests on Native material (N>4), at a load of 14,500 psf (i.e., 145 ft * 100 pcf) an average C_v = 0.0003 in²/sec is reported. (See Figure A-1).

% Consolidation:

Use Figure 13 of NAVFAC 7.1 p. 7.1-232 to find % consolidation. (See Figure A-2)

- Construction Time = 14.5 yr = t_o
- Thickness of Compressible Layer = 45 ft

$$T_o = \frac{C_v t_o}{H_{DR}^2} = \frac{0.0003\ \text{in}^2/\text{sec}\ (14.5\text{yr})(365\text{d}/\text{yr})(86400\ \text{sec}/\text{d})}{(45\ \text{ft}\cdot 12\text{in}/\text{ft})^2}$$

$$T_o = 0.47$$

Also, for $t = 14.5\text{yr}(365\text{d}/\text{yr}) = 5293$ day

$T_o = 0.47$ (same as above – final day of construction)

$U_v = 50\%$ ⇒ percent consolidation

(4) Divide native material beneath wet stack load into four zones. Calculate new effective confining pressure based on 50% consolidation and weight of wet stack material. See Figure A-3

Note that zone 4 does not "see" improvement, ∴ undrained shear strength remains the same.

$$\sigma_{vo}'\big|_{original} = \frac{45}{2}\text{ft}(120 - 62.4\ \text{pcf}) = 1296\ \text{psf}$$

Written by: JFR Date: 06/05/05 (YY/MM/DD) Reviewed by: ______ Date: __/__/__ (YY/MM/DD)

Client: TVA Project: KIF-Peninsula Project/Proposal No.: GR3731 Task No: 06

Zone ①: $\Delta\sigma = h_{gypsum}(\gamma_{gypsum}) = 145\ ft\ (100\ pcf) = 14{,}500\ psf$

$\sigma_{vo}'|_{new} = 50\%\ (\Delta\sigma) + \sigma_{vo}'|_{original}$

$= 50\%\ (14{,}500) + 1296\ psf$

$= 8546\ psf$

Zone ②: $\Delta\sigma = 95\ ft\ (100\ pcf) = 9500\ psf$

$\sigma_{vo}'|_{new} = 50\%\ (9500\ psf) + 1296\ psf$

$= 6046\ psf$

Zone ③: $\Delta\sigma = 45\ ft\ (100\ pcf) = 4500\ psf$

$\sigma_{vo}'|_{new} = 50\%\ (4500) + 1296\ psf$

$= 3546\ psf$

⑤ Determine new undrained shear strength:

(See Figure A-4 and A-3)

Zone ①: $S_u = 4050\ psf$

Zone ②: $S_u = 3400\ psf$

Zone ③: $S_u = 2700\ psf$

Note: ① Due to similar geometry / loading geometry use same values for Cross Section B-B'

② Mirror image values for critical slip surface search to the right (away from Clinch River)

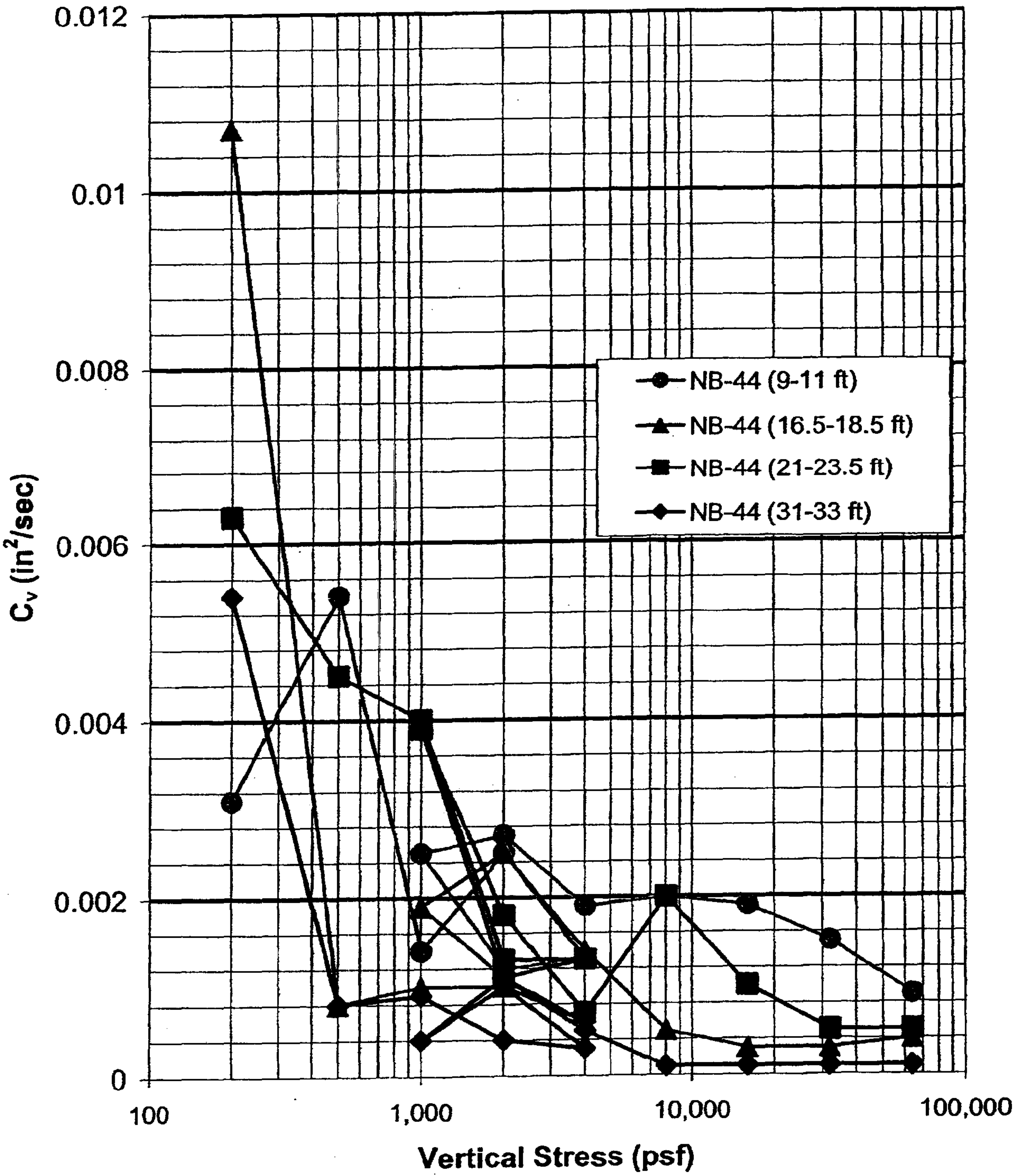

0.012
0.01
0.008
0.006
0.004
0.002
0
Cv (in²/sec)
100
1,000
10,000
100,000
Vertical Stress (psf)
NB-44 (9-11 ft)
NB-44 (16.5-18.5 ft)
NB-44 (21-23.5 ft)
NB-44 (31-33 ft)

Figure A-1

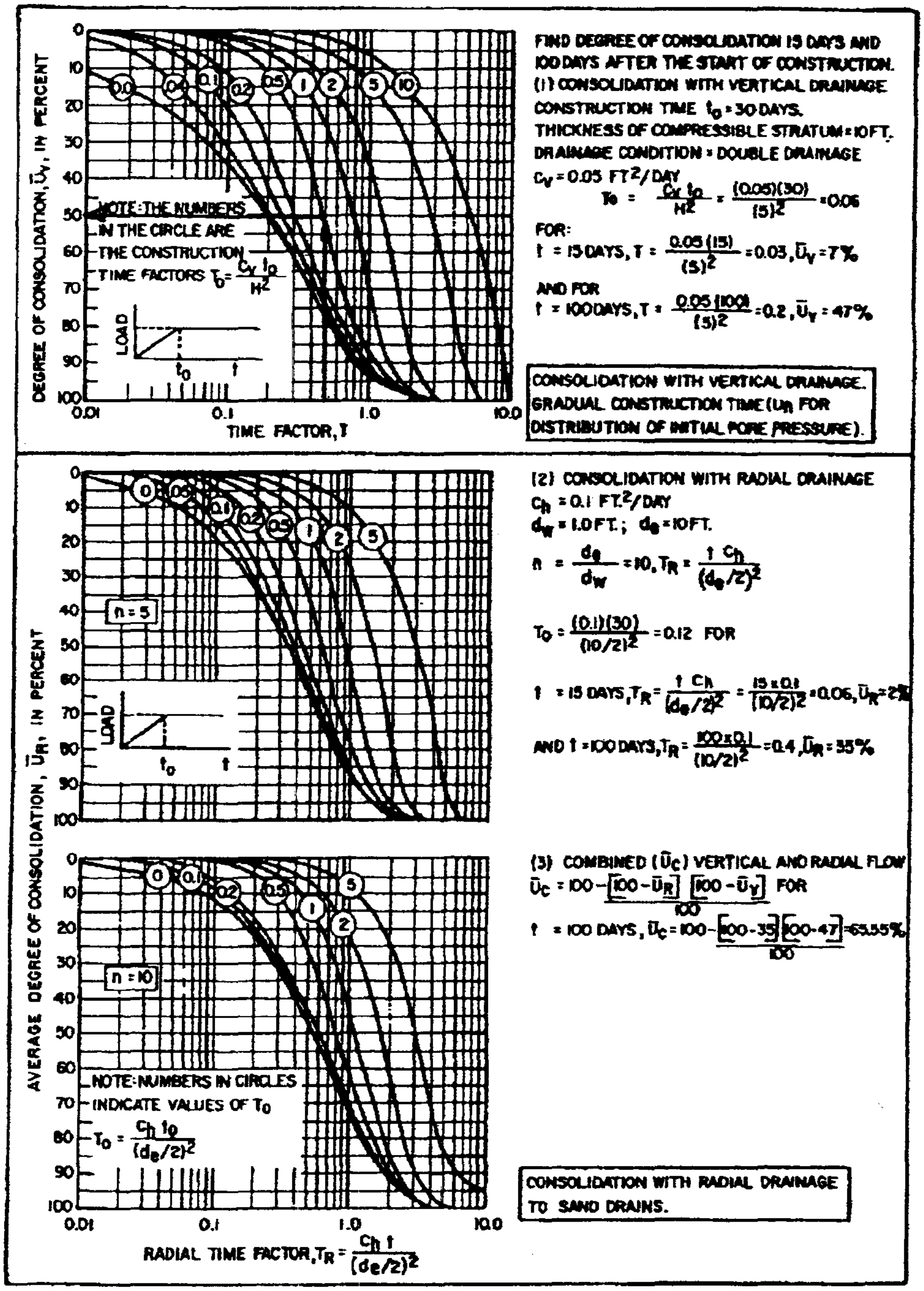


FIGURE 13
Time Rate of Consolidation for Gradual Load Application

Figure A-2

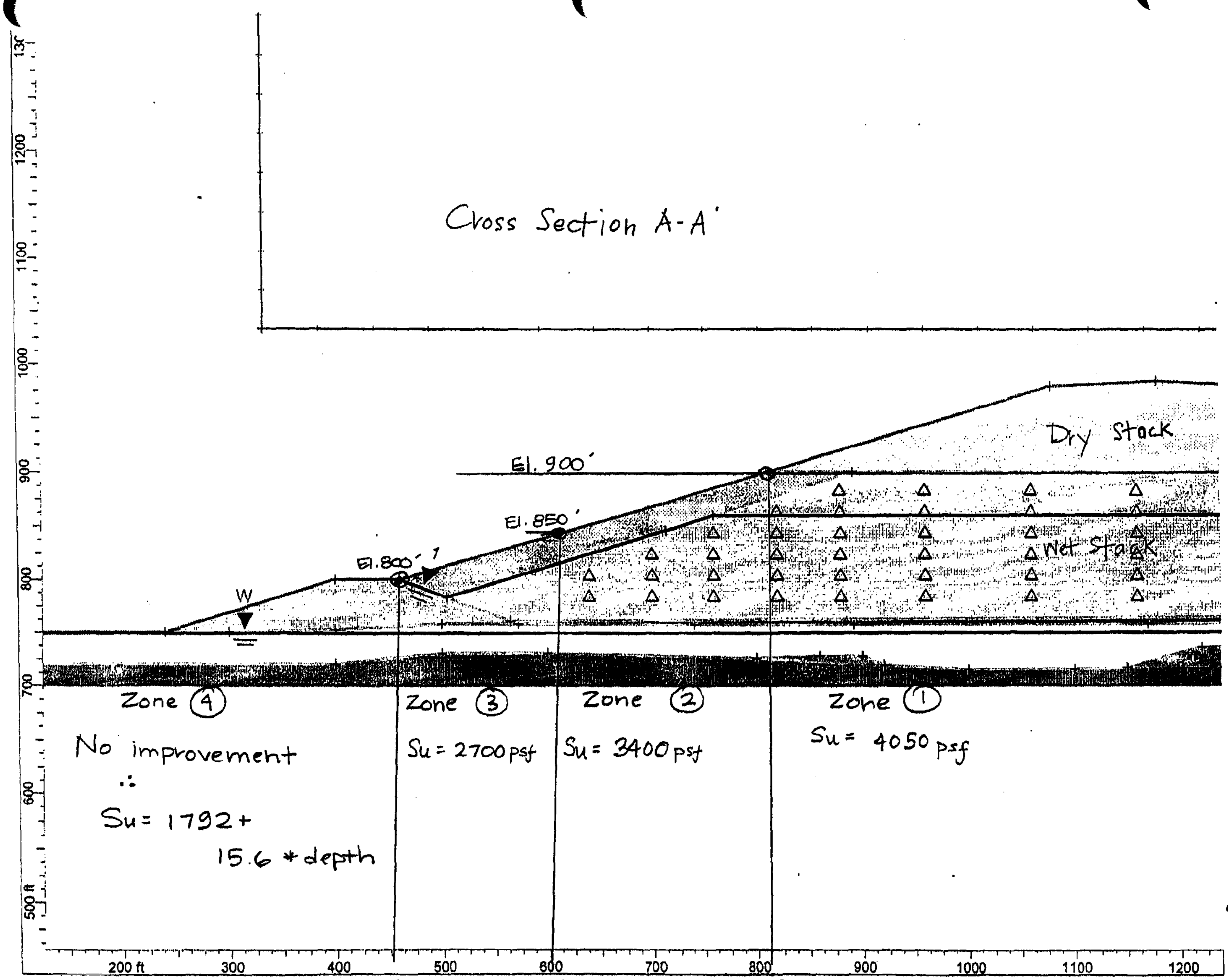

Cross Section A-A'
Dry Stock
Wet Stack
El. 900'
El. 850'
El. 800'
W
Zone (4)
No improvement
∴
Su = 1792 + 15.6 * depth
Zone (3)
Su = 2700 psf
Zone (2)
Su = 3400 psf
Zone (1)
Su = 4050 psf
456
600
813
200 ft
300
400
500
600
700
800
900
1000
1100
1200
500 ft
600
700
800
900
1000
1100
1200

Figure A-3

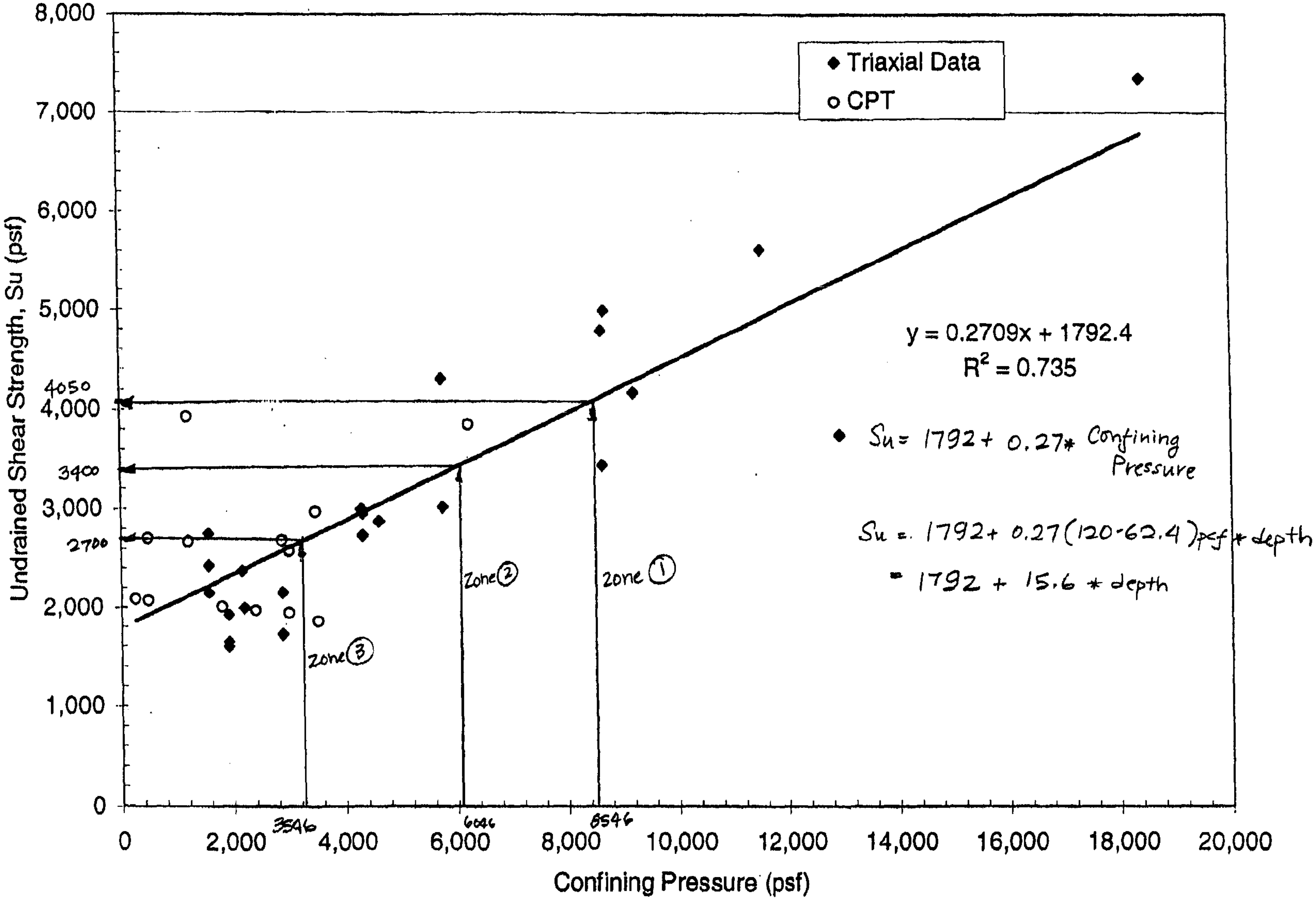


Figure A-4. Undrained Shear Strength (Su) as a function of Confining Pressure.

ATTACHMENT B

SLIDE OUTPUT

CROSS SECTION A-A' – STATIC

Written by: JFR Date: 5/5/2006 Reviewed by: PJS Date: 5/5/2006

Client: TVA Project: Kingston Fossil Plant Project/Proposal No.: GR3731 Task No.:

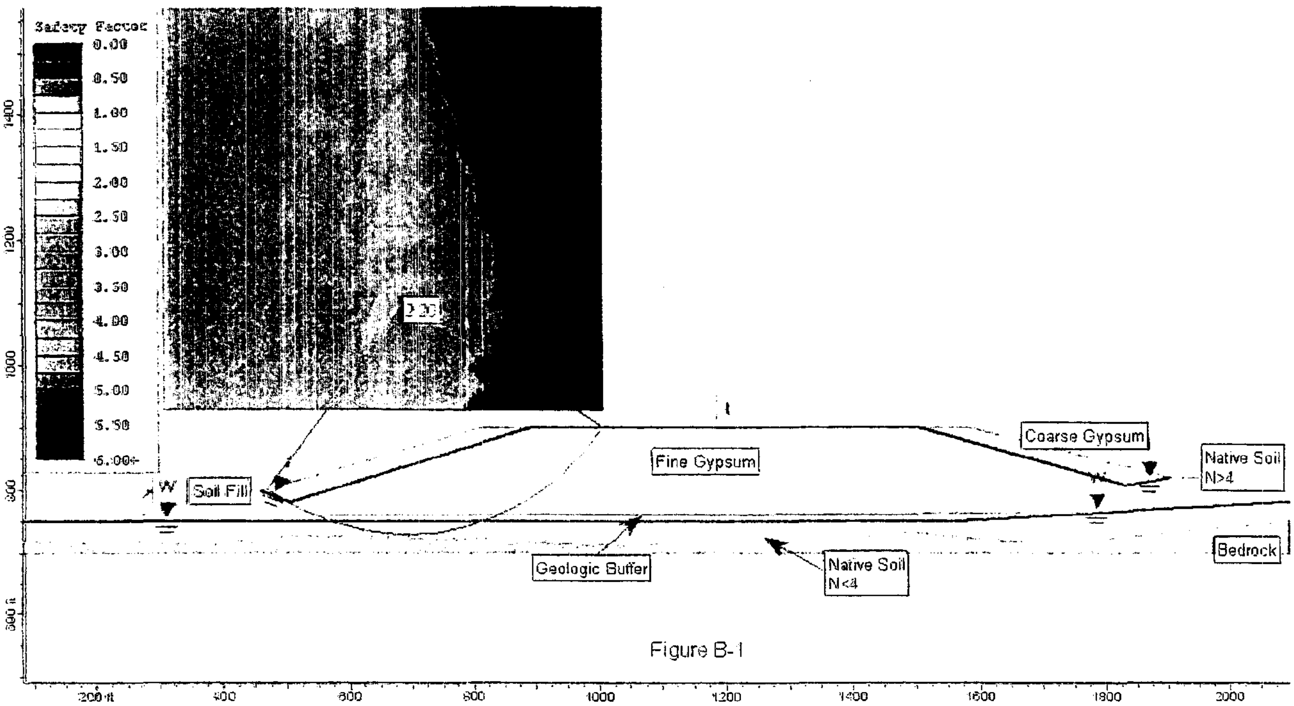


Figure B-1

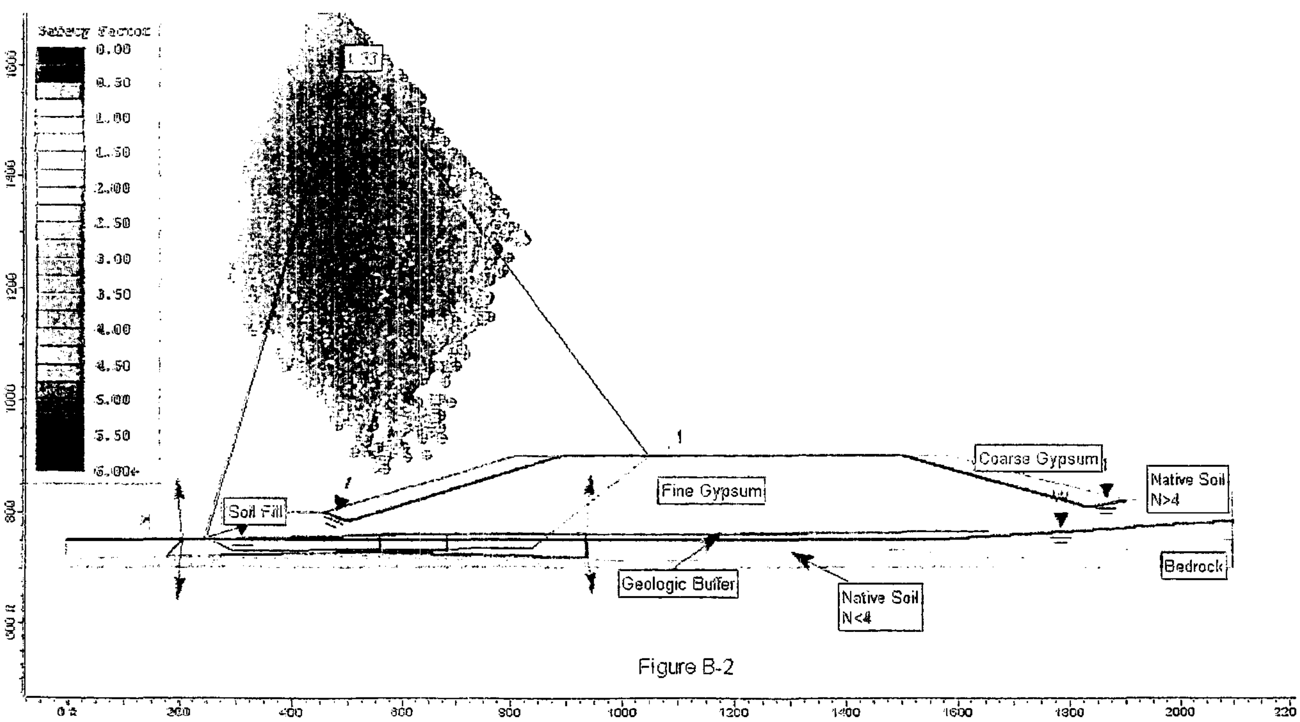


Figure B-2

TVA-00021327

Written by: JFR Date: 5/5/2006 Reviewed by: PJS Date: 5/5/2006

Client: TVA Project: Kingston Fossil Plant Project/Proposal No.: GR3731 Task No.:

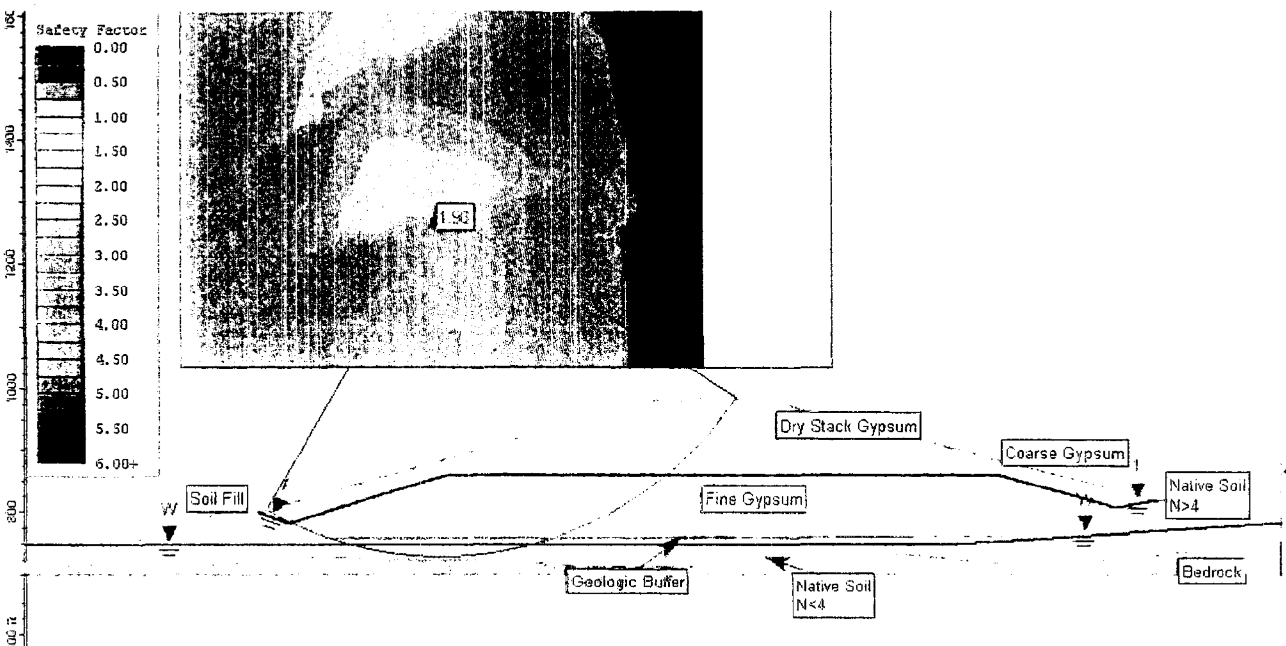


Figure B-3

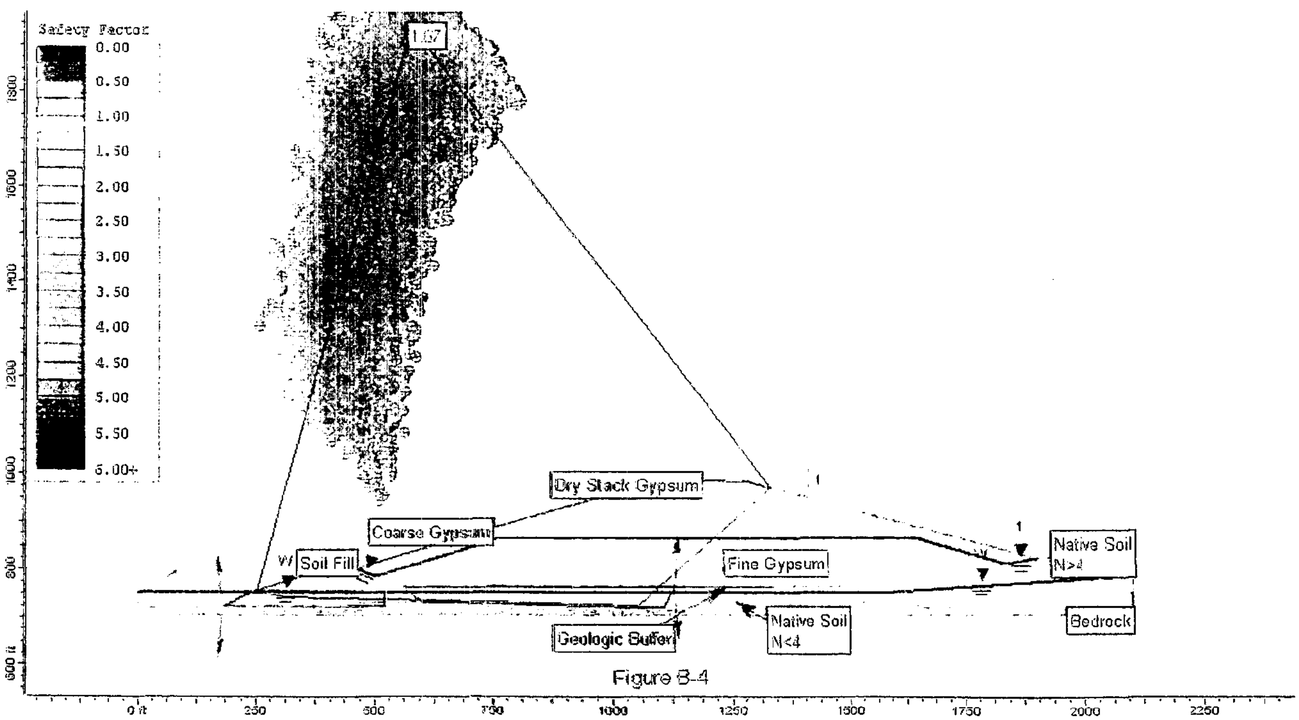


Figure B-4

Written by: JFR Date: 5/5/2006 Reviewed by: PJS Date: 5/5/2006

Client: TVA Project: Kingston Fossil Plant Project/Proposal No.: GR3731 Task No.:

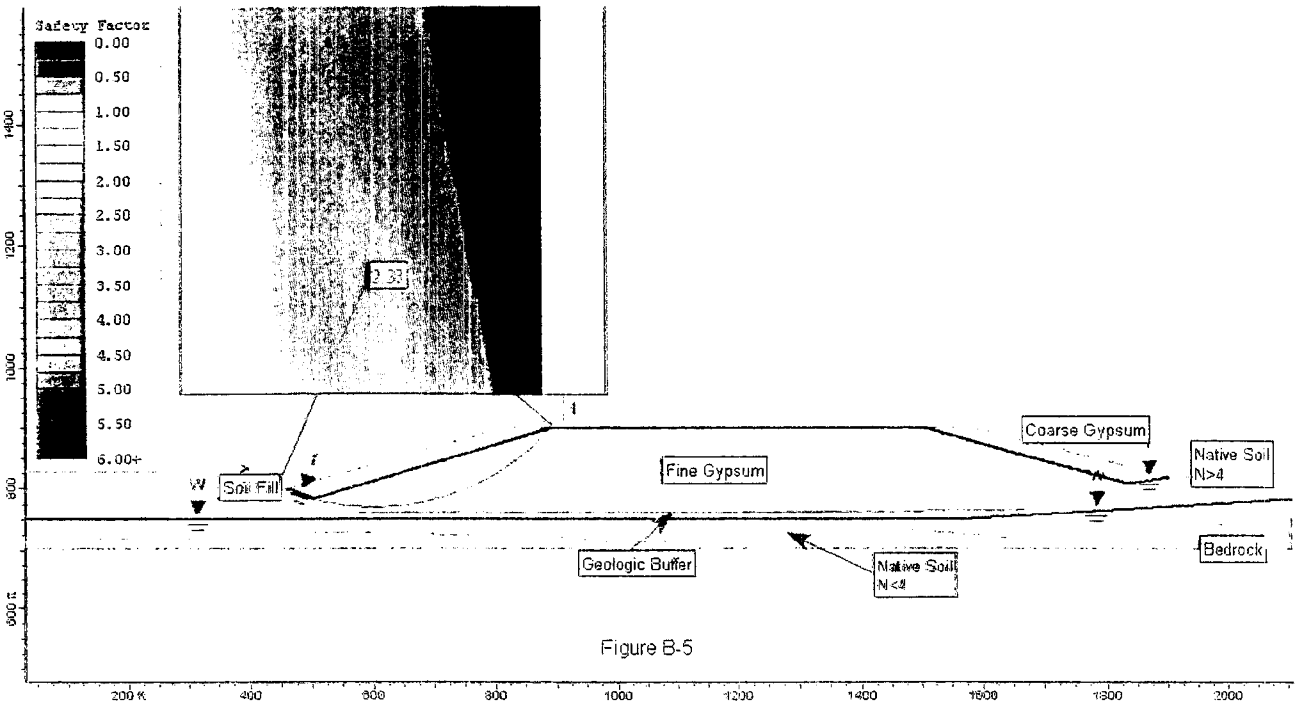


Figure B-5

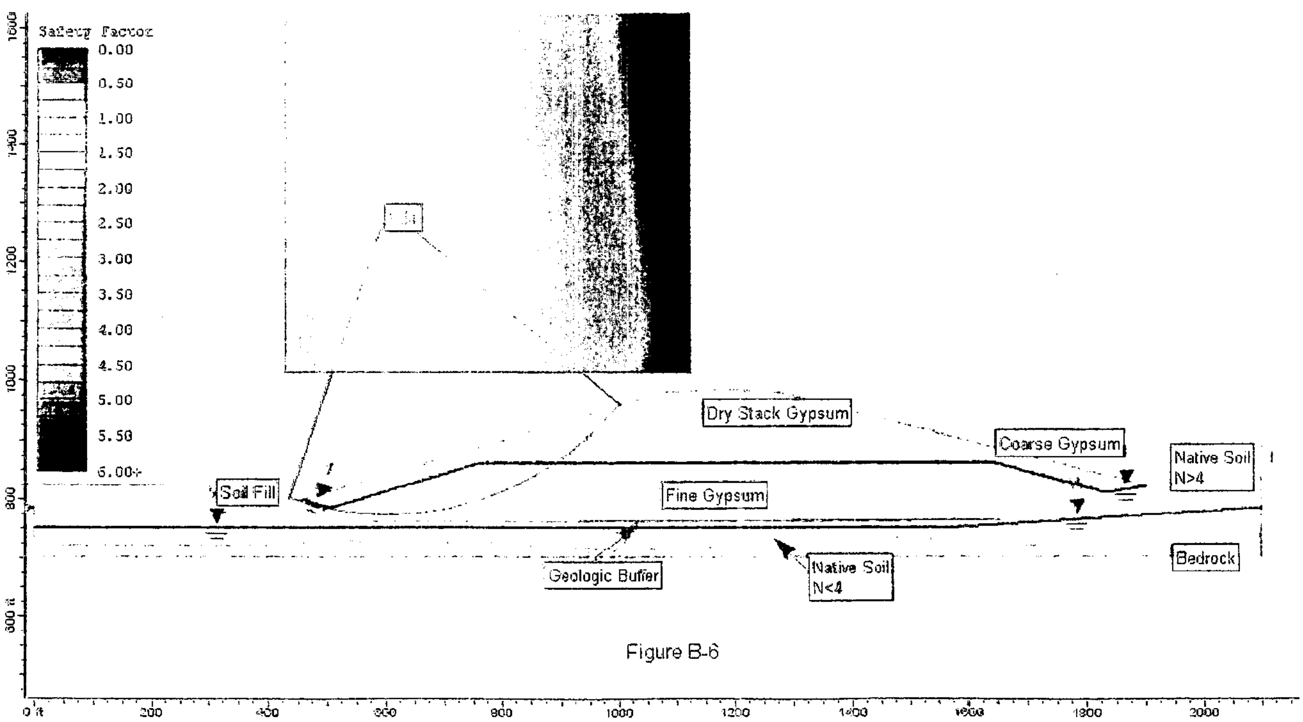


Figure B-6

Written by: JFR Date: 5/5/2006 Reviewed by: PJS Date: 5/5/2006

Client: TVA Project: Kingston Fossil Plant Project/Proposal No.: GR3731 Task No.:

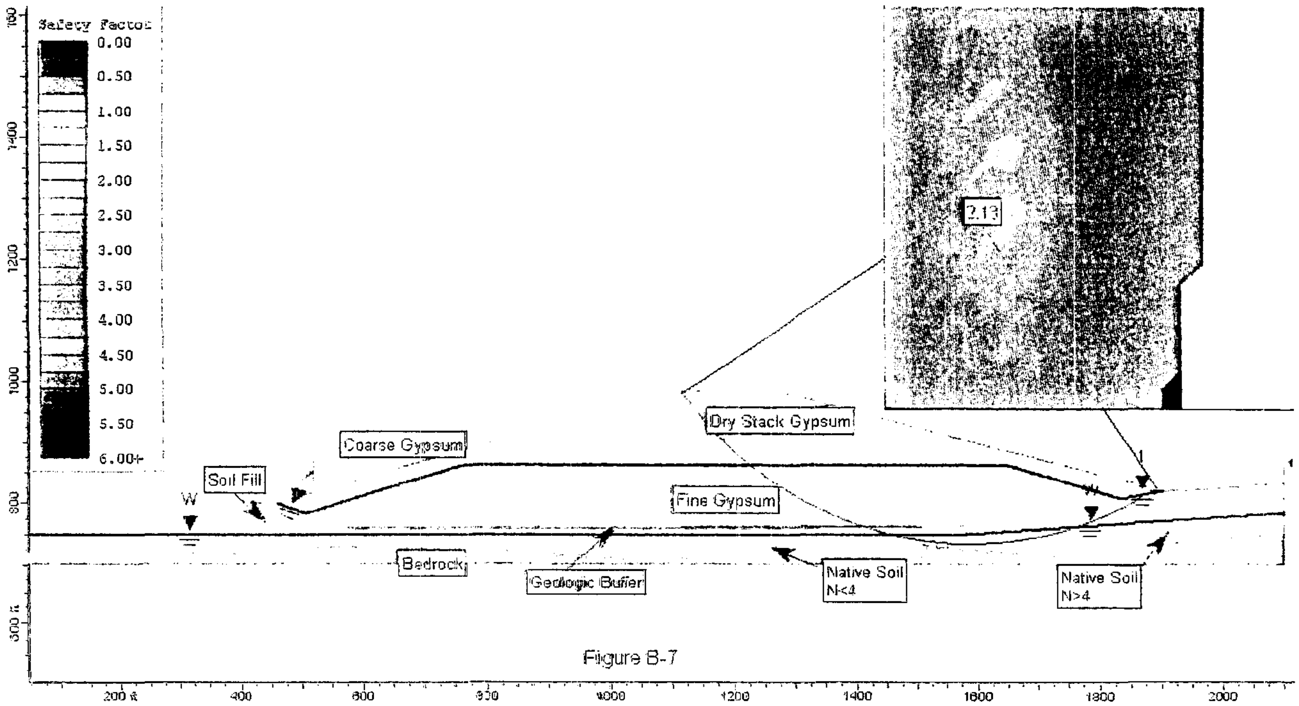


Figure B-7

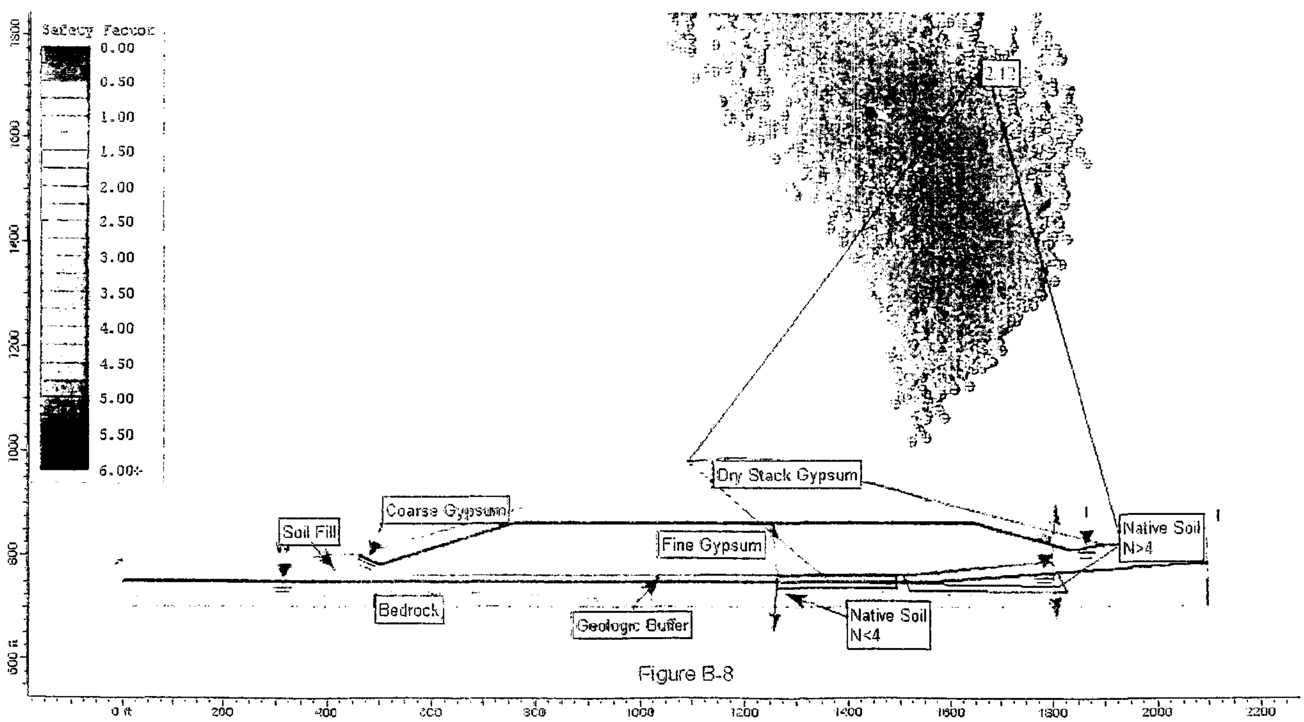


Figure B-8

Written by: JFR Date: 5/5/2006 Reviewed by: PJS Date: 5/5/2006

Client: TVA Project: Kingston Fossil Plant Project/Proposal No.: GR3731 Task No.:

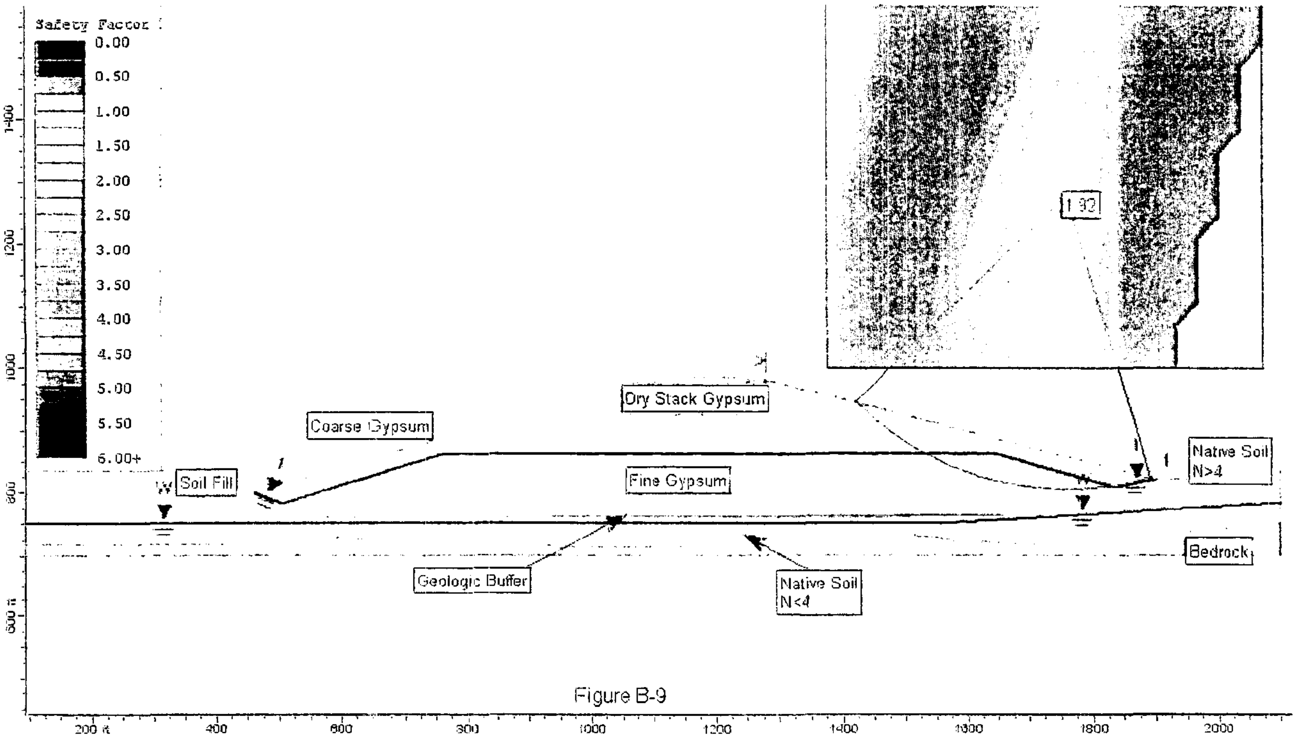


Figure B-9

ATTACHMENT C
SLIDE OUTPUT
CROSS SECTION B-B' – STATIC

Written by: JFR Date: 5/5/2006 Reviewed by: PJS Date: 5/5/2006

Client: TVA Project: Kingston Fossil Plant Project/Proposal No.: GR3731 Task No.:

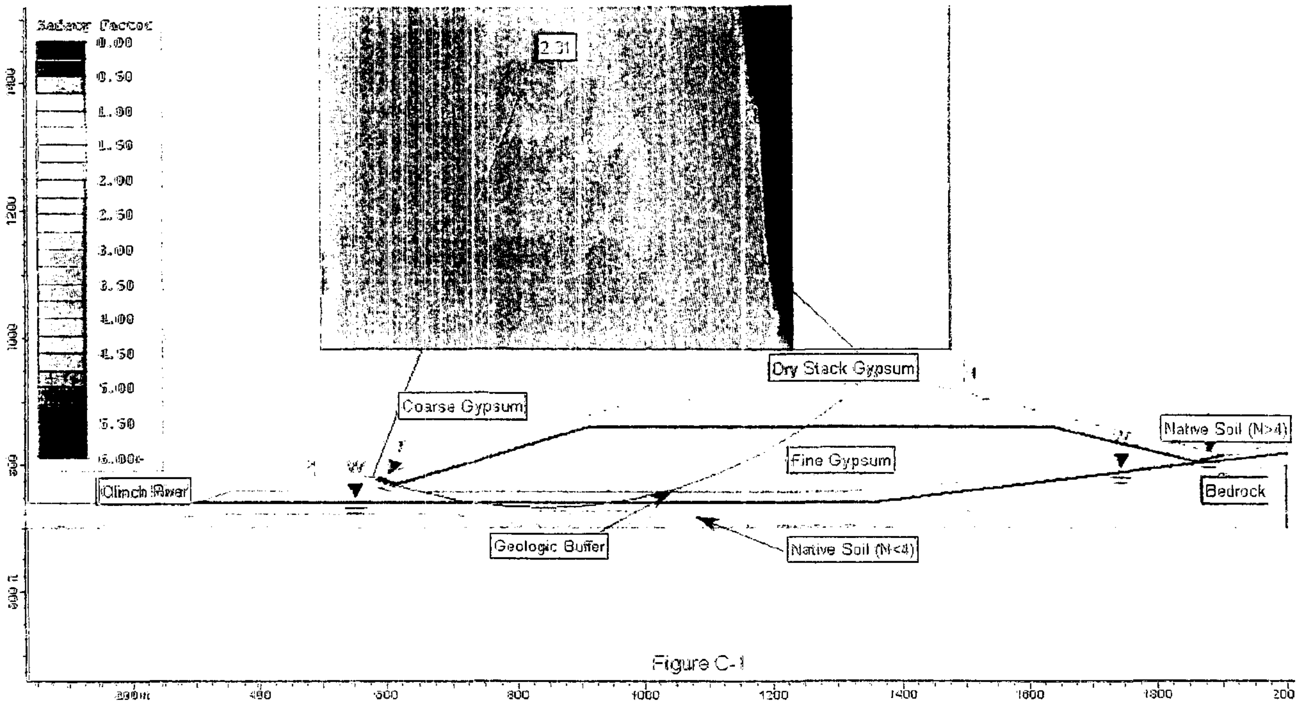


Figure C-1

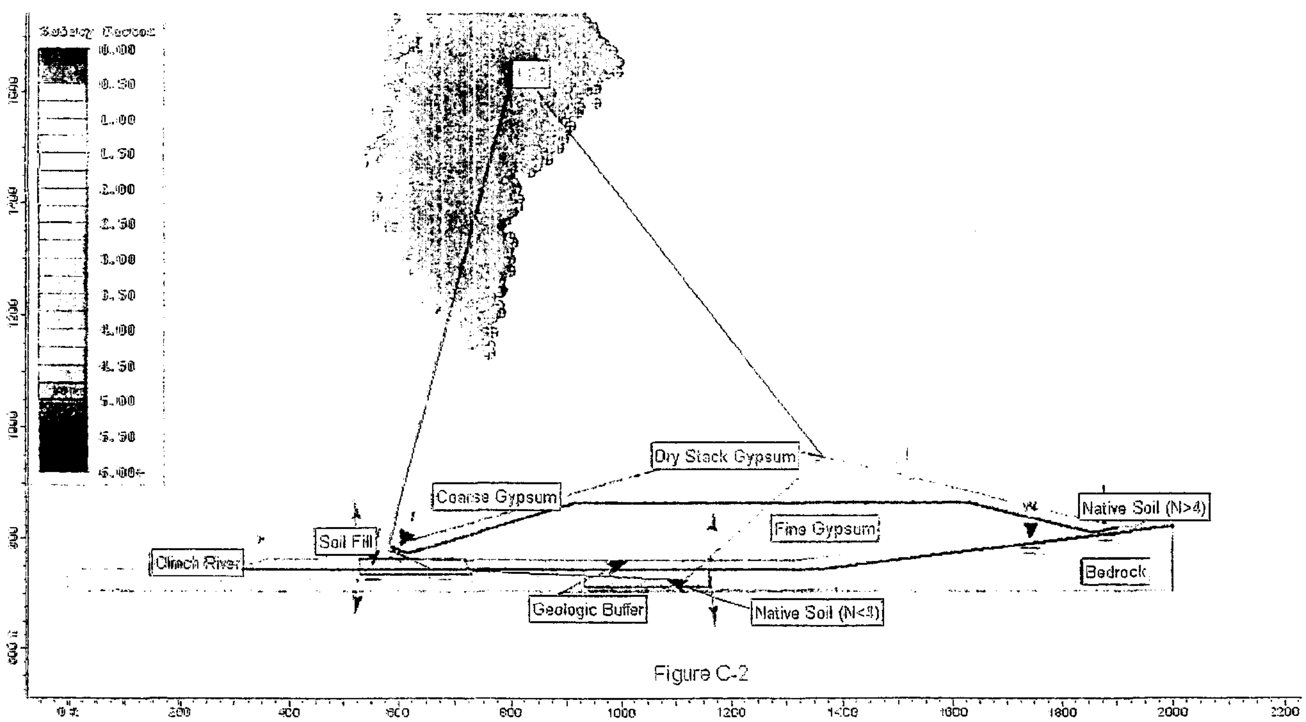


Figure C-2

Written by: JFR Date: 5/5/2006 Reviewed by: PJS Date: 5/5/2006

Client: TVA Project: Kingston Fossil Plant Project/Proposal No.: GR3731 Task No.:

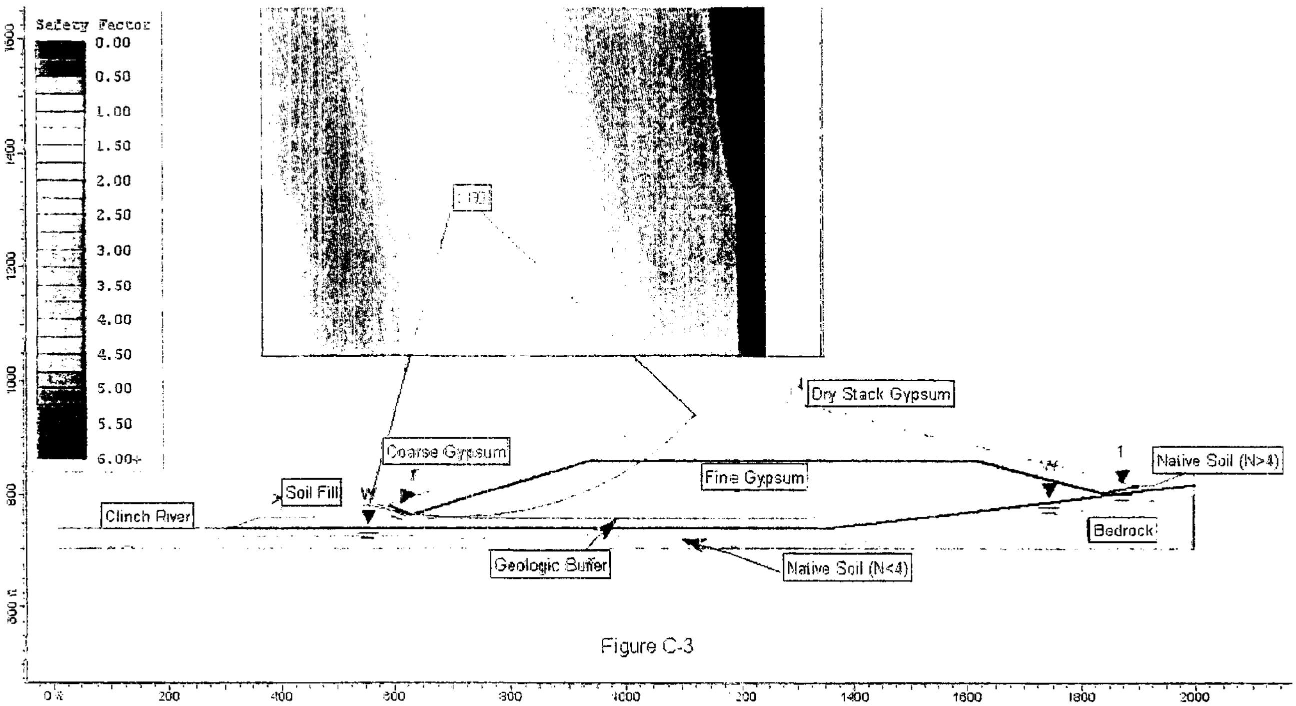


Figure C-3

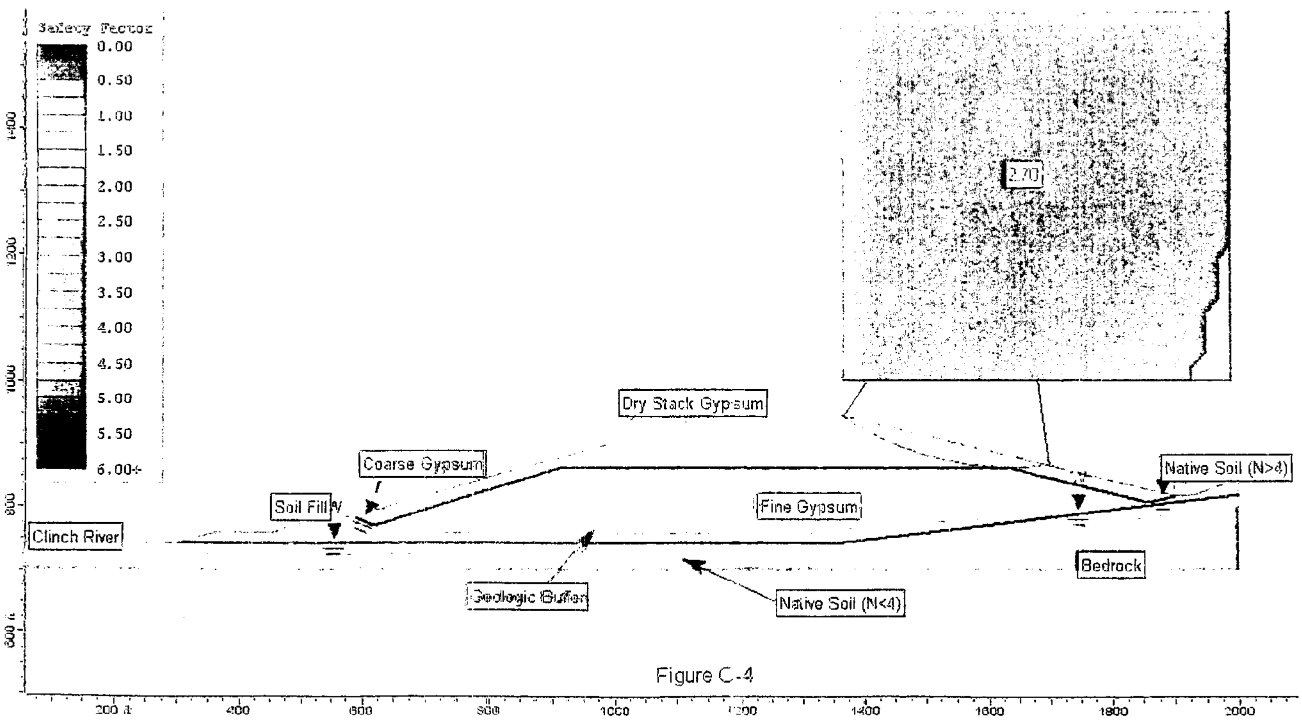


Figure C-4

Written by: JFR Date: 5/5/2006 Reviewed by: PJS Date: 5/5/2006

Client: TVA Project: Kingston Fossil Plant Project/Proposal No.: GR3731 Task No.:

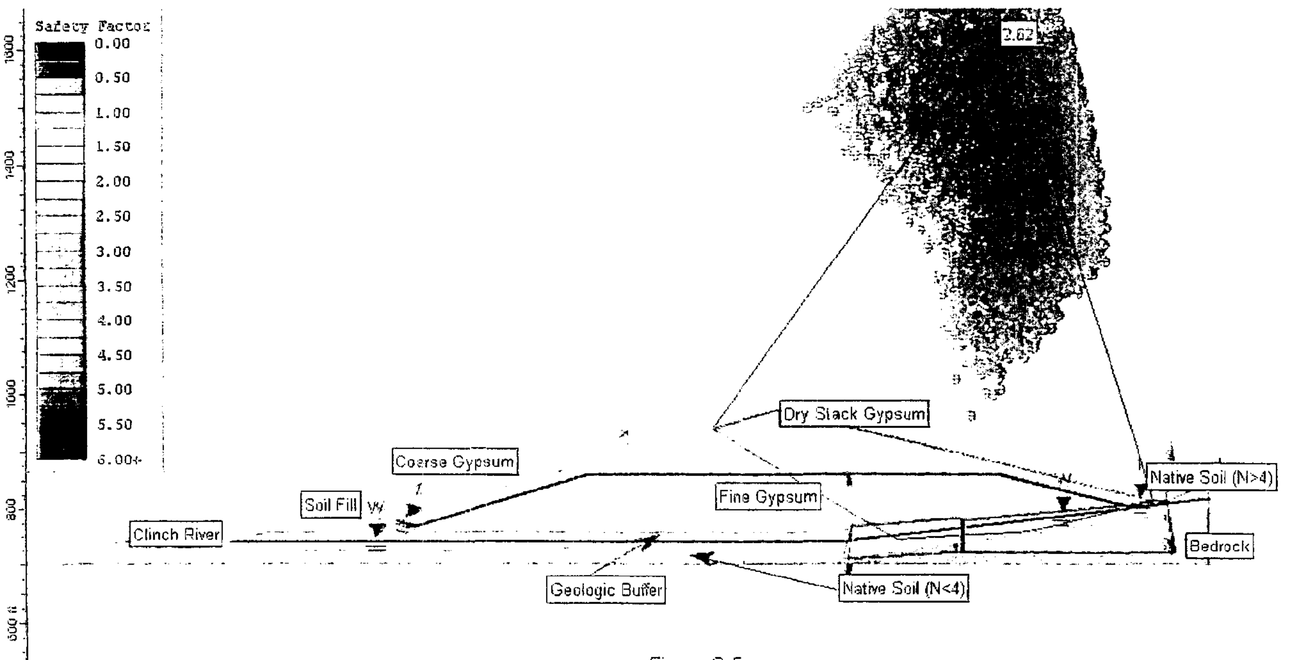


Figure C-5

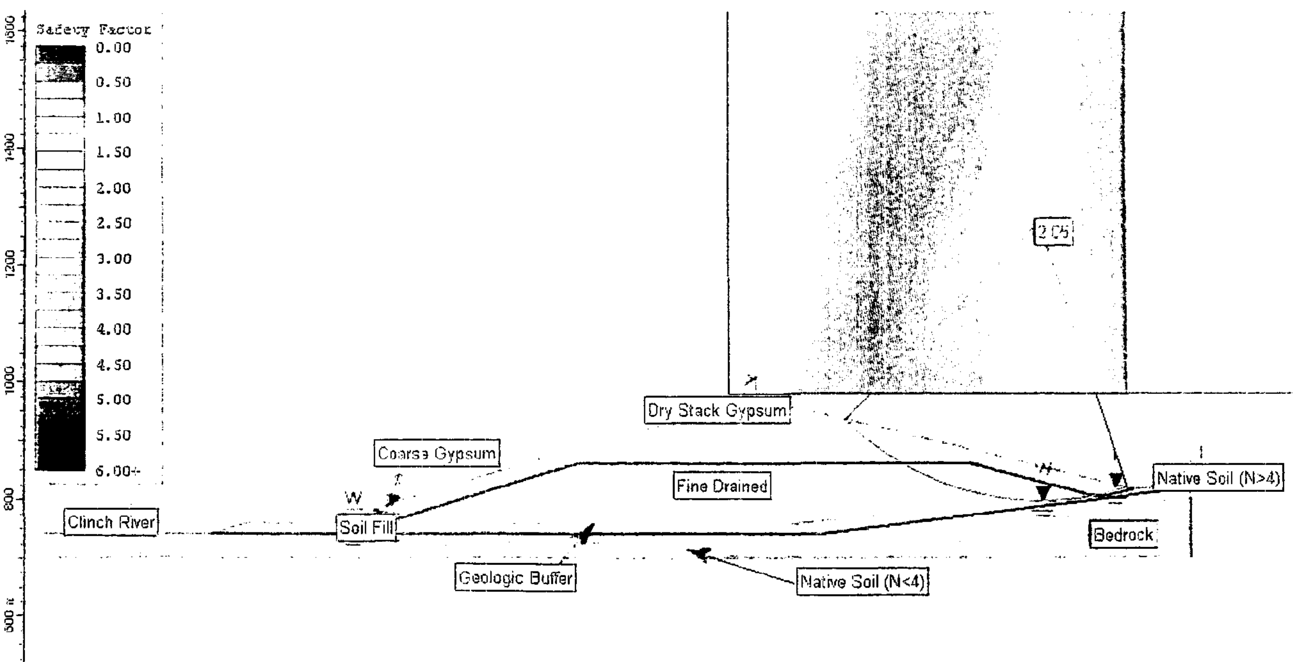


Figure C-6

ATTACHMENT D
SLIDE OUTPUT
CROSS SECTION A-A' – SEISMIC

Written by: JFR Date: 5/5/2006 Reviewed by: PJS Date: 5/5/2006

Client: TVA Project: Kingston Fossil Plant Project/Proposal No.: GR3731 Task No.:

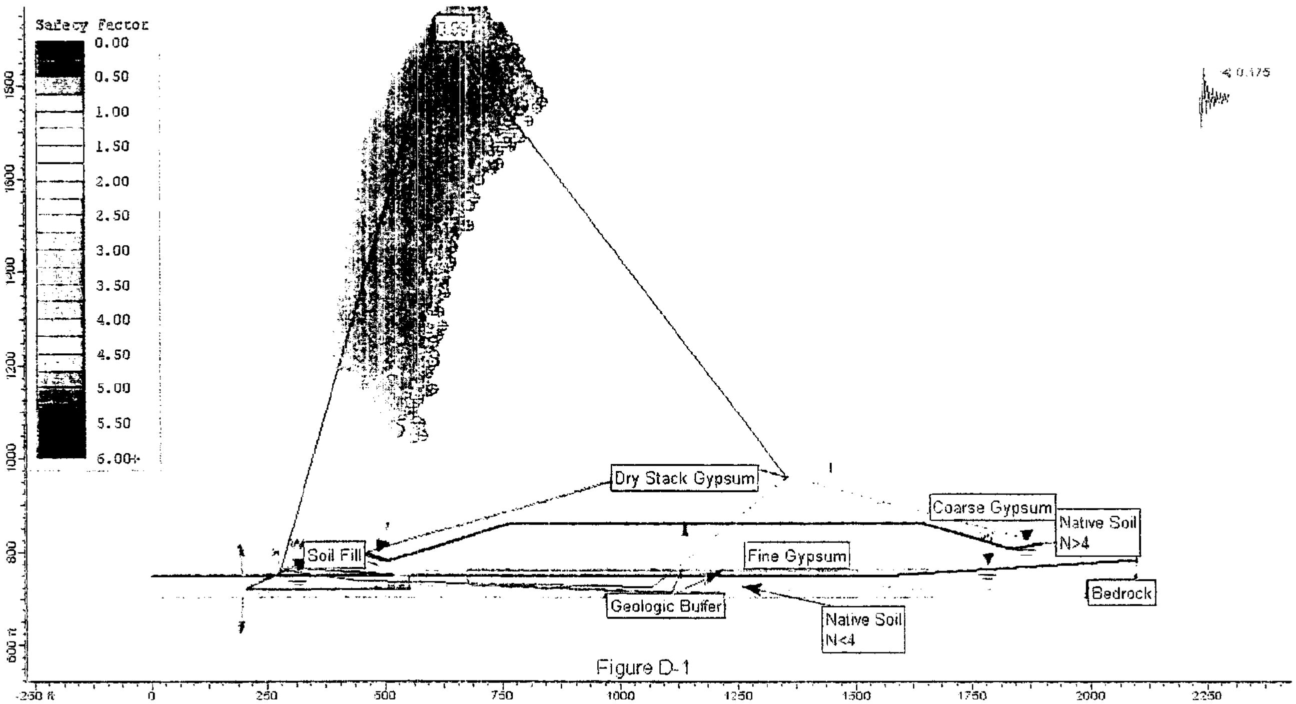


Figure D-1

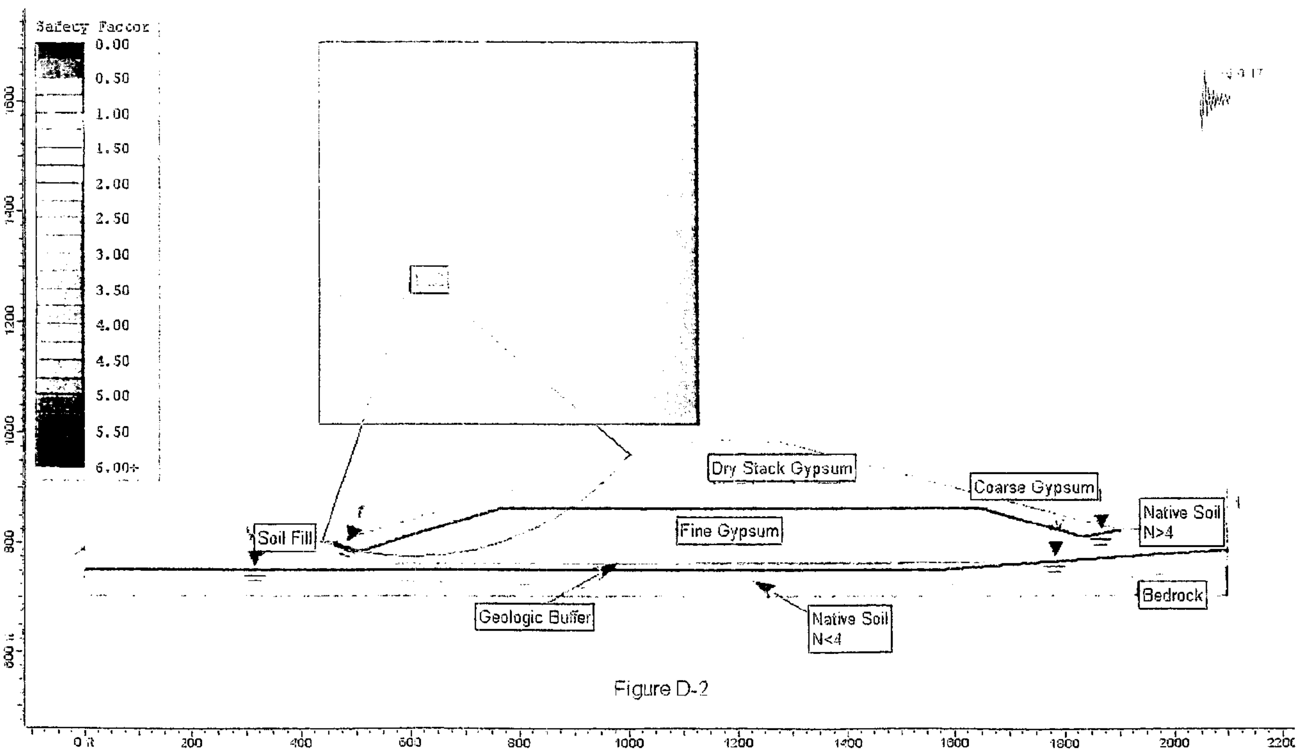


Figure D-2

ATTACHMENT E
SLIDE OUTPUT
CROSS SECTION B-B' – SEISMIC

Written by: JFR Date: 5/5/2006 Reviewed by: PJS Date: 5/5/2006

Client: TVA Project: Kingston Fossil Plant Project/Proposal No.: GR3731 Task No.:

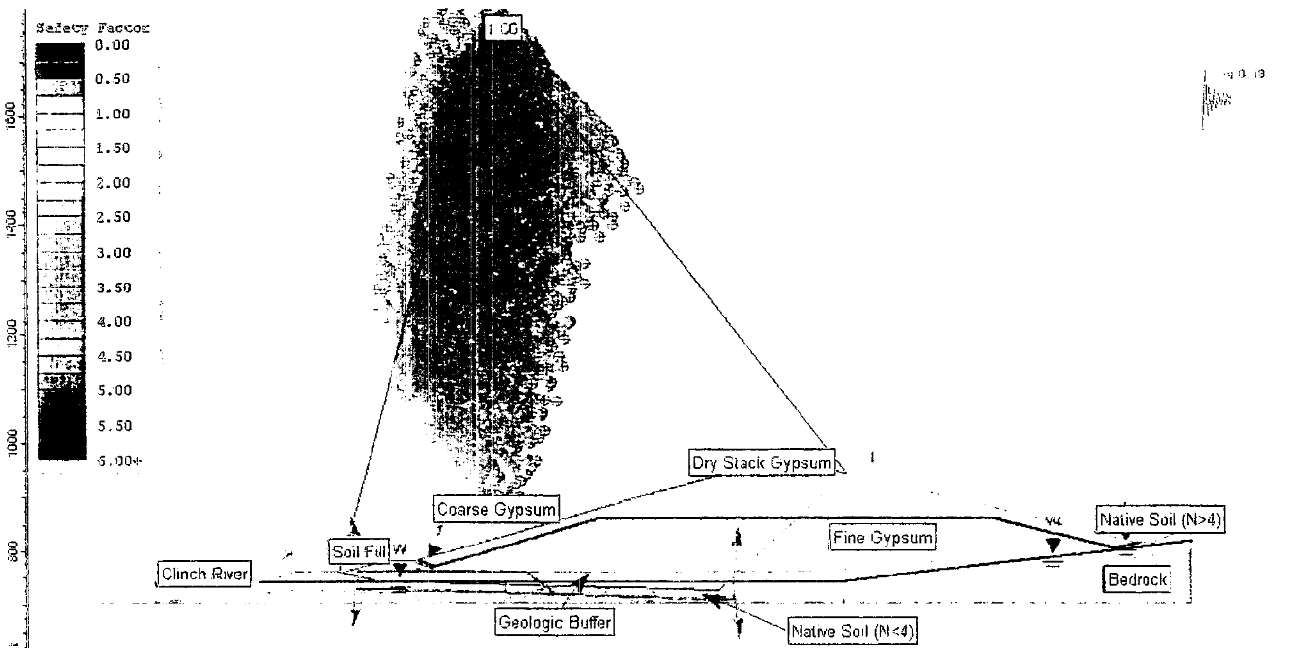


Figure E-1

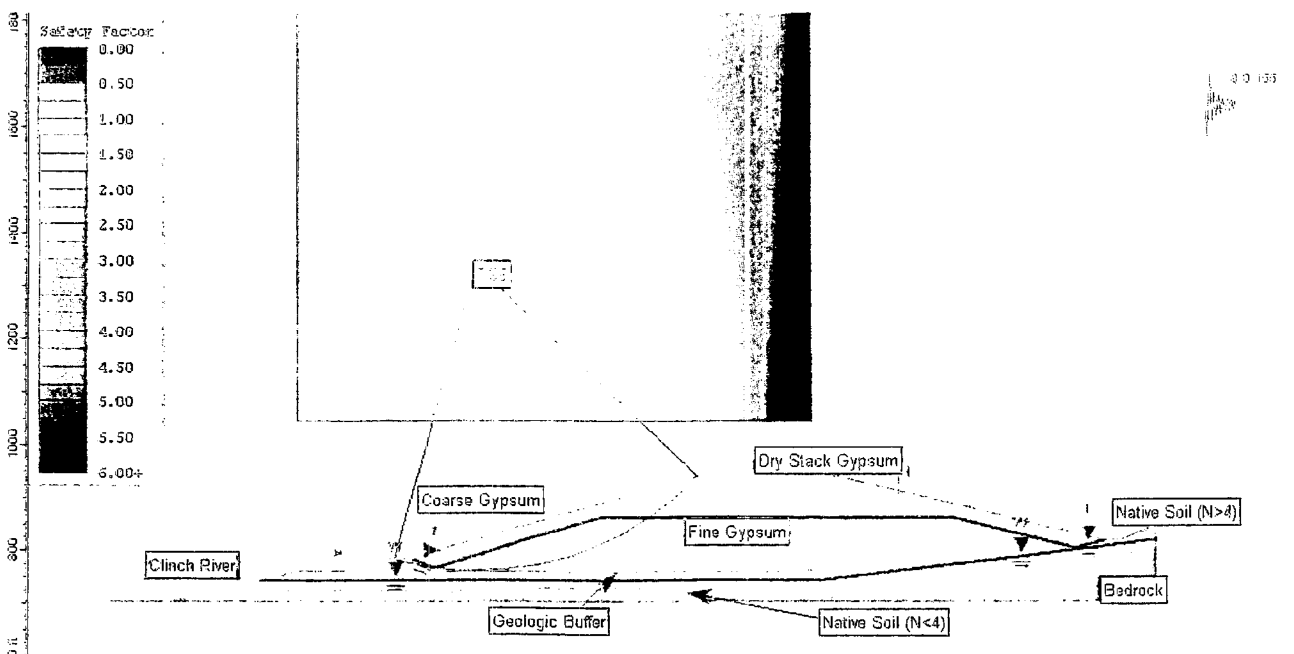


Figure E-2

SEEPAGE ANALYSIS

GEOSYNTEC CONSULTANTS

COMPUTATION COVER SHEET

Client: TVA **Project:** KIF Gypsum Disposal Facility **Project/Proposal #:** GR3731 **Task #:** 06

TITLE OF COMPUTATIONS SEEPAGE ANALYSIS

COMPUTATIONS BY:	Signature	T. Elkady	May 12, 2006 DATE
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Written by: Tamer Elkady Date: 5/10/2006 Reviewed by: R.N. Davies Date: 5/10/2006

Client: TVA Project: Gypsum Disposal Facility – KIF Project/Proposal No.: GR3731 Task No.: 06

SEEPAGE ANALYSIS

PURPOSE

The purpose of this calculation package is to present the results of seepage analyses performed for the proposed Gypsum Disposal Facility at the Kingston Fossil Plant (KIF) located in Roane County, Tennessee. This gypsum disposal facility will be owned, constructed, and operated by Tennessee Valley Authority (TVA). The analyses were performed to: (i) evaluate the effectiveness of the internal drainage system for the gypsum stack; (ii) estimate flow quantities through the internal drainage system; and (iii) estimate water levels within the disposal facility at different time periods throughout the life and post-closure period of the facility.

DESCRIPTION OF THE PROPOSED INTERNAL DRAINAGE SYSTEM FOR THE GYPSUM DISPOSAL FACILITY

The purpose of the internal drainage system for the proposed gypsum disposal facility is to facilitate drainage of water and reduce pore-water pressures within the gypsum stack. The internal drainage system consists of a central drainage corridor and perimeter drainage trenches. The central drainage corridor is located in Phase I and II and consists of a series of high density polyethylene (HDPE) perforated pipes encased in highly-permeable, geotextile-wrapped gravel surround. Water collected by the central drainage corridor is conveyed to an underdrain lift station, located outside the waste footprint and pumped into the proposed stormwater pond. A layout of the proposed central corridor for Phase I and II and location of the underdrain lift station is shown on Drawings 10W427-5 and 10W427-9. During gypsum disposal operations and as gypsum perimeter dikes are constructed, perimeter drainage trenches will be constructed at consistent vertical spacing within the constructed gypsum dike. The purpose of these perimeter drains is to minimize pore pressure build up along the inside of the outer slopes of the facility. The perimeter drainage trench will consist of a perforated pipe encased in highly-permeable, geotextile-wrapped gravel. Water collected by the perimeter trenches will be directed towards equally spaced outlet pipes which in turn convey collected water to the final cover drainage bench and/or perimeter channel. This water will then flow by gravity to the stormwater pond for subsequent disposal at the KIF discharge channel. Details of the perimeter drainage trenches are shown on Drawing 10W427-18.

METHOD OF ANALYSIS

Seepage analyses for the proposed disposal facility were performed using a two-dimensional finite element program SEEP/W V4.24. The program was used to model the movement of water and pore-pressure distribution within the gypsum stack under steady-state and transient conditions. The program was used also to estimate flow quantities through the proposed internal drainage system. Information required for the analyses includes:

- the geometry of the gypsum stack at the cross section location;

- the geometry of the internal drainage system (i.e., central drainage corridor and perimeter drainage trenches);
- the hydraulic properties of for gypsum; and
- boundary conditions and initial conditions (in case of transient analysis).

ANALYSIS CROSS-SECTION

The analysis of seepage flow within the gypsum disposal facility is considered a three-dimensional problem due to the limited lateral extent of the central drainage corridor and the discrete locations of the perimeter drainage trenches. Because of the limitation of SEEP/W in analyzing three-dimensional seepage flows, analysis can be approximated by analyzing seepage flow at several cross sections oriented perpendicular to the central drainage corridor. Flow through the central drainage corridor can then be computed by summing the contribution of flow quantities estimated from the selected cross-sections.

To reduce computational effort and time, analysis presented as part of this calculation package were performed for one cross section that contribute the maximum flow to the central drainage corridor (i.e., cross section with maximum width). Assuming the quantity of flow towards the central drainage corridor to be the same along the entire drainage corridor, the resulting estimate of flow volume through the central drainage corridor will be conservative. Location of analysis cross section with respect to final cover grades at the end of wet stack operations is shown in Figure 1. Cross section geometry and stratigraphy are shown in Figure 2. Details description of cross section stratigraphy is presented in the following section.

CROSS SECTION STRATIGRAPHY AND MATERIAL PARAMETERS

Material contained within the gypsum disposal facility consists mainly of coarse grained gypsum and fine grained gypsum. A brief description of the genesis of the gypsum anticipated to be encountered within the disposal facility is presented as follows:

- *Coarse Gypsum*: Coarse grained gypsum is a by-product of the rim-ditch operations of sluiced material placement. Coarser grained gypsum settles out in or near the rim ditch and is scooped out and compacted to form the perimeter dikes.

- *Fine Gypsum*: Fine grained gypsum is also a by-product of the rim-ditch method of sluiced material placement, however the finer grained material travels further from the discharge point and tends to be located towards the center of the gypsum pond than the coarser material.

The only characteristic of interest for the calculation of seepage flow and pore-water pressure distribution within the gypsum disposal facility is the hydraulic conductivity. Gypsum is currently not generated from the TVA Kingston Fossil Plant. Therefore, information on the hydraulic conductivity of gypsum was obtained from laboratory tests performed on similar gypsum material generated from other

TVA fossil plants (MACTEC, 1995; MACTEC, 2004). Hydraulic conductivity test results performed on representative gypsum material obtained from other TVA fossil plants are presented in Appendix A. According to these test results, the hydraulic conductivity of gypsum ranges from 1.5 x 10^{-4} cm/sec to 6.65 x 10^{-4} cm/sec. The average hydraulic conductivity of the coarse gypsum was calculated to be approximately 5 x 10^{-4} cm/sec. It is worth noting that the permeability tests performed on representative gypsum samples under a confining pressure ranging between 7 to 14 psi. To account for higher confining pressures anticipated within the gypsum stack, the hydraulic conductivity of fine gypsum was assumed to be 1 x 10^{-5} cm/sec.

The horizontal hydraulic conductivity (K_h) of the gypsum material is anticipated to be greater than the vertical hydraulic conductivity (K_v) due to the layered nature of the sedimented gypsum. Field measurements of water levels and hydraulic conductivity measurements within existing TVA disposal facilities indicated that the ratio of horizontal and vertical hydraulic conductivity (K_h/K_v) ranges between 2 to 4. For the purpose of this analysis, a K_h/K_v of 2 was considered. A summary of hydraulic conductivity used in the analysis are presented in Table1.

Table 1. Summary of Hydraulic Conductivity Used in the Seepage Analyses

Material	Hydraulic Conductivity (K, cm/sec)	K_h/K_v
Fine Gypsum	1 x 10^{-5}	2
Coarse Gypsum	5 x 10^{-4}	2

ANALYSIS CASES

Seepage analyses were preformed for the selected cross section considering three analysis cases. Description of these analysis cases is presented below:

Case I – Considering No Central Drainage Corridor (Steady State Condition): This case was analyzed to evaluate the effectiveness of the perimeter drainage trenches in reducing seepage pressures along the inside face of the facility outbound slope and estimate the maximum seepage flow towards the perimeter drainage trench.

Case II – Considering No Central drainage Corridor (Transient Condition): This case was analyzed to provide a base for comparison in demonstrating the effectiveness of the proposed central drainage corridor in facilitating water drainage and reducing water levels in the gypsum stack. Water levels within the wet gypsum stack was estimated at different time periods.

Case III - Considering a Central Drainage Corridor (Transient condition): This case was analyzed to evaluate water levels within the facility at different time intervals and the corresponding seepage flow into the proposed central drainage corridor.

FINITE ELEMENT MESH AND BOUNDARY CONDITIONS

Figure 3 presents the finite element mesh used for the analyses. Figure 4 presents boundary conditions for analysis cases I through III. For transient analyses (i.e., Case II and III), initial boundary condition assumes the initial water level to be at the top of the wet stack at an elevation approximately 928 ft above msl. Stated differently, it is assumed that flow towards the internal drainage system will commence when the wet stack reaches the end of wet disposal operations. This is considered to be a very conservative approach since the drainage through the central corridor will occur during the earlier stages of wet disposal resulting in water levels within the stack being lower than the assumed starting elevation. For analysis case III, the width of the central drainage corridor is considered 150 ft.

RESULTS AND CONCLUSIONS

Graphical output of the seepage analysis for Case I (i.e., steady state conditions – considering no central drainage corridor) is presented in Figures 5. Based on analysis results, the seepage flow towards perimeter drainage trenches drains is estimated to range from 7.76 x 10^{-6} to 5.51.0 x 10^{-5} ft^3/sec/ft, which is equivalent to approximately 5 to 35 gallons/day/ft.

Graphical output for the seepage analysis for Cases II and III are presented in Figures 6 and 7, respectively. Based on the results of modeling, it is noted that water levels within the stack will be reduced considerably quicker using the central drainage corridor (i.e., Case III) when compared to the case without a central drainage (Case II). The rate of reduction is estimated to be approximately twice that of the case with no internal drainage. This is considered beneficial in terms of: (i) reducing the head on the geologic buffer layer; and (ii) the factor of safety for slope stability will be improved as water levels are reduced in the stack.

Finally, it is worth noting that for the analyses presented herein, the following assumptions were made:

(i) the hydraulic conductivity of the gypsum are representative of gypsum material to be disposed of in the proposed facility; and

(ii) outlet pipes of the perimeter drainage trenches and central drainage corridor discharge will be inspected and maintained periodically to ensure that there is no clogging.

REFERENCES

MACTEC "Use of Coal Combustion By-Products as Engineered Fills," prepared by Law Engineering (currently MACTEC), November 1995.

MACTEC "Laboratory Testing Results – Samples from Gypsum Pond at Cumberland Fossil Plant," prepared for Parsons E&C on behalf of TVA, 13May, 2004.

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Client: TVA Project: Gypsum Disposal Facility – KIF Project/Proposal No.: GR3731 Task No.: 06

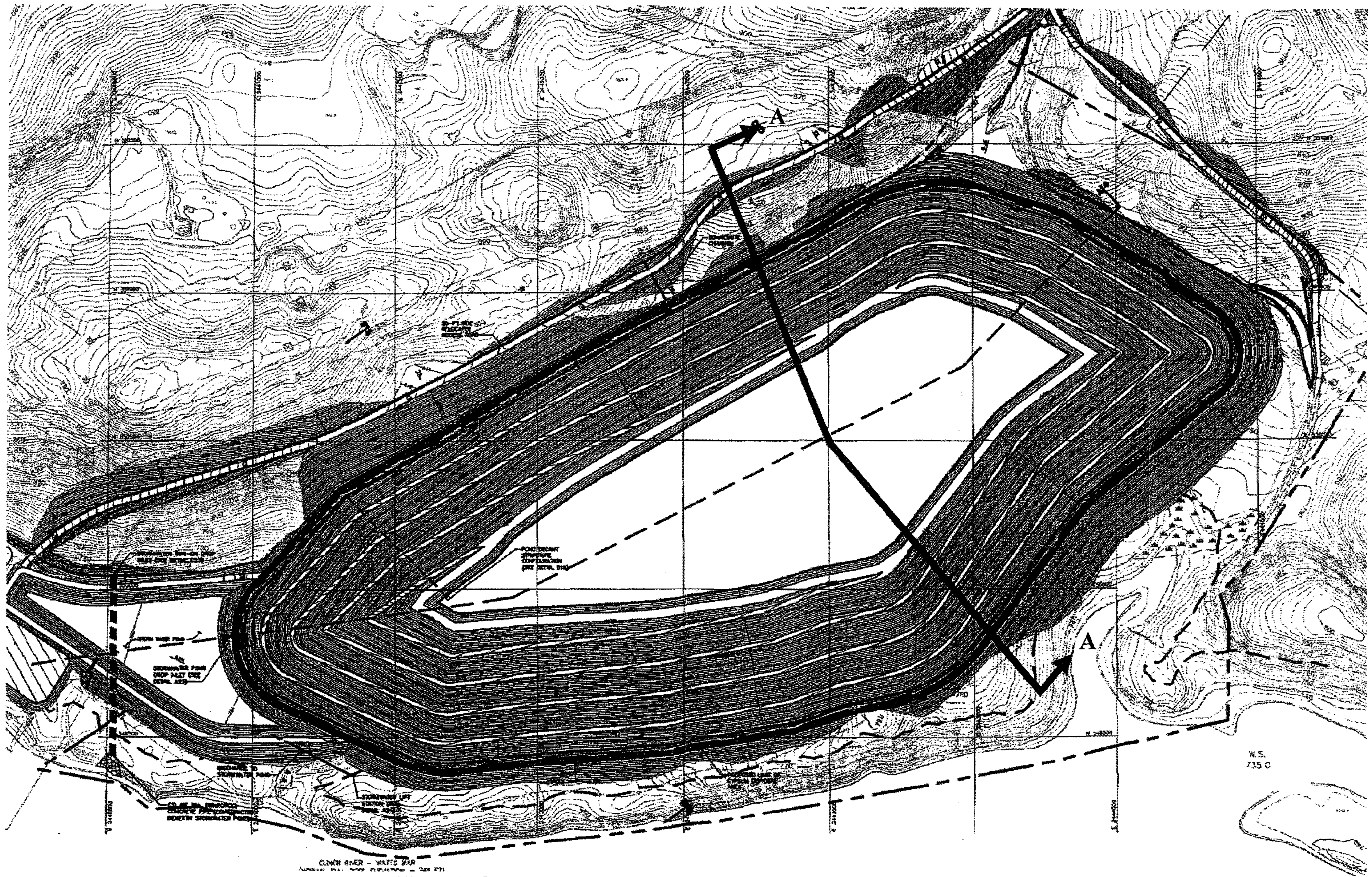


Figure 1. Cross Section Location with respect to Wet Stack Grading Plan

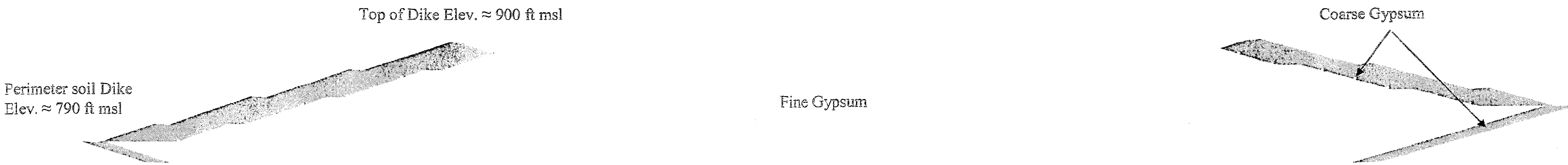


Figure 2. Cross Section Geometry and Stratigraphy

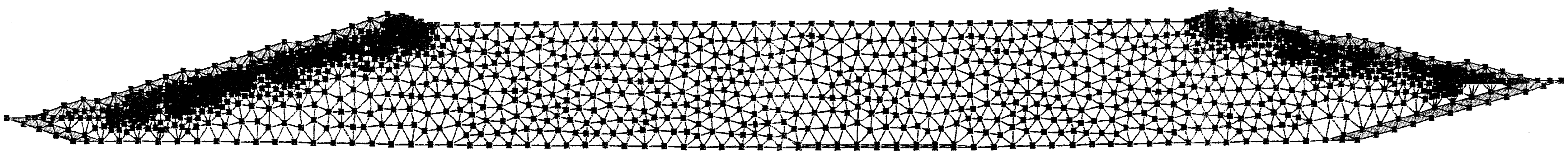
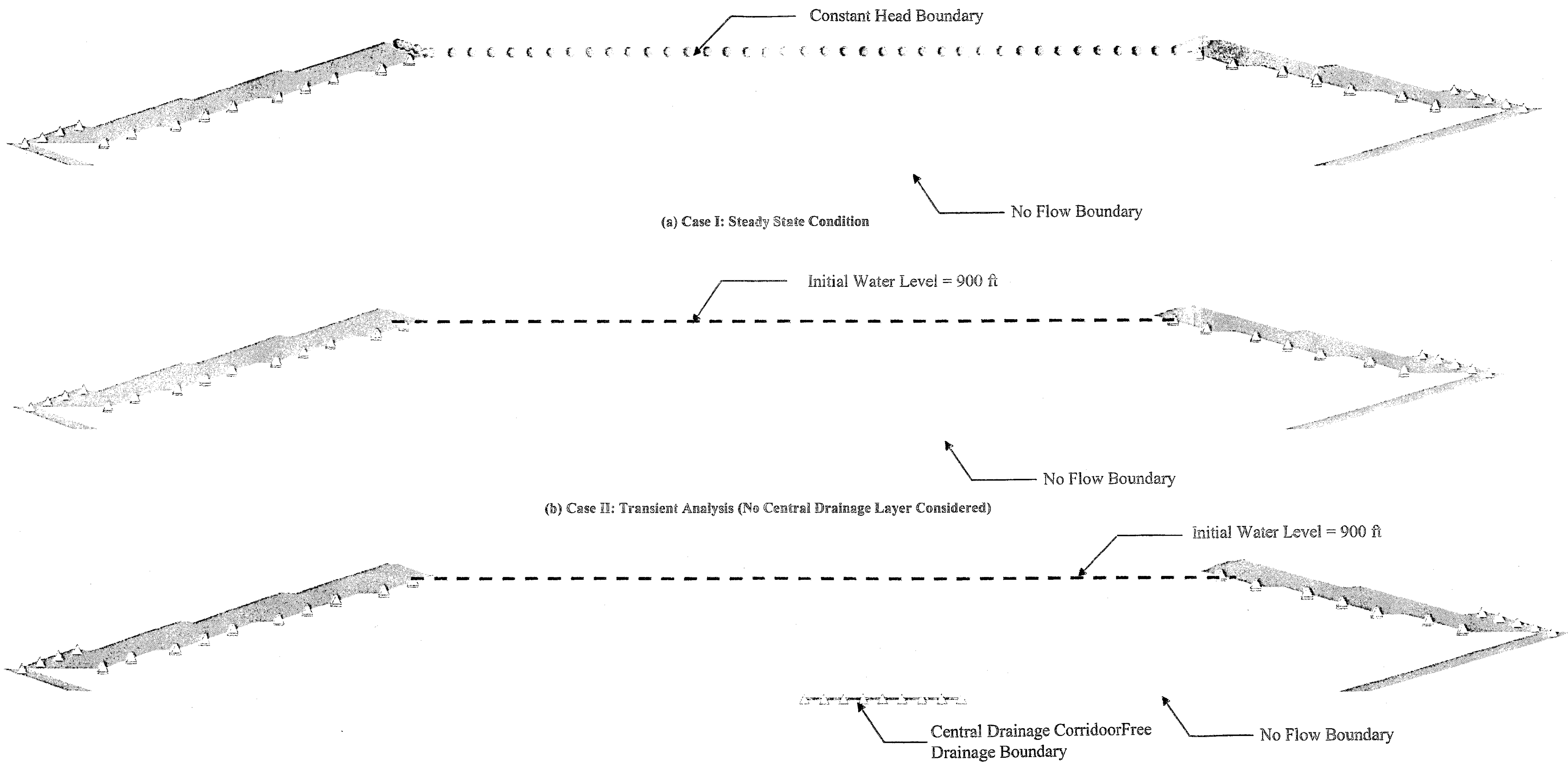


Figure 3. Finite Element Mesh



(c) Case III: Transient Analysis (Central Drainage Layer Considered)

Figure 4. Boundary Conditions and Initial Conditions

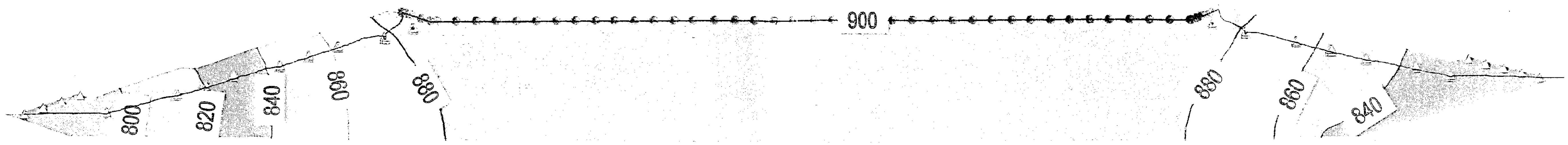


Figure 5. Finite Element Results for Case I - Total Head Distribution

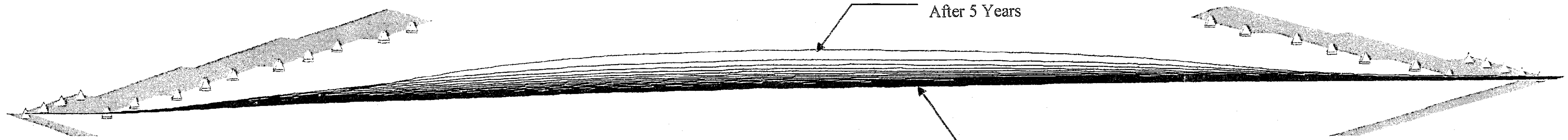


Figure 6. Transient Analysis Result – Case II

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Client: TVA Project: Gypsum Disposal Facility – KIF Project/Proposal No.: GR3731 Task No.: 06

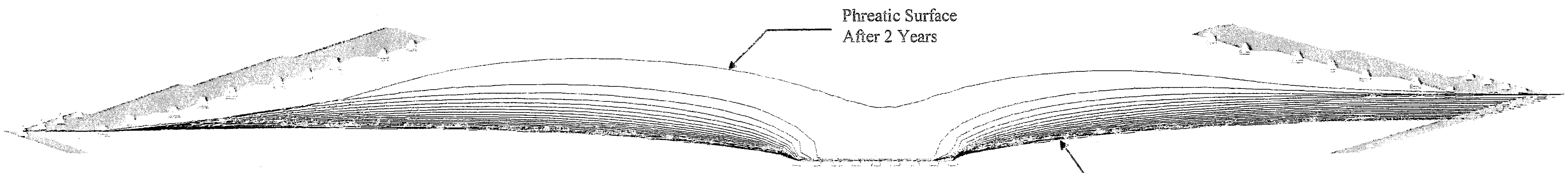


Figure 7. Transient Analysis Result- Case III

APPENDIX A
Permeability Laboratory Testing of Gypsum

Table A-1. Summary of Hydraulic Conductivity Test Results performed on Gypsum Obtained from different facilities

TVA Facility Name	Hydraulic Conductivity (cm/sec)
Cumberland	6.65×10^{-4}
Cumberland	5.02×10^{-4}
Cumberland	6.65×10^{-4}
Widows Creek	3.9×10^{-4}
Paradise	1.5×10^{-4}

PERMEABILITY TEST REPORT

TEST DATA:

Specimen Height (cm): 5.87
Specimen Diameter (cm): 7.24
Dry Unit Weight (pcf): 66.8
Moisture Before Test (%): 34.8
Moisture After Test (%): 54.3
Run Number: 1 ● 2 ▲
Cell Pressure (psi): 57.0
Test Pressure(psi): 52.0
Back Pressure(psi): 50.7
Diff. Head (psi): 1.3
Flow Rate (cc/sec): 4.40 x 10^-1
Perm. (cm/sec): 6.65 x 10^-4

SAMPLE DATA:

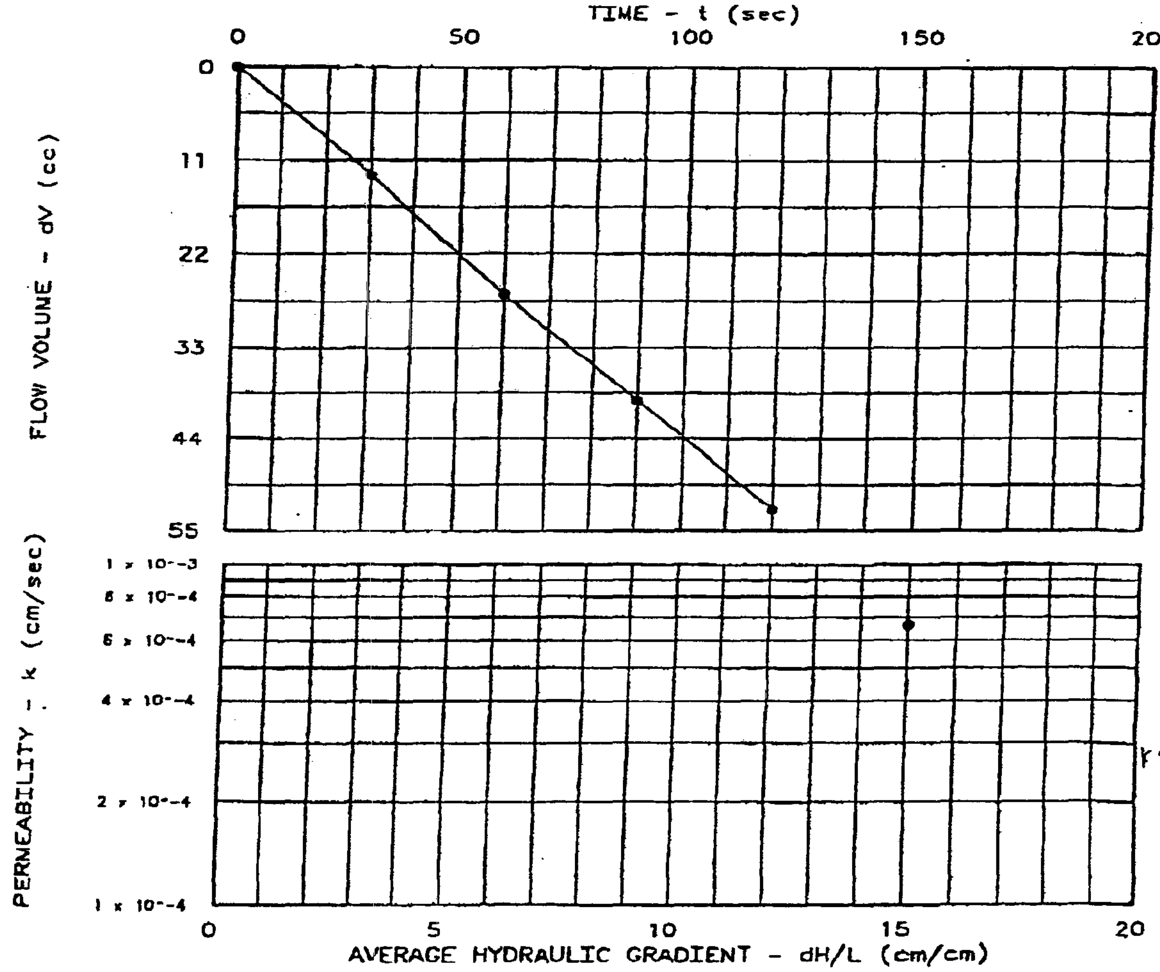
Sample Identification: Hole #2

Visual Description: Gypsum

Remarks:

Maximum Dry Density (pcf):
Optimum Moisture Content (%):

Percent Compaction:
Permeameter type: Flexible Wall
Sample type: Shelby Tube



4.3

k = A = Q

Project: TVA Kingston Fossil Plant - CUF Gypsum	Project No.: 3043041009
Location:	File No.: As# 2651
Date: 05-04-04	Lab No.: 6226
PERMEABILITY TEST REPORT	Tested by: JA
	Checked by: MH
	Test: CH - Constant head

HAB

PERMEABILITY TEST REPORT

TEST DATA:

Specimen Height (cm): 5.04
Specimen Diameter (cm): 7.33
Dry Unit Weight (pcf): 69.0
Moisture Before Test (%): 29.0
Moisture After Test (%): 48.6

Run Number:	1 •	2 ▲
Cell Pressure (psi):	57.0	4.3 psi
Test Pressure(psi):	52.0	
Back Pressure(psi):	50.7	
Diff. Head (psi):	1.3	
Flow Rate (cc/sec):	4.14 x 10--1	
Perm. (cm/sec):	5.02 x 10--4	

SAMPLE DATA:

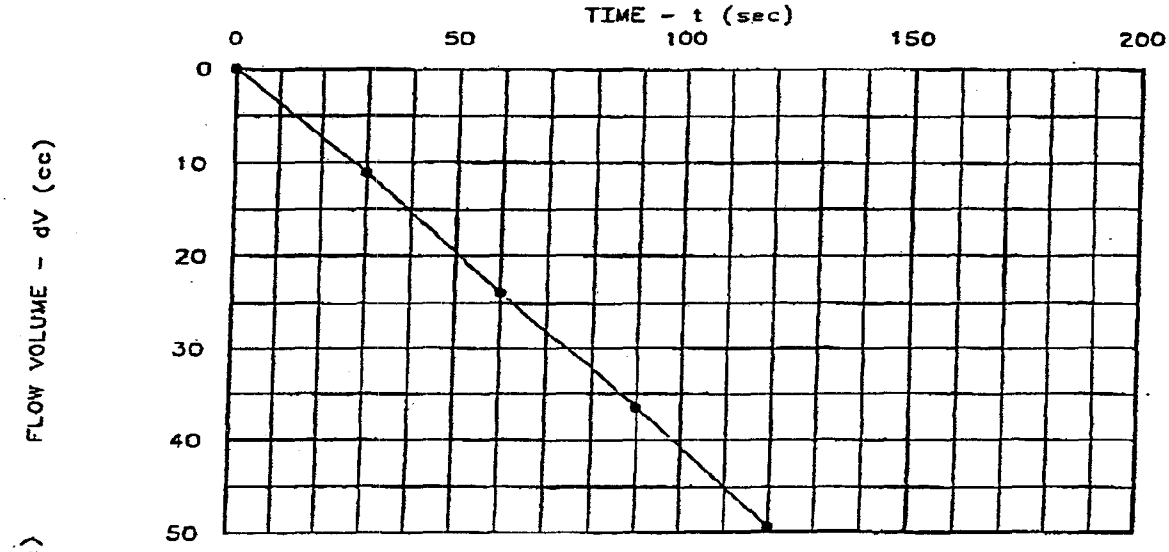
Sample Identification: Hole #3

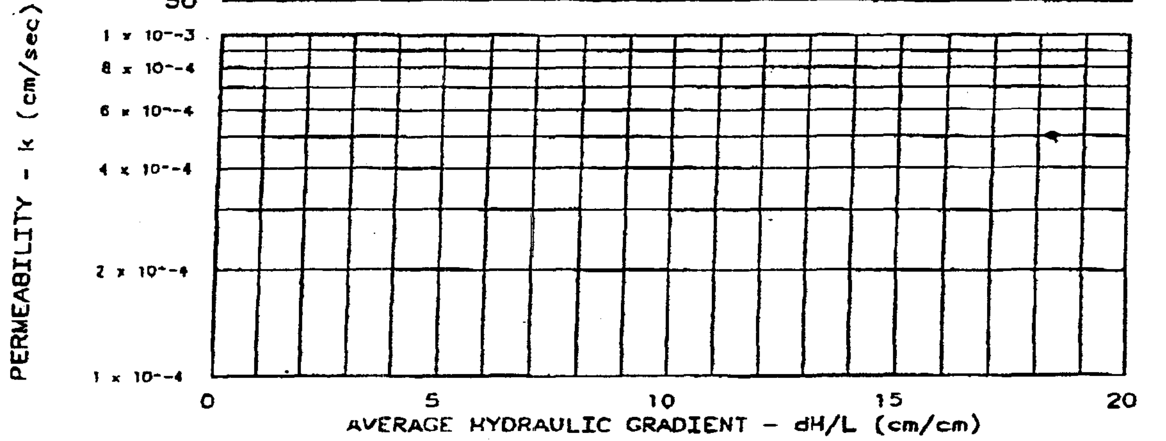
Visual Description: Gypsum

Remarks:

Maximum Dry Density (pcf):
Optimum Moisture Content (%):

Percent Compaction:
Permeometer type: Flexible Wall
Sample type: Shelby Tube





Project: TVA Kingston Fossil Plant - CUF Gypsum Location: Date: 05-04-04	Project No.: 3043041009 File No.: AS# 2651 Lab No.: 6226
PERMEABILITY TEST REPORT	Tested by: JA Checked by: MH Test: CH - Constant head

HAB

PERMEABILITY TEST REPORT

TEST DATA:

Specimen Height (cm): 5.05
Specimen Diameter (cm): 7.33
Dry Unit Weight (pcf): 65.6
Moisture Before Test (%): 34.3
Moisture After Test (%): 51.1
Run Number: 1 ■ 2 ▲
Cell Pressure (psi): 57.0
Test Pressure(psi): 52.0
Back Pressure(psi): 50.8
Diff. Head (psi): 1.2
Flow Rate (cc/sec): 4.93 x 10--1
Perm. (cm/sec): 6.65 x 10--4

SAMPLE DATA:

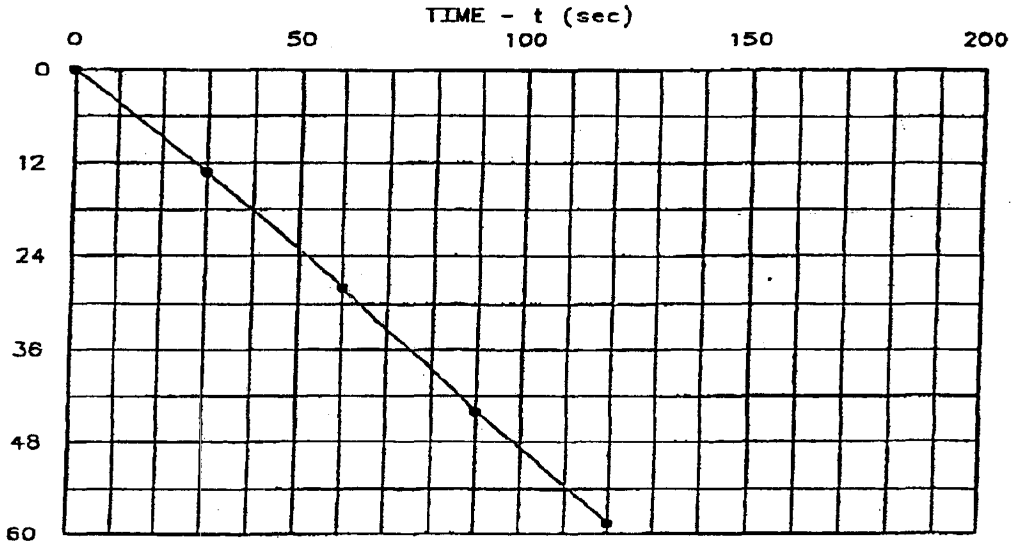
Sample Identification: Hole #5-A

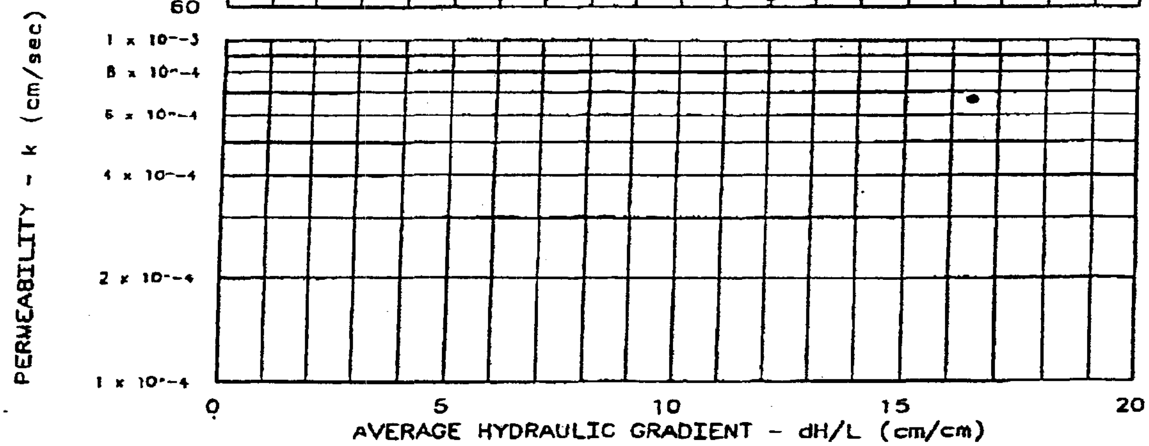
Visual Description: Gypsum

Remarks:

Maximum Dry Density (pcf):
Optimum Moisture Content (%):

Percent Compaction:
Permeometer type: Flexible Wall
Sample type: Shelby Tube





Project: TVA Kingston Fossil Plant - CUF Gypsum Location: Date: 05-04-04	Project No.: 3043041009 File No.: As# 2651 Lab No.: 6226
PERMEABILITY TEST REPORT	Tested by: JA Checked by: MH Test: CH - Constant head

HAB

HYDRAULIC CONDUCTIVITY

LAW ENGINEERING

Project No.	*5810860101*	Tested By	*HEJ*
Project Name	*TVA -Widows Creek*	Test Date	*10/09/95*
Boring No.	*Scrubber Gypsum*	Reviewed By	*RLB*
Sample No.	*Bag*	Review Date	10/19/95
Sample Depth			
Sample Description	*Gypsum*		

ASTM D5084 - Falling Head

Sample Type:	*Bag*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*22.2*
Wet Unit Weight, pcf:	*106.5*
Dry Unit Weight, pcf:	*87.2*
Compaction, %:	*94.7*
Hydraulic Conductivity, cm/sec. @20 °C:	***3.9E-04***

PERMEABILITY TEST - FALLING HEAD
(ASTM D5084 - 90)

LAW ENGINEERING

Job Number 5810860101
Project Name TVA -Widows Creek
Boring No. Scrubber Gypsum
Sample No. Bag
Sample Depth
Sample Description Gypsum

Tested By HEJ
Test Date 10/09/95
Reviewed By RLB
Review Date 10/19/95

Sample Data

Length, in		Diameter, in		Pan No.	AB-30
Location 1	6.000	Location 1	2.830	Dry Soil+Pan, grams	947.13
Location 2	6.000	Location 2	2.830	Pan Weight, grams	83.66
Location3	6.000	Location 3	2.830		
Average	6.000	Average	2.830	Moisture Content, %	22.2
		Wet Soil + Tare, grams	1054.96	Wet Unit Wt, pcf	106.5
		Tare Weight, grams	0.00	Dry Unit Wt, pcf	87.2

Chamber Pressure, psi 49
Back Pressure, psi 35
Confining Pressure, psi 14

Date Start	Date Finish	Time Start	Time Finish	Time (sec)	Division Start	Division Finish	H0 (cm)	Hf (cm)	k cm/sec	Temp (°C)	k cm/sec at 20 °C
				242	50.0	0.0	93.94	43.94	4.0E-04	21	3.9E-04
				242	50.0	0.0	93.94	43.94	4.0E-04	21	3.9E-04
				243	50.0	0.0	93.94	43.94	4.0E-04	21	3.9E-04

No. of Tria	Sample Type	Max. Densit (pcf)	Compaction %	Sample Orientation
3	Bag	92	94.7	Vertical

Avg. k at 20 °C 3.9E-04 cm/sec

a = area of burette in cm²
L = length of sample in cm
A = area of sample in cm²

Ho = initial head in cm
Hf = final head in cm
t = time in seconds

a = 0.34 cm²
A = 40.582 cm²
L = 15.24 cm

TVA-00021358

PER..ABILITY TEST - FALLING HEAD
(ASTM D5084 - 90)

LAW ENGINEERING

Job Number 5810860101
Project Name TVA-Paradise
Boring No. Scrubber Gypsum
Sample No. Bag
Sample Depth
Sample Description Gypsum

Tested By HEJ
Test Date 10/17/95
Reviewed By RLB
Review Date 10/19/95

Sample Data

Length, in		Diameter, in		Pan No.	T-19
Location 1	6.000	Location 1	2.830	Dry Soil+Pan, grams	820.30
Location 2	6.000	Location 2	2.830	Pan Weight, grams	50.64
Location3	6.000	Location 3	2.830		
Average	6.000	Average	2.830	Moisture Content, %	37.1
		Wet Soil + Tare, grams	1055.51	Wet Unit Wt, pcf	106.5
		Tare Weight, grams	0.00	Dry Unit Wt, pcf	77.7

Chamber Pressure, psi 44
Back Pressure, psi 30
Confining Pressure, psi 14

Date Start	Date Finish	Time Start	Time Finish	Time (sec)	Division Start	Division Finish	Ho (cm)	Hf (cm)	k cm/sec	Temp (°C)	k cm/sec at 20 °C
				452	0.0	22.0	127.11	105.11	1.6E-04	21	1.5E-04
				455	0.0	22.0	127.11	105.11	1.6E-04	21	1.5E-04
				453	0.0	22.0	127.11	105.11	1.6E-04	21	1.5E-04

No. of Tria	Sample Type	Max. Densit (pcf)	Compaction %	Sample Orientation
3	Bag	86	90.7	Vertical

Avg. k at 20 °C 1.5E-04 cm/sec

a = area of burette in cm^2
L = length of sample in cm
A = area of sample in cm^2

Ho = initial head in cm
Hf = final head in cm
t = time in seconds

a = 1.00 cm^2
A = 40.582 cm^2
L = 15.24 cm

TVA-00021359

HYDRAULIC CONDUCTIVITY

LAW ENGINEERING

Project No.	*5810860101*	Tested By	*HEJ*
Project Name	*TVA-Paradise*	Test Date	*10/17/95*
Boring No.	*Scrubber Gypsum*	Reviewed By	*RLB*
Sample No.	*Bag*	Review Date	10/19/95
Sample Depth			
Sample Description	*Gypsum*		

ASTM D5084 - Falling Head

Sample Type:	*Bag*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*37.1*
Wet Unit Weight, pcf:	*106.5*
Dry Unit Weight, pcf:	*77.7*
Compaction, %:	*90.7*
Hydraulic Conductivity, cm/sec. @20 °C:	***1.5E-04***

Laboratory data presented in Appendix C "Gypsum Testing and Physical Properties" were from the report titled "*Use of Coal Combustion By-products As Engineered Fills*" prepared by Law Engineering, Inc. dated November 10, 1995.

TVA - Fly Ash, Bottom Ash and Scrubber Sludge Study
Classification (Index Property) Summary
Law Engineering Project No. 5810860101

Source	Code	Material	Bucket Code	Date Collected	Moisture Content, %	Grain Size - ASTM D422 %Ret. on No. 4	%Pass No. 200	%Pass 0.005mm	Atterberg Limits ASTM D4318 LL	PL	PI	Specific Gravity	USCS Classification	AASHTO Classification
Allen	ALF	Boiler Slag - Fine Reed Rejects	A-B	5/11/95	0.06	0.0	18.2	0.8	NL	NP	N/A	2.75	SM	A-2-4(0.0)
			C-D		0.12	0.0	14.6	0.8	NL	NP	N/A	2.79	SM	A-2-4(0.0)
			E-F		0.10	0.0	16.0	0.8	NL	NP	N/A	2.81	SM	A-2-4(0.0)
Bull Run	BRF	Dry Fly Ash	A-B	4/4/95	0.02	0.0	91.2	16.6	NL	NP	N/A	2.36	ML	A-4(0.0)
			C-D	4/5/95	0.05	0.0	91.2	19.5	NL	NP	N/A	2.28	ML	A-4(0.0)
			E-F	4/6/95	0.03	0.0	90.7	17.5	NL	NP	N/A	2.37	ML	A-4(0.0)
		Bottom Ash - From Pond	A-B	3/29/95	6.99	23.0	4.0	....	NL	NP	N/A	2.31	SW	A-1-b
			C-D		6.07	21.3	6.9	....	NL	NP	N/A	2.29	SW-SM	A-1-b
			E-F		6.74	17.9	5.9	....	NL	NP	N/A	2.35	SW-SM	A-1-b
Colbert	COF	Dry Fly Ash - Units 1&2	A	5/25/95										
		- Units 3&4	B	5/25/95	0.01	0.0	81.6	14.9	NL	NP	N/A	2.02	ML	A-4(0.0)
		- Units 1&2	C	5/26/95										
		- Units 3&4	D	5/26/95	0.01	0.0	69.9	11.5	NL	NP	N/A	2.00	ML	A-4(0.0)
		- Units 1&2	E	5/30/95										
		- Units 3&4	F	5/30/95	0.12	0.0	83.6	3.9	NL	NP	N/A	1.95	ML	A-4(0.0)
		Bottom Ash - From Pond	A-B	5/25/95	8.02	7.2	13.6	....	NL	NP	N/A	2.15	SM	A-1-b
			C-D		6.86	15.9	10.8	....	NL	NP	N/A	2.08	SP-SM	A-1-b
			E-F		7.92	12.8	10.5	....	NL	NP	N/A	2.10	SP-SM	A-1-b
Cumberland	CUF	Dry Fly Ash - Units 1&2	A-B	4/17/95	0.31	0.0	95.1	30.0	NL	NP	N/A	2.57	ML	A-4(0.0)
		- Units 1&2	C-D	4/18/95		0.0	92.0	20.7	NL	NP	N/A	2.64	ML	A-4(0.0)
		- Units 1&2	E-F	4/19/95	0.01	0.0	93.2	29.8	NL	NP	N/A	2.65	ML	A-4(0.0)
		Bottom Ash - From Pond	A-B	4/6/95	14.32	30.9	1.1	....	NL	NP	N/A	2.59	SW	A-1-a
			C-D		13.66	46.2	2.2	....	NL	NP	N/A	2.66	SW	A-1-a
			E-F		5.08	32.2	2.8	....	NL	NP	N/A	2.63	SW	A-1-a
		Scrubber Gypsum	A-B	4/6/95	30.44	....	....	....	NL	NP	N/A	....	....	....
			C-D		30.39	....	....	....	NL	NP	N/A	3.41	....	....
			E-F		29.41	....	....	....	NL	NP	N/A	....	....	....
Gallatin	GAF	Dry Fly Ash - Unit 2 Hoppers	A-B	6/9/95	0.03	0.0	94.2	12.0	NL	NP	N/A	2.37	ML	A-4(0.0)
			C-D		0.01	0.0	95.2	13.8	NL	NP	N/A	2.40	ML	A-4(0.0)
			E-F		0.01	0.0	95.5	14.8	NL	NP	N/A	2.39	ML	A-4(0.0)
		Bottom Ash - From Pond	A-B	6/9/95	19.11	18.2	5.9	....	NL	NP	N/A	2.56	SP-SM	A-1-b
			C-D		7.32	27.0	4.0	....	NL	NP	N/A	2.57	SW	A-1-b
			E-F		10.20	18.8	5.6	....	NL	NP	N/A	2.52	SW-SM	A-1-b
John Sevier	JSF	Dry Fly Ash - Unit 4, Hoppers 11&12	A	5/25/95										
		- Unit 3, Hoppers 11&12	B		0.06	0.0	94.2	17.4	NL	NP	N/A	2.27	ML	A-4(0.0)
		- Unit 4, Hoppers 9, 10&13	C	5/25/95										
		- Unit 3, Hoppers 9&10	D		0.01	0.0	96.1	22.1	NL	NP	N/A	2.35	ML	A-4(0.0)
		- Unit 4, Hopper 15,	E	5/25/95										
		- Unit 3, Hopper 16			0.20	0.0	94.1	28.0	NL	NP	N/A	2.43	ML	A-4(0.0)
		- Unit 4, Hopper 15	F											
		Bottom Ash - From Pond	A-B	4/12/95	26.68	22.8	4.3	....	NL	NP	N/A	2.25	SP	A-1-a
			C-D		27.22	22.2	3.3	....	NL	NP	N/A	2.24	SW	A-1-a
			E-F		30.70	27.8	3.7	....	NL	NP	N/A	2.22	SW	A-1-a

TVA - Fly Ash, Bottom Ash and Scrubber Sludge Study
Classification (Index Property) Summary
Law Engineering Project No. 5810860101

Source	Code	Material	Bucket Code	Date Collected	Moisture Content, %	Grain Size - ASTM D422			Atterberg Limits ASTM D4318			Specific Gravity	USCS Classification	AASHTO Classification
						%Ret. on No. 4	%Pass No. 200	%Pass 0.005mm	LL	PL	PI			
Johnsonville	JOF	Ponded Fly Ash (New Dredge Cell)	A-B	6/7/95	28.82	3.2	47.1	2.4	NL	NP	N/A	2.36	SM	A-4(0.0)
			C-D		39.10	0.0	54.4	4.2	NL	NP	N/A	2.56	ML	A-4(0.0)
			E-F		31.07	1.8	59.2	3.5	NL	NP	N/A	2.31	ML	A-4(0.0)
		Ponded Fly Ash (Old Dredge Cell)	A-B	6/7/95	13.61	3.6	33.6	0.0	NL	NP	N/A	2.41	SM	A-2-4(0.0)
			C-D		10.98	8.7	42.2	4.1	NL	NP	N/A	2.43	SM	A-2-4(0.0)
			E-F		15.11	2.5	41.4	2.1	NL	NP	N/A	2.23	SM	A-4(0.0)
		Ponded Fly Ash (Active Ash Pond)	A-B	6/7/95	28.09	0.0	95.0	15.6	NL	NP	N/A	2.48	ML	A-4(0.0)
			C-D		31.07	0.0	94.8	14.8	NL	NP	N/A	2.48	ML	A-4(0.0)
			E-F		32.70	0.0	93.9	16.8	NL	NP	N/A	2.50	ML	A-4(0.0)
		Bottom Ash - From Pond	A-B	6/7/95	13.28	15.6	26.3	....	NL	NP	N/A	2.39	SM	A-1-b
			C-D		11.92	23.0	16.8	....	NL	NP	N/A	2.39	SM	A-1-b
			E-F		11.51	29.8	18.1	....	NL	NP	N/A	2.39	SM	A-1-b
Kingston	KIF	Ponded Fly Ash (Cell I)	A-B	5/3/95	28.28	0.0	86.4	13.6	NL	NP	N/A	2.28	ML	A-4(0.0)
			C-D		33.95	0.0	97.1	13.2	NL	NP	N/A	2.31	ML	A-4(0.0)
			E-F		30.95	0.0	94.0	13.1	NL	NP	N/A	2.30	ML	A-4(0.0)
		Ponded Fly Ash (Cell III)	A-B	5/3/95	36.09	0.0	96.5	22.6	NL	NP	N/A	2.31	ML	A-4(0.0)
			C-D			0.0	98.3	25.0	NL	NP	N/A	2.29	ML	A-4(0.0)
			E-F		36.19	0.0	96.1	18.4	NL	NP	N/A	2.34	ML	A-4(0.0)
		Bottom Ash - From Pond	A-B	5/3/95	9.62	21.9	9.7	....	NL	NP	N/A	2.37	SW-SM	A-1-b
			C-D		10.91	19.3	10.7	....	NL	NP	N/A	2.34	SP-SM	A-1-b
			E-F		17.15	18.4	11.3	....	NL	NP	N/A	2.33	SP-SM	A-1-b
Paradise	PAF	Ponded Fly Ash (East Cell)	A-B	5/17/95	....	0.0	99.4	20.9	NL	NP	N/A	2.82	ML	A-4(0.0)
			C-D		....	0.0	98.1	11.4	NL	NP	N/A	2.77	ML	A-4(0.0)
			E-F		....	0.0	98.5	18.7	NL	NP	N/A	2.93	ML	A-4(0.0)
		Boiler Slag (Reed Rejects)	A-B	5/18/95	....	0.0	5.8	0.0	NL	NP	N/A	2.78	SP-SM	A-1-b
			C-D		....	0.0	12.5	0.0	NL	NP	N/A	2.84	SM	A-2-4(0.0)
			E		....	1.0	10.2	0.0	NL	NP	N/A	2.73	SW-SM	A-1-b
		Scrubber Gypsum	A-B	5/17/95	....	....	....	....	NL	NP	N/A	....	....	....
			C-D		....	....	....	....	NL	NP	N/A	3.00	....	....
			E		....	....	....	....	NL	NP	N/A	....	....	....
Shawnee	SHF	Dry Fly Ash	A-B	4/6/95	0.14	0.0	91.6	7.6	NL	NP	N/A	2.14	ML	A-4(0.0)
			C-D	4/7/95	0.13	0.0	91.2	6.4	NL	NP	N/A	2.09	ML	A-4(0.0)
			E-F	4/10/95	0.16	0.0	90.1	7.5	NL	NP	N/A	2.11	ML	A-4(0.0)
		Bottom Ash - From Pond	A-B	4/5/95	23.64	20.0	11.2	....	NL	NP	N/A	2.14	SP-SM	A-1-b
			C-D		23.83	14.7	9.1	....	NL	NP	N/A	2.14	SP-SM	A-1-b
			E-F		21.11	18.3	9.3	....	NL	NP	N/A	2.09	SP-SM	A-1-b
		Spent Bed Material (SBM)	A-B	4/6/95	0.00	....	....	....	NL	NP	N/A	2.93	....	....
			C-D	4/7/95	0.00	....	....	....	NL	NP	N/A	2.86	....	....
			E-F	4/10/95	0.00	....	....	....	NL	NP	N/A	2.92	....	....
		Char	A-B	4/6/95	0.00	....	....	....	NL	NP	N/A	3.00	....	....
			C-D	4/7/95	0.00	....	....	....	NL	NP	N/A	2.99	....	....
			E-F	4/10/95	0.00	....	....	....	NL	NP	N/A	3.00	....	....
Widows Creek	WCF	Ponded Fly Ash (Ash Pond)	A-B	4/28/95	42.20	0.0	84.5	6.7	NL	NP	N/A	2.38	ML	A-4(0.0)
			C-D		75.19	1.5	84.6	8.2	NL	NP	N/A	2.40	ML	A-4(0.0)
			E-F		63.46	0.0	92.9	3.6	NL	NP	N/A	2.22	ML	A-4(0.0)
		Scrubber Gypsum	A-B	4/28/95	....	....	....	....	NL	NP	N/A	....	....	....
			C-D		....	....	....	....	NL	NP	N/A	3.01	....	....
			E-F		....	....	....	....	NL	NP	N/A	....	....	....
		Bottom Ash - From Pond	A-B	4/28/95	4.25	33.7	4.8	....	NL	NP	N/A	2.74	SW	A-1-a
			C-D		2.36	29.9	4.1	....	NL	NP	N/A	2.60	SW	A-1-a
			E-F		4.03	40.9	4.5	....	NL	NP	N/A	2.67	SW	A-1-a

TVA - Fly Ash, Bottom Ash and Scrubber Sludge Study
Volumetric Testing Summary
Law Engineering Project No. 5810860101

Source	Code	Material	Standard Proctor		Modified Proctor		Relative Density, Dry Method (pcf)	
			Max. Dry Dens. (pcf)	Opt. Moisture (%)	Max. Dry Dens. (pcf)	Opt. Moisture (%)	Minimum	Maximum
Allen	ALF	Boiler Slag (Fine Reed Rejects)	95.3	21.5	102.6	23.2	----	----
Bull Run	BRF	Dry Fly Ash	91.6	17.4	95.7	15.1	----	----
		Bottom Ash - From Pond	91.9	22.6	98.7	18.5	73.9	92.1
Colbert	COF	Dry Fly Ash (Units 1-4)	56.7	45.4	62.9	40.3	----	----
		Bottom Ash - From Pond	64.2	27.4	73.2	17.2	55.7	71.2
Cumberland	CUF	Dry Fly Ash (Units 1-2)	111.4	13.2	116.3	11.5	----	----
		Bottom Ash - From Pond	90.1	15.4	103.3	15.7	67.0	87.1
		Scrubber Gypsum	77.6	40.6	85.9	29.7	----	----
Gallatin	GAF	Dry Fly Ash (Unit 2 Hoppers)	86.6	21.4	88.9	18.8	----	----
		Bottom Ash - From Pond	92.0	25.5	102.5	20.9	71.3	90.7
John Sevier	JSF	Dry Fly Ash (Units 3-4)	83.7	18.6	86.7	17.8	----	----
		Bottom Ash - From Pond	78.9	30.3	96.2	21.9	55.7	73.9
Johnsonville	JOF	Ponded Fly Ash (New Dredge Cell)	75.8	31.4	92.5	20.6	----	----
		Ponded Fly Ash (Old Dredge Cell)	89.5	20.5	96.0	16.1	----	----
		Ponded Fly Ash (Active Ash Pond)	86.6	22.8	91.7	18.0	----	----
		Bottom Ash - From Pond	99.2	18.0	104.1	12.0	80.2	99.2
Kingston	KIF	Ponded Fly Ash (Cell I)	81.0	25.2	84.7	24.1	----	----
		Ponded Fly Ash (Cell III)	81.0	23.5	84.4	23.7	----	----
		Bottom Ash - From Pond	89.0	24.1	97.6	21.0	71.0	88.4
Paradise	PAF	Ponded Fly Ash (East Cell)	110.0	16.5	114.4	13.7	----	----
		Boiler Slag (Reed Rejects)	112.5	18.2	116.0	18.7	----	----
		Scrubber Gypsum	85.7	31.7	87.4	30.8	----	----
Shawnee	SHF	Dry Fly Ash	72.4	28.3	77.2	24.4	----	----
		Bottom Ash - From Pond	71.7	30.5	81.4	26.1	57.4	74.0
		Spent Bed Material (SBM)	----	----	----	----	----	----
		Char	----	----	----	----	----	----
Widows Creek	WCF	Ponded Fly Ash (Ash Pond)	67.0	39.8	73.5	27.8	----	----
		Scrubber Gypsum	92.0	23.1	99.9	19.4	----	----
		Bottom Ash - From Pond	106.2	17.6	120.8	15.8	83.0	103.3

lab\soil\tva\prgrm.xls (Proctor)

TVA - Fly Ash, Bottom Ash and Scrubber Sludge Study
Consolidation/Hydraulic Conductivity/Chemical Testing Summary
Law Engineering Project No. 5810860101

Source	Code	Material	Consolidation Compression Index, C_c	Hydraulic Conductivity (cm/sec)	Resistivity (Ohm-cm)	pH	Water Soluble Sulfate (mg/kg)	Water Soluble Chloride (mg/kg)
Allen	ALF	Boiler Slag (Fine Reed Rejects)	0.04	9.0E-4	30000	7.5	43	<10
Bull Run	BRF	Dry Fly Ash	0.04	4.0E-5	690	8.4	4630	<10
		Bottom Ash - From Pond	----	1.8E-2	7300	7.2	370	<10
Colbert	COF	Dry Fly Ash (Units 1-4)	0.08	2.8E-4	850	9.4	1660	<10
		Bottom Ash - From Pond	----	1.6E-2	4500	5.4	215	<10
Cumberland	CUF	Dry Fly Ash (Units 1-2)	0.01	2.2E-5	2600	11.6	5020	<10
		Bottom Ash - From Pond	----	6.8E-2	1200	2.7	4790	<10
		Scrubber Gypsum	0.12	1.2E-3	1100	7.8	4830	<10
Gallatin	GAF	Dry Fly Ash (Unit 2 Hoppers)	0.05	7.7E-5	420	10.6	5800	<10
		Bottom Ash - From Pond	----	2.9E-2	1600	2.8	1660	<10
John Sevier	JSF	Dry Fly Ash (Units 3-4)	0.05	5.5E-5	440	4.1	4910	<10
		Bottom Ash - From Pond	----	2.6E-2	5200	6.8	285	<10
Johnsonville	JOF	Ponded Fly Ash (New Dredge Cell)	0.06	5.0E-4	2800	8.1	83	<10
		Ponded Fly Ash (Old Dredge Cell)	0.10	5.8E-4	2600	6.8	1520	20
		Ponded Fly Ash (Active Ash Pond)	0.11	3.5E-5	690	8.4	2960	60
		Bottom Ash - From Pond	----	4.7E-3	740	6.0	2200	<10
Kingston	KIF	Ponded Fly Ash (Cell I)	0.05	8.3E-5	7700	7.6	200	<10
		Ponded Fly Ash (Cell III)	0.05	3.4E-5	6400	6.8	140	<10
		Bottom Ash - From Pond	----	9.1E-3	1900	4.0	490	<10
Paradise	PAF	Ponded Fly Ash (East Cell)	0.04	1.0E-5	2600	8.1	340	<10
		Boiler Slag (Reed Rejects)	----	1.3E-3	9700	4.3	220	<10
		Scrubber Gypsum	0.13	1.5E-4	1100	7.7	4630	10
Shawnee	SHF	Dry Fly Ash	0.04	9.2E-5	1000	11.5	2270	<10
		Bottom Ash - From Pond	----	8.9E-3	3000	8.1	4200	10
		Spent Bed Material (SBM)	----	----	----	12.0	4190	150
		Char	----	----	190	12.0	4130	980
Widows Creek	WCF	Ponded Fly Ash (Ash Pond)	0.12	1.8E-4	1400	9.2	1060	<10
		Scrubber Gypsum	0.07	3.9E-4	1200	6.7	3050	<10
		Bottom Ash - From Pond	----	3.4E-2	3100	8.0	4070	130

Note: Consolidation and Hydraulic Conductivity test specimen were remolded to approximately 95 percent of the Standard Proctor maximum dry density

lab soil tva prgrm.xls (Consol)

TVA-00021366

TVA - Fly Ash, Bottom Ash and Scrubber Sludge Study
Strength Testing Summary
Law Engineering Project No. 5810860101

Source	Code	Material	Triaxial CU with pore pressure				Direct Shear		Angle of Repose
			Effective Stress		Total Stress		Cohesion, c (ksf)	Internal friction, ϕ	
			Cohesion, c' (ksf)	Internal friction, ϕ'	Cohesion, c (ksf)	Internal friction, ϕ			
Allen	ALF	Boiler Slag (Fine Reed Rejects)	0.00	37.3	1.15	39.2	2.32	25.2	----
Bull Run	BRF	Dry Fly Ash	0.31	27.7	1.12	21.2	1.36	27.4	----
		Bottom Ash - From Pond	----	----	----	----	----	----	32.4
Colbert	COF	Dry Fly Ash (Units 1-4)	0.34	27.6	0.69	19.9	1.31	28.6	----
		Bottom Ash - From Pond	----	----	----	----	----	----	30.9
Cumberland	CUF	Dry Fly Ash (Units 1-2)	0.00	53.5	1.70	50.5	2.53	33.4	----
		Bottom Ash - From Pond	----	----	----	----	----	----	30.8
		Scrubber Gypsum	0.00	38.1	3.33	33.4	1.32	41.4	----
Gallatin	GAF	Dry Fly Ash (Unit 2 Hoppers)	0.00	31.7	0.57	26.2	1.37	34.5	----
		Bottom Ash - From Pond	----	----	----	----	----	----	31.8
John Sevier	JSF	Dry Fly Ash (Units 3-4)	0.22	22.4	0.26	17.7	1.11	33.6	----
		Bottom Ash - From Pond	----	----	----	----	----	----	27.4
Johnsonville	JOF	Ponded Fly Ash (New Dredge Cell)	0.23	32.4	1.26	25.8	1.29	32.4	----
		Ponded Fly Ash (Old Dredge Cell)	0.12	30.5	0.66	15.2	2.14	39.3	----
		Ponded Fly Ash (Active Ash Pond)	0.00	22.6	0.01	15.8	1.41	36.6	----
		Bottom Ash - From Pond	----	----	----	----	----	----	30.8
Kingston	KIF	Ponded Fly Ash (Cell I)	0.14	26.1	0.36	19.6	0.82	39.1	----
		Ponded Fly Ash (Cell III)	0.03	24.4	0.00	17.8	1.47	37.6	----
		Bottom Ash - From Pond	----	----	----	----	----	----	31.3
Paradise	PAF	Ponded Fly Ash (East Cell)	0.37	21.2	0.55	15.6	2.27	20.2	----
		Boiler Slag (Reed Rejects)	0.06	40.6	2.00	40.3	----	----	----
		Scrubber Gypsum	0.00	39.7	3.07	35.5	0.97	45.7	----
Shawnee	SHF	Dry Fly Ash	1.24	22.4	1.79	14.7	1.10	39.8	----
		Bottom Ash - From Pond	----	----	----	----	----	----	31.6
		Spent Bed Material (SBM)	----	----	----	----	----	----	----
		Char	----	----	----	----	----	----	----
Widows Creek	WCF	Ponded Fly Ash (Ash Pond)	1.85	25.5	1.94	21.5	1.70	31.2	----
		Scrubber Gypsum	0.00	37.8	3.01	33.1	0.55	28.9	----
		Bottom Ash - From Pond	----	----	----	----	----	----	29.0

Note: Triaxial CU and Direct Shear test specimen were remolded to approximately 95 percent of the Standard Proctor maximum dry density at or near optimum moisture content

lab roll tva prgm.xls (Static)

TVA-00021367

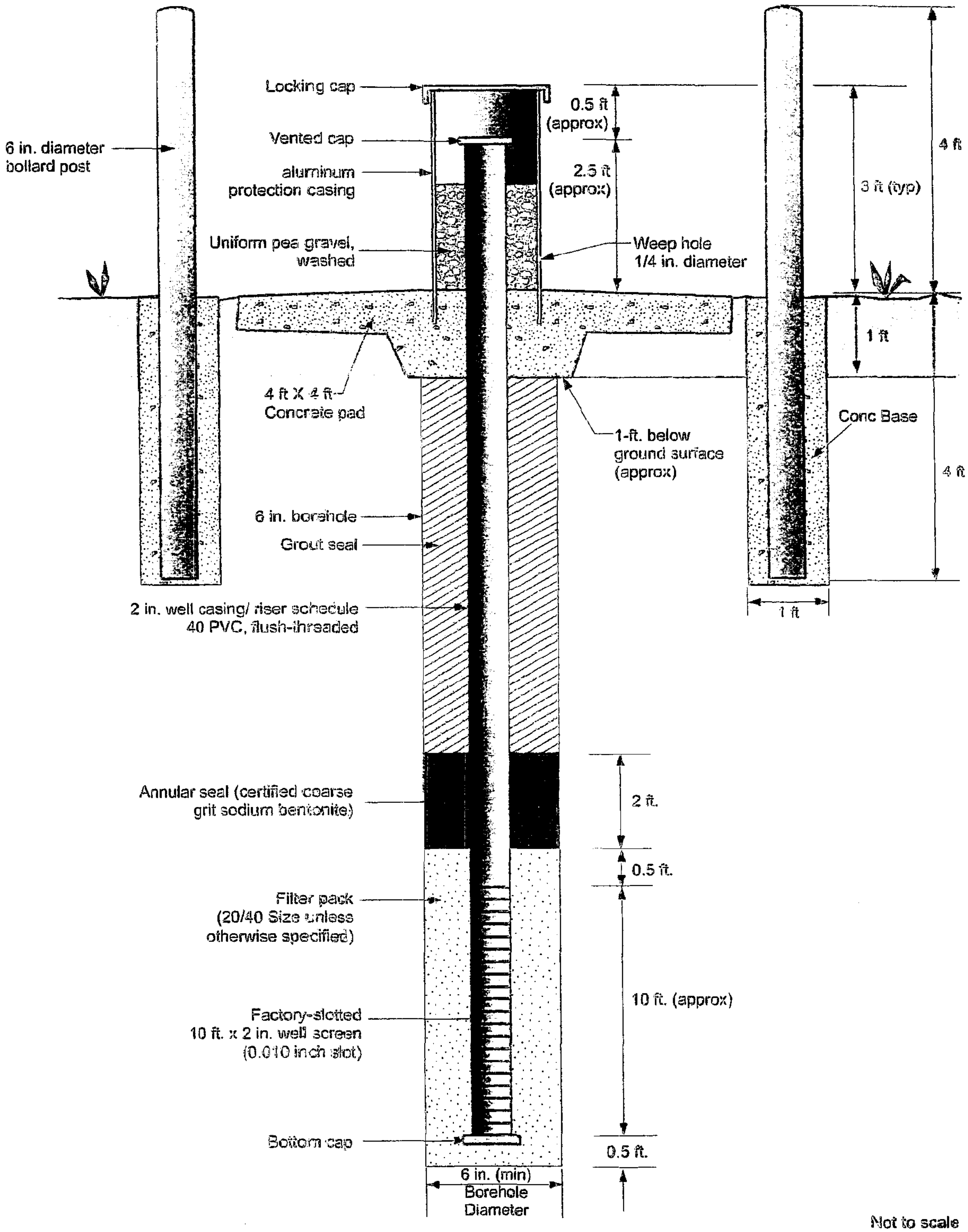
TVA - Fly Ash, Bottom Ash and Scrubber Sludge Study
Strength Testing Summary
Law Engineering Project No. 5810860101

Source	Code	Material	CBR %	Resilient Modulus (Standard Effort) K1	K2	K5	M_R at S_c=4psi, S_d=4psi	Resilient Modulus (Modified Effort) K1	K2	K5	M_R at S_c=4psi, S_d=4psi
Allen	ALF	Boiler Slag (Fine Reed Rejects)	37	2,662	0.09516	0.53980	6,419	2,468	0.14322	0.51069	6,110
Bull Run	BRF	Dry Fly Ash	2	3,225	-0.17750	0.54531	5,370	3,283	-0.01625	0.38843	5,500
		Bottom Ash - From Pond	35	1,857	0.10936	0.78070	6,378	1,977	0.13522	0.76648	6,901
Colbert	COF	Dry Fly Ash (Units 1-4)	9	1,353	-0.00868	0.56321	2,918	1,639	0.01011	0.53301	3,480
		Bottom Ash - From Pond	24	2,368	0.11934	0.58242	6,264	2,455	0.09488	0.59309	6,372
Cumberland	CUF	Dry Fly Ash (Units 1-2)	24	7,531	-0.03317	0.34550	11,612	10,959	0.14896	0.24877	19,021
		Bottom Ash - From Pond	15	2,194	0.09530	0.67882	6,417	1,994	0.13866	0.76150	6,945
		Scrubber Gypsum	20	9,623	0.09590	0.25471	15,646	11,738	0.08396	0.20475	17,515
Gallatin	GAF	Dry Fly Ash (Unit 2 Hoppers)	2	2,713	-0.09930	0.47991	4,598	3,602	-0.12389	0.45133	5,671
		Bottom Ash - From Pond	30	1,972	0.20995	0.65540	6,545	2,427	0.20416	0.61364	7,541
John Sevier	JSF	Dry Fly Ash (Units 3-4)	1	2,965	-0.08694	0.43636	4,813	4,033	-0.09489	0.39276	6,095
		Bottom Ash - From Pond	40	2,156	0.08085	0.76340	6,949	2,108	0.09702	0.69867	6,352
Johnsonville	JOF	Ponded Fly Ash (New Dredge Cell)	12	1,487	0.03358	0.63725	3,769	2,541	-0.01211	0.48836	4,917
		Ponded Fly Ash (Old Dredge Cell)	28	1,495	0.03707	0.78260	4,657	2,255	0.09559	0.65332	6,368
		Ponded Fly Ash (Active Ash Pond)	1	2,146	-0.18159	0.60215	3,844	3,980	-0.14235	0.42844	5,917
		Bottom Ash - From Pond	50	2,373	0.16927	0.51994	6,169	2,389	0.13323	0.56010	6,247
Kingston	KIF	Ponded Fly Ash (Cell I)	2	1,803	0.07728	0.41203	3,553	2,374	-0.04388	0.47386	4,309
		Ponded Fly Ash (Cell III)	1	2,592	-0.10787	0.48134	4,350	3,254	-0.09252	0.43051	5,199
		Bottom Ash - From Pond	60	1,427	0.13665	0.75876	4,938	1,822	0.19126	0.64487	5,807
Paradise	PAF	Ponded Fly Ash (East Cell)	4	5,929	-0.09595	0.40269	9,071	5,551	-0.06155	0.44309	9,421
		Boiler Slag (Reed Rejects)	55	1,661	0.06737	0.79102	5,460	1,715	0.08023	0.76411	5,529
		Scrubber Gypsum	14	9,420	0.10296	0.23790	15,110	10,977	0.08137	0.20492	16,325
Shawnee	SHF	Dry Fly Ash	9	2,390	-0.04340	0.45385	4,222	2,774	-0.03472	0.41978	4,731
		Bottom Ash - From Pond	25	1,928	0.11134	0.73640	6,244	1,558	0.08323	0.76224	5,030
		Spent Bed Material (SBM)	----	----	----	----	----	----	----	----	----
		Char	----	----	----	----	----	----	----	----	----
Widows Creek	WCF	Ponded Fly Ash (Ash Pond)	3	1,026	-0.02608	0.63430	2,384	3,283	-0.01625	0.38843	5,500
		Scrubber Gypsum	15	7,937	0.08949	0.23891	12,513	8,454	0.05337	0.26140	13,079
		Bottom Ash - From Pond	30	2,258	0.19103	0.66319	7,379	2,260	0.28011	0.26147	4,788

Note: CBR and Resilient Modulus test specimen were remolded to approximately 95 percent of the Standard Proctor (and Modified Proctor for Res. Mod.) maximum dry density at or near optimum moisture content

lab soil tva prgrm.xls (Dynamic)

RESIDUUM MONITORING WELL SCHEMATIC

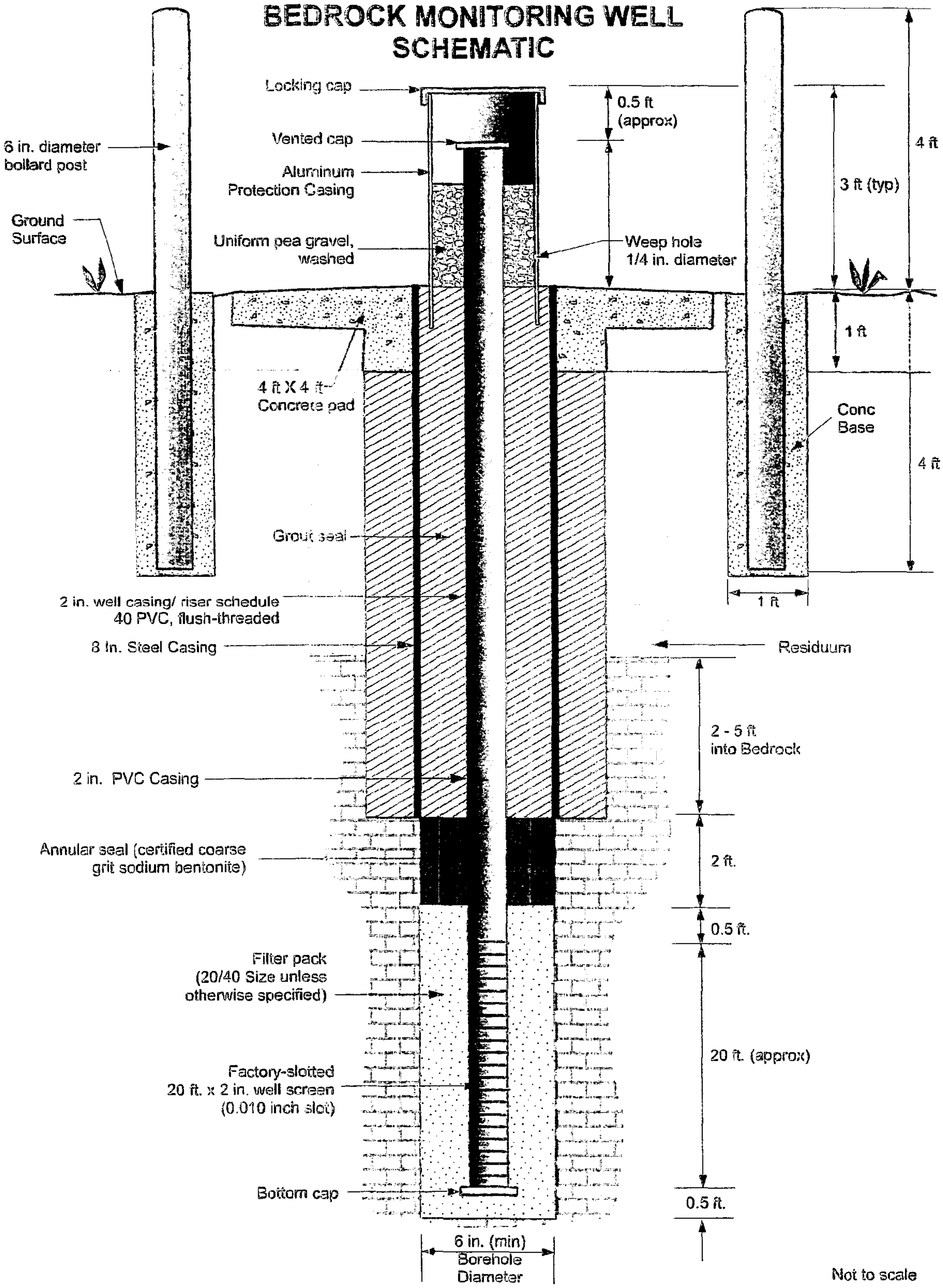


Not to scale

GEOSYNTEC CONSULTANTS
ATLANTA, GEORGIA

FIGURE NO.	1-2
PROJECT NO.	GR3731-06
DOCUMENT NO.	GA060000
FILE NO.	M-WELLS.CDR

BEDROCK MONITORING WELL SCHEMATIC



GeoSyntec Consultants
ATLANTA, GEORGIA

FIGURE NO.	1-3
PROJECT NO.	GR3731-06
DOCUMENT NO.	GA060000
FILE NO.	M-WELLS.CDR

TVA

Tennessee Valley Authority
Kingston Fossil Plant

GROUNDWATER MONITORING PLAN

COAL COMBUSTION BYPRODUCT DISPOSAL FACILITY - PENINSULA SITE

KIF450

Prepared By:

Tennessee Valley Authority
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1101 Market Street
Chattanooga, TN 37401-2801

May 2006

Title: GROUNDWATER MONITORING PLAN COAL-COMBUSION BYPRODUCT DISPOSAL FACILITY – PENINSULA SITE.			DCN# Plant/Unit: Kingston Fossil Plant
Vendor	Contract No.	Key Nouns:	
Applicable Design Documents	REV	EDMS NUMBER	DESCRIPTION
	R0		
References	R1		
	R2		

TENNESSEE VALLEY AUTHORITY
FOSSIL POWER GROUP
FOSSIL ENGINEERING SERVICES
SITE AND ENVIRONMENTAL ENGINEERING

	Revision 0	R1	R2
Date	May 2006		
Prepared	Todd Kafka		
Checked	Charlie Spiers		
Supervised	Harold L. Petty		

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Attachment

A TVA Quality Assurance Procedure No. ES-41.6 – Groundwater Sample Collection Techniques

1. INTRODUCTION

This Groundwater Monitoring Plan has been prepared to satisfy the requirements of Tennessee Department of Environment and Conservation (TDEC) Rule 1200-1-7 for the Proposed Coal Combustion Byproduct (CCB) Disposal Facility at the Kingston Fossil Plant (referenced hereafter as CCB disposal facility). The CCB disposal facility is located at the base of a peninsula at the confluence of the Clinch and Emory Rivers in Roane County, Tennessee. The CCB disposal facility will extend from the central portion of the peninsula to its southern margin adjacent to the Clinch River. The CCB disposal facility must conform to the Class II landfill regulations promulgated by the Division of Solid Waste Management (DSWM) of TDEC. The Groundwater Monitoring Plan describes procedures and protocols to evaluate the potential impacts from the proposed CCB disposal facility on groundwater quality beneath the Peninsula Site.

1.1 Summary of Site Geology and Hydrogeology

A hydrogeologic evaluation of the CCB disposal facility site was conducted by the Tennessee Valley Authority (TVA) in 2005 (Julian and Boggs, 2005). The evaluation compiled hydrogeologic data collected during previous geotechnical studies and site investigations. Groundwater conditions are currently monitored in five residuum piezometers, nine residuum monitoring wells, and four bedrock monitoring wells. The following is a summary of geologic and hydrogeologic characteristics of the site as presented in Julian and Boggs (2005):

- The CCB disposal facility site is hydraulically bounded on all sides – the Clinch River to the south forms a constant head boundary and the ridge-line to the north and northwest forms a no-flow boundary.

- The uppermost geologic unit at the site is a silty to clayey residuum. Silty alluvium is also occasionally present but is primarily encountered along the low-lying areas at the Site's western margin. The residuum deposits range in thickness between 8.5 to 120 feet. Vertical hydraulic conductivity (K_h) of undisturbed residuum samples ranged from 10^{-4} to 10^{-8} centimeters/second (cm/s).

- Carbonate bedrock, primarily dolomite, of the Knox Group underlies the unconsolidated residuum and alluvium. The Knox Group is regionally characterized as being prone to solution weathering particularly along joints and joint sets, resulting in a highly variable top of rock surface elevation. The top of bedrock surface at the CCB disposal facility is similarly variable, ranging in elevation from 677 to 851 feet mean sea level (msl) in the disposal area. The bedrock surface dips to the south-southeast.

- Dolines (sinkholes) present within the proposed disposal boundary have been found to be closed and not directly draining into the bedrock. Stable soil conditions have been observed at each of the dolines due to the presence of at least 35 ft. of void-free overburden and no evidence of soil stoping.

- Groundwater flow in the residuum generally follows topography, flowing from the ridge along the northern to northwestern Site boundary to the southeast towards the Clinch River. Saturated thickness of the residuum is variable based on seasonal influences (i.e., recharge via precipitation) and stage of the Emory and Clinch Rivers.

- Groundwater flow direction in the bedrock was not discussed in Julian and Boggs (2005). However, the bedrock flow direction was inferred to be southeasterly from the ridge based on water level measurements collected on March 2, 2006. This conclusion regarding the flow direction is tentative since it is based on only four bedrock monitoring points.

- Downward vertical hydraulic gradients have been documented at the two well pairs closer to the ridge (MW-10A/10B and MW-63A/63B). Downward vertical gradients at well pairs along the central portion of the disposal area have been negligible.

- Zones of varying hydraulic conductivity and flow were observed in six residuum wells and two bedrock wells using an electromagnetic borehole flowmeter (EMFM). In the residuum, zones of higher hydraulic conductivity tended to correlate to sandy intervals; the highest horizontal hydraulic conductivity (K_h) value for the higher zones was measured at $8x10^{-2}$ cm/s. The lowest K_h values were less than 10^{-6} cm/s and correlated with silty clay zones.

- The flowmeter profiles in the bedrock monitoring wells suggest that the epikarst interval (weathered zone near the top of bedrock) is potentially the most transmissive bedrock interval; however, the presence of well-connected fracture zones below the epikarst may also have similar hydraulic conductivity.

1.2 Proposed Groundwater Monitoring System

A groundwater monitoring system will be developed at the CCB disposal facility for the purposes of meeting TDEC monitoring requirements. The groundwater monitoring system is designed to assess the quality of groundwater unaffected by disposal processes and to monitor groundwater quality at the downgradient compliance boundary of the disposal facility. To meet these objectives, the proposed groundwater monitoring system includes upgradient and downgradient monitoring wells located outside of the projected limit of land disturbance of waste disposal development and operation. The limit of disturbance, therefore, becomes the effective groundwater compliance boundary.

The existing site residuum and bedrock monitoring wells lie within the footprint of the proposed disposal area, and thus, will not be used in the groundwater monitoring system. These wells will be plugged and abandoned in accordance with TDEC regulations prior to commencing disposal activities.

The proposed monitoring system includes upgradient and downgradient monitoring wells installed in both the residuum and bedrock units. Monitoring of both hydrogeologic units is warranted for two reasons: 1) the units are hydraulically connected with documented downward vertical flow potentials, and 2) groundwater flow in both units discharges into the Clinch River. Figure 1-1 depicts the 10 proposed monitoring well pair locations, their relation to the groundwater compliance boundary, the existing residuum monitoring wells and piezometers, and the residuum potentiometric surface from the March 2, 2006 gauging event. Residuum and bedrock wells at proposed pair locations are designated with "A" and "B" suffixes, respectively. The proposed locations may be shifted in the field depending upon access conditions.

The proposed disposal boundary will extend to the base of the ridge along the north and northwest Site boundary. Well pair MW-1A/1B will serve as an upgradient monitoring location for the Phase I disposal area and will be situated near the top of the ridge. Groundwater conditions upgradient of the Phase II disposal area will be evaluated at the MW-2A/2B well pair, located slightly below the ridge top. Although residuum locations are tentatively proposed at these two upgradient locations, it is possible that residuum monitoring in these locales may not be feasible since unsaturated conditions may be present in the thinly-developed residuum near the ridge top. Well pairs MW-3A/3B through MW-10A/10B are all intended to monitor groundwater quality downgradient from both the Phase I and II disposal areas.

1.2.1 Monitoring Well Design and Construction

The proposed monitoring well borings will be advanced using a combination of drilling technologies that are commonly used in the region, such as hollow-stem auger, air rotary drilling, and bedrock coring. Selection of the drilling technology will be made by TVA based on a number of important considerations such as site accessibility and appropriate drilling technology. The proposed monitoring wells will be constructed of 2-inch diameter PVC well screen and casing and shall be installed in 6-inch diameter boreholes in order to comply with TDEC monitoring well regulations. The design of each type of monitoring well is discussed separately below.

Residuum Monitoring Wells

The residuum monitoring wells will be constructed in the manner depicted in Figure 1-2. The residuum well borings will be advanced to bedrock refusal, which was found to vary between 35 and 59 feet below ground surface (bgs) during previous investigations at the Site. The well screen shall have a minimum length of 10 ft. and a slotted interval of 0.010 inches. The well will be set on a 6-inch thick footing of environmental-grade filter pack sand (20/40 grain size unless otherwise noted). The top of the filter pack will extend a minimum of six inches above the top slot of the well screen. A minimum 2-foot bentonite seal will be placed on top of the filter pack. The filter pack material and bentonite seal will be placed in the annulus through a 1-inch PVC tremie pipe when practical. The remaining annulus will be filled with a cement-bentonite grout.

The monitoring wells will be completed above grade with a stickup. Each well will have a vented PVC cap and a lockable, steel outer casing secured in a 4 ft. x 4 ft. concrete pad. The steel casing will be protected by four, 6-inch diameter steel bollards installed to a 4-foot height at the four corners of the concrete pad. The bollards will be set in concrete approximately 4 feet bgs.

Upon completion each well will be developed using a combination of methods such as air lift, surging, and pumping. After development the wells will be surveyed by a licensed surveyor for location and elevation of the top of casing.

Bedrock Monitoring Wells

Groundwater monitoring in the bedrock will utilize a single monitoring interval unless field observations indicate that multi-level monitoring is warranted. Bedrock monitoring wells will be constructed in the manner depicted in Figure 1-3, unless field conditions necessitate modifications. Bedrock borings will be advanced into the upper 20-30 feet of the bedrock to target the more permeable epikarst zone. The existing bedrock monitoring wells have total depths that vary between 61 and 104 feet bgs. The total depth of the proposed bedrock monitoring wells will be determined in the field based on observations during drilling such as fluid loss or gain, the presence of voids or fractures, or overall rock competency based on penetration rate. A 10-inch diameter borehole will be advanced through the residuum and into the upper 2 to 5 feet of competent bedrock. An 8-inch diameter, steel surface casing will be installed and grouted in place using a cement-bentonite grout, which will be allowed to cure for 24 hours. Bedrock borings will be advanced using drilling methodologies such as air rotary or wire-line coring to ultimately produce the 6-inch annular diameter required by TDEC for monitoring well borings.

The well screen shall have a minimum length of 20 feet to account for seasonal fluctuations in the groundwater levels. The screen will have a slotted interval of 0.010 inches. The bedrock well shall be completed, developed and surveyed in the same manner as the residuum monitoring wells, discussed previously above.

2. GROUNDWATER MONITORING PROGRAM

The following section discusses the Groundwater Monitoring Program that is proposed for the Site in accordance with the TDEC Solid Waste regulations established in Rule 1200-1-7-.04.

2.1 Detection Monitoring Program

Sitewide groundwater monitoring will consist of a Detection Monitoring Program. The requirements of Rule 1200-1-7-.04 state that the Detection Monitoring Program includes quarterly sampling during the landfill's first year of operation to establish a statistical baseline and initial background concentrations in the wells before waste is placed in the facility. Thereafter, the Detection Monitoring Program is reduced to semi-annual sampling. During the quarterly and semi-annual sampling events, groundwater samples from the proposed monitoring wells (Figure 1-1) will be analyzed for the 17 inorganic constituents listed in Table 2-1. As stipulated in Rule 1200-7-.04, none of the volatile organic compounds listed in Appendix I of TDEC Solid Waste Regulations are required in the Detection Monitoring Program for Class II disposal facilities.

Table 2-1: Inorganic Constituents and Analytical Methods for Detection Monitoring

Parameter	EPA Method
Antimony	6010/6020
Arsenic	6010/6020
Barium	6010/6020
Beryllium	6010/6020
Cadmium	6010/6020
Chromium	6010/6020
Cobalt	6010/6020
Copper	6010/6020
Fluoride	6010/6020
Lead	6010/6020
Mercury	7470/7471
Nickel	6010/6020
Selenium	6010/6020
Silver	6010/6020
Thallium	6010/6020
Vanadium	6010/6020
Zinc	6010/6020

Adapted from Appendix I (TDEC 1200-1-7.04)

Upon completion of the quarterly events conducted in the first year, the groundwater concentrations of the constituents in Table 2-1 will be evaluated to determine a representative background concentration. These background concentrations, approved by TDEC, will then be used to screen all subsequent groundwater samples collected during the Detection Monitoring Program.

Field procedures for all groundwater sampling events are discussed in Section 3.0.

2.1.1 Reporting

Within 60 days of the end of each sampling event, TVA will submit a report to TDEC that serves as a summary of the sampling event procedures, analyses and results, and statistical evaluation. As specified in TDEC's *Ground Water Monitoring Guidance for Solid Waste Landfill Units (GW Monitoring Guidance Document),* the report will include the following items:

1. Description of sampling procedures, field measurements (i.e, water quality parameters), purge volumes, dates and times of sampling, and weather conditions;

2. Elevation (mean sea level) of each monitoring well's top of casing and ground surface;

3. Groundwater flow direction and rate across the site;

4. Scaled site basemap that includes all monitoring well locations, the potentiometric surface elevation for the sampling event, the property boundary, and the active and closed fill areas;

5. Summary of sampling parameters and analysis method;

6. Copies of chain of custody forms and laboratory reports;

7. Tabulated sample results compared against background groundwater quality concentrations and groundwater protection standards;

8. Summary of the statistical method used for determining a statistically significant increase (SSI) (meeting the requirements of Rule 1200-1-7-.04) and the results of the statistical analysis;

9. Scaled site basemap that presents the location of each monitoring well and concentrations of the constituents/parameters that were found to statistically exceed background concentrations or groundwater quality protection standards;

10. A schedule for the next sampling event; and,

11. A certification meeting the requirements of Rule 1200-1-7.02(2)(a) 7, 8, and 10.

2.1.2 Statistical Data Evaluation

In accordance with the Detection Monitoring Program requirements, TVA will evaluate the semi-annual results to determine if any constituent exhibits a SSI in concentration. Statistical analyses will be performed using non-parametric prediction intervals (NPI) with an intra-well basis (Gibbons 1990, 1994). This statistical method is currently being used by TVA for assessing groundwater compliance data from the GCB Disposal Facility at KIF and is discussed in detail in Appendix E of the report prepared by Boggs (2005). In general, the NPI method assumes that the distribution of baseline and future compliance sampling data are identical in the absence of contamination from a disposal facility. An upper prediction limit (UPL) for each constituent is determined based on the maximum concentration detected during the baseline sampling period. If the UPL is exceeded during a subsequent sampling event, the well is independently resampled a statistically determined number of times to achieve the desired level of confidence. If all the resample measurements exceed the UPL, the original exceedance is considered an SSI. If at least one of the resample results is below the UPL, the original exceedance is considered insignificant.

If an SSI is determined, TVA will comply with the requirements of Rule 1200-1-7-.04 which requires:

1. notifying TDEC within 14 days indicating which constituents have shown an SSI;

2. establishing an Assessment Monitoring Program within 90 days; or,

3. demonstrating, at TVA's discretion, that the SSI is the result of contamination from source other than the proposed CCB disposal facility or is the result of an error in sampling, analysis, statistical methods, or natural variability.

If the demonstration is not made within 90 days, an Assessment Monitoring Program must be established.

2.2 Assessment Monitoring Program

Within 90 days of triggering an Assessment Monitoring Program, TVA will sample groundwater from the groundwater monitoring system. TVA proposes that these samples be analyzed for the Appendix I inorganic constituents and any parameters specified by TDEC as being characteristic of the waste, but not for the Appendix II constituents of Rule 1200-1-7-.04. Due to the composition and geochemical reactivity of the disposed gypsum, analysis of the Appendix II constituents is unwarranted since they are primarily organic compounds, such as volatile organics, semi-volatile organics, pesticides, and PCBs. As a result, the remaining discussion in this section will refer to the Appendix I constituents and any parameters specified by TDEC as being characteristic of the waste as the Assessment Monitoring Constituents.

The Assessment Monitoring Program consists of Phase 1, 2, and 3 as stipulated in TDEC's GW Monitoring Guidance Document. Each phase is described separately below.

2.2.1 Phase 1

Phase 1 consists of two separate sampling events and several reporting requirements.

Initial Assessment Sampling Event – During this sampling event, all downgradient monitoring points are sampled and analyzed for the Assessment Monitoring Constituents. TVA may request deletion of some constituents if justification can be provided that they should not be reasonably expected to be derived from waste contained in the landfill. This request must be made within the first 30 days of the 90-day timeframe.

Background Sampling for Identified Assessment Monitoring Constituents – This Phase 1 task entails four independent samplings of upgradient and downgradient monitoring points for the Assessment Monitoring Constituents detected in the Initial Assessment Sampling Event that had not been previously detected. The four events will be used to establish background groundwater concentrations for any Assessment Monitoring Constituents without a published background concentration.

Additionally, TVA must:

1. notify TDEC of all detected Assessment Monitoring Constituents within 14 days of receipt of results; and
2. submit a summary report of the results that complies with the reporting requirements of Section 2.1.1 above.

If the Assessment Monitoring Constituents are below groundwater protection standards, TVA will proceed to Phase 2; if any Assessment Monitoring Constituents exceed groundwater protection standards, TVA will notify TDEC within 14 days of the exceedances and proceed to Phase 3 (Groundwater Quality Assessment Program).

At the end of Phase 1, TVA may also submit a written request for alternative groundwater protection standards for constituents without MCLs. The request must satisfy criteria set forth in Rule 1200-1-7-.04(7)(a) ii.

2.2.2 Phase 2

Phase 2 requires two semi-annual sampling events. The first sampling event includes all Appendix I inorganic constituents, any additional approved parameters, and any Assessment Monitoring Constituents previously detected. The second sampling event includes all Assessment Monitoring Constituents and any other approved parameters. As with Phase 1, TVA may request in writing 60 days before sampling to delete any Assessment Monitoring Constituents that are not reasonably expected to be derived from gypsum disposed at the facility.

Each semi-annual sampling event will be summarized in a report that adheres to the requirements discussed previously in Section 2.1.1. If all Assessment Monitoring Constituents are below their groundwater protection standards, the site remains in Phase 2 until these constituents are shown to be statistically below their representative background concentrations for two consecutive sampling events. If any Assessment Monitoring Constituents exceeds groundwater protection standards, TVA must notify TDEC within 14 days of the exceedance and proceed to Phase 3 (Groundwater Quality Assessment Program).

2.2.3 Phase 3 - Groundwater Quality Assessment Program

TVA will submit a Groundwater Quality Assessment Plan (GWQAP) to TDEC within 45 days of discovering an exceedance of a groundwater quality protection standard by an Assessment Monitoring Constituent. Furthermore, TVA must initiate a corrective measures assessment within 90 days of discovering the exceedances as stipulated in Rule 1200-1-7-.04(7)(a)7. During this time, TDEC is authorized to require TVA to take any measure necessary to protect human health and the environment. TVA may not return to Detection Monitoring until the Assessment Monitoring Constituent concentrations are below groundwater protection standards for 3 years or a negotiated timeframe approved by TDEC.

The GQWAP must include the following tasks:

1. Determine a) if solid waste or its constituents have entered groundwater, b) the rate and extent of waste migration or its constituents in groundwater, and c) the concentration of the waste or its constituents in groundwater;

2. Specify the number of additional groundwater sampling locations and the depth(s) of additional well(s) to define the horizontal and vertical extent of release (at least one monitoring well must be installed at the compliance boundary in the direction of migration);

3. Identify domestic and commercial water use sources within a one-mile radius from the center of the disposal facility and report the findings of this survey (i.e., topographic map with sources identified by name, address, coordinates and phone numbers) to TDEC with 45 days; and

4. Conduct quarterly sampling of selected groundwater monitoring points for analysis of parameters with SSIs.

In accordance with Rule 1200-1-7-.02(2)(a) 7, 8, and 10, a qualified groundwater scientist and TVA representative must certify the GQWAP.

As the GQWAP is being developed and approved and throughout its implementation, TVA will conduct quarterly sampling and analysis of all monitoring points and submit results in quarterly reports. The analytes for each quarter include:

<u>Quarters 1 and 3</u>: all Assessment Monitoring Constituents (i.e., Appendix I inorganics, waste-characteristic constituents, and any additional approved parameters); and

<u>Quarters 2 and 4</u>: all constituents with an SSI.

3. GROUNDWATER SAMPLING AND ANALYSIS METHODS

The following section briefly summarizes the primary components of the groundwater sampling and analysis plan to be utilized at the CCB disposal facility Site. These components are described in detail in TVA's Quality Assurance Procedure *Groundwater Sample Collection Techniques* (Attachment A); the document contains requirements for initial groundwater level measurements, groundwater sample collection, preservation, shipment, record-keeping, chain of custody, quality assurance and quality control, and copies of groundwater quality data field worksheets and other pertinent forms.

3.1 Groundwater Level Gauging

Each sampling event will commence with a Sitewide groundwater level gauging event to provide a "snapshot" of groundwater head distribution. These measurements will be collected to the nearest 0.01 ft. and will be used to prepare Sitewide potentiometric surface maps of residuum groundwater and bedrock groundwater to represent groundwater conditions at the time of sampling. The groundwater level data are documented on the Groundwater Level Measurements Form included in Attachment A.

3.2 Groundwater Purging and Sampling

The volume of stagnant groundwater inside each monitoring well will be calculated and removed by purging prior to sampling to ensure that a representative groundwater sample is obtained. The appropriate purging equipment (i.e, bailers, submersible pumps, bladder pumps, etc.) will be chosen based on factors such as groundwater level depths, turbidity, and well recharge. At least two well volumes will be removed from each well during purging while minimizing the amount of water level drawdown to the extent practicable. Wells with poor recharge may be completely purged dry and sampled upon recovery within a 24-hour period. The total volume purged at each well will vary based on its recharge rate and the chemical stability of the groundwater water quality field parameters shown in Table 3-1. The field instruments used to collect water quality data will be appropriately calibrated each day in accordance with TVA's policies and procedures and the manufacturer's instructions.

Table 3-1: Field Parameters

Parameter	Method	Purpose
Conductivity	Field instrument with sensor and probe	Determine groundwater geochemical stability
Dissolved Oxygen (DO)	Field instrument with sensor and probe	Determine groundwater geochemical stability
Temperature	Field instrument with sensor and probe	Determine groundwater geochemical stability
pH	Field instrument with sensor and probe	Determine groundwater geochemical stability
Redox Potential (ORP)	Field instrument with sensor and probe	Determine groundwater geochemical stability
Depth to Water	Water level indicator	Determine amount of water level drawdown
Acidity/Alkalinity	Standard titration method	Geochemical parameter; one-time measurement

All field parameters except acidity/alkalinity are recorded at regular time or volume intervals during purging on a Groundwater Data Field Worksheet (Chemical Data) (shown in Attachment A) to monitor the variability in groundwater chemistry. Once two well volumes have been purged and groundwater pH, conductivity, temperature, dissolved oxygen (DO), and redox potential (ORP) parameters are stable (i.e., within 5% during three consecutive readings with no apparent upward or downward trends), it can be reasonably assumed that groundwater chemistry is consistent and that a sample would be representative of conditions in the aquifer; otherwise, purging continues until these parameters stabilize as specified above. Groundwater sampling generally uses the same equipment that purged the well, unless that equipment is not practical for sampling (i.e., a high discharge pump that cannot reduce flow enough to carefully fill sample containers). Groundwater samples will be unfiltered and collected in appropriate, pre-preserved sample containers. The containers will be labeled with the well name, date/time of sample collection, requested analyses, and preservative. This information will also be recorded on a chain of custody form after sample collection. A final reading of water quality parameters will be conducted immediately after sample collection but not from the sample aliquot itself.

The sample containers will be stored on ice at 4°C inside a cooler. The sample containers will be secured inside the cooler to prevent breakage while in transit to the receiving laboratory. The samples will be shipped to a Tennessee certified analytical laboratory with adequate lead time to ensure holding times are met.

3.3 Laboratory Analyses

During Detection Monitoring, the analytical laboratory will conduct analyses for the 17 Appendix I inorganic constituents shown previously in Table 2-1. With the exception of mercury, the inorganics will be analyzed by EPA Method 6010/6020. Mercury will be analyzed by EPA Method 7470/7471.

3.4 Recordkeeping

A project field logbook will be maintained by TVA personnel or their representative during each groundwater sampling event. The logbook will be used to record pertinent data and observations throughout the entire sampling event. The field logbook are maintained by the lead engineer and will remain in the office at all times when not in use.

Field forms for all sampling activities are included as part of Attachment A. These include:

- Groundwater Quality Data Field Worksheet (Chemical Data) – TVA 30066A
- Groundwater Quality Data Field Worksheet (Physical Data) – TVA 30066B
- Groundwater Level Measurements (Field) – TVA 11552
- Acidity and Alkalinity Worksheet – TVA 30533

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Gibbons, R. D. 1994. *Statistical Methods for Groundwater Monitoring.* J. Wiley & Sons, Inc. New York, New York.

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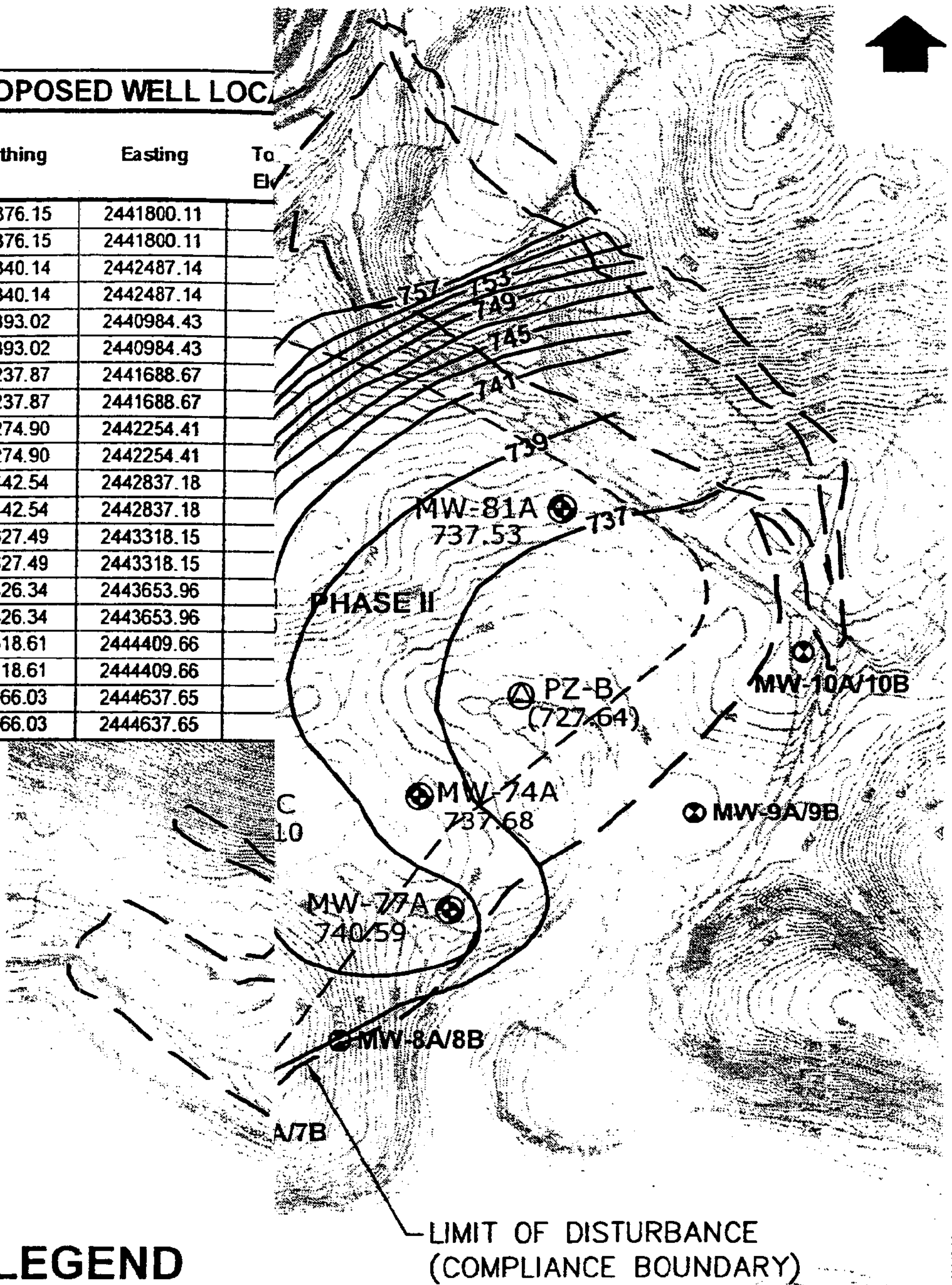
TDEC-DSWM. Ground Water Monitoring Guidance for Solid Waste Landfill Units.

FIGURES

PROPOSED WELL LOC

Well ID	Northing	Easting
MW-1A	550876.15	2441800.11
MW-1B	550876.15	2441800.11
MW-2A	551340.14	2442487.14
MW-2B	551340.14	2442487.14
MW-3A	549393.02	2440984.43
MW-3B	549393.02	2440984.43
MW-4A	549237.87	2441688.67
MW-4B	549237.87	2441688.67
MW-5A	549274.90	2442254.41
MW-5B	549274.90	2442254.41
MW-6A	549442.54	2442837.18
MW-6B	549442.54	2442837.18
MW-7A	549627.49	2443318.15
MW-7B	549627.49	2443318.15
MW-8A	549826.34	2443653.96
MW-8B	549826.34	2443653.96
MW-9A	550318.61	2444409.66
MW-9B	550318.61	2444409.66
MW-10A	550666.03	2444637.65
MW-10B	550666.03	2444637.65



0 400
SCALE IN FEET

LEGEND

MW-N	EXISTING MONITORING WE ELEVATION OF WATER LE
MW-66A (737.45)	WATER LEVEL NOT USED
PZ-E 737.09	EXISTING PIEZOMETER ELEVATION OF WATER LE
737	RESIDUUM GROUNDWATER (ELEVATION OF WATER L 2006)
MW-4A/4B	PROPOSED MONITORING W ("A" WELL IN RESIDUUM,

GEOSYNTEC CONSULTANTS
KENNESAW, GA

ROJECT NO.	GR3731-06	FIGURE NO.	1-1
CUMENT NO.		FILE NO.	3731X048

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ATTACHMENT

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TENNESSEE VALLEY AUTHORITY
ENGINEERING SERVICES

QUALITY ASSURANCE PROCEDURE

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No. ES-41.6

Title: GROUNDWATER SAMPLE COLLECTION TECHNIQUES

Revision:	0
Effective Date:	4/29/94
Prepared by:	L. F. Graser 4-26-94
Technical Reviewer Engineering Services	A. J. Danzig 5-4-94
Technical Reviewer Engineering Services	J. L. Miller
Technical Reviewer Engineering Services	D. J. Bruggink 5-6-94
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Concurred by: Manager, Hydraulic Engineering	P. A. March 5/27/94
Concurred by: Manager, Chatt Engineering	J. W. Shipp 5/6/94
Concurred by: Clean Water Initiative	N. E. Carriker
Concurred by: Environmental Chemistry	G. Quintero

TVA 30025 (RD-RBO 8-91)

Title: GROUNDWATER SAMPLE COLLECTION TECHNIQUES

No. ES-41.6
Page 1 of 1

REVISION LOG

Rev. No.	Date Approved	Revision Description	Reason for Revision
0	4/29/94	Procedure ES-41.6 replaces DS-41.6 Title and organizational changes made.	To reflect reorganization

TVA 30037 (S&F OPS 5-88)

1.0 OBJECTIVE

To prescribe specific, detailed instructions for Engineering Services (ES) personnel involved in the collection of water samples in accordance with standard practices generally accepted by the U.S. Environmental Protection Agency (EPA), U.S. Geological Survey (USGS), and TVA.

2.0 SCOPE

The techniques described herein are limited to those to be used by ES personnel for routine studies. They do not apply to special studies that may require special apparatus and/or handling or specially trained personnel. For example, the collection of groundwater samples at Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites (i.e., "Superfund" sites), certain Resource Conservation and Recovery Act (RCRA) sites, and those activities which fall under the scope of the Superfund Amendments and Reauthorization Act (SARA) of 1986 are not within the scope of this procedure. This procedure applies to collection of routine groundwater samples in connection with TVA's regional water management program activities and assessment of groundwater quality in the vicinity of TVA power facilities.

3.0 REFERENCES

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3.2 Handbook--Groundwater, Environmental Protection Agency, EPA/625/6-87/016, Cincinnati, OH, 1987.

3.3 A Guide to Groundwater Sampling-Technical Bulletin No. 362, National Council of the Paper Industry for Air and Stream Improvement, Inc., New York, NY, 1982.

3.4 Practical Guide for Groundwater Sampling, Environmental Protection Agency, EPA/600/2-85/104, Ada, Oklahoma, 1985.

3.5 Macrodispersion Experiment Management Policies and Requirements (EPRI RP 2485-05), TVA Engineering Laboratory Report No. WR28-2-520-136, Chapters 4.2.6, "Field Tracer Sampling," and 4.2.7, "Field Monitoring and Sampling," 1987.

3.6 Fletcher G. Driscoll, Groundwater and Wells, Johnson Division, St. Paul, Minnesota, Second Ed., 1982.

3.7 40 CFR 136, "Guidelines Establishing Test Procedures for the Analysis of Pollution," Table II - Required Containers, Preservation Techniques, and Holding Times.

3.8 Methods for Chemical Analysis of Water and Wastes, Environmental Protection Agency, EPA-600/4-79-020, Cincinnati, OH, 1979.

3.9 Standard Methods for the Examination of Water and Wastewater, 18th Ed., American Public Health Association, Washington, D.C., 1992.

3.10 Handbook for Sampling and Sample Preservation of Water and Wastewater, Environmental Protection Agency, EPA-600/4-82-029, Cincinnati, OH, 1982.

3.11 Sampling Guidelines for Groundwater Quality, Electric Power Research Institute, EA-4952, Research Project 2485-1, Palo Alto, CA, 1987.

3.12 Groundwater Manual for the Electric Utility Industry, Electric Power Research Institute, CS-3901, Research Project 2301-1 (volumes 1, 2, and 3), Palo Alto, CA, 1985.

3.12.1 Volume 1: Geological Formations and Groundwater Aquifers.

.12.2 Volume 2: Groundwater Related Problems.

3.12.3 Volume 3: Groundwater Investigations and Mitigation Techniques.

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3.14 ES-41.1, "Collection and Handling of Samples."

3.15 ES-41.2, "Water Sample Collection Techniques."

3.16 ES-41.4, "Trace Organics Sample Collection Techniques."

3.17 ES-42.1, 42.3, 42.4, 42.7, 42.8, and 42.11, "Water Quality Field Analyses."

3.18 ES-43.1, 43.2, 43.3, 43.7, and 43.8, "Standardization of Field Instruments."

3.19 ES-5.20, "STORET - Water Quality Data Management."

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4.0 ABBREVIATIONS AND DEFINITIONS

4.1 Definitions

4.1.1 Definitions of job titles and general responsibilities of managerial and supervisory personnel in ES are given in section 5.0.

4.2 Abbreviations

4.2.1 BOD--Biochemical Oxygen Demand

4.2.2 DO--Dissolved oxygen

4.2.3 CHATT ENGG--Chattanooga Engineering Services

4.2.4 Dw--Depth of well in meters

4.2.5 Dws--Distance to water surface from top of well R.P. in meters

4.2.6 EDM--Environmental Data Management (CHATT ENGG)

4.2.7 ES--Engineering Services

4.2.8 ENVIR CHEM--Environmental Chemistry, Water Management Services

4.2.9 EPA--United States Environmental Protection Agency

4.2.10 MLS--Multilevel sampling well

4.2.11 NPDES--National Pollutant Discharge Elimination System

4.2.12 ORP-Oxidation-reduction potential (REDOX)

4.2.13 pH--Measure of hydrogen ion concentration

4.2.14 QAC--Quality Assurance Coordinator

4.2.15 R.P.--Reference Point

4.2.16 USGS--United States Geological Survey

4.2.17 Vw--Volume of water in well measured in liters

5.0 RESPONSIBILITIES

5.1 Functional Area Manager--The manager responsible for various functions such as field engineering projects in a geographical area (i.e., eastern, central, or western geographical locations). The manager directly supervises project engineers and team members in his geographical area.

5.2 Project Engineer--The person responsible for a particular area of expertise, subfunction, or specific projects within the geographical area. The project engineer assists and reports directly to the functional area manager, advises and acts as a resource to teams within his area of expertise and provides technical help to other teams as needed.

5.3 Technical Lead Engineer--The person responsible for a particular project(s) or tasks. These responsibilities include coordination with client organizaion(s), workplan preparation, budget estimates, scheduling of field studies to meet project deadlines, technical adequacy of the work performed and report preparation. All of these lead engineer responsibilities are assumed by team members for their own support of the team.

.4 Quality Assurance Coordinator--The QAC is the functional area manager or his designate and is responsible for Engineering Services procedures that are assigned to that functional area. The QAC assigns a technical writer or reviewer for each procedure. The QAC assures that procedures are correct and up-to-date by requiring technical writers and reviewers to certify in writing on a yearly basis that assigned procedures have received a thorough review. The QAC works closely with the organization Quality Assurance Manager.

5.5 Survey Leader--The survey leader is the individual responsible for a particular piece of work. This individual is responsible for seeing that field work is performed in a technically adequate, timely, and safe manner. The survey leader is responsible for the equipment and supplies; technical supervision of personnel while in the field; collection, handling, and shipping of samples. The survey leader, more than any other person, is responsible for being familiar with the procedures. The survey leader reports directly to the lead engineer for which the work is being done.

5.6 Engineering Services personnel--Personnel assigned to a particular work activity or team. Responsible for conducting tasks in a technically adequate manner and for following QA procedures. Any certification must be current for collection or handling samples (i.e., radiological, hazardous waste, water quality, etc.).

5.7 The Environmental Chemistry Lab, Water Management Services (ECHEM), performs chemical, and physical analyses.

5.8 CHATT ENGG EDM is responsible for coding, keypunching, processing, reviewing, validating, retrieving, and reporting field and laboratory data related to ambient groundwater quality.

6.0 PROCEDURES/REQUIREMENTS

6.1 Workplans

6.1.1 A written workplan is usually prepared in advance of the sampling activities. This written workplan must be coordinated with the client organization and other service organizations. The workplan must receive concurrence by all affected organizations and will address, at a minimum, the purpose of the monitoring activities, the choice of water characteristics to be measured, the method or methods to be employed in collection of the samples, the locations and frequency of sampling, project deadlines, schedules, parameters to be analyzed by the laboratory, budget requirements, and collection of auxiliary data.

6.1.2 If special sample collection requirements, handling techniques, or analyses are required (other than the standard procedures contained in this manual), they will be spelled out in detail in the workplan or in supplemental procedures. All items which will affect the quality of the data to be collected must be addressed in the written workplan and/or referenced to the appropriate ES procedures. The written workplan must be approved by the lead engineer prior to any fieldwork. Also, any workplan revisions must be approved by the lead engineer prior to any field activities associated with a particular workplan revision.

6.2 General Requirements and Instructions for Groundwater Sampling

6.2.1 "Collection and Handling of Samples" (reference 3.14) will be followed as appropriate. In addition, particular attention must be given to the following requirements.

6.2.2 The survey leader will review the workplan in detail and consult with his or her lead engineer prior to the first survey to ensure that no misunderstanding exists about how, when, where, and what samples are to be collected.

6.2.3 Before starting a new work activity at a TVA facility (i.e., nuclear, steam, hydro, etc.), the survey leader will contact the facility manager or his/her designee (usually the Results Section supervisor at a steam plant) and inform them of the work to be performed and on what schedule it will be done. To ensure recognition of any situations which may require special safety awareness, the survey leader will communicate with the plant manager or his/her designee and discuss safety procedures which need to be observed, unusual conditions to be aware of, and names of ES personnel working at the TVA facility.

6.2.4 The survey leader will select and assemble the needed equipment (pumps, meters, Hydrolabs, filtration apparatus, tapes/plunkers, compressor, generators, titration equipment, pH/conductance/ORP standards, buckets, etc), sample containers, workplan, maps, well driller logs, and forms and field worksheets. The survey leader will ensure that all equipment and supplies are appropriately cleaned, in good working order and within their laboratory calibration interval as specified in ES-43.1, attachment 1 (reference 3.18). It is recommended that an equipment checklist be prepared on the initial field survey and that it be referred to and updated on each subsequent survey.

2.5 The survey leader may obtain a summary of the last four sets of field data for use to validate and compare information at the time it is being collected. A computer printout can be obtained from CHATT ENGG-EDM to facilitate this data validation process.

6.2.6 Generally, the survey leader should monitor the wells in a particular order as determined by their typical pH values. For instance, all wells below a pH of 7.0 should be sampled, then all wells above a pH of 7.0 should be sampled. The monitoring equipment should be restandardized between the two ranges of wells using the appropriate pH buffers.

6.2.7 Also, water levels of the wells and reference points should be measured prior to any sampling and recorded. These measurements should be made in as short of a time interval (hrs.) as possible. These "snapshot measurements" should be converted to water level elevations (meters above MSL). Both values should be recorded in a table and presented with well/R.P. description, time of measurement, and depth to well bottom (in meters) along with any pertinent remarks.

6.3 Groundwater Sample Collection Techniques

6.3.1 Quality Control of Sampling Operations

6.3.1.1 Every effort will be made to collect a representative and uncontaminated sample. After each sample is collected, it will be visually examined for any foreign material that is not representative. If any foreign material is observed, or suspected, the sample will be discarded and new sample recollected in a fresh sample container. Do not immerse anything--even a thermometer--in the sample. Always pour the sample directly into the specified containers one at a time. Transferral to another container will greatly increase the opportunity for contamination and cross contamination.

6.3.1.2 Many sample containers contain chemical preservatives. These preservatives may be a source of contamination to other samples, may be ineffective if diluted, or may be harmful if allowed to contact skin or eyes. Use care when handling sample containers with chemical preservatives. Fill sample containers individually, one at a time, to prevent cross contamination of preservatives: uncap the container, fill it directly from the sampler, and recap the sample container immediately. Do not place flexible sample tubing inside the containers unless specifically instructed to do so. Do not lay caps on surfaces that might contaminate them. Do not overfill containers. If any of these potential sources of contamination occur, discard the affected portion of the sample, and collect another portion in a fresh container.

6.3.1.3 Sample collection methods for groundwater may include the use of a submersible centrifugal pump, pneumatic bladder pump, single or 10-channel peristaltic pump, check valve bailer, lysimeter, or perhaps a gas lift pump. The method used to collect a groundwater sample must be compatible with the water quality characteristics of interest. All of these methods, in one or more ways, alter the quality of the sample while it is being collected. In most instances, the submersible centrifugal (low flow, variable speed) pump, the pneumatic bladder pump, or check valve bailer, when used properly, will collect the most representative (least altered) sample for a variety of constituents (particularly volatile organics and reduced/dissolved species). The use of gas lift devices for collection of groundwater quality samples is not recommended. Chapter 6 of reference 3.2 provides additional details.

6.3.1.4 When collecting groundwater samples, the sample should be obtained as close to the discharge of the source or wellhead as possible to reduce the potential for contamination, precipitation of solute, and loss of dissolved gasses. Treated (chlorinated or filtered) or stored groundwater samples, such as from some private or domestic wells are of limited value. Care must be taken to limit sample contact with air and agitation that would interfere with the field determination of pH, ORP, dissolved gasses, acidity, and alkalinity, or the laboratory determination of volatile organics and reduced species.

6.3.1.5 On occasion it may be desirable to determine concentrations of dissolved inorganic constituents (i.e., dissolved minerals or dissolved metals) in groundwater. In such cases, by definition, the sample is filtered through a 0.45 *µm* average pore diameter cellulose ester membrane filter (Millipore Cat. No. HAWP04700 or equivalent) during (pressure filtration) or immediately after (vacuum filtration) sample collection. Techniques used to filter groundwater samples should be discussed in detail in the project's workplan. In most cases, the preferred method for filtration of groundwater is an "in-line" pressure filtration technique which eliminates sample contact with the atmosphere and utilizes the sampling pump's pressure for filtration. <u>The field worksheets and request for laboratory analysis forms must clearly indicate when samples are filtered in the field</u>. Also, all bottles must be properly marked for which constituent the sample was performed (e.g., DM, dissolved metals and etc.). Samples for field analysis (temperature, DO, pH, conductance, ORP, alkalinity, etc.) and certain laboratory analyses (ferrous and manganous ions, sulfide, organics, turbidity, suspended solids, etc.) are never filtered. Additional details in regard to sample filtration procedures are given in section 6.2.2 of reference 3.15.

Condition the filter prior to sampling with 200 to 300 mL of deionized, distilled water (Super Q). This hydrates the filter to lessen the chance of channelization through the filter during sampling. Collect a filter blank with Super Q water after conditioning at the frquency specified in section 6.3.1.7. If filtration difficulties are anticipated because of high solids concentrations, try to develop the well to reduce the level of solids. If too much mud is still present, measure the Hydrolab parameters and pump up as much sample as possible. Let it stand in a sealed, clean container, and decant enough sample for filtering.

6.3.1.6 Samples collected for extremely low levels (i.e., less than one part per billion) of trace organics and/or trace elements may easily be contaminated by contact with foreign materials. Motor oil, gasoline, soft plastics, etc., may be potential sources of contamination for trace organic/pesticide sampling, while soil and dust, which is ubiquitous at fossil plants, may be potential sources of contamination for many trace elements. Reference 3.16 and section 6.3.3.5 below discuss routine precautions which are taken to minimize potential sources of contamination. The permanent installation of a groundwater sampling device in each monitoring well has many advantages. It will eliminate the possibility of the introduction of foreign material during the lowering of sampling equipment into the well and the potential for cross contamination between wells caused by the possible carryover of contaminants on the sampling equipment from one well to another. In those cases where special attention must be paid to extremely low levels of organics or trace elements, permanent installation of sampling equipment/pumps in each groundwater monitoring well is recommended.

6.3.1.7 Unless otherwise specified in the project's workplan, duplicate groundwater samples will be collected at every 20th well (i.e., five percent site specific of the samples collected). Further details in regard to collection of duplicate samples are given in section 6.15.3 of reference 3.14. Also, filter blanks shall be taken when dissolved samples are collected.

6.3.2 Standardization of Field Equipment and Field Measurements

6.3.2.1 ES procedures for standardization of field instruments (reference 3.18) must be followed, as appropriate, with particular attention given to the following instruments which are commonly used by ES in the collection of groundwater quality samples.

6.3.2.1.1

Field Instruments (reference 3.18)	ES Procedure
Hydrolabs	ES-43.2
YSI Conductance Meters	ES-43.3
Orion pH Instruments	ES-43.7
Thermometers	ES-43.8

6.3.2.1.2 Field instruments will be standardized as specified in the above referenced procedures. At a minimum, instruments will be standardized before and after field measurements are made and whenever the accuracy of the instrument is questioned. Form TVA 30035, "Instrument Standardization, Field Standardization of Instruments," will be completed to document all field standardizations of instruments.

6.3.2.2 ES procedures for water quality field analyses (reference 3.17) must be followed, as appropriate, with particular attention given to the following analyses which are commonly used by ES in the collection of groundwater quality samples.

6.3.2.2.1

Water Quality Field Analyses (reference 3.17)	ES Procedure
Alkalinity and Acidity (Ref. Attachment 6 for summary worksheet)	ES-42.1
Total and fecal coliform bacteria	ES-42.2
Conductance	ES-42.3
Dissolved Oxygen (DO)	ES-42.4
Oxidation-Reduction Potential (ORP)	ES-42.7
pH	ES-42.8
Temperature	ES-42.11

6.3.3 Collection of Well Samples Using a Submersible Pump

6.3.3.1 To obtain a representative sample of groundwater, it must be understood that the composition of the water within the well casing and in close proximity to the well is probably not representative of the overall groundwater quality at the sampling site. This is due to the possible presence of drilling contaminants near the well, introduction of foreign material from the surface, casing corrosion, and/or because environmental conditions such as the oxidation-reduction potential (ORP or REDOX) may differ drastically near the well from the conditions in the surrounding water-bearing materials. Consequently, **each well must be flushed** (purged) of standing (i.e., stagnant) water until it contains fresh water from the surrounding aquifer. The recommended length of time required to pump a well and the rate at which a well can be pumped before sampling are dependent on many factors including the physical characteristics of the well, the hydrogeological nature of the aquifer (i.e., hydraulic conductivity), the type of sampling equipment being used, and the water quality parameters of interest.

6.3.3.2 Prior to any sampling or pumping of a well, measure and record the distance to the water surface (Dws) with an acoustic or electric plunker. Also measure and record the depth of the well (Dw) on each survey. Do not rely on past well depth data, since the well may be silting in. Depth measurements (measured to the nearest 0.01 meter i.e. nearest cm.) are usually referenced to the top of the inner well casing and not the outer protective casing. All data, measurements, observations, and computations are to be recorded on form TVA 30066A, "Groundwater Quality Data Field Worksheet (Chemical Data)," attachment 1. In addition, if the well to be sampled is a new well or has never been sampled, form TVA 30066B, "Groundwater Quality Data Field Worksheet (Physical Data)," attachment 2, which documents information about type of well, owner of well, location of well, well drillers log/information, etc., must also be completed.

6.3.3.3 Calculate the volume of water in the well as shown below:

Well Casing ID (mm)	Liters Per Meter
51 (2")	2.027
76	4.560
102 (4")	8.107
127	12.668
153 (6")	18.228

Vw (in liters) = (Dw - Dws) x liters/meter

where:

Vw = Volume of well, liters;
Dw = Depth of well, meters; and
Dws = Depth to water surface, in meters

6.3.3.4 If a submersible pump is not already permanently installed, such as might be the case at "dedicated" pump wells, private or domestic wells, the preferred method of purging and sampling a well is to use a low flow (variable speed controlled) centrifugal pump, a pneumatic bladder pump, or a peristaltic pump (shallow wells). However, in situations where large volumes of water must be purged from a well, resulting in long pumping times (i.e., greater than one hour), a centrifugal pump with a higher pumping capacity (4 to 16 liters per minute) may be used for purging only instead of the lower capacity bladder pump (1-3 liters per minute). All such cases should be specifically addressed in each project's workplan. Domestic wells with a submersible pump already permanently installed can be sampled from a convenient tap or faucet after letting the water run for several minutes.

6.3.3.5 Prior to lowering the pump into the well, (when advantageous) a large ~~tarpaulin or~~ heavy sheet of plastic should be spread on the ground to cover the necessary portion of the work area. This "good housekeeping" practice will help minimize the potential for contamination caused by contact of the soil with the pump and/or pump tubing. Immediately prior to placing the pump into the well, rinse the outside of the pump and the first meter of pump tubing with deionized water. Successive lengths of pump/sample tubing shall be rinsed/wiped with deionized (DI) water before insertion into the well casing.

6.3.3.6 Carefully lower the pump intake to approximately 0.6 to 1.3 meters below the water surface (dependent upon the length of the pump head). The pump should not be lowered below the top of the well screen or to the bottom of the well unless specific instructions to do so are given in the workplan. Studies have shown that lowering the pump to the bottom of a well (below the well screen) may result in a poor flushing of the column of water above the pump if the transmissivity of the aquifer is high. In such cases the pump would be primarily removing inflowing water from the lower portion of the well casing and not effectively removing the water in the upper water column. Pumping from near the surface (and lowering the pump with the drop in the water surface) ensures that inflowing water moves up through the water column and that no stagnant water will remain in the well after purging. The past performance of a well should be used to indicate the appropriate steps for lowering the pump. If the well's recharge rate is slow, the pumping rate will need to be reduced to minimize the drawdown of the water level in the well, or in extreme cases the well maybe completely evacuated ("pumped dry") and allowed to recharge overnight before sampling. At no time should the water level be drawn below the top of the well screen, unless dictated by a very slow recharge rate, requiring "next day" sampling.

6.3.3.7 While purging the well, continuously monitor the time, pumping rate, and distance to water surface. The pumping rate should be adjusted (when possible or reasonable) to minimize the drawdown of the water surface in the well. Using a Hydrolab flow-through cell system to avoid groundwater-air contact, also monitor the groundwater's temperature, pH, DO, conductance, and ORP. Record all the stabilization test data on form TVA 30066A, "Groundwater Data Field Worksheet," attachment 1, approximately every five minutes or less if purge time is expected to be of a short duration. At each well, while recording and monitoring the field stabilization test data (i.e., pumping rate, water surface, temperature, pH, DO, conductivity, and ORP), the survey leader will compare the data being collected with previously collected field data. A computer printout of the last four sets of field results, obtained from the CHATT ENGG, will facilitate this comparison and ensure, on the spot, that valid and comparable data are being obtained.

6.3.3.8 Unless otherwise stated in the workplan, when at least two well volumes of water have been purged from the well and the Hydrolab readings (temperature, pH, DO, conductivity, and ORP) have stabilized, (i.e., do not change by more than 5 percent or have essentially ceased any obviously upward or downward trend between readings), samples may be collected. If the water quality readings have not stabilized after removal of two well volumes, remove a third well volume (if conditions permit), then begin sampling. When filling the various sample bottles/containers, care must be taken to minimize sample aeration, and to gently fill each bottle. This will often necessitate the lowering of the pumping rate to less than one liter per minute to avoid the turbulence caused by the high velocity of the water as it is discharged from the pump tubing. Be sure to record the pumping rate, temperature, pH, DO, conductivity, ORP, etc., at the time of sample collection and record the distance to the water surface immediately upon completion of sampling.

6.3.3.9 If the well's recharge is slow, the pumping rate will need to be reduced to minimize the drawdown of the water surface level in the well. If a well becomes dry during the purging, it must be allowed to recover before sampling to avoid taking a nonrepresentative sample. It may be necessary to allow 24 hours or longer for recovery. If circumstances are encountered which are not addressed in this procedure or in the project's workplan, notify the lead engineer immediately for instructions.

6.3.3.10 After purging and sampling, sample water should be removed from the pump and tubing before sampling another well. A centrifugal pump should have the check valve removed so that water will drain back into the well when the pump is turned off. Before reuse of any pump/sample tubing at any successive well, place the pump head in a container of deionized water (Super Q) and pump through two line volumes of Super Q water to flush the pump and lines thoroughly. NOTE: The "DI" flush water must be removed with two line volumes of sample water. The outside of lines should be wiped with a clean rag or paper towel soaked with DI water. This process shall be repeated at each well that is sampled.

6.3.4 Collection of Samples Using a Bailer

6.3.4.1 Prior to sampling a well with a bailer, measure and record the distance to the water surface and the depth of the well as given in section 6.3.3.2.

6.3.4.2 Calculate the volume of water in the well as shown in 6.3.3.3.

6.3.4.3 Prior to sampling a well with a bailer, thoroughly flush the sampler with deionized water. (As an alternate method, a pre-cleaned disposable Teflon bailer may be used.) Carefully lower the sampler to the water surface. Do not drop the sampler or let it free fall to the water surface, as this will cause aeration of the sample. Gently lower the sampler into the water. Retrieve the bailer. Repeat this process until two well volumes of water have been removed or as specified in the project's workplan.

6.3.4.4 Collect the samples by carefully lowering the sampler to the well screen or the perforated section of the well casing or to the depth specified in the workplan. Care should be taken to avoid striking the bottom of the well with the sampler.

6.3.4.5 Fill the specified bottles/containers directly from the sampler. Slow and careful transfer is important to minimize sample aeration. When filtered samples are requested, use a bailer fitted with an in-line filter. Measure and record temperature, pH, DO, conductivity, ORP, and the distance to the water surface immediately after collection of the sample.

6.3.5 Collection of Samples From Multilevel Sampling (MLS) Wells

6.3.5.1 A typical MLS well, see attachment 3, will consist of several (often 20 to 30) small diameter, flexible sampling tubes. Each tube will have a filter, usually a nylon mesh, on the intake end of the tube with the intake ends of these tubes spaced at known distances below the ground surface. These flexible sampling tubes are housed and extend to the surface inside a PVC pipe as shown in attachment 3.

6.3.5.2 Groundwater samples will be collected from MLS wells using peristaltic 10-channel pumps (i.e., two 10-channel pumps for 20 flexible sampling tubes, three 10-channel pumps for 30 flexible sampling tubes, etc.). In all sample collections from MLS wells, the 10-channel peristaltic pumps will be used in parallel to purge all tubes and collect all samples simultaneously. Every effort will be made to collect representative and uncontaminated samples. An important consideration in obtaining a valid, representative sample is first the removal of the standing water which has been trapped in the multilevel flexible sample tubing since the last sample collection. However, to avoid stressing the aquifer and perhaps altering its natural movement, this purging of the trapped water in the tubing will be minimized. One of the reasons for using the small diameter flexible tubing is that it minimizes the amount of water which is purged. For example, one meter of 5 mm ID tubing contains approximately 19.6 mL of water. Therefore, the purging of two tubing volumes would result in the purging of approximately one liter of water from each sample tube (assuming 25 meter lengths of 5 mm ID tubing) prior to collection of the samples. Specific purging instructions for individual MLS wells will be detailed in each project's workplan.

6.3.5.3 To collect samples at MLS wells, connect the MLS flexible sampling tubes to the 10-channel peristaltic pump tubes by mating like numbered (colored) tubes number 1 through 30 (assuming there are 30 flexible sample tubes and that three 10-channel pumps are used).

6.3.5.4 Place waste containers beneath each sampling tube, turn on the 10-channel peristaltic pumps, and simultaneously purge all the sample tubes of stagnant water by pumping approximately two volumes of water from each sample tube. (One meter of 5 mm ID tubing contains approximately 19.6 mL of water.) Discard the purge water as appropriate or as outlined in the customer's request documentation. Record on the field worksheets any tubes which do not produce water or produce only small quantities of water.

6.3.5.5 After purging the MLS sample tubes, place sample bottles/containers marked with sample identification numbers and in proper numerical order under each correspondingly numbered sample tube. Fill the bottles/containers to the required volume and repeat this step until all types of sample bottles (i.e., metals, minerals, nutrients, sulfide, etc.) have been collected.

6.3.5.6 During the collection of the MLS groundwater samples, it is important to keep track of the fluid volume in each bottle/container, because each sampling tube will not discharge at the same rate. As a bottle or container reaches the proper volume of sample, the sample collector will clamp off the appropriate peristaltic pump tube while allowing the remaining bottles/containers to continue to fill. Finally, after the last bottle or container has filled and the pump tube has been clamped off, the 10-channel peristaltic pumps can be shut off.

6.3.5.7 Immediately after collection of MLS well samples, make field measurements for those water quality characteristics specified in the project's workplan (e.g., temperature, pH, DO, conductivity, ORP, alkalinity, etc.).

6.3.6 <u>Collection of Samples Using a Peristaltic Pump</u>

6.3.6.1 A peristaltic pump can be used to collect a sample from a shallow well (water surface less than 7.6 meters below ground surface), spring or seep.

6.3.6.2 Prior to sampling a shallow well, measure and record the distance to the water surface and the depth of the well as given section 6.3.3.2.

6.3.6.3 Calculate the volume of water in the well as shown in 6.3.3.3.

6.3.6.4 Lower the tygon or teflon tubing connected to the peristaltic pump into the water. Remove at least two volumes of water before collection of samples from a shallow well. No purging of water is necessary if collecting a sample from a spring or seep, since the water is naturally flowing.

6.3.6.4 Fill the specified containers, process the samples, and make the water quality field measurements as specified in the project's workplan. Measure (or estimate) and record the spring or seep discharge rate (or the pumping rate if sampling a shallow well) on form TVA 30066A, "Groundwater Quality Data Field Worksheet," attachment 1.

6.3.7 Collection of Samples Using a Lysimeter (Pressure-Vacuum Soil Water Sampler)

6.3.7.1 General Instructions--Lysimeter (pressure/vacuum soil water samplers) can generally be installed and used at any depth up to approximately 15 meters. The access tubes (i.e., pressure/vacuum tube and sample discharge tube) from the lysimeter can extend above the ground surface directly above the lysimeter, or if conditions require, the access tubes can be laid in a trench, terminating above the ground surface at some distance from the lysimeter. The ends of the access tubes should be installed so that they will be protected from damage by mechanical equipment, livestock, etc. The tube ends should be covered or plugged to prevent debris from entering the tubes and later contaminating the samples. The ground surface directly above the lysimeter should not be covered in any manner that would interfere with the normal percolation of soil moisture down to the depth of the lysimeter. Attachment 4 shows a typical lysimeter installation.

6.3.7.2 Access Tubes--The "pressure/vacuum" access tube and the "sample discharge" access tube are usually small diameter polyethylene tubes (e.g., 5 mm I.D.) that extend from the porous ceramic collection device to the ground surface. Typically the tubes are inserted through a cap or plug at the open end of the porous collection cup as shown in attachment 4. One end of the "sample discharge" tube extends nearly to the bottom of the porous ceramic collection cup with the other (discharge) end extending to the ground surface. The discharge end of this tube must be marked and identified as the tube from which the samples are collected. The "pressure/vacuum" access tube is installed slightly differently. One end of the "pressure/vacuum" tube is inserted only about an 2.5 cm past the cap or plug with the other end also extending to the ground surface. The fit of the tubing through the cap or plug and the fit of the cap or plug at the open end of the porous collection cup must be tight and well seated so as to be able to maintain a pressure-vacuum seal.

6.3.7.3 Installing a Soil Water Sampler--Installation of a lysimeter can be performed in several ways. Methods for installation of a lysimeter must be specified in the project's workplan. Typically a 102 mm hole is cored using a T-handle bucket auger. The augered soil should be sifted through a 6.0 mm mesh screen to remove any larger rocks and pebbles. This sifted soil will provide a reasonably uniform backfill for filling in around the inplaced lysimeter. The following discussion details some of the more common methods for installation of a lysimeter. The primary concern in all the methods is that the porous ceramic cup of the lysimeter be in tight, intimate contact with the soil so that soil moisture can move readily from the soil through the pores of the ceramic cup where it can then be withdrawn through the sample discharge tube.

6.3.7.3.1 Native Soil Backfill Method--After the hole has been cored to the desired depth, insert the lysimeter and backfill the hole with native screened (sifted) soil, tamping continuously with a small-diameter rod to ensure good soil contact with the porous ceramic cup and to prevent surface water from channeling down the cored hole.

6.3.7.3.2 Soil Slurry Method--After the hole has been cored, mix a substantial quantity of the sifted soil from the bottom of the hole with water to make a slurry which has a consistency of cement mortar. This slurry is then poured into the bottom of the cored hole. Immediately after the slurry has been poured, push the lysimeter into the hole so that approximately the bottom third of the lysimeter is completely embedded in the soil slurry. Backfill the remaining voids around the lysimeter with sifted soil, tamping lightly with a small-diameter rod to ensure good soil contact with the lysimeter. Backfill the remainder of the hole, tamping firmly, to prevent surface water from running down the cored hole. The first set(s) of soil water samples collected after installing a lysimeter by this soil slurry method may need to be discarded to avoid differences in water chemistry between the water used to prepare the slurry and the natural soil water.

6.3.7.3.3 Sand and Soil Method--Core hole to the desired depth. Pour into the hole, to a depth of about 51 mm, crushed 200 mesh pure silica sand of almost talcum powder consistency (commercially available under trade names of Super-Sil and Silica Flour). Insert the lysimeter and pour in additional sand until at least the bottom third of the lysimeter is covered. Backfill the remainder of the hole with sifted native soil, tamping to ensure good soil contact with the lysimeter and to prevent surface water from channeling down between the lysimeter and the soil.

6.3.7.3.4 Bentonite-Sand-Soil Method--Core hole to the desired depth. Pour into the hole, to a depth of about 51 mm, a small quantity of wet bentonite clay. This will isolate the lysimeter from soil below. Next, pour in a small quantity of 200 mesh silica-sand and insert the lysimeter. Pour in additional sand until at least the bottom third of the lysimeter is covered. Backfill with sifted native soil to a level about 51 mm above the lysimeter, tamping lightly. Again add about two inches of wet bentonite clay as a plug to further isolate the lysimeter and guard against possible channeling of water down the hole. Finally, backfill the remainder of the hole slowly with sifted native soil, tamping continuously. Allow sufficient time for the wet bentonite clay to harden before using the lysimeter to collect soil water samples.

6.3.7.4 Collecting a Soil Water Sample--After the lysimeter has been installed, a pinch clamp is securely tightened on the sample discharge tube, and a vacuum is applied to the pressure/vacuum tube. A vacuum of approximately 60 centibars (46 cm of mercury) is applied. A pinch clamp is then securely tightened on the pressure/vacuum tube. The lysimeter is then left undisturbed for a predetermined period of time, determined by experience and trial and error or as set forth by work plan instructions.

6.3.7.4.1 The vacuum within the lysimeter causes the soil moisture to move from the soil through and into the porous ceramic cup. The rate at which the soil water will collect in the lysimeter depends on the capillary conductivity of the soil and the amount of vacuum that has been created within the lysimeter. In most soils of good conductivity, substantial soil water samples can be collected within a few hours. Under more difficult conditions it may require several days to collect an adequate volume of sample.

6.3.7.4.2 In general, vacuums of 50-85 centibars (38 cm - 64 cm of mercury) are normally applied to the lysimeter. However, in very sandy soils it has been shown that high vacuums may result in a slow rate of sample collection. In coarse, sandy soils, the high vacuums may deplete the soil moisture in the immediate vicinity of the porous ceramic cup and, hence, reduce the capillary conductivity, which results in lower sample collection rates. In loam and gravelly clay loam, collection rates of 300-500 mL/day at 50 centibars (38 cm of mercury) are common. On waste water disposal sites, collection rates of up to 1500 mL/day have been observed.

6.3.7.4.3 To recover the soil water from the lysimeter, attach the pressure/vacuum access tube to the pressure port on a pump. Place the sample discharge tube into the sample bottle or container being careful to avoid and minimize sample contamination from the surrounding soil excavation. Open both pinch clamps (one on the pressure/vacuum tube and one on the sample discharge tube) and gently apply pressure to develop enough pressure within the lysimeter to force the collected soil water out of the lysimeter and into the sample bottle or container.

6.3.7.4.4 Subsequent samples are collected by again creating a vacuum within the lysimeter and repeating the above steps, sections 6.3.7.4 through 6.3.7.4.3

7.0 HANDLING OF SAMPLES

7.1 Sample Identification--All sample bottles and sample containers shall be labeled with a permanent sample identification number. This sample identification number or tag number must be unique for each sample collected and must be cross referenced on all field sheets (forms TVA 30066A and 30066B), and Analysis Request and Custody Record forms (TVA 30488). Prior to packaging and shipping of samples, all containers and bottles shall be inspected for tag numbers and cross checked against all field sheets, and Analysis Request and Custody Record forms. Additional explanation of sample identification requirements are given in section 6.11, reference 3.14 .

7.2 Packing and Shipping of Samples--Sample containers should be closely protected against contamination while transporting them to the survey site, during sampling, field handling and analysis processes, and while transporting them back to the laboratory. Detailed instructions for packing and shipping the various kinds of samples are given in reference 3.7. These requirements are summarized in attachment 1 of reference 3.15. As soon as possible, samples shall be packed on ice. To avoid breakage, care must be taken when packing bottles and containers in shipping chests. Copies of the Analysis Request and Custody Record forms must be sent to the laboratory with the samples. Check to make sure all paperwork has been accurately completed and sealed in a plastic bag to prevent water damage. All shipping containers shall be clearly addressed and shall be sealed and closed with strapping tape.

7.3 Holding Times--The time which elapses between sample collection and sample analysis is critical for many constituents (e.g., BOD, ortho-phosphorus, turbidity, nitrite, etc.). So that the laboratory can complete the analyses within the appropriate holding times, samples must be shipped or transported so as to arrive within the time limits given in attachment 1, reference 3.15. (ES 41.2) Any time samples are to be collected with holding times less than 48 hours, the laboratory must be notified in advance. All collections of samples should be coordinated with the laboratory.

7.4 Chain-of-Custody--The sample collector is responsible for the care and custody of the samples until they are properly dispatched to the receiving laboratory. The sample collector will ensure that each sample is under his/her control at all times. When samples are dispatched to the laboratory for analyses, the sample collector will retain a copy of the completed Analysis Request and Custody Record form(s), the originals of which accompany the samples. All samples shipped to the laboratory will be listed on the custody record form and cross referenced with their unique sample tag (identification) number. The custody record form should reveal the name and telephone number of the sample collector/shipper and the date of shipment. Shipping record receipts for shipments (UPS, Greyhound bus, etc.) will be retained by the sample collector/shipper as part of the permanent chain-of-custody documentation. Upon receipt, the laboratory will inspect for the shipping container for broken seals and will inspect the samples for breakage, missing samples, tampering, etc. The laboratory will verify all samples by cross referencing tag numbers between the custody record and the sample bottles received to ensure that all samples which were shipped have been received complete and intact. The laboratory will immediately notify the sample collector/ES/shipper of any discrepancies. For non-routine sampling or if shipping after Wednesday of a given week, the shipper should verify the arrival of the samples at the laboratory.

7.5 Field Data Worksheets--Copies of all field data worksheets will be sent to the CHATT ENGG-EDM in Chattanooga. Section 8.3 gives additional details.

8.0 RECORDKEEPING

8.1 Project Notebooks

8.1.1 A project field notebook and/or file shall be maintained by the ES survey leader to record pertinent information and observations. The project field notebook accompanies the survey leader to the field. The survey leader shall record and/or file all physical measurements and field analyses performed in the project notebook/file. In addition, auxiliary data often prove very useful in the interpretation of the results. Thus, water surface elevations of nearby ash ponds, basins, lakes, streams, etc., gas bubbles in the sample line, rapid development of turbidity or color in the sample, equipment problems, clogged sampling ports at MLS wells, weather conditions, deviations from workplans or this procedure, or any number of other observations could prove very helpful and should be recorded. Project field notebooks, should there be a change in personnel, should include all information necessary to properly conduct the field survey. At a minimum this would include: the original project workplan with all approved revisions; sample identification (tag) numbers and descriptions of the well locations; copies of past survey field worksheets and groundwater level observations; computer printouts of prior field data; a survey equipment checklist; and all field instrument calibration records. Also included in the field notebook might be maps, sample collection and handling instructions, bus schedules, names and telephone numbers of project personnel, and any miscellaneous notes to aid in conducting the survey.

8.1.2 A project office notebook and/or file are maintained by the lead engineer. The project office notebooks remain in the office at all times and are available for reference by ES, client, and other project organizations. In addition to containing the original approved project workplan and all approved revisions, it should contain information relating to the project such as memoranda, budget estimates, progress reports, data reports, correspondence with client organizations, etc.

8.2 Survey Reports--Following completion of each groundwater field survey, the ES survey leader will prepare a draft report to the client organization which will be finalized by the lead engineer. The report shall contain:

a. A cover letter addressed to the client from the lead engineer which describes the field activities and notes any unusual conditions (weather, equipment problems, breach of well security, etc.);
b. The Ground Water Quality Data Field Worksheets;
c. Special worksheets (e.g., Acidity and Alkalinity);
d. Instrument Standardization Forms;
e. Groundwater Level Measurements Form; and
f. Analysis Request and Custody Record Form.
g. Other Forms (i.e. bacterial organism worksheet)

Note: The survey leader is responsible for proper routing of the five (color coded) field sheets).

8.3 Disposition of Forms

8.3.1 Forms TVA 30066A and B, Groundwater Quality Data Field Worksheets, attachments 1 and 2, are used any time physical and/or chemical groundwater measurements are made. The original (white copy) is sent to and is filed by CHATT ENGG-EDM. Copies are retained by ES field office per attachment 7 (distribution) and may be sent to the client organization(s) at their request.

8.3.2 Form TVA 11552 (or similar project specific form/table), Groundwater Level Measurements (Field), attachment 5, is used as required, when groundwater elevations are observed or recorded on ash ponds, coal pile runoff ponds, metal cleaning waste ponds, rivers, lakes, groundwater wells, etc. The original (white copy) is sent to and is filed by CHATT ENGG (EDM). Copies are retained by ES field office per attachment 7 (distribution) and may be sent to the client organization(s) at their request.

8.3.3 Form TVA 30488, Tennessee Valley Authority, Water Management Services, Environmental Chemistry Analysis and Custody Record, is used to ship samples to the ECHEM Laboratory and identify the desired analyses. It is to be used anytime samples are shipped or delivered to the ECHEM Laboratory to ensure that the proper number and types of samples as specified in the approved project workplan, are in fact received by the

ECHEM Laboratory. The original (white copy) is sent with the samples to the laboratory. Copies are retained by ES field office per attachment 7 (distribution) and one copy (pink) is sent to CHATT ENGG-EDM. Reference 3.15 contains an example of form TVA 30488.

8.3.4 Form TVA 11064, Sample Custody Record, is only used when samples are shipped or delivered to an external TVA laboratory to aid ES in its internal record keeping functions, or as an aid for shipping/record keeping, for sample custody to an external TVA laboratory. Reference section 3.15 of ES-41.2, contains an example of form TVA 11064.

8.3.5 Form TVA 991, Request for Analysis, is only used for samples requiring external TVA laboratory analyses. It specifies which analyses are to be performed or which workplan is to be followed for sample analyses. The original is sent with the samples to the external TVA laboratory, additional copies will be retained by ES. Reference 3.15 contains an example of form TVA 991.

8.3.6 Form TVA 30533, Acidity and Alkalinity Field Worksheet is to be used by ES, the original is sent to CHATT ENGG-EDM and copies distributed per attachment 7 (distribution).

8.3.7 Retention periods and file locations for these forms are given in attachment 7.

CE 0127V

LIST OF ATTACHMENTS

1. Groundwater Quality Data Field Worksheet (Chemical Data), form TVA 30066A.
2. Groundwater Quality Data Field Worksheet (Physical Data), form TVA 30066B.
3. Schematic Drawing of a Multilevel Sampling (MLS) well.
4. Typical Lysimeter Installation.
5. Groundwater Level Measurements (Field), form TVA 11552.
6. Acidity and Alkalinity Field Worksheet, TVA Form 30533.
7. Records (Use, Distribution, and Retention).

ATTACHMENT 1
GROUNDWATER QUALITY DATA FIELD WORKSHEET (CHEMICAL DATA), FORM TVA 30066A

GROUNDWATER DATA FIELD WORKSHEET

SHEET OF

PRELIMINARY DATA

PROJECT/SITE			PURGE DATE ▶	YEAR / MONTH / DAY
WELL NO.	DEPTH TO WATER (m) 4196	BOTTOM OF WELL (m) 4194	SURVEY LEADER	FIELD CREW
WELL DIAM (mm) 4198	DEPTH OF SCREEN OR OPEN BORE HOLE (CIRCLE) (m) 4191 TO (m) 4190			
[BOTTOM OF WELL - DEPTH TO WATER] x VOL. FACTOR =		WELL VOLUME	TARGET PURGE VOL.	ACTUAL PURGE VOL.
[( )m - ( )m] x ( ) l/m =		4187 (l)	(l)	4188 (l)
SAMPLE TAG NO.	(Circle) UNFLT FLT BOTH		FILTER TYPE/SIZE	

PURGE PUMP (Circle) BLADDER CENTRIFUGAL PERISTALTIC BAILER OTHER (list) ______

SAMPLE PUMP (Circle) BLADDER CENTRIFUGAL PERISTALTIC BAILER OTHER (list) ______

NOTES AND WQ OBSERVATIONS	ET CT TIME (min)	PUMP RATE (l/min)	DEPTH TO WATER (m)	PUMP DEPTH (m)	TEMP (°C)	pH (units)	DO (mg/l)	COND (µs/cm)	(+/-) ORP (mV)	
BEGIN PURGE ⟶										

REMARKS:

Reviewed by:
Survey Ldr: Date
FE Proj. Eng: Date

SAMPLE READINGS ⟶										
SAMPLE DATE YR / MO / DAY		4199		4192	10	400	300	94	90	
PUMP DURATION min	(min) TIME	(l/min) SAMPLE RATE	(m) WATER SURFACE	(m) SAMPLE DEPTH	(°C) TEMP	pH	(mg/l) DO	(µs/cm) CONDUC-TIVITY	(mV) ORP (+/-)	

ADDITIONAL SAMPLE DATA
TURBIDITY 1350 (circle): CLEAR 1 SLIGHTLY TURBID 2 TURBID 3 HIGHLY TURBID 4
COLOR: ODOR:

PHENOL ALK. mg/l	415	MINERAL ACIDITY mg/l	436	WELL DIAM mm	VOL. FACTOR l/m
TOTAL ALK. mg/l	431	CO_2 ACIDITY mg/l	437		

BOTTLES REQUIRED (circle):

SCOD	TIC	FERROUS	MINERAL	PHENOL	OTHERS (list):
COD	SOC	METALS	DIS MINERAL	FILT TIC	
TOC	O&G	DIS METALS	NUTRIENT	TSS/TDS	

WELL DIAM mm		VOL. FACTOR l/m
51	(2 in)	2.027
76	(3 in)	4.560
102	(4 in)	8.107
127	(5 in)	12.668
152	(6 in)	18.228

TVA 30066A (FD BUS 1-93)

DISTRIBUTION: (1) Original - Data Mgt (2) Pink - Lab With Samples (3) Blue - Unit Leader (Office Notebook) (4) Green - Survey Leader (Field Notebook) (5) Yellow - F.E. Project Engineer

ATTACHMENT 2
GROUNDWATER QUALITY DATA FIELD WORKSHEET (PHYSICAL DATA), FORM TVA 30066B

Ground Water Quality Data Field Worksheet
(Physical Data)

Project ______________________________
Well Name/Number ______________ Spring Name/Number ______________
Owner's Name ______________________________
Address ______________________________
Phone Number ______________________________

Well/Spring Information

Lat ______________ Long ______________ State ______________
Location ______________________________
Well Depth (ft.) ______________________________
Depth of Well Screen (ft.) ______________________________
Approximate Water Surface Depth (ft.) ______________________________
Description of Reference Point Used to Make Depth Measurement ______________________________
____
Elevation of Reference Point (MSL-ft.) ______________________________
Water Use ______________________________
Volume of Water Use (GPD) ______________________________
Type Casing ______________________________
Casing Dimensions ID __________ (in) OD __________ (in) Length __________ (ft)
Does well have permanently installed pump? __________ If so, type of pump __________,
capacity (gpm) __________, discharge flow rate (gpm) __________

Well Drillers Log Data

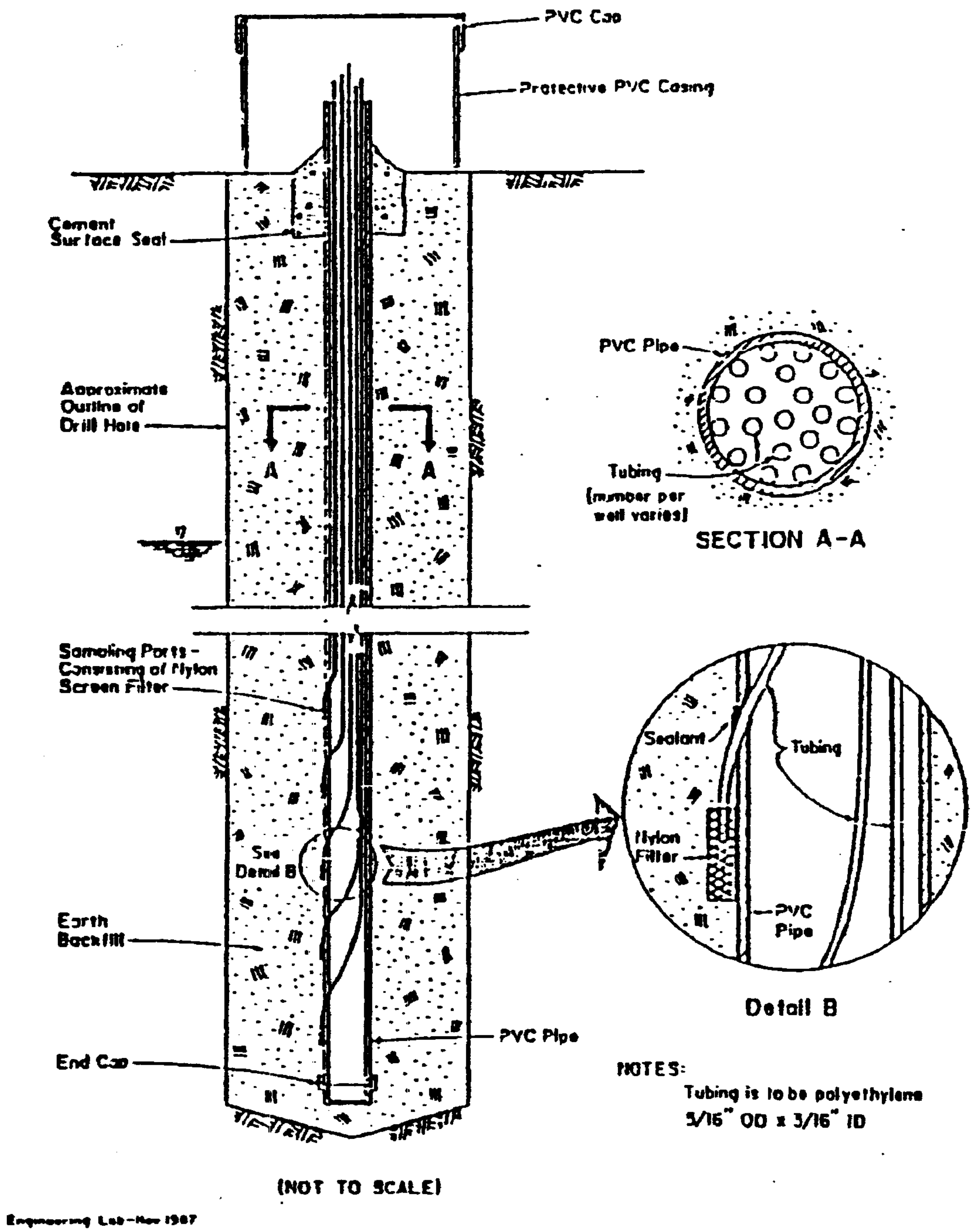
(Attach sketch and/or provide written detailed description)

Remarks: ______________________________
____
____
____
____

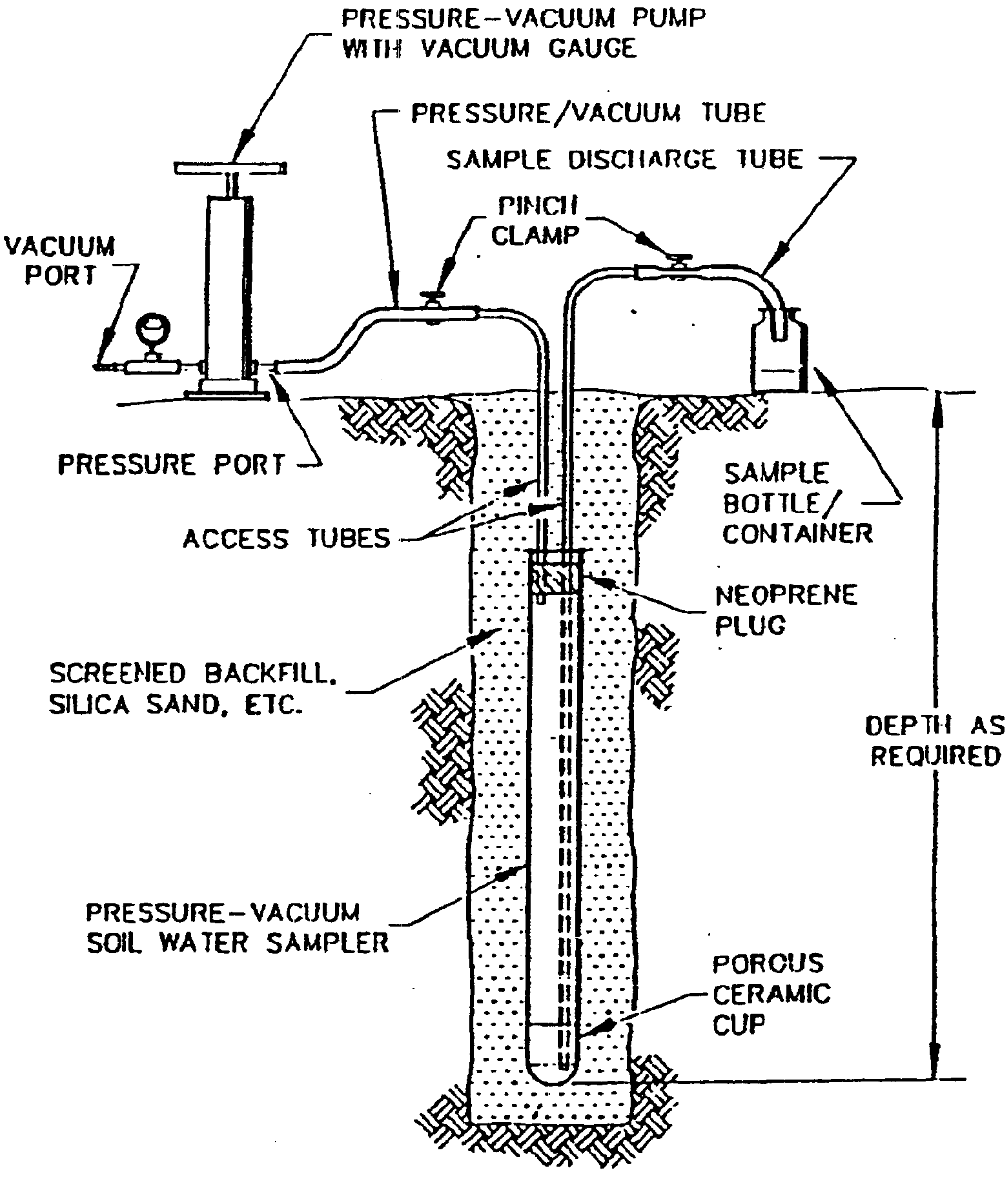
TVA 30066B (WROPS-1-88)   Reviewed by ______________ Date __________

ATTACHMENT 3

SCHEMATIC DRAWING OF A MULTILEVEL SAMPLING (MLS) WELL



ATTACHMENT 4
TYPICAL LYSIMETER INSTALLATION (PRESSURE-VACUUM SOIL WATER SAMPLER)



TYPICAL LYSIMETER INSTALLATION
(PRESSURE-VACUUM SOIL WATER SAMPLER)

ATTACHMENT 5

TENNESSEE VALLEY AUTHORITY
ENGINEERING SERVICES
GROUND-WATER LEVEL MEASUREMENTS (FIELD)

Date___________

Location_________________

Measured by_______________

Well/ RP No. (P84068)*	Description	Reference Point (RP)	Time (ET)	Well RP Elevation(m)	Depth to Water Surface(m) (4195)*	Water Level Elevation (m) (4189)*	Depth to Well Bottom (m) (4194)*	Remarks

* STORET codes

TVA 11552 (5/94)

ATTACHMENT 6
ACIDITY AND ALKALINITY FIELD WORKSHEET, FORM TVA 30533

PRELIMINARY DATA

ACIDITY AND ALKALINITY FIELD WORKSHEET

PROJECT/SITE	COLLECTION DATE	NORMALITY
SURVEY LEADER		ACID
FIELD CREW		BASE

SAMPLE TAG NO.	INITIAL pH	SAMPLE VOL TI-TRATED (ml)	FAC-TOR	ALKALINITY TITRATION(S): ml ACID TO pH 8.3	PHENOL ALK (mg/L) (Ca CO₃)	TOTAL ml ACID TO pH 4.5	TOTAL ALK. (mg/L) (Ca CO₃)	ACIDITY TITRATION(S): ml BASE TO pH 3.7	MINERAL ACIDITY (mg/L) (Ca CO₃)	TOTAL ml BASE TO pH 8.3	CO₂ ACIDITY (mg/L) (Ca CO₃)

ALKALINITY OR ACIDITY (mg/L $CaCO_3$) = $\frac{A \times N \times 50{,}000}{V}$

A = ml TITRANT
N = TITRANT NORMALITY
V = SAMPLE VOLUME

NORMALITY	SAMPLE VOL. TITRATED	FACTOR
0.02N	100 ml	10
0.02N	50 ml	20

REVIEWED BY:

Survey Leader ______ Date ______

FE Proj. Eng. ______ Date ______

DISTRIBUTION: (1) Original - Data Management (2) Pink - Lab with samples (3) Blue - Unit Leader (Office Notebook) (4) Green - survey Leader (Field Notebook) (5) Yellow - F.E. Project Engineer (AJDMDB)

TVA 30533 (RD-BUS 4-92)

ATTACHMENT 7
RECORDS (USE, DISTRIBUTION, AND RETENTION)

Record	Use	Distribution[d]	Retention	Time[a,b,c]
TVA 30066A	GW Data Chemical, Field Worksheet	1-Original to CHATT ENGG-EDM	Files	20 yrs
		2-Copy (pink) ECHEM	as needed	as needed
		3-Copy (blue) ES Field Office	Office notebook	2-3 yrs
		4-Copy (green) ES Field Office	Field notebook	2-3 yrs
		5-Copy (yellow) ES Field Office	Lead Engineer	2-3 yrs
TVA 11552	Groundwater Elevations (wells, water bodies, etc.)	1-Original to CHATT ENGG-EDM	Files	20 yrs
		2-Copy (pink) extra	Lead Engineer	
		3-Copy (blue) ES Field Office	Office notebook	2-3 yrs
		4-Copy (green) ES Field Office	Field notebook	2-3 yrs
		5-Copy (yellow) ES Field Office	Lead Engineer	2-3 yrs
TVA 30488	Request for Analysis and Custody Record	1-Original to ECHEM	ES sample analysis (marked up copy immediately to ES if discrepancies occur)	as needed
		2-Copy (pink) to CHATT ENGG -EDM	Files	20 yrs
		3-Copy (blue) ES Field Office	Office notebook	2-3 yrs
		4-Copy (green) ES Field Office	Field notebook	2-3 yrs
		5-Copy (yellow) ES Field Office	Lead Engineer	2-3 yrs
TVA 11064	Sample Custody Record	1-Original to Lab (outside TVA)	Return to ES w/ sample analysis (Field notebook)	2-3 yrs
		2-Copy (pink) extra	Lead Engineer	
		3-Copy (blue) ES Field Office	Office notebook	2-3 yrs
		4-Copy (green) ES Field Office	Field notebook	2-3 yrs
		5-Copy (yellow) ES Field Office	Lead Engineer	2-3 yrs
TVA 991	Request for Analysis	1-Original to Lab (outside TVA)	Return to ES w/ sample analysis (Field notebook)	2-3 yrs
		2-Copy (pink) extra	Lead Engineer	
		3-Copy (blue) ES Field Office	Office notebook	2-3 yrs
		4-Copy (green) ES Field Office	Field notebook	2-3 yrs
		5-Copy (yellow) ES Field Office	Lead Engineer	2-3 yrs
TVA 30533	Acidity and Alkalinity Field Worksheet	1-Original to CHATT ENGG-EDM	Files	20 years
		2-Copy (pink) extra (client)	Lead Engineer	-
		3-Copy (blue) ES Field Office	Office notebook	2-3 yrs
		4-Copy (green) ES Field Office	Field notebook	2-3 yrs
		5-Copy (yellow) ES Field Office	Lead Engineer	2-3 yrs
Various	Laboratory Results	1-Original to CHATT ENGG by Lab	Files STORET	2 yrs
		2-Copy to ES Field Office	Office notebook	2-3 yrs
		3-Copy to client as required by ES after review	as needed	as needed

a. Retention time for STORET-related data and field sheets is 20 years
b. Retention time for STORET-related laboratory results report forms is 2 years beyond project completion.
c. ES retention time is 2 years MINIMUM after total completion of project and 3 years MINIMUM for on-going projects.
Color coded copies may not be available for all forms.

TVA

Tennessee Valley Authority
Kingston Fossil Plant

CLOSURE AND POST-CLOSURE PLAN

COAL COMBUSTION BYPRODUCT DISPOSAL FACILITY - PENINSULA SITE

KIF450

Prepared By:

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May 2006

Title: CLOSURE AND POST-CLOSURE PLAN COAL-COMBUSTION BYPRODUCT DISPOSAL FACILITY – PENINSULA SITE.				DCN# Plant/Unit: Kingston Fossil Plant
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FOSSIL POWER GROUP
FOSSIL ENGINEERING SERVICES
SITE AND ENVIRONMENTAL ENGINEERING

	Revision 0	R1	R2
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CLOSURE AND POST-CLOSURE PLAN
COAL COMBUSTION BYPRODUCT
DISPOSAL FACILITY –
PENINSULA SITE

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1 INTRODUCTION

1.1 Purpose

The following Closure and Post-Closure Plan (C/PC Plan) has been developed for the proposed Coal Combustion Byproduct (CCB) Disposal Facility located at Tennessee Valley Authority's (TVA's) Kingston Fossil Plant (KIF). This plan is submitted in accordance with the Tennessee Department of Environment and Conservation's Division of Solid Waste Management (TDSWM), Rule 1200-1-7-.03 (2). Closure and post closure activities will be conducted in accordance with the current Subtitle D regulations adopted by the Tennessee Department of Environment and Conservation (TDEC). The purpose of this document is to: (i) describe necessary activities associated with the closure of the disposal facility; and (ii) describe the monitoring and maintenance activities for the facility during the post-closure period. A copy of this C/PC Plan will be kept at the facility, or another approved location.

1.2 Site Location and Description

The CCB disposal facility is located on land currently owned by TVA at the Kingston Fossil Plant (KIF). KIF is located near the city of Harriman in Roane County, TN. Access to the Site is via the plant main entrance which is located on Swan Pond Road. Swan Pond Road is located off Highway 70 between the cities of Kingston and Harriman.

The proposed CCB disposal facility will be located on a peninsula landform at the confluence of the Clinch and Emory Rivers. The CCB disposal facility will extend from the central portion of the peninsula to its southern margin adjacent to the Clinch River. Existing ground surface elevation across the proposed disposal site ranges from approximately 735 ft. to 860 ft. Mean Sea Level (msl).

1.3 Expected Year of Closure

TVA estimates that approximately 547,500 cy of settled gypsum will be produced each year. Under worst case conditions (i.e., no marketing of gypsum), TVA estimates the facility life expectancy indicated in the following sections of the plan. Facility life expectance should be considerably greater than these worst case projections, but is subject to external factors (e.g., demand for gypsum) that are beyond TVA's control.

1.3.1 Phase I

Drawing No. 10W427-8 (Phase II Initial Grading Plan and Soil Dikes) depicts the final grades for Phase I at the end of wet cast operation. Based on this design, there are 6,513,000 cy of disposal capacity available. Assuming a disposal rate of 547,500 cy annually gypsum, Phase I will provide 12 years of disposal capacity under worst case conditions. Completion of disposal operations in Phase I is expected by 2021.

1.3.2 Phase II

Depending on the success of gypsum marketing, TVA may construct Phase II. The final grading plan for Phase I and II at the end of wet cast operation is shown in Drawing No. 10W427-11 (Phase I and Phase II Final Cover Grading Plan (Wet Stack)). Phase I and Phase II combined have an estimated disposal capacity of 13,371,000 cy. Therefore, under worst case conditions, and assuming a disposal rate of 547,500 cy annually, the combined life of Phase I and Phase II wet stack is approximately 24.5 years.

1.3.3 Dry Stack

The CCB disposal facility has been designed to allow dry stacking of gypsum above elevation 900 ft. msl. The additional dry stacking capacity of Phase I and Phase II combined is approximately 2,634,000 cy. With this additional capacity, the estimated life of the facility under worst case conditions is 29 years.

1.4 Facility Contact Information

The following is a list of responsible parties involved in the permitting, design, operation, maintenance, quality control and quality assurance of the CCB disposal facility at TVA's Kingston Fossil Plant.

1. Owner: Tennessee Valley Authority (TVA)
   Contact: Plant Manager
   Tennessee Valley Authority
   Kingston Fossil Plant
   714 Swan Pond Road
   Harriman, Tennessee 37748
   Phone (865) 717-2501

As of the date of this revision, the plant manager is Mr. Michael T. Beckham.

Please direct any correspondence in regards to this document to the designated Solid Waste Specialist. The Solid Waste Specialist for Kingston Fossil Plant is:

Larry C. Bowers
1101 Market Street, LP 5D-C
Chattanooga, Tennessee 37402-2801
Phone: (423)751-4947
Fax: (423)751-7011

2. State: Tennessee Department of Environment and Conservation
   Division of Solid Waste Management
   Tennessee Department of Environment and Conservation
   2700 Middlebrook Pike, Suite 220
   Knoxville, Tennessee 37921-5602
   Phone: (865) 594-6035
   Fax: (865) 594-6115
   Contact as of the date of this manual is Mr. Larry Cook, Environmental Field Office Manager.

Tennessee Department of Conservation
Division of Solid Waste Management
Central Office
401 Church Street
5th Floor, L&C Tower
Nashville, TN 37243-1533
Phone: (615) 532-0780
Fax: (615) 532-0886

Contact as of the date of this manual is Mr. Mike Apple, Division Director.

2 CLOSURE PLAN

Information presented in this document has been organized and presented consistent with the permit application requirements presented in Rule 1200-1-7-.04 (9) (d) and Rule 1200-1.-:03 (2). Sections within this document have been titled and enumerated consistent with the regulations to facilitate the review process. The regulatory requirements are cited in italics at the start of each section followed by a text description indicating how the specific requirement has been or will be addressed.

2.1 Closure Requirements (ref. 1200-1-7-.04 (8))

Regulatory requirement:

(a) General Performance Standard

1. *The operator must close the disposal facility or disposal facility parcel in a manner that:*
   - *(i) Minimizes the need for further maintenance; and*
   - *(ii) Controls, minimizes, or eliminates, to the extent necessary to prevent threats to public health and the environment, post-closure escape of solid waste, solid waste constituents, leachate, contaminated rainfall, or waste decomposition products to the ground or surface waters or to the atmosphere.*
2. *The operator must care for a disposal facility or disposal facility parcel for the period of time after closure, specified in subparagraph (d) of this Rule, in a manner that assures that the performance objectives of part 1 of this subparagraph are continuously met.*

This Closure Plan provides direction to close the disposal facility in a manner that will minimize the need for further maintenance of the facility. It further specifies measures to control, minimize, or eliminate threats to public health and the environment.

(a) Adherence to plan - The operator must initiate and complete closure activities and conduct post-closure care activities in accordance with the approved closure/post-closure care plan, if such plan has been prepared and approved for the disposal facility or disposal facility parcel being closed.

The operator will initiate and complete closure activities and conduct post-closure activities in accordance with the approved closure and post-closure plan at the time of closure of the facility.

(b) Closure Requirements - The following requirements apply to active portions of the facility:

1. *The operator must notify the Division Director of his intent to close at least 60 days prior to the date he expects to begin final closure of the disposal facility or disposal facility parcel.*

2. *The operator must complete closure activities including grading and establishing vegetative cover in the shortest practicable time, not to exceed 180 days, after any fill areas or any portion of the fill areas have achieved final grade, unless the Commissioner allows otherwise in the permit. Permits may provide, or be modified to provide, minimum areas for closure which will be shown in closure plans. Such modifications of closure plans, for the sole purpose of identifying minimum closure areas, shall be deemed minor modifications. When these complete closure areas reach final grade, these areas shall be closed as otherwise provided in this part and within the 180 day time frame provided herein.*

TVA will notify the Director of the Tennessee Division of Solid Waste Management of its intent to close the facility at least 60 days prior to closure. Closure activities will begin within 30 days, after the date on which the disposal unit receives the known final receipt of waste, and the closure activities (including final cover placement, grading, drainage, and establishment of vegetative cover) of each unit will be completed within 180 days following the beginning of closure as previously mentioned, except where an extension is requested and approved by the Tennessee Division of Solid Waste Management.

2.2 Final Cover and Alternative Final Cover Systems (ref. 1200-1-7-.04 (8) (c))

Regulatory requirement:

3. *Unless otherwise noted in the permit a depth of compacted final cover material (e.g., soil) shall be placed on the disposal facility or disposal facility parcel in the shortest practicable time, not to exceed 90 days, after achieving final grade of any fill area or any portion of a fill area. At least the top twelve inches of this cover material shall be soil which will support the growth of suitable vegetation (e.g., topsoil).*

   (i) *At Class I and Class II facilities the depth of final cover system shall be at least 36 inches of soil of which a minimum of 12 inches shall be for the support of vegetative cover.*

   The design of the final cover system shall be such that the infiltration volume of water will be equal to or less than the percolation volume through the bottom liner system or a design which includes a compacted soil layer of at least 24 inches which has a permeability no greater than 1×10^{-7} cm/sec, whichever is less. This design shall be supported by the use of the HELP model or other equivalent method approved by the Commissioner.

   An alternate final cover system may be used provided that it is demonstrated to the satisfaction of the Commissioner that the final cover system provides equivalent or superior performance to the minimum performance standard in this subpart.

   (ii) *At Class III and Class IV facilities, unless the Commissioner determines that a greater depth is needed to achieve the general*

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performance standard of subparagraph (a) of this paragraph, the depth of final cover shall be at least 30 inches of compacted soil. The final cover consists of an 18 inch low permeability layer overlain by a 12 inch protective layer.

(iii) At Class I, II, III, and IV facilities, with approval of the Commissioner any other low permeability layer construction techniques or materials may be used to provide the final cover, provided that it provides equivalent or superior performance to the requirements of this part.

Final cover will be placed over the disposal facility or disposal facility parcel in the shortest time practical, not to exceed 90 days, after achieving final grade.

Details of the final cover system are illustrated on Drawing No. 10W427-20 (Final Cover System Details). As shown in the drawing, the final cover system will consist of the following profile, from top to bottom:

- a 12-inch thick protective cover soil (vegetative cover) that is capable of sustaining native plant growth;
- a 24-inch thick compacted clay layer exhibiting hydraulic conductivity of less than or equal to 1×10^{-7} cm/sec; and
- a 6-inch thick intermediate cover soil.

The final cover grading plan is presented in Drawing No. 10W427-12 (Phase I and II Final Cover Grading Plan (Wet and Dry Stack)). As shown in this drawing, the final cover will be graded to a minimum slope of 4 percent and a maximum slope of 33.3 percent.

Consistent with the regulations, the use of alternative final cover systems are acceptable if it can be demonstrated that the alternative system provides equivalent or superior performance to the minimum performance standard. An alternative final cover has been developed for this facility and may be substituted as an alternative. The proposed alternative final cover consists of (from top to bottom):

- a 12-inch thick vegetative layer that is capable of sustaining native plant growth;
- a geocomposite drainage layer, consisting of a High-Density PolyEthylene (HDPE) geonet with geotextile filters heat bonded to both sides of the geonet;
- a 40-mil thick HDPE geomembrane; and
- a 12-inch thick compacted soil layer.

The calculation package titled "*Final Cover System Demonstration*", included in this permit application demonstrates, using the Hydraulic Evaluation of Landfill Performance (HELP) model, that the alternative final cover system provides equivalent or superior performance, (in terms of equivalent reduction in infiltration) to the minimum requirements of the prescribed final cover system. The alternative final cover system will be implemented only after approval of the Commissioner of the Tennessee Division of Solid Waste Management.

2.3 Drainage System (ref. 1200-1-7-.04 (8) (c))

Regulatory requirement:

4. *The final surface of the disposal facility or disposal facility parcel shall be graded and/or provided with drainage facilities in a manner that:*

    (i) Minimizes precipitation run-on from adjacent areas onto the disposal facility or disposal facility parcel;
    (ii) Minimizes erosion of cover material (e.g., no steep slopes);
    (iii) Optimizes drainage of precipitation falling on the disposal facility or disposal facility parcel (e.g., prevent pooling); and
    (iv) Provides a surface drainage system which is consistent with the surrounding area and in no way significantly adversely affects proper drainage from these adjacent lands.

The proposed grading plan of the drainage system (surface water management system) for the TVA Kingston Fossil Plant disposal facility is provided in Drawing No. 10W427-13 (Surface Water Management Plan). Runoff from primarily undisturbed areas to the north of the disposal area (referred to as "run-on") will be intercepted by a system of drainage channels to prevent from "running-on" to the active portion of the disposal area. This system of drainage channels will collect and convey run-on to Watts Bar Lake Clinch River to the south of the disposal area, through a drop inlet and culvert system which will be located underneath the bottom of the stormwater pond. The stormwater management system for this facility is designed such that run-on from undisturbed areas (i.e., outside the limits of the disposal area) will bypass the stormwater pond located to the south-west of the disposal area.

Erosion of soil material on the final cover system will be minimized through slope stabilization techniques. The final cover slope will not exceed a 33 percent (i.e., 3 horizontal: 1 vertical) slope. The maximum slope length of the steepest slope (between drainage benches) is 90 feet. The cover system optimizes drainage and precipitation run-off by maintaining minimum top slopes of 4 percent to prevent ponding of water on top of the cover. Benches will intercept surface water runoff from the cover slopes and convey the runoff to downdrain pipes, which will convey the runoff to the perimeter drainage channels located at the toe of the cover system. The perimeter drainage channels are sloped towards the south-west corner of the disposal area and will connect to a drop-inlet and twin 36-inch diameter culvert system under the perimeter access road conveying runoff to the stormwater pond. All drainage structures have been designed to accommodate at least a 25-year, 24-hour storm event. The surface water management system has been designed to be consistent with the surrounding area and does not significantly affect proper drainage from or to adjacent lands.

In addition, vegetation will be established on the final cover system surface as the fill progresses to prevent erosion of final cover material.

2.4 Vegetative Cover (ref. 1200-1-7-.04 (8) (c))

Regulatory requirement:

> 5. *In order to minimize soil erosion, as soon as practicable after final grading, the operator shall take steps as necessary to establish a protective vegetative cover of acceptable grasses over disturbed areas of the site. These steps shall include seeding, mulching, and any necessary fertilization at a minimum, and may include additional activities such as sodding of steeper slopes and drainage ways if such are necessary.*

As soon as practical after final grading, the operator will take necessary steps to establish a protective vegetative cover of acceptable grasses over disturbed areas of the site. These steps shall include seeding, mulching, and any necessary fertilization at a minimum, and may include additional activities such as sodding of steeper slopes and drainage ways if necessary. Application rates for seeding and fertilizing of indigenous grass/vegetation are provided in the *Material* Specifications and Construction Quality Assurance and Quality Control (QA/QC) Plan included as Appendix F in this permit application. Temporary erosion control blankets may be used if necessary to provide seedbed protection and prevent wash-out of seed and fertilizer during vegetation establishment. The closure will be scheduled to ensure at least one month remains in the growing season to establish a grass cover, or alternatively the entire cover will be re-seeded at the start of the next growing season, after confirming that the grades of the cover and the condition of the cover soil are in accordance with the QA/QC plan.

2.5 Other Erosion and Sediment Control Measures (ref. 1200-1-7-.04 (8) (c))

Regulatory requirement:

> 6. *In addition to the drainage and grading requirements and vegetative cover requirements, the operator shall take other measures as may be necessary to minimize and control erosion and sedimentation (e.g., soil stabilization, sediment ponds) at the site.*

In addition to the drainage, grading, and vegetative cover requirements, other measures such as soil stabilization through riprap protection, and sediment ponds will be implemented to minimize and control erosion and sedimentation at the site. The perimeter ditches, drainage benches, and culvert outlet areas will be lined with riprap. The stormwater pond located to the south-west of the disposal area was sized to accept sediment of 67 cubic yards per acre of disturbed area. Additional erosion control problems will be addressed with appropriate structural and non-structural sediment and erosion control practices as prescribed within the plans or the most recent edition of the Tennessee Erosion and Sediment Control Handbook.

2.6 Leachate Collection System (ref. 1200-1-7-.04 (8) (c))

Regulatory requirement:

> *7. As required in his permit, or as otherwise necessary to prevent threats to human health and the environment, the operator shall establish and/or complete a system for collecting, removing, and treating leachate generated by the disposal facility or disposal facility parcel.*

Leachate from this facility will consist of consolidation water resulting from the self-weight consolidation of the gypsum material. Consolidation water will be collected using the perimeter drains depicted on Drawing No. 10W427-16 (Operational and Typical Details I) and the central drainage corridor depicted on Drawing No. 10W427-18 (Drainage System Details I). Consolidation water will be managed together with stormwater run-off and will be routed through the stormwater pond prior to being pumped (with stormwater) to the plant's discharge channel for discharge under KIF's existing NPDES permit. In addition, decant water from the sluicing operations will also be routed to the stormwater pond.

2.7 Gas Collection System (ref. 1200-1-7-.04 (8) (c))

Regulatory requirement:

> *8. As required in his permit, or as otherwise necessary to prevent threats to human health and the environment, the operator shall establish and/or complete a system for collecting and venting or otherwise controlling the vertical and horizontal escape of gases generated in the disposal facility or disposal facility parcel.*

Since this disposal facility accepts only gypsum waste, and no gas is expected to be generated from the waste, Rule 1200-1-7-.04 (8) (c) 8 is not applicable to this facility.

2.8 Borrow Area Reclamation

Borrow areas which are used for excavation and construction of final cover soil will be reclaimed by regrading, stabilizing, and establishing permanent vegetation, within 30 days of ceasing borrow activities. Borrow and stockpile areas will be graded to allow positive drainage off-site. Additional erosion controls will be addressed with appropriate structural and non-structural sediment and erosion control practices as prescribed within the plans or the most recent edition of the Tennessee Erosion and Sediment Control Handbook.

2.9 Closure Sequence

Upon achieving the appropriate final grades for the gypsum waste, the disposal facility will be closed in the following sequence (for clarity, this closure sequence refers only to the proposed final cover system, rather than the alternative final cover system):

1) Prior to construction of the final cover system, an on-site or off-site borrow source for soil material will be identified, and both field and laboratory tests will be performed to ensure that the properties of the soil from the proposed borrow area satisfy material acceptance criteria provided in the QA/QC plan.

2) Closure will then begin by installing the compacted soil layer in a controlled manner in lifts using materials from the designated borrow source. The QA/QC plan will be followed to monitor the consistency of the compacted soil layer as it is placed.

3) The vegetative soil cover will be installed on top of the compacted soil layer under the supervision of the TVA site construction manager and a professional engineer registered in the State of Tennessee. To aid in root development, this layer will be moderately compacted.

4) Finally, the surface of the cover will be seeded and/or vegetated, and fertilizer will be added to promote germination and growth. Application rates for seeding and fertilizing are provided in the QA/QC plan.

In case of contingent closure, the disposal facility shall be re-graded to prevent the ponding of water. The grade of the final cover surface of the facility may not be less than 4 percent and no greater than 33.3 percent.

2.10 Closure Certification and Notification (ref. 1200-1-7-.04 (8) (c))

Regulatory requirement:

9. *The operator must notify the Division Director in writing within 60 days of his completion of closure of the disposal facility or disposal facility parcel. Such notification must include a certification by the operator that the disposal facility or disposal facility parcel has been closed in accordance with the approved closure/post-closure care plan. Within 21 days of the receipt of such notice the Division Director shall inspect the facility to verify that closure has been completed and in accordance with the approved plan. Within 10 days of such verification, the Commissioner shall approve the closure in writing to the operator. Closure shall not be considered final and complete until such approval has been made.*

TVA will close the Kingston Fossil Plant Disposal Facility in accordance with the closure plan approved by TDEC Division of Solid Waste Management. Upon completing all the requirements outlined in the closure plan, TVA will provide the Division of Solid Waste Management with certification, signed by an independent professional engineer registered in the State of Tennessee, verifying compliance with closure requirements within 60 days after completing the closure requirements.

3 POST-CLOSURE PLAN

3.1 Post-Closure Care Period (ref. 1200-1-7-.04 (8) (a) and (d))

Regulatory requirement:

(a) General Performance Standard

(ii) The operator must care for a disposal facility or disposal facility parcel for the period of time after closure, specified in subparagraph (d) of this Rule, in a manner that assures that the performance objectives of part 1 of this subparagraph are continuously met.

(d) Post-Closure Care Period - For Class I and Class II disposal facilities, post-closure care must continue for 30 years after the date of final completion of closure of the disposal facility or disposal facility or parcel unless a shorter period is established in the approved closure/post-closure care plan. For Class III and IV disposal facilities, post-closure care must continue for 2 years after the date of final completion of closure of the facility or facility parcel. The postclosure care period may be reduced or extended based on cause by amendment of the approved closure/post-closure care plan as provided in rule 1200-1-7-.03(2)(e).

TVA will provide post-closure care for the disposal facility for a period of thirty (30) years after completion of disposal facility closure activities, in accordance with this Post-Closure Plan.

3.2 Post-Closure Care Activities

3.2.1 Final Contours and Drainage System (ref. 1200-7-.04 (8) (e))

Regulatory requirement:

(e) Post-Closure Care Activities - During the post-closure care period, the operator must, at a minimum, perform the following activities on closed portions of his facility:

1. Maintain the approved final contours and drainage system of the site such that the objectives of part (c) 4 of this paragraph are continuously met;

The approved final contours and drainage system will be maintained at the site. The effectiveness of the final cover will be maintained by making repairs to the cover as necessary to correct the effects of subsidence and erosion, as well as preventing run-on and run-off from eroding/damaging the final cover system. If settlement or other structural problems occur in the final cover system, the cover will be regraded. The problem area will be stripped of the vegetation layer and fill dirt will be applied to the area. The disturbed area will be covered with soil and reseeded as specified in the design. If excessive surface cracks appear on the soil cover, the cracks will be properly graded with suitable soil and appropriate vegetative cover will be re established to prevent the infiltration of surface water.

The disposal area final cover has been designed with a series of benches and downdrains to provide for positive, non-erosive drainage of run-off into the perimeter ditches located along the toe of the disposal area cover. The ditches convey water and sediment to a stormwater pond located on the south-west portion of the site as shown on Drawing No. 10W427-13 (Surface Water Management Plan). The pond is designed to control run-on and run-off from all storms up to the 100-year, 24-hour storm event. Based on the analyses included in Appendix B in this permit application, additional storage volume has been reserved in these ponds to provide sediment storage of at least 67 cubic yards per acre of site area.

The sediment will be removed when the sediment level reaches the specified sediment cleanout elevation of the silt gauge, or when the specified elevation is obscured by water for a long period of time. The sediment cleanout elevation has been specified for the stormwater pond in the *Surface Water Management* analyses package. The sediment ponds will be cleaned using a dragline, clamshell or dredge, or drained and excavated using a backhoe, front-end loader, dozer, or other equipment. The outlet and inlet structures of the stormwater pond will be maintained by the operator throughout the life of the disposal facility and during the post-closure period.

3.2.2 Vegetative Cover (ref. 1200-7-.04 (8) (e))

Regulatory requirement:

> 2. *Ensure that a healthy vegetative cover is established and maintained over the site.*

The vegetative cover will be inspected on a monthly basis so as to maintain a healthy stand of vegetation. Areas containing distressed vegetation will be reseeded. The vegetative cover over the site will be maintained by mowing on a regular schedule. Initially the grass will be cut quarterly; however, once the grass is established, it will be cut twice a year. The mowing schedule is intended to limit the growth of weeds or rooting of brush species that could undermine the final cover. If an area has less than 25 percent coverage by grass, the area will be reworked and reseeded. Fertilizer may be applied to promote the re-establishment of a self-sustaining vegetative cover. Significant depressions or gullies that develop will be promptly repaired by filling with soil and seeding. The details of the vegetative cover are provided in the QA/QC plan.

Regulatory requirement:

> 3. *Maintain the drainage facilities, sediment ponds, and other erosion/sedimentation control measures (if such are present at the landfill), at least until the vegetative cover is established sufficiently enough to render such maintenance unnecessary.*

Until vegetation of the final cover is fully established, sediment transport will be retarded by temporary silt fences. Sediment transported from the cover before vegetation is fully established will be conveyed to the stormwater pond. Should excessive cleaning and maintenance of the stormwater pond be needed due to erosion of soil from the cover, temporary sediment control measures will be installed to reduce the sediment load until the vegetative cover is fully established. Stormwater channels will be lined to prevent erosion. The channels will be inspected monthly and after major storm events for structural and erosion problems. If damage to the channel is discovered, it will be repaired as appropriate.

3.2.3 Leachate Collection System (ref. 1200-7-.04 (8) (e))

Regulatory requirement:

> 4. *Maintain and monitor the leachate collection, removal, and treatment system (if such is present at the facility);*

Leachate from this facility will consist of consolidation water resulting from the self-weight consolidation of the gypsum material. Maintenance of the collection system will include inspecting the underdrain lift station, removing sediment and debris (if needed), verifying operation of pumps, inspecting perimeter drains on outer sideslopes, ensuring that outlets are clear and unobstructed.

3.2.4 Gas Collection System (ref. 1200-7-.04 (8) (e))

Regulatory requirement:

> 5. *Maintain and monitor the gas collection and control system (if such is present at the facility);*

Since this disposal facility accepts only gypsum waste, and no gas is expected to be generated from the waste, Rule 1200-1-7-.04 (8) (e) 5 is not applicable to this facility.

3.2.5 Groundwater Monitoring Plan (ref. 1200-7-.04 (8) (e))

Regulatory requirement:

> 6. *Maintain and monitor the ground and/or surface water monitoring system (if such is present at the facility). The monitoring system and sampling and analysis program established in the permit shall be*

> *continued during the post-closure care period, unless the permit is modified to establish a different system or program. Monitoring data must be reported in writing to the Division Director within 30 days after the completion of the analyses.*

The groundwater monitoring during the post-closure care period will be performed in conformance with the Groundwater Monitoring Plan presented in Appendix D of this permit application. The locations of existing and proposed groundwater monitoring wells are shown on Drawing No. 10W427-3 (Site Development Plan). Monitoring data will be reported in writing to the Division Director within 30 days after the completion of the analyses.

3.2.6 Inspections

Personnel from TVA will make visual inspections of the site on a regular basis, at least quarterly, for the duration of the post-closure care period. Maintenance or other corrective measures needed to prevent the deterioration of the closure system will be identified during the inspections.

Features to be inspected include the disposal site, surface-water and ground-water monitoring points, security devices, and storm-water control features. Each inspection will be documented and will include, at a minimum, the following information: date and time of inspection, name of inspector, notation of observations made, nature of any remedial actions to be taken, and recommendation for corrective measures.

3.2.7 Post-Closure Certification (ref. 1200-7-.04 (8) (e))

Regulatory requirement:

> 7. *Following completion of the post-closure care period for each SWLF unit, the owner or operator must file with the Department a certification verifying that post-closure has been completed in accordance with the post-closure plan.*

The operator will notify the Division Director in writing of its completion of the post-closure care period of the disposal facility within 60 days of completion of the post-closure care period. An independent professional engineer in the State of Tennessee will certify that the post-closure activities were completed in accordance with the post-closure care plan.

4 NOTICE IN DEED TO PROPERTY (ref. 1200-7-.04 (8) (f))

Regulatory requirement:

(f) Notice in Deed to Property - the operator must ensure that, within 90 days of completion of final closure of the facility and prior to sale or lease of the property on which the facility is located, there is recorded, in accordance with State law, a notation on the deed of property or on some other instrument which is normally examined during a title search that will in perpetuity notify any person conducting a title search that the land has been used as a disposal facility and its use is restricted in accordance with the approved closure/post-closure plan.

Within 90 days of completion of final closure activities of the facility and prior to final sale or lease of the property on which the facility is located, TVA will ensure that there is recorded, in accordance with State law, a notation on the deed to the property or some other instrument, which is normally examined during a title search that will in perpetuity notify any person conducting a title search that the land has been used as a disposal facility, and the use of the property is restricted in accordance with the approved closure/post-closure plan.

CLOSURE AND POST-CLOSURE COST ESTIMATE

Cost Estimate
Work Sheet A
Closure Activities - Compacted Clay Final Cover Option

Notes:

1) This worksheet is to be submitted as part of the C/PC Plan.
2) Provide a cost for all activities that apply.
3) Additional cost information may be attached as needed.
4) All soils used for final cover construction are from on-site sources.

I. Establishing Final Cover

A. Top Soil	
1. Quantity Needed (cu.yd.)	179,147.05
2. Excavation Unit Cost ($/cu.yd.)	$3.95
3. Excavation Cost (1. * 2.)	$707,630.85
4. Placement/Spreading Unit Cost ($/cu.yd.)	$9.21
5. Placement Cost (1. * 4.)	$1,649,944.33
TOTAL Top Soil (3. + 5.)	$2,357,575.18
B. Landfill Cap	
1. On-Site Clay	
a. Quantity Needed (cu.yd.)	394,123.51
b. Excavation Unit Cost ($/cu.yd.)	$3.95
c. Excavation Cost (a. * b.)	$1,556,787.86
d. Placement/Spreading Unit Cost ($/cu.yd.)	$9.21
e. Placement Cost (a. * d.)	$3,629,877.53
f. Compaction Unit Cost ($/cu.yd.)	$1.32
g. Compaction Cost (a. * f.)	$520,243.03
TOTAL On-site Clay (c. + e. + g.)	$5,706,908.42
2. Off-Site Clay	
a. Quantity Needed (cu.yd.)	
b. Purchase Unit Cost ($/cu.yd.)	
c. Purchase Cost (a. * b.)	$0.00
d. Delivery Unit Cost ($/cu.yd.)	
e. Delivery Cost (a. * d.)	$0.00
f. Placement/Spreading Unit Cost ($/cu.yd.)	
g. Placement Cost (a. * f.)	$0.00
h. Compaction Unit Cost ($/cu.yd.)	
i. Compaction Cost (a. * h.)	$0.00
TOTAL Off-Site Clay (c. + e. + g. + i.)	$0.00

3. Quality Control/Testing of Clay	
a.	
b.	
c.	
TOTAL Clay Testing (LS)	$26,318.64
TOTAL Landfill Cap	$5,733,227.06

C. Synthetic Membrane	
1. Quantity Needed (sq.yd.)	
2. Purchase Unit Cost ($/sq.yd.)	
3. Purchase Cost (1. * 2.)	$0.00
4. Installation Unit Cost ($/sq.yd.)	
5. Installation Cost (1. * 4.)	$0.00
TOTAL Synthetic Membrane (3. + 5.)	$0.00

D. Geotextile Filter Fabric	
1. Quantity Needed (sq.yd.)	
2. Purchase Unit Cost ($/sq.yd.)	
3. Purchase Cost (1. * 2.)	$0.00
4. Installation Unit Cost ($/sq.yd.)	
5. Installation Cost (1. * 4.)	$0.00
TOTAL Geotextile Filter Fabric (3. + 5.)	$0.00

TOTAL for Establishing Final Cover (A. + B. + C. + D.) [redacted]

II. Establishing Vegetative Cover

A. Labor ($/acre)	$460.58
B. Seeding ($/acre)	$460.58
C. Fertilizing ($/acre)	$328.97
D. Erosion Control Matting ($/acre)	$65.80
E. Number of Acres	101

TOTAL for Establishing Vegetative Cover (A. + B. + C. + D.) * E. [redacted]

III. Establishing/Completing a System to Minimize & Control Erosion/Sedimentation

A. Sedimentation Pond

1. Excavation/Construction ($)

2. Materials (e.g. pipe. Riprap) ($)	
TOTAL for Sedimentation Pond (1. + 2.)	$0.00

B. Diversion Ditch

1. Construction ($)	
2. Materials ($)	
TOTAL for Diversion Ditch (1. + 2.)	$0.00

C. Temporary Structures (Filtrexx Siltsoxx)

1. Quantity needed (ft)	6550.36
2. Materials unit cost ($/ft)	$2.00
3. Materials cost ($)	$13,100.72
4. Construction unit cost ($/ft)	$1.50
5. Construction cost ($)	$9,825.54
TOTAL for Temporary Structures (3. + 5.)	$22,926.26

TOTAL for establishing or completing a system to minimize & control erosion & sedimentation (A. + B. + C.)	$22,926.26

IV. Establishing or Completing Leachate Collection Removal, & Treatment System

A. Installation

1. Number of Feet	
2. Piping System Unit Cost ($/ft)	
3. Piping System Cost (1. * 2.)	$0.00
4. Storage Tanks ($)	
5. Pumps ($)	

TOTAL for Establishing or Completing Leachate System (3. + 4. + 5.)	$0.00

V. Establishing or Completing a System to Collect or Vent Gases

A. Installation

1. Materials (e.g. piping)	
2. Equipment (e.g. pumps)	
3. Labor (e.g. drilling)	

TOTAL for Establishing or Completing a System to Collect or Vent Gases (1. + 2. + 3.)	$0.00

VI. Establishing or Completing Groundwater/Surface Water Monitoring System

A. Installation

1. Number of Wells	
2. Drilling Unit Cost ($/Well)	
3. Drilling Cost (1. * 2.)	$0.00
4. Materials Unit Cost ($/Well)	
5. Materials (1. * 4.)	$0.00
6. Equipment (e.g. pumps)	
7. Labor	
TOTAL for Establishing or Completing Groundwater Monitoring System (3. + 5. + 6. + 7.)	$0.00

TOTAL CLOSURE COSTS (SUM OF TOTALS FOR SECTIONS I. THOUGH VI.)	$8,246,567.70

Cost Estimate
Work Sheet A
Closure Activities - Composite Final Cover Option

Notes:

1) This worksheet is to be submitted as part of the C/PC Plan.
2) Provide a cost for all activities that apply.
3) Additional cost information may be attached as needed.

I. Establishing Final Cover

A.	**Top Soil**	
1.	Quantity Needed (cu.yd.)	179,149.05
2.	Excavation Unit Cost ($/cu.yd.)	$3.95
3.	Excavation Cost (1. * 2.)	$707,638.75
4.	Placement/Spreading Unit Cost ($/cu.yd.)	$9.21
5.	Placement Cost (1. * 4.)	$1,649,962.75
	TOTAL Top Soil (3. + 5.)	$2,357,601.50
B.	**Landfill Cap**	
1.	On-Site Clay	
a.	Quantity Needed (cu.yd.)	179,149.05
b.	Excavation Unit Cost ($/cu.yd.)	$3.95
c.	Excavation Cost (a. * b.)	$707,638.75
d.	Placement/Spreading Unit Cost ($/cu.yd.)	$9.21
e.	Placement Cost (a. * d.)	$1,649,962.75
f.	Compaction Unit Cost ($/cu.yd.)	$1.32
g.	Compaction Cost (a. * f.)	$236,476.75
	TOTAL On-site Clay (c. + e. + g.)	$2,594,078.24
2.	Off-Site Clay	
a.	Quantity Needed (cu.yd.)	
b.	Purchase Unit Cost ($/cu.yd.)	
c.	Purchase Cost (a. * b.)	$0.00
d.	Delivery Unit Cost ($/cu.yd.)	
e.	Delivery Cost (a. * d.)	$0.00
f.	Placement/Spreading Unit Cost ($/cu.yd.)	
g.	Placement Cost (a. * f.)	$0.00
h.	Compaction Unit Cost ($/cu.yd.)	
i.	Compaction Cost (a. * h.)	$0.00
	TOTAL Off-Site Clay (c. + e. + g. + i.)	$0.00

3. Quality Control/Testing of Clay

a.		
b.		
c.		
TOTAL	Clay Testing (LS)	$26,318.64
TOTAL	Landfill Cap	$2,620,396.88

C. Synthetic Membrane

1.	Quantity Needed (sq.yd.)	488,583
2.	Purchase Unit Cost ($/sq.yd.)	$4.50
3.	Purchase Cost (1. * 2.)	$2,198,622.86
4.	Installation Unit Cost ($/sq.yd.)	$0.10
5.	Installation Cost (1. * 4.)	$48,858.29
TOTAL	Synthetic Membrane (3. + 5.)	$2,247,481.15

D. Geotextile Filter Fabric

1.	Quantity Needed (sq.yd.)	488,583
2.	Purchase Unit Cost ($/sq.yd.)	$4.50
3.	Purchase Cost (1. * 2.)	$2,198,622.86
4.	Installation Unit Cost ($/sq.yd.)	$0.10
5.	Installation Cost (1. * 4.)	$48,858.29
TOTAL	Geotextile Filter Fabric (3. + 5.)	$2,247,481.15

TOTAL for Establishing Final Cover
(A. + B. + C. + D.) [redacted]

II. Establishing Vegetative Cover

A.	Labor ($/acre)	$460.58
B.	Seeding ($/acre)	$460.58
C.	Fertilizing ($/acre)	$328.97
D.	Erosion Control Matting ($/acre)	$65.80
E.	Number of Acres	101

TOTAL for Establishing Vegetative Cover
(A. + B. + C. + D.) * E. [redacted]

III. Establishing/Completing a System to Minimize & Control Erosion/Sedimentation

A. Sedimentation Pond

1.	Excavation/Construction ($)	
2.	Materials (e.g. pipe. Riprap) ($)	

TOTAL	for Sedimentation Pond (1. + 2.)	$0.00

B. Diversion Ditch

1.	Construction ($)	
2.	Materials ($)	
TOTAL	for Diversion Ditch (1. + 2.)	$0.00

C. Temporary Structures (Filtrexx Siltsoxx)

1.	Quantity needed (ft)	6550.36
2.	Materials unit cost ($/ft)	$2.00
3.	Materials cost ($)	$13,100.72
4.	Construction unit cost ($/ft)	$1.50
5.	Construction cost ($)	$9,825.54
TOTAL	for Temporary Structures (3. + 5.)	$22,926.26

TOTAL for establishing or completing a system to minimize & control erosion & sedimentation (A. + B. + C.) [redacted]

IV. Establishing or Completing Leachate Collection Removal, & Treatment System

A. Installation

1.	Number of Feet	
2.	Piping System Unit Cost ($/ft)	
3.	Piping System Cost (1. * 2.)	$0.00
4.	Storage Tanks ($)	
5.	Pumps ($)	

TOTAL for Establishing or Completing Leachate System (3. + 4. + 5.) [redacted]

V. Establishing or Completing a System to Collect or Vent Gases

A. Installation

1.	Materials (e.g. piping)	
2.	Equipment (e.g. pumps)	
3.	Labor (e.g. drilling)	

TOTAL for Establishing or Completing a System to Collect or Vent Gases (1. + 2. + 3.) [redacted]

VI. Establishing or Completing Groundwater/Surface Water Monitoring System

A. Installation	
1. Number of Wells	
2. Drilling Unit Cost ($/Well)	
3. Drilling Cost (1. * 2.)	$0.00
4. Materials Unit Cost ($/Well)	
5. Materials (1. * 4.)	$0.00
6. Equipment (e.g. pumps)	
7. Labor	
TOTAL for Establishing or Completing Groundwater Monitoring System (3. + 5. + 6. + 7.)	$0.00

TOTAL CLOSURE COSTS (SUM OF TOTALS FOR SECTIONS I. THOUGH VI.)	$9,628,726.14

Cost Estimate
Work Sheet B
Post Closure Activities

Notes:

1) This worksheet is to be submitted as part of the C/PC Plan.
2) This facility will be maintained and monitored for 30 years after final closure of Class I and II landfills and 2 years after final closure of Class III and IV landfills.
3) Fill in blanks for all activities which apply.
4) All costs are to be calculated on an ANNUAL BASIS

I. Survey Inspections to Confirm Final Grade and Drainage are Maintained

A.	Transportation	INCLUSIVE
B.	Labor	INCLUSIVE
TOTAL	for Surveying Inspections (A. + B.)	$15,791.18

II. Maintain Healthy Vegetation

A.	Transportation	INCLUSIVE
B.	Labor	$3,947.80
C.	Seeding	$3,947.80
D.	Fertilizing	$2,763.46
E.	Mulching	$657.97
F.	Rodent Control	
G.	Mowing	$15,791.18
TOTAL	for Maintaining Healthy Vegetation (A. + B. + C. + D. + E. + F. + G.)	$27,108.21

III. Maintain Drainage Facilities, Sediment Ponds, & Erosion/Sediment Control Measures

A.	Transportation	N/A
B.	Labor	$7,895.59
C.	Cleaning out of Systems	$0.00
D.	Repair of Gullies or Rills	
1.	Soil Acquisition	
a.	Quantity	1,000.00
b.	Purchase Unit Cost ($/cu.yd.)	$1.32
c.	Purchase Cost (a. * b.)	$1,320.00
d.	Delivery Unit Cost ($/cu.yd.)	$5.26

e. Delivery Cost (a. * d.)	$5,260.00
2. Placement/Spreading/Compaction	$5,000.00
3. Revegetation	$3,000.00
TOTAL D.	$14,580.00
TOTAL for Maintaining Drainage (A. + B. + C. + D.)	$22,475.59

IV. Maintain and Monitor Leachate Collection, Removal, & Treatment System

A. Treatment of Leachate	
1. On-Site	
a. Quantity (cu.yd.)	
b. Treatment Unit Cost ($/cu.yd.)	
c. Treatment Costs (a. * b.)	$0.00
d. Sewer Discharge Unit Cost	
e. Discharge Costs (a. * d.)	$0.00
TOTAL 1. On-Site (c. + e.)	$0.00
2. Off-Site	
a. Quantity (cu.yd.)	
b. Hauling Unit Cost ($/cu.yd.)	
c. Hauling Costs (a. * b.)	$0.00
d. Treatment Unit Cost ($/cu.yd.)	
e. Treatment Costs (a. * d.)	$0.00
TOTAL 2. Off-Site (c. + e.)	$0.00
TOTAL for Treatment of Leachate (A.) (1. or 2. TOTAL)	$0.00
B. Maintenance of Leachate Collection System	
1. Transportation	
2. Labor	
3. Repairs/Materials	
a. Pumps	$3,000.00
b. Cleaning out System	$3,000.00
c. Leak Detection	
d. Lift station	$4,000.00
TOTAL 3. (a. + b. + c. + d.)	$10,000.00
TOTAL B. (1. + 2. + 3.)	$10,000.00
TOTAL for Monitoring and Maintaining Leachate System (A. + B.)	$10,000.00

V. Maintain and Monitor Gas Collection or Venting System

A.	Transportation	
B.	Labor	
C.	Repairs/Materials	
	1. Cleaning	
	2. Caps	
	3. Other	
	TOTAL C. (1. + 2. + 3.)	$0.00
TOTAL	for Maintaining & Monitoring Gas Control Systems (A. + B. + C.)	$0.00

VI. Maintain and Monitor Groundwater and/or Surface Water Monitoring System

A.	Installation	
	1. Number of Wells/Springs	20.00
	2. Number of Samples/Well	2.00
	3. Unit Costs of Analysis	$1,315.93
	4. Cost of Sampling + Analysis (1. * 2. * 3.)	$52,637.28
	5. Labor Cost/Well	
	6. Labor Costs (1. * 5.)	
	TOTAL A. (4. + 6.)	$52,637.28
B.	Inspection & Maintenance of System	
	1. Transportation	
	2. Labor	5,263.73
	3. Repairs/Materials	
	a. Caps	$526.37
	b. Tubing	$526.37
	c. Pumps	$526.37
	d. Well Replacement	$526.37
	e. Other	$526.37
	TOTAL 3. (a. + b. + c. + d. + e.)	$2,631.86
	TOTAL B. (1. + 2. + 3.)	$7,895.59
TOTAL	for Maintaining & Monitoring Groundwater Systems (A. + B.)	$60,532.87

TOTAL CLOSURE COSTS, ANNUAL BASIS (SUM OF TOTALS FOR SECTIONS I. THOUGH VI.)	**$135,907.85**
INFLATION RATE UTILIZED	**5.00%**
30 YR BASIS (Annual Cost * Inflation Rate Over 30 Years)	**$9,481,039**

SUMMARY OF ANNUAL COST, 30 YEAR BASIS

Annual Cost	Year	Inflation Rate	Annual Cost with Inflation
$135,907.85	1	5.0%	$142,703
	2	5.0%	$149,838
	3	5.0%	$157,330
	4	5.0%	$165,197
	5	5.0%	$173,457
	6	5.0%	$182,130
	7	5.0%	$191,236
	8	5.0%	$200,798
	9	5.0%	$210,838
	10	5.0%	$221,380
	11	5.0%	$232,449
	12	5.0%	$244,071
	13	5.0%	$256,275
	14	5.0%	$269,088
	15	5.0%	$282,543
	16	5.0%	$296,670
	17	5.0%	$311,503
	18	5.0%	$327,078
	19	5.0%	$343,432
	20	5.0%	$360,604
	21	5.0%	$378,634
	22	5.0%	$397,566
	23	5.0%	$417,444
	24	5.0%	$438,316
	25	5.0%	$460,232
	26	5.0%	$483,244
	27	5.0%	$507,406
	28	5.0%	$532,776
	29	5.0%	$559,415
	30	5.0%	$587,386
	TOTAL, 30 YR BASIS		$9,481,039

TVA

Tennessee Valley Authority
Kingston Fossil Plant

MATERIAL SPECIFICATIONS AND CONSTRUCTION QUALITY ASSURANCE/QUALITY CONTROL PLAN

COAL COMBUSTION BYPRODUCT DISPOSAL FACILITY - PENINSULA SITE

KIF450

Prepared By:

Tennessee Valley Authority
Fossil Engineering Services
1101 Market Street
Chattanooga, TN 37401-2801

May 2006

Title: MATERIAL SPECIFICATIONS AND CONSTRUCTION QUALITY ASSURANCE/QUALITY CONTROL PLAN COAL-COMBUSION BYPRODUCT DISPOSAL FACILITY – PENINSULA SITE.			DCN# Plant/Unit: Kingston Fossil Plant
Vendor	Contract No.	Key Nouns:	
Applicable Design Documents	REV	EDMS NUMBER	DESCRIPTION
	R0		
References	R1		
	R2		

TENNESSEE VALLEY AUTHORITY
FOSSIL POWER GROUP
FOSSIL ENGINEERING SERVICES
SITE AND ENVIRONMENTAL ENGINEERING

	Revision 0	R1	R2
Date	May 2006		
Prepared	Nelson Breedon		
Checked	Mike Monteleone		
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LIST OF ATTACHMENTS

Attachment 1 TVA Vegetation Specification

1 INTRODUCTION

This Material Specifications and Construction Quality Assurance/Quality Control Plan (QA/QC Plan) is prepared for the proposed Coal Combustion Byproduct (CCB) Disposal Facility located at the Tennessee Valley Authority (TVA) Kingston Fossil Plant – Peninsula Site (hereinafter referenced as CCB disposal facility). The CCB disposal facility will be developed in two phases; namely Phase I and II. The purpose of this QA/QC Plan is to outline procedures for verifying that proper materials, construction techniques, and installation procedures are used by the Constructor, and that the design intent is met. This QA/QC plan has been developed to satisfy the requirements of rule 1200-1-7-.04(9)(c)19. In addition, this QA/QC Plan is intended to define problems that may occur during construction and to provide a mechanism for resolving these problems as they occur.

The elements of construction of the CCB disposal facility requiring field monitoring and documentation under this plan include: subgrade/structural fill, soil dike for Phases I and II, geologic buffer, gypsum dikes, and final cover system construction.

The program described by this Plan is independent of the quality control (QC) program conducted by the Constructor. This QA/QC Plan is intended to provide verification that the Constructor has met his obligation in the supply and installation of the specified materials. This plan does not replace the contract documents (design drawings and documents) regarding the selection and installation of materials.

The construction and operation of this facility involves initial facility construction, as well as on-going construction operations. TVA conducts dike inspections at all fossil plants yearly, and will be performed for the CCB Disposal Facility. Because this facility will be raised during the operational phase, certification activities should be an on-going process during operation, but limited to those periods where dikes are being raised. This can be viewed as an extension of the yearly dike inspections. It is anticipated that during dike raising activities, surveillance by technicians to sample and test material and observe construction techniques would also provide assurance that construction activities are in conformance with the drawings. As construction proceeds, the Certification Engineer can adjust the frequency and type of testing and inspection/surveillance as needed.

2. DEFINITIONS AND USE OF TERMS

This section provides definitions for terms used in the QA/QC Plan.

Owner – Tennessee Valley Authority

Constructor – the individual or firm, responsible for disposal facility-related construction and operational activities. This definition applied to any party performing work defined in the construction documents. TVA may use their own construction organization, Heavy Equipment Division (HED), for initial construction activities, and plant operations personnel (TVA Yard Operations) may perform dike raising activities described herein. TVA may also subcontract construction at it's discretion.

Construction Manager – the official representative of the Owner responsible for overseeing construction of the project. If TVA uses the HED for initial construction, and TVA Yard Operations for operation, the Construction Manager and Constructor are one in the same.

Conformance Testing - includes testing that is performed by the Certification Engineer to conform and qualify material prior to their use.

Certification Engineer – individual appointed by the Owner who is responsible for performing tasks outlined in this QA/QC Plan. The Certification Engineer will be selected by TVA FES and shall be a registered Professional Engineer in the state of Tennessee.

Design Engineer – the individual(s) or firm(s) responsible for the preparation of design documents and significant design changes during construction as determined by the Certification Engineer. The design engineer shall be a registered Professional Engineer in the state of Tennessee. TVA Fossil Engineering Services (FES) is the responsible engineering organization for design and certification of this facility.

Earthwork – an activity involving the use of soil or rock materials. It also includes activities involving the use of byproducts in the construction of waste disposal facilities.

Performance Testing – includes those activities that occur during and following material installation including dike raising activities during facility operation.

Project Design Drawings and Documents – all project related drawings and documents, including design modifications and record drawings.

Project Documents – includes Constructor submittals, construction drawings, record drawings, specifications, shop drawings, field inspection reports, and project schedule.

Quality Control (QC) – functions performed by the Constructor and material supplier to verify that work performed conforms to project design drawings and documents.

Quality Assurance (QA) – provides verification that QC functions have been performed in substantial compliance with the project design drawings and documents, this function will normally be provided by a Certification Engineer chosen by TVA.

Record Drawings – drawings recording the locations, elevations, and details of the facility after construction is completed.

Surveyor – the individual responsible for preparation of as-constructed surveys of the completed subgrade, geologic buffer, soil dike fill, final surface of gypsum fill, final cover compacted clay layer, and completed vegetation layer. The surveyor shall be a registered Surveyor in the state of Tennessee.

Testing Laboratory – one or more laboratories capable of conducting the required conformance and performance laboratory testing of soils and geosynthetics required by this QA/QC Plan.

3 CERTIFICATION ENGINEER

The Certification Engineer (or personnel under his direct supervision) will closely monitor construction of the various components of the CCB disposal facility which includes: structural fill, soil dike fill, geologic buffer, gypsum dike construction; and the construction of the soils and geosynthetic components of the final cover system. The Certification Engineer will be a Professional Engineer licensed to practice in the state of Tennessee, who is knowledgeable in the field of soil mechanics and geosynthetics, and will have a good working knowledge of the equipment and procedures generally used in the construction of landfills.

The Certification Engineer has the following duties:

- provide written, certified documentation attesting to conformance with the design requirements and the QA/QC Plan with respect to conditions of structural fill, soil dike fill, geologic buffer, gypsum dike construction, and the construction of the soils and geosynthetic components of the final cover system;
- be present at appropriate intervals during construction of the soil components, perform appropriate tests, and obtain samples for laboratory analyses;
- observe material delivery and unloading;
- use the results of tests and laboratory analyses to document conformance with project requirements;
- provide to TVA and the Constructor the results of observations and test as the work progresses. Coordinate with Constructor when modifications to the plans are necessary to ensure compliance with the design drawings, specifications, and QA/QC Plan;
- schedule and coordinate inspection and testing activities; and
- reject defective work and verify that corrective measures have been implemented.

The Certification Engineer may utilize qualified field technicians to perform testing described and to provide as necessary additional oversight during construction.

4. PROJECT MEETINGS

4.1 Design Review Meeting (Optional)

Following the completion of the design and after review and approval by the State of Tennessee Department of Environment and Conservation (TDEC), Division of Solid Waste Management (DSWM), a design review meeting will be held. The purpose of this meeting, which the Owner, Construction Manager, and the Certification Engineer shall attend, is to accomplish the following activities:

- identify key personnel;
- provide all parties with relevant documents;
- review the project design drawings, documents, and QA/QC Plan;
- confirm responsibilities of each party;
- review reporting and documenting procedures;
- define lines of communication;
- establish work area procedures; and
- review sampling and testing procedures.

The meeting will be documented by the Certification Engineer or person designated by the Construction Manager. Copies of the minutes and relevant documents will be provided to all parties.

4.2 Pre-construction Meeting

A pre-construction meeting will be held at the site prior to the start of construction. The Owner, Construction Manager, Certification Engineer, Constructor, and others designated by the Owner will attend this meeting. In certain cases, many, if not most of these functions may be performed directly by the Owner. The purpose of the meeting is to accomplish the following activities:

- review the construction drawings and documents, QA/QC Plan, work area procedures, construction procedures, and other related issues;

- define lines of communication and authority;

- review the project schedule;

- review best management practices for erosion and sediment control and construction stormwater management during each phase of construction;

- review testing procedures and procedures for correcting and documenting; construction deficiencies, repairs, and retesting;

- review testing and record drawing documentation procedures; and

- conduct a site inspection to discuss work areas, work plans, stockpiling, equipment and material laydown areas, access roads, and related items.

This meeting will be documented by the Construction Manager or authorized representative, and copies of the documentation will be distributed to all parties.

4.3 Progress Meetings

A progress meeting will be held daily just prior to commencement or just following the completion of work. This meeting will be attended by the Construction Manager, and the Constructor's on-site superintendent and the Certification Engineer. The following activities will be discussed during this meeting:

- review the previous days activities and accomplishments;

- review work locations and scheduled work;

- discuss problems; and

- review test data.

This meeting will be documented by the Certification Engineer, and copies of the documentation will be distributed to the Owner, Construction Manager, and Constructor.

4.4 Deficiency Meetings

As required, meetings will be held to discuss problems or deficiencies. At a minimum, these meetings will be attended by the Construction Manager, Certification Engineer, and the Constructor's on-site superintendent. If the problem requires a design modification, the Design Engineer and Constructor's project manager should also be present. The meeting will be documented by the Certification Engineer.

5. BASE GRADE SOIL COMPONENT CONSTRUCTION

5.1 Introduction

This section addresses material specifications and CQA activities associated with preparation and construction of the soil and aggregate components of the base grade system. Details of the soil components of the base grade system are provided in the Drawings Plans. These components include:

- subgrade/structural fill;
- soil dikes;
- geologic buffer; and
- gravel drainage layer.

The soil and aggregate components of the base grade system shall meet requirements related to material characteristics and construction quality. Both field and laboratory tests shall be performed prior to construction to evaluate if the characteristics of soil and aggregate from proposed sources meet the material acceptance requirements of the permit and design specifications. Throughout construction, additional field and laboratory testing shall be performed to evaluate if the placed material meets the requirements of the permit and construction documents with regard to material acceptance and construction quality.

5.2 Test Methods And Sampling Requirements

Tables 1 and 2 present the laboratory and field test methods which shall be used to determine material characteristics and evaluate construction quality for the soil and aggregate components of the base grade system. The tests shall be conducted in accordance with the current versions of the corresponding standard methods given.

Table 3 provides information regarding the minimum test frequencies. The table also includes the locations at which samples shall be collected, the sample size, and the acceptance criteria.

5.3 Subgrade/Structural Fill

Subgrade refers to a surface which is exposed after stripping topsoil, excavating or filling to design grades. The prepared subgrade should conform to the contours shown on the grading plan, as indicated in the Design Drawings and verified by the Surveyor. Vegetation shall be stripped and the surface proof rolled. Potentially deleterious materials such as organics or soft materials shall be removed and the resulting voids filled with acceptable material, appropriately compacted. As required, structural fill will be used to establish design subgrade elevations.

After proof rolling and/or other suitable techniques, visual examination of the subgrade preparation by the Certification Engineer should be sufficient to evaluate its suitability as a foundation for the geologic buffer.

Conformance and performance testing of the subgrade/structural fill shall be accomplished in accordance with Table 3. The subgrade should be accepted by the Certification Engineer if it does not pump or rut excessively. If excessive pumping or rutting occurs, the area should be reworked or removed by undercutting to more suitable material if possible. The surface of the finished subgrade will be surveyed in accordance with Section 11 of this QA/QC Plan to provide as-built documentation prior to placement of the geologic buffer.

5.4 Soil Dikes

Soil dikes refers to the soil material that will be used to construct the perimeter soil dikes shown on the Design Drawings. Soil dike material shall consist of relatively homogenous, silty, and clayey soils which are substantially free of debris, rock, plant materials, frozen materials, foreign objects, and organics. The soil dike geometry should conform to the contours shown on the grading plan, as indicated in the Design Drawings, and verified by the Surveyor.

Conformance and performance testing of the soil dike material shall be accomplished in accordance with Table 3. The surface of the finished subgrade will be surveyed in accordance with Section 11 of this QA/QC Plan to provide as-built documentation prior to placement of the perimeter gypsum dike.

5.5 Geologic Buffer

Geologic buffer material shall consist of relatively homogenous, silty, and clayey soils which are substantially free of debris, rock, plant materials, frozen materials, foreign objects, and organics. The geologic buffer may be constructed from recompacted soils from within the disposal factory footprint (if suitable) or from the borrow area. The borrow area for the geologic buffer material will be identified in the Design Drawings and the material will be tested to provide an Acceptable Permeability Zone (APZ) to meet the required permeability of less than or equal to 1×10^{-7} cm/s. The Certification Engineer shall obtain samples from within the identified borrow area and subject the soils to conformance testing procedures, frequency, and requirements indicated in Table 3 to verify that the APZ that has been developed is acceptable and that the material does meet the project requirements.

Geologic buffer material shall be placed in 8 to 10 in. loose (6 to 8 in. compacted) lifts. The lift depth shall be verified by a manual method (i.e., use of stakes or cones). Soil clods shall be broken down, and moisture conditioning shall be conducted to preserve the homogeneity of the soil and to obtain a relatively uniform moisture content through the soil mass. The moisture content of the geologic buffer soils shall be field tested during processing, placement, and compaction. The action of heavy equipment on the geologic buffer shall be observed for penetration, pumping, and cracking which would indicate that the material is unsuitable and should be re-conditioned. Performance testing shall be accomplished to verify the requirements listed in Table 3 are met.

The finished surface of the geologic buffer shall be firm, uniform, and relatively smooth. Surveying shall be performed to verify that the finished geologic buffer thickness is equal to or greater than 3 ft and that the minimum drainage grade to the central drainage corridor is met.

Perforations created by nuclear density probe, stakes, or any other methods shall be filled with bentonite, a soil-bentonite mixture, or an Engineer approved equal.

5.6 Gravel Drainage Layer

Gravel drainage layer shall be placed around pipes located within the central drainage corridor and the perimeter drainage trenches. The gravel drainage layer shall be composed of aggregates meeting the Conformance testing requirements provided in

Table 3. The gravel drainage aggregate shall be substantially free of organics, frozen material, foreign objects, or other deleterious materials.

5.7 Potential Problems And Deficiencies

During construction, the frequency of testing may be increased at the discretion of Certification Engineer or the Construction Manager when visual observations of construction performance indicate a potential problem. Additional testing for suspected areas will be considered when:

- excessive pumping or cracking of material occurs;
- under adverse weather conditions;
- work is conducted in difficult areas; and
- high frequency of failing tests is observed.

If a defect is discovered in the earthwork product, the Certification Engineer shall immediately determine the extent and nature of the defect. If the defect is indicated by an unsatisfactory test result, the Certification Engineer shall determine the extent of the deficient area by additional tests, observations, a review of records, or other appropriate means and notify the Constructor and Construction Manager.

The Certification Engineer shall schedule appropriate retests after the work deficiency has been corrected. Retests recommended by the Certification Engineer must verify that the defect has been corrected before any additional work is performed in the area of the deficiency

6. GYPSUM DIKE CONSTRUCTION AND PLACEMENT

6.1 Placement

The sequence for the construction and placement of the perimeter and outer gypsum dikes is illustrated in the Design Drawings and described herein. After the soil dikes are constructed, sluiced gypsum will be placed within the disposal area and the perimeter gypsum dike will be constructed from gypsum sedimented within the disposal area. The perimeter gypsum dike is considered an extension to the soil dikes and will provide a platform for the construction of the outer gypsum dikes. Once the perimeter gypsum dikes are constructed, a rim ditch operation will commence and outer gypsum dikes will be constructed using gypsum. Gypsum will continue to be disposed and the outer dikes will be raised progressively using the upstream method of construction.

Gypsum can also be used to divide the disposal area, as required, into smaller subareas areas. This arrangement allows for the sedimentation of gypsum in one subarea while the other subarea is filled with sluiced gypsum. Once rim ditch construction has been completed, and a subarea has been filled, another subarea will begin to receive sluiced gypsum. During the inactive phase of the first subarea, raising of the outer gypsum dikes may begin. Gypsum is excavated from the rim ditch using long-reach trackhoes and placed along the perimeter of the outer gypsum dikes. Leveling, spreading, and compaction will be accomplished using a small dozer. The outer gypsum dikes will generally be raised in five-foot height increments, with individual lift thicknesses being approximately one to two feet thick. The individual lift thicknesses should be such that material can be placed, spread, shaped and compacted to obtain a uniform consistency and be constructed to the lines and grades on the Design Drawings. Perimeter drainage trenches shall be installed as shown on the Design Drawings. It is important that elevations be checked during construction and adjustments made to avoid damage to the drains. The Design Drawings contain instructions and procedures to prevent this from occurring.

6.2 Monitoring and Testing

Monitoring and testing for gypsum dike construction will include the following activities:

- Monitoring of the perimeter gypsum dike construction is required to verify that material has the desired consistency, and is being placed, shaped, and compacted to the proper shape. It is anticipated that surveillance and monitoring activities will be more frequent in the beginning, and will be reduced as successful operation is being demonstrated. The frequency of monitoring will be determined by the Certification Engineer in concert with TVA FES.

- After the completion of perimeter gypsum dike construction, and the area filled with gypsum, outer gypsum dike raising can begin from the second lift. The technician shall take random samples at four locations along the rim ditch along the outer dike at approximate evenly spaced locations. Samples will be tested for grain size to determine variation in material. This information shall be reviewed by the Certification Engineer. Additionally, if considered necessary by the Certification Engineer, strength testing of material at the beginning and end points of the rim ditch along the outer dike may be performed to determine any variation in strength parameters. Operation of the rim ditch may be adjusted at the discretion of the Certification Engineer. This process can be repeated if determined necessary by the Certification Engineer in concert with TVA FES, but it is expected that as stack progression continues, the need for such testing will diminish over time if satisfactory results are obtained. This process may need to be repeated when Phase II construction begins, or if more frequent testing is deemed necessary by the Certification Engineer in concert with TVA FES.

- It is anticipated that quarterly inspections will be performed by the Certification Engineer during dike raising activities as a minimum, and the frequency increased if necessary. The technician should be present to inspect construction of the drains to ensure that the requirements on the Design Drawings are being met. The frequency of these visits shall be determined by the Certification Engineer in concert with TVA FES.

- As stack construction progresses, TVA will perform surveys to determine the remaining life of the facility. These surveys will be reviewed by the Certification Engineer to ensure that grading is being adequately maintained on the side slopes.

7. FINAL COVER SYSTEM SOIL COMPONENT CONSTRUCTION

7.1 Introduction

This section addresses material specifications and CQA activities associated with the construction of the soil components for the final cover system. Details of the soil components of the final cover system are provided in the Design Drawings. These components include:

- intermediate cover;
- compacted clay layer;
- compacted soil Layer; and
- vegetative soil layer.

The soil components of the final cover system shall meet requirements related to material specification and construction quality provided in this QA/QC Plan. Both field and laboratory tests shall be performed prior to construction to evaluate if the characteristics of soil from proposed sources meet the material acceptance requirements.

7.2 Test Methods and Sampling Requirements

Tables 1 and 2 present the laboratory and field test methods which shall be used to determine material characteristics and evaluate construction quality for the soil components of the final cover system. The tests shall be conducted in accordance with the current versions of the corresponding standard methods given.

Table 4 provides information regarding the minimum test frequencies and values. The table also includes the locations at which samples shall be collected, the sample size, and the acceptance criteria.

7.3 Intermediate Cover

Intermediate cover refers to the layer of soil covering the gypsum by-product in the facility to reach the planned grades for the bottom of compacted clay layer material.

Vegetation and other potentially deleterious materials such as organics or soft materials shall be removed and the resulting voids filled with acceptable material and appropriately compacted. The surface shall be proof rolled prior to the placement of subsequent lifts or layers.

After proof rolling and/or other suitable techniques, visual examination of the intermediate cover preparation by the Certification Engineer should be sufficient to evaluate its suitability as a foundation for the compacted soil layer.

The intermediate cover should be accepted by the Certification Engineer if it does not pump or rut excessively. If excessive pumping or rutting occurs, the area should be reworked or removed by undercutting to more suitable material.

The surface of the finished intermediate cover will be surveyed in accordance with Section 11 of this QA/QC Plan to provide for as-built documentation prior to placement of the compacted clay layer or compacted soil layer.

7.4 Compacted Clay Layer

Soils for the compacted clay layer shall consist of relatively homogenous, silty, and clayey soils which are substantially free of debris, rock, plant materials, frozen materials, foreign objects, and organics. If an approved borrow source is not identified in the permit or permit application, the Construction Manager and Constructor shall identify a borrow area for the compacted clay layer. The Certification Engineer shall obtain samples from within the identified borrow area and subject the soils to the Conformance testing requirements indicated in Table 4 to and develop an APZ for the soil to achieve the required permeability of less than or equal to 1×10^{-7} cm/sec.

Based on the results of these laboratory tests, material which may meet the requirements of compacted clay layer material shall be identified. A range of moisture/density values which results in the required permeability should be determined based on the laboratory testing data. This range will then be used as the acceptable range of moisture/density values for field compaction control.

The compacted clay layer material shall be placed in 8 to 10 in. loose (6 to 8 in. compacted) lifts. The lift depth shall be verified by a manual method (i.e., hand auguring). Soil clods shall be broken down, and moisture conditioning shall be conducted to preserve the homogeneity of the soil and to obtain relatively uniform moisture content through the layer. The moisture content of the compacted clay layer may be field tested during processing and placement when requested by the Constructor for verification purposes. The action of heavy equipment shall be observed for penetration, pumping, and cracking of the compacted soil layer surface. Performance testing shall be accomplished in accordance with Table 4.

The finished surface shall be firm, uniform, and relatively smooth. Perforations in the compacted clay layer created by nuclear density probes, stakes, or any other methods shall be filled with bentonite, a soil-bentonite mixture, or an Engineer approved equal.

The surface of the finished compacted soil layer will be surveyed in accordance with Section 11 of this QA/QC Plan to provide for as-built documentation prior to placement of the geomembrane.

7.5 Compacted Soil Layer

Material for the compacted soil layer shall consist of relatively homogenous, silty, and clayey soils which are substantially free of debris, rock, plant materials, frozen materials, foreign objects, and organics. If an approved borrow source is not identified in the permit or permit application, the Construction Manager and Constructor shall identify a borrow area for the compacted soil layer. The Certification Engineer shall obtain samples from within the identified borrow area and subject the soils to the Conformance testing requirements indicated in Table 4. Based on the results of these laboratory tests, material which may meet the requirements of compacted soil layer shall be identified.

The compacted soil layer material shall be placed in 8 to 10 in. loose (6 to 8 in. compacted) lifts. The lift depth shall be verified by a manual method (i.e., hand auguring). Soil clods shall be broken down, and moisture conditioning shall be conducted to preserve the homogeneity of the soil and to obtain relatively uniform moisture content through the layer. The moisture content of the compacted soil layer may be field tested during processing and placement when requested by the Constructor for verification purposes. The action of heavy equipment shall be observed for penetration, pumping, and cracking of the compacted soil layer surface. Performance testing shall be accomplished in accordance with Table 4.

The finished surface shall be firm, uniform, and relatively smooth. Perforations in the compacted soil layer created by nuclear density probes, stakes, or any other methods shall be filled with bentonite, a soil-bentonite mixture, or an Certification Engineer approved equal.

The surface of the finished compacted soil layer will be surveyed in accordance with Section 11 of this QA/QC Plan to provide for as-built documentation prior to placement of the vegetative cover.

7.6 Vegetative Soil Layer

The soil to be utilized for establishing the vegetative cover shall be capable of sustaining a healthy stand of vegetation, and shall consist of soil reasonably free from subsoil, noxious weeds, stones larger than two inches in diameter, or other deleterious matter that would prevent the formation of a suitable seed bed.

Low ground-pressure equipment shall be used to place the material for the vegetative soil layer over the geosynthetics (if geosynthetics option is used). The equipment shall be operated over the full depth of the layer. In areas traversed by heavy trucks and other non low ground-pressure equipment a minimum material thickness of three (3) feet shall be maintained. Care should be exercised when material is being placed around pipes and other appurtenances to prevent damage to these components. The material shall be placed by pushing the material upslope only. Vegetative soil layer material should not be placed from the top of the slope. The finished surface of the vegetative soil layer shall be roughened to help prevent erosion from occurring, seeded as described in the Vegetation Specification included in Attachment 1 of this QA/QC Plan. The final surface shall be surveyed in accordance with Section 11 of this QA/QC Plan for as-built documentation. Soil thickness verification will be performed by manual methods (i.e., hand auguring and/or thickness markers) due to possible settlement of the gypsum layers during final cover construction activities.

7.7 Potential Problems And Deficiencies

During construction, the frequency of testing may be increased at the discretion of the Certification Engineer or the Construction Manager when visual observations of construction performance indicate a potential problem. Additional testing for suspected areas will be considered when:

- excessive pumping or cracking of material occurs;
- under adverse weather conditions;
- work is conducted in difficult areas; and
- high frequency of failing tests is observed.

If a defect is discovered in the earthwork product, the Certification Engineer shall immediately determine the extent and nature of the defect. If the defect is indicated by an unsatisfactory test result, the Certification Engineer shall determine the extent of the deficient area by additional tests, observations, a review of records, or other appropriate means. All deficiencies shall be corrected by the Constructor.

The Certification Engineer shall schedule appropriate retests after the work deficiency has been corrected. Retests recommended by the Certification Engineer must verify that the defect has been corrected before any additional work is performed by the Constructor in the area of the deficiency.

8 GEOMEMBRANE

8.1 Manufacture, Shipment, And Storage

The following addresses the activities associated with the manufacture of the geomembrane; the shipment, handling, and delivery of geomembrane to the site; conformance testing of delivered geomembrane; and the storage of the geomembrane prior to installation.

8.1.1 Manufacture of Polyethylene Geomembrane

The Geomembrane Manufacturer shall provide documentation that the material meets the requirements of this section and that adequate quality control measures have been implemented during the manufacturing process.

8.1.1.1 Resin Quality

The raw material shall be first quality polyethylene resin containing no more than 2 percent clean recycled polymer by weight, and meeting the specification outlined in Table 5.

Prior to the shipment of polyethylene geomembrane material, the Geomembrane Manufacturer shall provide the Construction Manager and the Certification Engineer with the following information:

- the origin (Resin Supplier's name and resin production plant), identification (brand name number), and production date of the resin;
- a copy of the quality control certificates issued by the Resin Supplier;
- reports on the tests conducted by the Manufacturer to verify the quality of the resin used to manufacture the geomembrane rolls and extrudate rods meet the requirements in Table 5; and
- a statement that no reclaimed polymer is added to the resin (however, the use of polymer recycled during the manufacturing process may be permitted if

performed with appropriate cleanliness and if recycled polymer does not exceed 2 percent by weight).

At the Owner's discretion and cost, testing may be carried out on the resin by the Geosynthetics QA Laboratory for purposes of verifying conformance. If the results of the Geomembrane Manufacturer and the Geosynthetics QA Laboratory testing differ, the testing will be repeated by Geosynthetics QA Laboratory, and the Geomembrane Manufacturer will be permitted to monitor this testing. The results of this latter series of tests will prevail, provided that the applicable test methods have been followed.

8.1.1.2 Certification of Property Values

In addition to information regarding the raw material, the Geomembrane Manufacturer shall provide the Construction Manager and the Certification Engineer with the following prior to shipment of the geomembrane:

- a properties sheet certification including, at a minimum, guaranteed values for all specified properties presented in Table 5; and
- a list of quantities and descriptions for materials other than the base polymer which comprise the geomembrane.

The Certification Engineer shall verify that the property values certified by the Geomembrane Manufacturer meet the test methods and values shown on Table 5.

8.1.1.3 Quality Control Certificates

Prior to shipment, the Geomembrane Manufacturer shall provide the Construction Manager and the Certification Engineer with quality control certificates for the geomembrane provided. The quality control certificate will be signed by a responsible party employed by the Geomembrane Manufacturer. The quality control certificate will include:

- roll numbers and identification; and
- sampling procedures and results of quality control testing.

The Manufacturer shall be required to perform, at a minimum, the tests presented in Table 5. The Certification Engineer shall:

- verify that the quality control certificates have been provided at the specified frequency or all rolls; and
- review the quality control certificates and verify that the test methods and values meet the requirements presented in Table 5.

8.1.2 Shipment and Handling

Shipment of the geomembrane to the site is the responsibility of the Geomembrane Manufacturer. Handling on-site is the responsibility of the Geosynthetics Installer.

The Certification Engineer shall confirm that:

- handling equipment used on-site poses minimal risk of damage to the geomembrane; and
- the Geosynthetics Installer's personnel handle the geomembrane with care.

Upon delivery at the site, the Geosynthetics Installer and the Certification Engineer shall confirm that roll identification corresponds to quality control certificates issued by the manufacturer.

Rolls without proper identification shall be rejected by the Construction Manager and Certification Engineer.

8.1.3 Conformance Testing of Geomembrane

Upon, or prior to, delivery of the rolls of geomembrane, the Certification Engineer shall verify that samples are removed and forwarded to the Geosynthetics CQA Laboratory for testing to verify conformance with the test methods and values presented in Table 6.

8.1.3.1 Sample Collection

Using the packing list provided by the manufacturer or a sequential inventory list made by the Certification Engineer, rolls shall be selected for sampling. If the material is shipped in identifiable lots or manufacturing runs, sample selection should be adjusted to assure that the minimum frequency is met and that each different lot or manufacturing run is represented by at least one sample.

Samples will be taken across the entire width of the roll and will not include the first 3 linear ft of the roll. Unless otherwise specified, samples will be 3 ft long by the roll width. The Certification Engineer will mark the machine direction on the samples with an arrow.

8.1.3.2 Test Results

The results of the conformance testing shall be evaluated in accordance to the following procedure:

- If the average test values for the sample meet the requirement presented in Tables 5 and 6, the sample passes.
- If the average test value for the sample does not meet one or more of the required values, additional evaluation procedures will be implemented by the Certification Engineer.
- For the failing parameter(s), perform one additional test on the sample. This test may be performed by another Geosynthetics CQA Laboratory at the discretion of the Certification Engineer and the Construction Manager.
- If the test values for the additional tests meet the required values, the roll and adjacent rolls pass and are acceptable.
- If the test value does not meet requirements, reject the roll, collect samples from the closest numerical roll on both sides of the failed roll and test for the failed parameter(s). If one or both of these tests do not meet requirements, those roll(s) will be rejected and the Certification Engineer and Construction Manager shall determine further testing protocol and criteria for identifying the limits of rejected rolls.

8.1.4 Storage

The Geosynthetics Installer and/or Constructor shall be responsible for the storage of the geomembrane on site. Storage space should protect the geomembrane from theft, vandalism, water, weather, or damage.

8.2 Geomembrane Installation

The installation of the geomembrane and anchoring in place is crucial to the performance of the geomembrane. Geomembrane installation activities shall be monitored by the Certification Engineer.

The Certification Engineer shall document that:

- the Surveyor has verified lines and grades of the compacted soil layer; and
- the requirements of Section 7 of this QA/QC Plan are satisfied.

The Geosynthetics Installer shall certify in writing that the surface on which the geomembrane will be installed is acceptable. This subgrade acceptance certificates shall be given by the Geosynthetics Installer to the Certification Engineer prior to commencement of geomembrane installation in the area under consideration. The Certification Engineer will document the acceptance certification for the CQA Final Report.

It is the Geosynthetics Installer's responsibility to protect the compacted soil layer after it has been accepted. After the supporting soil has been accepted by the Geosynthetics Installer, it shall be the responsibility of the Geosynthetics Installer and the Certification Engineer to indicate to the Construction Manager any change in the clay condition that may require repair work.

8.2.1 Geomembrane Placement

The placement of field panels of geomembrane is the responsibility of the Geosynthetics Installer and shall be performed in accordance with the previously submitted panel layout and the following subsections.

8.2.1.1 Panel Layout

At the geosynthetics Pre-Construction Meeting, the Geosynthetics Installer shall provide the Construction Manager and the Certification Engineer with a drawing of the facility to be covered showing expected seam location and layout (Panel Layout Drawing). The Certification Engineer shall review the panel layout drawing and verify it is consistent with the acceptance state of practice and the QA/QC Plan.

The panel layout should be oriented to maximize panel lengths and minimize seams and material waste. In corners and odd-shaped geometric locations, the number of seams should be minimized. Horizontal seams should be greater than 10 ft from the toe of slopes, or areas of potential stress concentration, unless otherwise authorized.

8.2.1.2 Field Panel Identification

The Certification Engineer shall document that the Installer labels each field panel with an "identification code" (number and/or letter) consistent with the panel layout plan. This identification code shall be agreed upon by the Construction Manager, Geosynthetics Installer, and Certification Engineer. It is the responsibility of the Geosynthetics Installer and the Certification Engineer to verify that each field panel placed can be traced to the original manufacturers roll number.

The Certification Engineer shall establish a table or chart showing correspondence between roll numbers and field panel identification codes. The field panel identification code will be used for all quality assurance records.

8.2.1.3 Installation Schedule

Field panels shall be placed one at a time unless otherwise approved by the Certification Engineer and the Construction Manager. Each field panel shall be seamed after its placement to minimize the number of unsealed field panels exposed to weather.

It is usually beneficial to "shingle" overlaps in the downward direction to facilitate drainage in the event of precipitation. It is also beneficial to proceed in the direction of prevailing winds. Scheduling decisions must be made during installation, in accordance with varying conditions. In any event, the Geosynthetics Installer shall be fully responsible for the decision made regarding placement procedures.

The Certification Engineer shall record the identification code, location, date of installation, time of installation, weather conditions and ambient temperature.

8.2.1.4 Weather Conditions

Geomembrane placement shall not proceed when sheet temperature, measured by placing a thermometer on the surface of the sheet, is below 32°F (0°C) for fusion or extrusion welding. Deviations from this temperature criterion shall only occur when authorized by the Construction Manager and with the concurrence of the Certification Engineer. Geomembrane placement shall not be performed during precipitation, fog, snow, in an area of ponded water, or in the presence of excessive winds. Limited exceptions may be granted if the Geosynthetics Installer has established satisfactory installation methods under marginal weather conditions and has submitted an Inclement Weather Placement Plan.

The Certification Engineer shall verify that the above conditions are fulfilled and shall inform the Construction Manager if the conditions are not fulfilled.

8.2.1.5 Anchorage System

Anchor trenches shall be excavated by the Constructor (unless otherwise specified) to the lines and widths shown on the Design Drawings prior to geomembrane placement. The Certification Engineer shall verify that anchor trenches have been constructed according to the plans.

Slightly rounded corners will be provided in trenches where the geomembrane adjoins the trench to avoid sharp bends in the geomembrane. Loose soil shall not underlie the geomembrane in the trenches. Seaming shall continue through the anchor trench.

8.2.1.6 Method of Placement

The following is the responsibility of the Geosynthetics Installer; the Certification Engineer shall document that these conditions are satisfied:

- equipment used does not damage the geomembrane by handling, traffic, excessive heat, leakage of liquids, or other means;

- the prepared surface underlying the geomembrane has not deteriorated since previous acceptance, and is still acceptable immediately prior to geomembrane placement;

- personnel working on the geomembrane do not smoke, wear damaging shoes, or engage in other activities that could damage the geomembrane;

- the method and equipment used to unroll the panels does not cause scratches or crimps in the geomembrane and does not damage the underlying layer;

- the method used to place the panels minimizes wrinkles (especially differential wrinkles between adjacent panels);

- placed geomembrane panels shall extend a minimum of five feet (5 ft) beyond the toe of slope.

- adequate temporary loading and/or anchoring (e.g., sand bags, tires), not likely to damage the geomembrane, has been placed to prevent uplift by wind (in case of high winds, continuous loading, e.g., by adjacent sand bags, is recommended along the edges of panels to minimize the risk of wind flow under the panels).; and

- direct contact with the geomembrane is minimized; i.e., the geomembrane is protected by geotextile, extra geomembrane, or other suitable materials, in areas where excessive traffic may be expected.

The Certification Engineer shall inform the Construction Manager if the above conditions are not fulfilled.

8.2.1.7 Damage

The Certification Engineer shall visually observe each panel, after placement and prior to seaming, for damage. The Certification Engineer shall advise the Construction Manager which panels, or portions of panels, should be rejected, repaired, or accepted. Damaged panels or portions of damaged panels which have been rejected shall be marked and their removal from the work area recorded by the Certification Engineer.

As a minimum, the Certification Engineer shall document that:

- the panel is placed in such a manner that it is unlikely to be further damaged; and
- any tears, punctures, holes, thin spots, etc. are either marked for repair or the panel is rejected.

8.2.2 Field Seaming

Field seaming is the responsibility of the Geosynthetics Installer and shall be performed in accordance with approved methods.

Approved processes for field seaming are extrusion seaming and fusion seaming. Proposed alternate processes shall be documented and submitted to the Certification Engineer for approval. Only seaming equipment which has been specifically approved by make and model by the Certification Engineer shall be used. The Geosynthetics Installer shall submit seaming equipment documentation to the Construction Manager and the Certification Engineer for inclusion into the CQA Final report.

The following is the responsibility of the Geosynthetics Installer; the Certification Engineer shall verify that these conditions are met:

- the Geosynthetics Installer maintains on-site the number of spare operable seaming apparati decided at the Pre-Construction Meeting;
- equipment used for seaming is not likely to damage the geomembrane;
- the extruder is purged prior to beginning a seam and until heat-degraded extrudate has been removed from the barrel;
- for cross seams, the edge of the cross seam is ground to a smooth incline (top and bottom) prior to seaming;
- the electric generator used during geosynthetics installation is placed on a flat smooth base and a rub sheet such that no damage occurs to the geomembrane; and
- a smooth insulating plate or fabric is placed beneath the hot seaming apparatus after usage.

8.2.2.1 Extrusion Seaming

The extrusion seaming apparatus shall be equipped with gauges giving the relevant temperatures of the apparatus such as the temperatures of the extrudate, nozzle, and preheat.

The Geosynthetics Installer shall provide documentation on the extrudate to the Construction Manager and the Certification Engineer, and shall certify that the extrudate is compatible with the design specifications, and is comprised of the same resin as the geomembrane sheeting.

The Certification Engineer shall log apparatus temperatures, ambient temperatures, extrudate temperatures, and sheet temperatures a minimum of every five hours. Apparatus temperatures should be checked randomly during seaming operations to ensure the settings used to complete trial seams are maintained.

8.2.2.2 Fusion Seaming

The fusion seaming apparatus must be automated self-propelled devices, equipped with gauges giving the applicable temperatures. The pressure setting shall be verified by the Geosynthetics Installer prior to each seaming period.

The Certification Engineer shall log ambient temperatures, sheet temperatures, and seaming apparatus temperatures, speeds, and pressures.

8.2.2.3 Seam Preparation

The following is the responsibility of the Geosynthetics Installer; the Certification Engineer shall verify that these conditions are met:

- prior to seaming, the seam area is clean and free of moisture, dust, dirt, oils, greases, debris of any kind, and foreign material; the material to be jointed must be wiped with a clean cloth just prior to seaming;
- a rub sheet must be used to protect the underlying layer while cutting any materials;

- if seam overlap grinding is required, the process is completed according to the Geomembrane Manufacturer's instructions within 1 hour of the seaming operation, and in a way that does not damage the geomembrane;

- as a general guidance, the panels of geomembrane shall have a finished overlap; of a minimum of 3 in. for extrusion seaming and 4 in. for fusion seaming, but in any event sufficient overlap will be provided to allow peel tests to be performed on the seam;

- no solvent or adhesive is used unless the product is approved in writing by the Construction Manager (samples will be submitted to the Construction Manager for testing and evaluation);

- the procedure used to temporarily bond adjacent panels together does not damage the geomembrane (in particular, the temperature of hot air at the nozzle of any seaming apparatus is controlled such that the geomembrane is not damaged).

- no abrading is visible when welding is complete; and

- seams are aligned with the fewest possible number of wrinkle and "fishmouths".

The Certification Engineer shall observe all appropriate temperatures and conditions, and shall log and report to the Construction Manager any deviation.

8.2.2.4 Trial Seams

Trial seams shall be made on fragment pieces of geomembrane to verify that seaming conditions are adequate and in accordance with Table 7. Such trial seams shall be made at least once every 5 hours. A passing trial seam shall be made for each seaming device and technician for each material being welded (i.e., smooth to textured, textured to textured) for each technician. A change in technician or machine on a previously passed trial seam warrants the welding of a new passing trial seam. A trial seam shall also be made in the event that the sheet temperature varies more than 18°F (10°C) since the last passing trial seam. Trial seams shall be made under the same conditions as actual seams. If seaming apparatus is turned off for any reason, a new passing trial seam must be completed for that specific seaming apparatus.

The Geosynthetics Installer shall provide the tensiometer required for shear and peel testing of trial seams in the field. The tensiometer shall be automatic and shall have a direct digital readout. The tensiometer shall be calibrated prior to use at the site. The Geosynthetics Installer shall provide the Certification Engineer with the calibration certification.

The trial seam sample shall be at least 5 ft long by 1 ft wide (after seaming) with the seam centered lengthwise.

Six specimens, each 1 in. wide shall be cut from the trial seam sample by the Geosynthetics Installer. Three specimens shall be tested in shear and three in peel using a field tensiometer. For each fusion specimen, both tracks shall be tested. A passing welded seam is achieved in peel and shear when the specimen meets the criteria of Table 7.

If a specimen fails, the entire operation shall be repeated. If the additional specimen fails, the seaming apparatus and seamer shall not be accepted and shall not be used for seaming until the deficiencies are corrected and two consecutive successful full trial seams are achieved.

The Certification Engineer shall observe trial seam procedures. The remainder of the successful trial seam sample shall be assigned a number and marked accordingly by the Certification Engineer, who will also log the data, hour, ambient temperature, number of seaming unit, name of seamer, and pass or fail description. This portion of the sample shall be retained for the Construction Manager's archives.

8.2.2.5 General Seaming Procedure

Unless otherwise specified, the general seaming procedure used by the Geosynthetics Installer shall be as follows.

- For fusion seaming, a movable protective layer of plastic may be required to be placed directly below each overlap of geomembrane that is to be seamed. This is to help prevent any moisture build-up between the sheets to be seamed. This layer is temporary and shall be removed upon completion of the seam.

- If field conditions necessitate, a firm substrate will be provided by using a flat board or similar hard surface directly under the seam overlap to achieve proper support.

- Wrinkles at the seam overlaps will be cut along the ridge of the wrinkle in order to achieve a flat overlap. The cut wrinkles will be seamed and any portion where the overlap is inadequate will then be patched with an oval or round patch of the same geomembrane extending a minimum of 6 in. beyond the cut in all directions.

- Seaming will extend to the outside edge of panels to be placed in the anchor trench.

- No field seaming shall take place without the Geosynthetics Field Superintendent and representatives of the Certification Engineer being present.

The Certification Engineer shall verify that the above seaming procedures are followed, and shall inform the Construction Manager if they are not.

8.2.2.6 Non-Destructive Seam Continuity Testing

The Geosynthetics Installer shall non-destructively test field seams over their full length using a vacuum test unit (for extrusion or single wedge fusion seams only), air pressure test, or other approved method. The testing shall be carried out to the accepted standards of the industry. The purpose of non-destructive tests is to check the continuity of seams. It does not provide any information on seam strength. Continuity testing shall be carried out as the seaming work progresses (maximum of 3,000 lineal ft of seam to be welded prior to beginning nondestructive testing), not at the completion of all field seaming, unless otherwise approved by the Construction Manager. The Geosynthetics Installer shall complete any required repairs in accordance with this QA/QC Plan. Non-destructive testing shall not be permitted before sunrise or after sunset unless the Geosynthetics Installer demonstrates capabilities to do so.

Air Pressure Testing:

Unless otherwise specified, the general air pressure testing procedure used by the Geosynthetics Installer shall be as follows:

- Inflate the test channel to 30 to 35 psi, close valve, and observe initial pressure after approximately 2 minutes.
- Initial pressure settings are read after a 2 minute "relaxing period". Initial pressure setting shall be between 30 and 35 psi. The purpose of the "relaxing period" is to permit the air temperature and pressure to stabilize.
- Observe and record the air pressure 5 minutes after "relaxing period" ends and initial pressure setting is used. If loss of pressure exceeds 3 psi, or if the pressure does not stabilize, locate the faulty area and repair.
- At the conclusion of the pressure test, the end of the seam opposite the pressure gauge is cut. A decrease in a gauge pressure must be observed or the air channel will be considered "blocked" and the test will have to be repeated after the blockage is located and corrected.
- Remove needle or other approved pressure feed device and seal the resulting hole by extrusion welding.
- Test results will be recorded by the Certification Engineer.

Non-complying Air Pressure Test:

In the event of a non-complying air pressure test, the following procedure shall be followed:

- Check the seam and seals and retest the seam.
- If deviation with specified maximum pressure differential reoccurs cut 1 in. samples from each end of the suspect area.
- Perform destructive peel tests on the samples using the field tensiometer.

- If all samples pass destructive testing, the installer may:
    - Cap-strip the suspect area;
    - When sufficient overlap exists (1.5 in.), heat tack the overlap and extrusion weld the entire seam; or
    - Further isolate the air pressure failure as agreed upon by the Certification Engineer and Construction Manager.
- If one or more samples fail the peel tests, additional samples will be taken. When two passing samples are located, the suspect areas will be considered non-complying. In this section the seam shall be cap stripped, or the overlap left by the wedge welder will be heat tacked in place along the entire length of the seam and will be extrusion welded. Test the entire length of the repaired seam by vacuum testing.
- If the seam is in non-compliance due to air channel blockage, the blockage shall be isolated, as agreed upon by the Certification Engineer and the Construction Manager.
- All sections shall be retested and repaired in accordance with this section.

Vacuum Testing:

Unless otherwise specified, the general vacuum testing procedure used by the Geosynthetics Installer shall be as follows.

- Turn on the vacuum pump to reduce the vacuum box to approximately 5 psi.
- Apply a generous amount of a solution of liquid soap and water to the area to be tested.
- Place the vacuum box over the area to be tested and apply sufficient downward pressure to "seat" the seal strip against the liner.
- Close the bleed valve and open the vacuum valve.

- Ensure that a leak tight seal is created.
- For a period of not less than 15 seconds, examine the geomembrane through the viewing window for the presence of soap bubbles.
- If no bubbles appear after 15 seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 3 in. overlap, and repeat the process.

Non-Complying Vacuum Test:

In the event of a non-complying vacuum test, the following procedure shall be followed.

- Mark all areas where soap bubbles appear and repair the marked areas, as specified in this section.

CQA Responsibilities:

The Certification Engineer shall:

- document all continuity testing;
- record location, date, unit number, name of tester, and outcome of all testing; and
- inform the Geosynthetics Installer and Construction Manager of any required repairs.

When defects are located, the Certification Engineer shall:

- observe the repair and retesting of the repair;
- mark on the geomembrane that the repair has been made; and
- document the results.

Non-Testable Areas:

The Geosynthetics Installer shall use the following procedures at locations where seams cannot be non-destructively tested:

- Seams shall be cap-stripped with the same geomembrane material.
- If the seam is accessible to testing equipment prior to final installation, the seam shall be non-destructively tested prior to final installation.
- If the seam cannot be tested prior to final installation, the seaming and cap-stripping operations shall be observed by the Certification Engineer and Geosynthetics Installer for uniformity and completeness.

8.2.2.7 Destructive Seam Testing

The Geosynthetics Installer will not be informed in advance of the locations where the seam samples will be taken.

Sampling Procedure:

Samples shall be cut by the Installer as the seaming progresses to have passing laboratory test results before the geomembrane is covered by another material. The Certification Engineer shall:

- observe sample cutting;
- assign a number to each sample, and mark it accordingly;
- record the sample location on the layout drawing; and
- record the reason for taking the sample at this location (e.g., statistical routine, suspicious feature of the geomembrane).

All holes in the geomembrane resulting from destructive seam sampling shall be immediately repaired in accordance with repair procedures described in Subsection

8.2.3 of this QA/QC Plan. The continuity of the new seams in the repaired area will be tested.

Size of Samples:

At a given sampling location, two types of samples shall be taken by the Geosynthetics Installer.

First, two specimens for field testing shall be taken. Each of these specimens will be 1 in. wide by 12 in. long, with the seam center parallel to the width. The distance between these two specimens will be 42 in. (or 30 in. see below). If both specimens pass the field tests described under the heading entitled "Field Testing," a sample for laboratory testing shall be taken.

The sample for laboratory testing shall be located between the two specimens for field testing. The destructive sample will be 12 in. wide by 42 in. long if the Geomembrane Installer requests a sample; otherwise the destructive samples will be 30 in. with the seam centered lengthwise. The sample shall be cut into three parts and distributed as follows:

- One portion to the Geosynthetics Installer for laboratory testing, 12 in. × 12 in.;
- One portion to the Construction Manager for archive storage, 12 in. × 12 in.;
- One portion for Geosynthetics CQA Laboratory testing, 12 in. × 18 in.

Final determination of the sample sizes shall be made at the Pre-Construction meeting.

Field Testing:

Two 1 in. wide specimens shall be tested in the field with the tensiometer, for peel and shear respectively, and shall meet the minimum requirements presented in Table 7. If any field test sample fails to pass, then the procedures outlined in this section will be followed.

The Certification Engineer shall review field tests and mark all samples and portions with their number. The Certification Engineer shall also log the date and time, ambient temperature, number of seaming unit, name of technician, seaming apparatus temperatures and speeds, and pass or fail description.

Geosynthetics QA Laboratory Testing:

Destructive test samples shall be packaged and shipped, if necessary, by the Certification Engineer in a manner that will not damage the test sample. The Construction Manager shall be responsible for storing the archive samples. Test samples shall be tested by the Geosynthetics CQA Laboratory.

Testing will include shear and peel as shown in Tables 7. At least five specimens will be tested for each test method. A maximum of one non-film tear bond (FTB) failure is acceptable, for each method, provided that strength requirements are met on that sample.

The Geosynthetics CQA Laboratory shall provide test results, in writing, no more than 24 hours after they receive the samples. The Geosynthetic CQA Laboratory shall document the results of seam testing. The Certification Engineer shall review laboratory test results as soon as they become available, and make appropriate recommendations to the Construction Manager.

Destructive Test Failure:

The following procedures shall apply whenever a sample fails a destructive test, whether that test is conducted by the Geosynthetics CQA Laboratory, the Geosynthetics Installer's Laboratory, or by the field tensiometer.

- The Geosynthetics Installer can reconstruct the seam between any two passed destructive seam test locations; or
- The Geosynthetics Installer can trace the seaming path to an intermediate location (at least 10 ft from the point of the failed test in each direction) and take a small sample for an additional field test at each location. If these additional samples pass field tensiometer testing, then full destructive laboratory samples are taken. If these destructive laboratory samples pass the

tests, then the seam shall be reconstructed between these locations by capping for extrusion or fusion welds, by extrusion welding the flap for fusion welds, or by removing and replacing the seam. If either the field tensiometer or the laboratory test sample fails, then the process is repeated to establish the zone in which the seam should be reconstructed.

If a fusion type seam fails destructive testing and the Geosynthetics Installer chooses to cap the seam, only acceptable capping methods will be allowed.

All acceptable seams must be bounded by two locations from which destructive samples passing laboratory tests have been taken. In cases exceeding 150 ft of reconstructed seam, a sample shall be taken from the zone in which the seam has been reconstructed. This sample must pass destructive testing or the procedure outlined here must be repeated.

The Certification Engineer shall document all actions taken in conjunction with destructive test failures.

8.2.3 Defects and Repairs

Seams and non-seam areas of the geomembrane shall be examined by the Certification Engineer for identification of defects, holes, blisters, undispersed raw materials and any sign of contamination by foreign matter. Because light reflected by the geomembrane helps to detect defects, the surface of the geomembrane will be clean at the time of examination. The surface shall be swept or washed by the Geosynthetics Installer if the amount of dust or mud inhibits examination.

8.2.3.1 Repair Procedures

Any portion of the geomembrane exhibiting a flaw, failing a destructive, or failing a non-destructive test, shall be repaired. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure shall be approved by the Construction Manager and the Certification Engineer. The procedures available include:

- Patching - Apply a new piece of geomembrane sheet over, and at least 6 in. beyond the limits of a defect. The patch shall be extrusion seamed to the underlying geomembrane. This method should be used to repair large holes, tears, destructive test locations, undispersed raw materials, and contamination by foreign matter.

- Spot Seaming - Apply a "bead" of extrudate, maximum length of 6 in., over a defect. Spot seaming should be used only to repair dents, pinholes, pressure test air holes, or other minor, localized flaws.

- Capping - Apply a new strip of geomembrane along the length of a delineated faulty seam. The cap strip shall extend at least 6 in., beyond the limit of the seam and the edges will be extrusion seamed to the underlying geomembrane. This method should be used to repair lengths of extrusion or fusion seamed to the underlying geomembrane.

- Welding Flap - Where an adequate flap exists (i.e., 1.5 in. or more), extrusion weld the flap of a fusion seam. At the ends of this repair, the flap shall be cut to allow the extrusion weld to enclose the failed area.

- Replacement - The faulty seam is removed and replaced.

In addition, the following provisions shall be satisfied:

- Surfaces of the geomembrane which are to be repaired will be abraded no more than one hour prior to the repair;

- All surfaces must be clean and dry at the time of the repair;

- All seaming equipment used in repairing procedures must be approved;

- The repair procedures, materials, and techniques will be approved in advance of the specific repair by the Certification Engineer and Geosynthetics Installer;

- Patches or caps will extend at least 6 in. beyond the edge of the defect, and all corners of patches will be rounded;

- Seam repairs over 150 ft long will require a destructive test to be taken from the repair.

8.2.3.2 Verification of Repairs

Each repair shall be numbered and logged by the Certification Engineer and the Geosynthetics Installer. Each repair shall be non-destructively tested using the methods described in this section as appropriate. Repairs which pass the non-destructive test will be taken as an indication of an adequate repair. However, if the Certification Engineer suspects a repair to be questionable, although it passes non-destructive testing, a destructive test can be requested. Failed tests will require the repair to be redone and retested until a passing test results. The Certification Engineer shall observe non-destructive testing of repairs and shall record the date of the repair and test outcome.

8.2.3.3 Large Wrinkles

When seaming of the geomembrane is completed (or when seaming of a large area of the geomembrane is completed) and prior to placing overlying materials, the Certification Engineer shall observe the geomembrane wrinkles. Wrinkles exceeding six inches in height shall not be permitted. The Certification Engineer will indicate to the Construction Manager which wrinkle should be cut and resealed by the Geosynthetics Installer. The seam thus produced will be tested like any other repair.

8.2.4 Backfilling of Anchor Trench

Anchor trenches will be adequately drained, to prevent ponding or otherwise softening of the adjacent soils while the trench is open. Anchor trenches shall be backfilled and compacted as soon as possible after completion of geosynthetics installation. Care shall be taken when backfilling the trenches to prevent any damage to the geosynthetics.

The Certification Engineer shall observe the backfilling operation and advise the Construction Manager of any problems.

8.2.5 Geomembrane Certification/Acceptance

The Geosynthetics Installer and the Geomembrane Manufacturer shall retain ownership and responsibility for the geosynthetics in the facility until acceptance by the Owner.

The geomembrane shall be accepted by TVA when:

- the installation is completed;
- verification of the adequacy of seams and repairs, including associated testing, is complete;
- Geosynthetics Installer's representative furnishes the Construction Manager with certification that the geomembrane was installed in accordance with the Geomembrane Manufacturer's recommendations as well as the Design Drawings and specifications;
- all documentation of installation is completed including the Certification Engineer final report; and
- certification, including record drawings, sealed by a Professional Engineer has been received by the Construction Manager.

The Certification Engineer shall provide certification that installation has proceeded in accordance with this Plan for the project, except as noted to the Construction Manager.

8.2.6 Materials in Contact with the Geomembrane

The quality assurance procedures indicated in this Subsection are only intended to verify that the installation of these materials does not damage the geomembrane. Additional quality assurance procedures provided in other sections of this QA/QC Plan are necessary to verify that the systems built with these materials are constructed to perform as designed.

8.2.6.1 Geocomposite

Extreme care shall be exercised so as not to damage the geomembrane during placement of the geocomposite and the materials overlying the geocomposite. The Certification Engineer shall verify that the geocomposite is installed in accordance with the procedures described in Section 9 "Geocomposite" of this QA/QC Plan.

8.2.6.2 Appurtenances

The Design Engineer shall provide design specifications for appurtenances to the Construction Manager and the Certification Engineer.

The Certification Engineer shall verify that:

- installation of the geomembrane in appurtenance areas, and connection of geomembrane to appurtenances have been made according to the design specifications;

- extreme care is taken while seaming around appurtenances since neither non-destructive nor destructive testing may be feasible in these areas; and

- the geomembrane has not been visibly damaged while making connections to appurtenances.

The Certification Engineer will inform the Construction Manager if the above conditions are not fulfilled.

9 GEOCOMPOSITE

9.1. Manufacturers Documentation

Prior to delivery, the Geocomposite Manufacturer shall provide documentation which demonstrates that the property values of the material meet the requirements as specified in Table 8. Delivered rolls of geocomposite shall be appropriately labeled.

9.1.1 Certification of Property Values

Prior to shipment the Geocomposite Manufacturer shall provide the Construction Manager and Certification Engineer with a list of guaranteed minimum properties (Table 8) for the type of geocomposite to be supplied. The Geocomposite Manufacturer shall also provide the Construction Manager and Certification Engineer with a written certification signed by a responsible party that the geocomposite actually delivered has properties which meet or exceed the guaranteed properties. Geotextile will be thermally bonded to geonet components of geocomposite.

The Certification Engineer shall examine the Manufacturer's certifications to verify that the property values listed on the certifications meet or exceed the project requirements. Deviations from the project requirements shall be reported to the Construction Manager.

9.1.2 Labeling

The Geocomposite Manufacturer shall identify all rolls of geocomposite. Each geocomposite roll shall have a weatherproof label which contains the following:

- manufacturer's name;
- product identification;
- lot number;
- roll number; and
- roll dimensions.

The Certification Engineer shall examine rolls upon delivery and any deviation from the above requirements shall be reported to the Construction Manager.

9.2 Shipment And Storage

Geocomposite cleanliness is essential to performance; therefore, measures must be taken during shipment and storage to protect the geocomposite from dust and dirt. Geocomposite rolls shall be wrapped in plastic sheets or otherwise protected. Wrappings protecting the geocomposite rolls should be removed less than 1 hour prior to unrolling the geocomposite.

The Certification Engineer shall verify that the geocomposite is free of dirt and dust prior to being installed. If the geocomposite is judged dirty or dusty, it shall be washed by the Geosynthetics Installer prior to installation. Washing operations shall be approved by the Certification Engineer.

The Certification Engineer shall examine rolls prior to installation; any deviation from the above requirements shall be reported to the Construction Manager. Damaged rolls shall be rejected and replaced at no cost to TVA.

9.3 Conformance Testing Of Geocomposite

Upon or prior to delivery of the rolls of geocomposite, the Certification Engineer may remove and forward samples to the Geosynthetics CQA Laboratory for testing to verify conformance with the design specifications listed in Table 9.

9.3.1 Sample Collection

Using the packing list provided by the manufacturer or a sequential inventory list made by the Certification Engineer, rolls may be selected for sampling at a minimum frequency of one sample per 100,000 ft^2 of material. If the material is shipped in identifiable lots or manufacturing runs, sample selection should be adjusted to assure that the minimum frequency is met and that each different lot or manufacturing run is represented by at least one sample. If a roll is not identifiable by roll number, the Certification Engineer shall notify the Construction Manager immediately. If the roll cannot be tracked, the Construction Manager shall reject the roll.

Samples will be taken across the entire width of the roll and will not include the first 3 lineal ft. Unless otherwise specified, samples will be 3 ft long by the roll width. The Certification Engineer will mark the machine direction on the samples with an arrow.

9.3.2 Test Results

The results of the conformance testing shall be evaluated in accordance to the following procedure:

- If the test values for the sample meet all of the values given in Table 8 and the Manufacturer's guaranteed minimum values, the sample passes.
- If the test value for the sample does not meet one or more of the required values, additional evaluation procedures will be implemented by the Certification Engineer.
- For the failing parameter(s), perform one additional test on the sample. This test may be performed by another Geosynthetics CQA Laboratory at the discretion of the Certification Engineer and the Construction Manager.
- If the test values for the additional test meet the required values, the roll and adjacent rolls pass and are acceptable.
- If the test value does not met requirements, reject the roll, collect samples from the closest numerical roll on both sides of the failed roll, and test for the failed parameter(s). If one or both of these tests do not meet requirements, those roll(s) will be rejected and the Certification Engineer and Construction Manager shall determine further testing protocol and criteria for identifying the limits of rejected rolls.

9.4. <u>Handling And Placement</u>

The Geosynthetics Installer shall handle the geocomposite in such a manner as to minimize damage and comply with the following:

- After the wrapping has been removed; the geocomposite shall not be exposed to sunlight for more than the duration specified by the Geotextile Manufacturer.

- On slopes, the geocomposite shall be secured in the anchor trench and then rolled down the slope in such manner as to continually keep the geocomposite sheet in tension. If necessary, the geocomposite shall be positioned by hand after being unrolled to minimize wrinkles. Geocomposite can be placed in the horizontal direction (i.e., across the slope) in some special locations (e.g., at the toe of the slope, or, if an extra layer of geocomposite is required, this extra layer can be placed in the horizontal direction). Such locations shall be identified by the Design Engineer in the Design Drawings.

- The geocomposite shall extend a minimum of 10 feet beyond the toe of slope.

- In the presence of wind, the geocomposite shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during placement and remain until replaced with overlying material.

- Unless otherwise specified, the geocomposite shall not be welded to geomembrane.

- The Geosynthetics Installer shall take necessary precautions to prevent damage to underlying layers during placement of the geocomposite. Care should be taken not to leave tools on or in the geocomposite.

- During placement of the geocomposite, care shall be taken not to entrap dirt or excessive dust that could cause clogging of the drainage system, and/or stones that could damage the adjacent geomembrane. If any dirt, excessive dust, and/or any stones are entrapped in or below the geocomposite, the geocomposite and underlying liner shall be washed or swept prior to placement of material on it.

The Certification Engineer shall note any deviation and report it to the Construction Manager.

9.5 Stacking And Joining

Stacked geocomposite shall be placed in the same direction to prevent the stands of one layer from penetrating the channels of the lower layer, thereby significantly reducing the transmissivity. Geocomposite shall not be laid in direction perpendicular to the underlying geocomposite unless otherwise specified by the Design Engineer.

Adjacent geocomposite panels shall be joined according to the plans and CQA Panel. As a minimum, the following requirements shall be met:

Geonet components:

- Adjacent rolls shall be overlapped by at least 4 in.
- These overlaps shall be secured by tying.
- Tying shall be achieved by nylon cable ties. Tying devices will be white or yellow for easy observation. Metallic devices are not allowed.
- Tying devices shall be placed every 5 ft down the slope, every 2 ft across the slope, and every 6 ft on horizontal surfaces.

Geotextile Components:

- The bottom layers of geotextile shall be overlapped. The top layer of geotextile shall be continuously sewn (i.e., spot sewing is not allowed). Geotextile panels shall be overlapped a minimum of 4 in. prior to sewing.
- No horizontal seams shall be allowed on slopes steeper than 10 horizontal to 1 vertical.
- Polymeric thread, with chemical resistance properties equal to or exceeding those of the geotextile component, shall be used for all sewing. The seams shall be sewn using stitch Type 401. The seam type shall be Federal Standard Type SSN-1.

Geocomposite:

- In the corners of the side slopes of rectangular areas of the disposal areas, where overlaps between perpendicular geocomposite strips are required, and extra layer of geocomposite shall be unrolled along the slope, on top of the previously installed geocomposite, from top to bottom of the slope.

- When more than one layer of geocomposite is installed, joints shall be staggered.

The Certification Engineer shall note any deviation and report it to the Construction Manager.

9.6 Repair

Any holes or tears in the geocomposite shall be repaired by placing a patch extending 2 ft beyond the edges of the hole or tear. The patch shall be secured to the original geocomposite by tying every 6 in. If the hole or tear width across the roll is more than one-half the width of the roll, the damaged area shall be cut out and the two portions of the geocomposite shall be joined.

The Certification Engineer shall observe any repair, note any deviation with the above requirements and report them to the Construction Manager.

9.7 Placement of Materials on Geocomposites

The placement of materials on the geocomposite shall be as soon as possible, such that:

- the geocomposite and underlying geomembrane are not damaged;

- minimal slippage of the geocomposite on the underlying geomembrane occurs; and

- no excess tensile stresses occur in the geocomposite.

If portions of the geocomposite are exposed, the Certification Engineer shall periodically place marks on the geocomposite and the underlying geomembrane and measure the elongation of the geocomposite during the subsequent construction activities. Before a subsequent layer of geosynthetic is placed on the geocomposite the Certification Engineer should observe the geocomposite and underlying liner to determine if any dirt, excessive dust, or any stones are entrapped in, or below, the liner. If so, the geocomposite and geomembrane must be washed or the geocomposite removed so that the liner can be cleaned.

Any deviation shall be noted by the Certification Engineer and reported to the Construction Manager.

10 GEOTEXTILE

10.1 Manufacturers Documentation

Prior to delivery, the Geotextile Manufacturer shall provide documentation to demonstrate that the property values of the material meet requirements as specified in Table 10. Delivered rolls of geotextile shall be appropriately labeled.

10.1.1 Certification of Property Values

The Geotextile Manufacturer shall provide the Construction Manager and Certification Engineer with a list of guaranteed "minimum average roll value" properties (as defined by the Design Engineer) for the type of geotextile to be supplied, as defined in Table 10. The Geotextile Manufacturer shall provide the Construction Manager and Certification Engineer with a written certification signed by a responsible party that the geotextile actually delivered have properties which meet or exceed the guaranteed "minimum average roll values" properties.

The Certification Engineer shall examine the Geotextile Manufacturer's certifications to verify that the property values listed on the certifications meet or exceed requirements listed in this QA/QC Plan. Deviations shall be reported to the Construction Manager.

10.1.2 Labeling

The Geotextile Manufacturer shall identify all rolls of geotextile. Each geotextile roll shall have a weatherproof label which contains the following:

- manufacturer's name;
- product identification;
- lot number;
- roll number;
- roll weight; and

- roll dimensions.

In addition, if any special handling of the geotextile is required, it shall be so marked on the top surface of the geotextile, e.g., "This Side Up". Rolls without proper identification shall be rejected by the Construction Manager.

The Certification Engineer shall examine rolls upon delivery and any deviation form the above requirements shall be reported to the Construction Manager.

10.2 Shipment and Storage

During shipment and storage, the geotextile shall be protected from ultraviolet light exposure, precipitation, snow or other inundation, mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions. Geotextile rolls shall be wrapped in plastic sheets or otherwise protected. Wrappings protecting the geotextile rolls should be removed less than one hour prior to unrolling the geotextile.

Geotextile shall not be exposed to precipitation prior to being installed. Wet geotextile is heavy which makes it difficult to deploy. During cold weather, the geotextile must be protected from freezing.

The Certification Engineer shall observe rolls upon delivery and prior to installation, any deviation from the above requirements shall be reported to the Construction Manager. Any damaged rolls shall be rejected and replaced at no cost to TVA.

10.3 Conformance Testing of Geotextile

Prior to the deployment of the rolls of geotextile, the Certification Engineer may remove and forward samples to the Geosynthetics CQA Laboratory for testing to verify conformance with the design specifications. Testing shall be accomplished using the parameters listed in Table 11.

10.3.1 Sample Collection

Using the packing list provided by manufacturer or a sequential inventory list made by the Certification Engineer, rolls may be selected for sampling at a minimum frequency of one sample per 100,000 ft^2 of material. If the material is shipped in identifiable lots or manufacturing runs, sample selection should be adjusted to assure that the minimum frequency is met and that each different lot or manufacturing run is represented by at least one sample. If a roll is not identifiable by roll number, the Certification Engineer shall inform the Construction Manager immediately. If the roll cannot be tracked, the Construction Manager shall reject the roll.

Samples will be taken across the entire width of the roll and will not include the first 3 lineal ft. Unless otherwise specified, samples will be 3 ft long by the roll width. The Certification Engineer will mark the machine direction on the samples with an arrow.

10.3.2 Test Results

The results of the conformance testing shall be evaluated in accordance to the following procedure:

- If the test values for the sample meet all of the required values, the sample passes.
- If the test value for the sample does not meet one or more of the required values, additional evaluation procedures will be implemented by the Certification Engineer.
- For the failing parameter(s), perform one additional test on the sample. This test may be performed by another Geosynthetics CQA Laboratory at the discretion of the Certification Engineer and the Construction Manager.
- If the test values of the additional test meet the required values, the roll and adjacent rolls pass and are acceptable.
- If the test values do not meet requirements listed in Tables 10 and 11, reject the roll, collect samples from the closest numerical roll on both sides of the failed roll and test for the failed parameter(s). If one or both of these tests do not meet requirements, those roll(s) will be rejected and the Certification Engineer and Construction Manager shall determine further testing protocol and criteria for identifying the limits of rejected rolls.

10.4 Handling and Placement

The Geosynthetics Installer shall handle the geotextile in such a manner as to minimize damage and shall comply with the following:

- After the wrapping has been removed; the geotextile shall not be exposed to sunlight for more than the duration specified by the Geotextile Manufacturer.

- In the presence of wind, the geotextile shall be weighted with sandbags or the equivalent. Sandbags shall be installed during the placement and shall remain until replaced with the appropriate overlying material.

- Geotextile shall be kept continually under tension to minimize the presence of wrinkles in the geotextile.

- The geotextile shall be cut using an approved geotextile cutter only. If in-place, special care must be taken to protect other materials from damage which could be caused by the cutting of the geotextile.

- The Geosynthetics Installer shall take necessary precautions to prevent damage to the underlying layers during placement of the geotextile.

- During placement of geotextile, care shall be taken not to entrap stones, excessive dust, or moisture that could damage the geomembrane, generate clogging of drains or filters, or hamper subsequent seaming.

- After installation, the entire surface of the geotextile shall be examined, and harmful foreign objects, such as needles, shall be removed.

- If white geotextile is used, precautions will be taken against "snow blindness" of personnel.

The Certification Engineer shall note any deviation and report it to the Construction Manager.

10.5 Seams and Overlaps

The Geotextile seams shall be continuously sewn using thread, which is at least as chemically resistant and UV resistant as the geotextile. The thread shall be approved by the Certification Engineer and Construction Manager. Spot sewing is not permitted, except for repairs, and thermal bonding shall not be permitted without the written approval of the Construction Manager. The geotextile shall be overlapped a minimum of 4 in. prior to seaming. The Geosynthetics Installer shall pay particular attention that no material is inadvertently inserted beneath the geotextile. Within the Central Drainage Corridor the geotextile panels may be overlapped a minimum of 2 ft. between adjacent panels and the overlap sand bagged, in place of sewing of adjacent panels.

The Certification Engineer shall note any deviation and report it to the Construction Manager.

10.6 Repair

Any holes or tears in the geotextile shall be repaired by the Geosynthetics Installer as follows:

- A patch made from the same geotextile shall be sewn in place with a minimum of 24 in. overlap in all directions.

Care shall be taken to remove any soil or other material which may have penetrated the torn geotextile.

The Certification Engineer shall observe any repair, note any deviation from the above requirements and report them to the Construction Manager.

10.7 Placement of Materials on Geotextiles

The Geosynthetics Installer shall place materials on the geotextile taking the following precautions:

- cause no damage to geotextile;
- allow minimal slippage of the geotextile on underlying layers;

- equipment used for packing the overlying material shall not be driven directly on the geotextile;
- a minimum thickness of 1 ft of soil must be maintained between light, low ground-pressure equipment (such as a wide pad Caterpillar D-6 or lighter) and the geotextile;
- a minimum thickness of 1.5 ft of soil must be maintained between rubber-tired vehicles and the geotextile unless approved by the Design Engineer and Construction Manager; and
- in heavily trafficked areas such as access ramps, soil thickness shall be at least 3 ft.

Any deviation shall be noted by the Certification Engineer and reported to the Construction Manager.

11. SURVEYING AND CONSTRUCTION TOLERANCES

The minimum thickness of the intermediate cover, compacted clay layer, and vegetative layer in the final cover shall be surveyed to verify that the minimum soil thicknesses specified in the Design Drawings are met. Other construction tolerances are as noted on the drawings.

Surveying will be performed under this section to document as-built conditions, and will be the responsibility of the Constructor. The as-built survey will be performed by a Surveyor registered in the state of Tennessee. Intermediate surveying for construction layout, slope staking, etc., may be performed by the Constructor's personnel.

The completed surfaces of subgrade, top of geologic buffer, top of soil dikes and gypsum dikes, completed outer gypsum dikes, top of intermediate cover, and top of vegetative cover will be surveyed. Geomembrane panels shall be surveyed and this survey shall include as-built information of: seam intersections, cross seams, repair locations, destructive sample locations, well or pipe penetration locations, and location of anchor trenches. In applicable cases, surveys will be performed before placement of the overlying drainage layer, to verify that grades and elevations are in accordance with the approved plans. At a minimum, survey points shall be established on a 50 ft. x 50 ft. grid. Survey grid points shall be located such that the same grid can be reused for subsequent as-built surveys as the completion of each layer progresses. Soil layer thickness shall be obtained to the nearest 0.001 ft. and reported to the nearest .01 ft.

The Certification Engineer may request additional survey information as required for certification.

12 REPORTING AND DOCUMENTATION

12.1 Deficiencies

When deficiencies are discovered, the Certification Engineer shall immediately determine the nature and extent of the problem, notify the Constructor, and complete required documentation. In all cases, the Certification Engineer will notify the Constructor within one-half hour of discovering the deficiency. If the deficiency will cause construction delays of more than four hours or will necessitate substantial rework, the Certification Engineer shall also notify the Construction Manager.

The Constructor shall correct the deficiency to the satisfaction of the Certification Engineer. If the Constructor is unable to correct the problem, the Certification Engineer will prepare a nonconformance report and will develop and present suggested solutions to the Construction Manager for approval.

The corrected deficiency shall be re-tested before additional work is performed. All retests, and the steps taken to correct the problem, will be documented by the Certification Engineer.

12.2 Documentation

The QA/QC Plan depends on through monitoring and documentation of construction activities. Therefore, the Certification Engineer shall document that Quality Assurance requirements have been addressed and satisfied. Documentation shall consist of daily record keeping, construction problem resolutions, photographic records, design revisions, weekly progress reports, and a certification and summary report.

12.2.1 Daily Record Keeping

At a minimum, daily records shall consist of field notes, summaries of the daily meetings with the Constructor, observations and data sheets, and construction problems and resolution reports. This information shall be submitted to the Construction Manager for review and approval.

A Daily Meeting Report will be prepared each day, summarizing discussions held with a Constructor. This report will include the following items:

a. date, project name, and location;

b. names of parties involved in discussions;

c. data on weather conditions;

d. listing and location of construction activities underway during the time frame of the Daily Summary Report;

e. equipment present on-site;

f. descriptions of areas and/or activities being inspected and/or tested, and related documentation;

g. description of off-site materials received;

h. scheduled activities;

i. items discussed;

j. signature of the Certification Engineer.

12.2.2 Observation and Test Sheets

Observation and test data sheets shall include the following information:

a. date, project name, and location;

b. weather data;

c. reduced-scale site plan showing work areas, including sample and test locations;

d. description of ongoing construction;

e. summary of test results identified as passing, failing, or in the event of a failed test, retest;

f. calibration of test equipment;

g. summary of decisions regarding acceptance of the work and/or corrective actions taken;

h. signature of the Certification Engineer.

12.2.3 Construction Problem Reports

This report identifies and documents construction problems and resolutions. It is intended to document problems involving significant rework and is not intended to document items easily corrected unless the problems are recurring. At a minimum, this report shall include the following items:

a. detailed description of the problem;

b. location and cause of the problem;

c. how the problem was identified;

d. resolution of the problem;

e. personnel involved;

f. signature of the Certification Engineer and Construction Manager.

12.2.4 Survey Control

The following procedures will be followed with respect to the as-built survey of the components of the CCB disposal facility.

- The subgrade, geologic buffer, soil dikes, perimeter gypsum dikes, outer gypsum dikes, compacted clay and soil layers, and vegetative soil layer will be surveyed to verify that grades and elevations are in accordance with the approved Design Drawings. A comparison of the pre- and post-component construction surveys will be conducted to verify construction thickness.

- The Surveyor shall promptly submit results of each survey to the Construction Manager. Survey results shall include: copy of any field notes, electronic and hard copy of the survey point file, and electronic and hard copy of survey drawing.

- The Certification Engineer will certify that the components meet the requirements in the Design Drawings and will submit approval to the Construction Manager.

12.2.5 Design Changes

Design changes may be required during construction. In such cases, the Certification Engineer shall notify the Construction Manager, who will then notify the responsible State Agencies. Design changes shall only be made with written agreement of the Construction Manager.

12.2.6 Weekly Progress Reports

The Certification Engineer will prepare weekly progress reports summarizing construction and quality control activities. At a minimum this report, submitted to the Construction Manager, shall contain the following information:

a. date, project name, and location;

b. summary of work activities;

c. summary of deficiencies and/or defects and resolutions;

d. signature of Certification Engineer.

12.2.7 Certification Reports

The Certification Engineer will be required to submit the following certification reports. The first certification report will cover the construction of the base grade components for the disposal area including: subgrade/structural fill, geologic buffer, soil dikes, gravel drainage layer and will be required prior to disposal of gypsum. A certification report will also be required for final cover system construction.

The final certification report will be required after the gypsum has reached final permitted grades. This report will cover the capping phase of construction and will be required after closure of the facility. This report will address final gypsum-fill slopes, compacted clay layer, geosynthetics, and vegetative layer.

At completion of each phase of construction, the Certification Engineer shall submit a certification report to the Construction Manager. This report shall certify that the work has been performed in substantial compliance with the approved Design Plans. At a minimum, this repot shall contain the following information:

a. summary of all construction activities;

b. testing laboratory test results;

c. observation and test data sheets;

d. sampling and testing location plan;

e. description of significant construction problems and their resolution;

f. list of changes from the approved plans and the justification for these changes;

g. record drawings; and

h. a certification statement signed and sealed by the Certification Engineer.

TABLES

TABLE 1

LABORATORY TEST METHODS
FOR THE EVALUATION OF SOIL AND AGGREGATE

COMMON TEST NAME	PARAMETER DEFINED	STANDARD METHOD
Soil Classification	Unified Soil Classification System	ASTM D 2487
Sieve and Hydrometer Analysis	Particle Size Distribution of Coarse and Fine Grained Soils	ASTM D 422
Sieve Analysis for Aggregates	Particle Size Distribution for Aggregates	ASTM C 136
Atterberg Limits	Liquid and Plastic Limits, Plasticity Index	ASTM D 4318
Standard Proctor Density	Moisture/Density Relationship Using 5.5 lb (2.46 kg) Rammer and 12 in. (305 mm) Drop	ASTM D 698
Moisture Content	Water to Dry Weight Ratio	ASTM D 2216
Permeability: Flex Wall Permeameter	Permeability (Hydraulic Conductivity) on Undisturbed or Remolded Samples of Soil	ASTM D 5084
Permeability: Constant Head	Permeability (Hydraulic Conductivity) of Aggregates	ASTM D 2434
Carbonate Content	Carbonate Content of Aggregate	ASTM D 3042

Notes: 1) Not all tests are required for this site; refer to Tables 3 and 4 in the CQA Plan.

2) Latest version of the applicable ASTM International or USDA testing standards shall be used when conducting tests.

TABLE 2

FIELD TEST METHODS
FOR THE EVALUATION OF SOIL AND AGGREGATE

COMMON TEST NAME	PARAMETER DEFINED	STANDARD METHOD
Visual Classification	Maximum Particle Size, General Material Characteristics	ASTM D 2488
USDA Classification	Classification of Ability to Support Vegetation	USDA Method
Nuclear Densometer	In-Place Density and Moisture Content	ASTM D 2922 and ASTM D 3017
Moisture Content	In-Place Moisture as Check on Nuclear Densometer Measurements	ASTM D 2216
Sand Cone Density	In-Place Density as Check on Nuclear Densometer Measurements	ASTM D 1556
Drive Tube Sample	In-Place Density as Check on Nuclear Densometer Measurements	ASTM D 2937
Lift Depth Check	Thickness of Placed Soils or Aggregates	Visual Confirmation

Notes: (1) Not all tests are required for this site; refer to Tables 3 and 4 in the CQA Plan.

(2) Latest version of applicable ASTM International or USDA testing standards shall be used when conducting tests.

TABLE 3

MINIMUM TEST FREQUENCIES FOR SOIL AND AGGREGATE MATERIALS IN BASE GRADE SYSTEM CONSTRUCTION

LINER COMPONENT	REQUIRED TEST	MINIMUM FREQUENCY	SAMPLE SIZE[a]	ACCEPTANCE CRITERIA
Subgrade/Structural Fill Conformance Testing[c]	Visual Observation	As required	N/A	Substantially free of debris, large rocks, plant materials, or other deleterious material.
	Sieve Analysis	1 per source & 1 per 5,000 yd^3	5-10 lb	Max. 4 in. particle size
	Standard Proctor Density	1 per source & 1 per 10,000 yd^3	50-100 lb	Determination of window of acceptable moisture content given required dry density. Maximum dry unit weight greater than 90 lb/ft^3.
Subgrade/Structural Fill Performance Testing[d]	Visual Observation	As required	N/A	Final surface: firm, smooth, and uniform
	Lift Depth Check	As required		6 to 8 in. compacted lift
	Nuclear Densometer In-place Density and Moisture Content	1 per 100 ft grid per lift	N/A	≥ 95% Standard Proctor maximum dry density, Moisture content -4% +4% of optimum.
	Moisture Content	1 per 10 nuclear densometer tests	Varies	Check nuclear densometer measurements to verify moisture correction.
	Sand Cone Density or Drive Tube Sample	1 per 25 nuclear densometer tests	Varies	Check nuclear densometer measurements to verify moisture correction and density.
Soil Dike Conformance Testing[c]	Visual Observation	As required	N/A	Substantially free of debris, large rocks, plant materials or other deleterious material. Must not pump or rut excessively.
	Sieve Analysis	1 per source & 1 per 5,000 yd^3	5-10 lb	1 inch max. particle size
	Atterberg Limits	1 per source & 1 per 5,000 yd^3	5-10 lb	Plasticity index: 10 or more[b]
	Standard Proctor Density	1 per source & 1 per 5,000 yd^3	50-100 lb	Determination of window of acceptable moisture content given required dry density. Maximum dry unit weight greater than 90 lb/ft^3.
	Moisture Content	1 per 5,000 yd^3	Varies	Determine if adequate moisture is present prior to compaction
	Soil Classification	1 per source & 1 per 5,000 yd^3	5-10 lb	SC, CL, CH, MH, ML, or SM

TABLE 3 (continued)

MINIMUM TEST FREQUENCIES FOR SOIL AND AGGREGATE MATERIALS IN BASE GRADE SYSTEM CONSTRUCTION

LINER COMPONENT	REQUIRED TEST	MINIMUM FREQUENCY	SAMPLE SIZE[a]	ACCEPTANCE CRITERIA
Soil Dike Performance Testing[d]	Observation			
	Nuclear Densometer In-Place Density and Moisture Content	1 per 100 ft grid per lift	N/A	≥ 95% Standard Proctor maximum dry density. Moisture content -4 to +4% of optimum
	Moisture Content	1 per 5 nuclear densometer tests	Varies	Check nuclear densometer measurements to verify moisture correction.
	Sand Cone Density or Drive Tube Sample	1 per 25 nuclear densometer tests	Varies	Check nuclear densometer measurements to verify moisture correction and density.
	Lift Depth Check	As required	N/A	6 to 8 in. compacted lift
Geologic Buffer Conformance Testing[c]	Visual Observation	As required	N/A	Substantially free of debris, large rocks, plant materials, or other deleterious material.
	Sieve Analysis	1 per source & 1 per 5,000 yd^3	5-10 lb	1 inch max. particle size
	Atterberg Limits	1 per source & 1 per 5,000 yd^3	5-10 lb	Plasticity Index: 10 or more[b]
	Standard Proctor Density	1 per source & 1 per 5,000 yd^3	50-100 lb	Determination of window of acceptable moisture content given required dry density.
	Moisture Content	1 per 5,000 yd^3	Varies	Determine if adequate moisture is present prior to compaction
	Flexible Wall Permeability (remolded)	1 per 10,000 yd^3	50 lb	$\leq 1 \times 10^{-7}$ cm/sec; Certification Engineer to use approved borrow area specification APZ, but shall verify APZ throughout construction.
	Soil Classification	1 per source & 1 per 5,000 yd^3	5-10 lb	SC, CL, CH, MH, or ML
Geologic Buffer Performance Testing[d]	Visual Observation	As required	N/A	Final surface: firm, smooth, and uniform. Perform lift depth check.
	Nuclear Densometer In-place Density and	1 per 100 ft grid per lift	N/A	≥ 95% Standard Proctor maximum dry density and within the approved APZ

MINIMUM TEST FREQUENCIES FOR SOIL AND AGGREGATE MATERIALS IN BASE GRADE SYSTEM CONSTRUCTION

LINER COMPONENT	REQUIRED TEST	MINIMUM FREQUENCY	SAMPLE SIZE[a]	ACCEPTANCE CRITERIA
	Moisture Content			
Geologic Buffer Performance Testing (continued)[d]	Moisture Content	1 per 5 nuclear densometer tests	Varies	Check nuclear densometer measurements to verify moisture correction.
	Sand Cone Density or Drive Tube Sample	1 per 25 nuclear densometer tests	Varies	Check nuclear densometer measurements to verify moisture correction and density.
	Lift Depth Check	As required	N/A	6 to 8 in. compacted lift
Gravel Drainage Layer Conformance Testing[c]	Visual Observation	As required	N/A	Angular and substantially free of debris, large rocks, plant materials, or other deleterious material.
	Sieve Analysis	1 per source & 1 per 5,000 yd^3	5-10 lb	Max. 5% passing #200 sieve.
	Constant Head Permeability	1 per source & 1 per 5,000 yd^3	50 lb	$\geq 1 \times 10^{-1}$ cm/sec
	Carbonate Content	1 per source	50 lb	<10% by weight

[a] In general, where the symbol "N/A" (not applicable) is used, the test is performed on in-place materials.

[b] Minor variations shall be allowed in acceptance criteria for the geologic buffer in order to maintain permeability less than 1×10^{-7} cm/sec. Under no circumstances shall acceptance criteria be enforced which result in permeability greater than 1×10^{-7} cm/sec

[c] Conformance testing is performed on borrow sources and placed material to ensure the minimum required values are met and the material remains consistent.

[d] Performance testing is performed on materials after placement is complete to ensure that the lift or layer meets design requirements.

TABLE 4

MINIMUM REQUIREMENTS AND TEST FREQUENCIES FOR SOIL COMPONENTS OF THE FINAL COVER SYSTEM

LINER COMPONENT	REQUIRED TEST	MINIMUM FREQUENCY	SAMPLE SIZE[a]	ACCEPTANCE CRITERIA
Compacted Clay Layer Conformance Testing[c]	Visual Observation	As required	N/A	Substantially free of debris, large rocks, plant materials, or other deleterious material.
	Sieve Analysis	1 per source & 1 per 5,000 yd^3	5-10 lb	1 inch max. particle size
	Moisture Content	1 per 5,000 yd^3	Varies	Determine if adequate moisture is present prior to compaction
	Atterberg Limits	1 per source & 1 per 5,000 yd^3	5-10 lb	Plasticity Index: 10 or more[b]
	Standard Proctor Density	1 per source & 1 per 5,000 yd^3	50-100 lb	Determination of window of acceptable moisture content given required dry density.
	Soil Classification	1 per source & 1 per 5,000 yd^3	5-10 lb	SC, CL, CH, ML, or MH
	Flexible Wall Permeability (remolded)	As required to determine acceptable results	50 lb	$\leq 1 \times 10^{-7}$ cm/sec
Compacted Clay Layer Performance Testing[d]	Visual Observation	As required	N/A	Final surface: firm, smooth and uniform.
	Moisture Content	1 per 5 nuclear densometer tests	Varies	Check nuclear densometer measurements to verify moisture correction.
	Nuclear Densometer In-place Density and Moisture	1 per 100 ft grid per lift	N/A	≥ 95% Standard Proctor maximum dry density[b]
	Sand Cone Density or Drive Tube Sample	1 per 25 nuclear densometer is used	Varies	Check nuclear densometer measurements to verify moisture correction and density.
	Lift Depth Check	As required	N/A	6 to 8 in. compacted lift
	Flex Wall Permeability	1 per acre per lift	Thin walled tube	$\leq 1 \times 10^{-7}$ cm/sec

TABLE 4 (continued)

MINIMUM TEST FREQUENCIES FOR SOIL COMPONENTS OF THE FINAL COVER SYSTEM CONSTRUCTION

LINER COMPONENT	REQUIRED TEST	MINIMUM FREQUENCY	SAMPLE SIZE[a]	ACCEPTANCE CRITERIA
Compacted Soil Layer Conformance Testing[c]	Visual Observation	As required	N/A	Substantially free of debris, large rocks, plant materials, or other deleterious material. Must not pump or rut excessively.
	Sieve Analysis	1 per source & 1 per 5,000 yd^3	5-10 lb	Max. 1 in. particle size
	Standard Proctor Density	1 per source & 1 per 10,000 yd^3	50-100 lb	Determination of window of acceptable moisture content given required dry density. Maximum dry unit weight greater than 90 lb/ft^3.
Compacted Soil Layer Performance Testing[d]	Visual Observation	As required	N/A	Final surface: firm, smooth, and uniform
	Lift Depth Check	As required		6 to 8 in. compacted lift
	Nuclear Densometer In-place Density and Moisture Content	1 per 100 ft grid per lift	N/A	≥ 95% Standard Proctor maximum dry density, Moisture content -4% +4% of optimum.
	Moisture Content	1 per 10 nuclear densometer tests	Varies	Check nuclear densometer measurements to verify moisture correction.
	Sand Cone Density or Drive Tube Sample	1 per 25 nuclear densometer tests	Varies	Check nuclear densometer measurements to verify moisture correction and density.

[a] In general, where the symbol "N/A" (not applicable) is used, the test is performed on in-place materials.

[b] Minor variations shall be allowed in acceptance criteria for compacted clay layer in order to maintain permeability less than 1×10^{-7} cm/sec. Under no circumstances shall acceptance criteria be enforced which result in permeability greater than 1×10^{-7} cm/sec

[c] Conformance testing is performed on borrow sources and placed material to ensure the minimum required values are met and the material remains consistent.

[d] Performance testing is performed on materials after placement is complete to ensure that the lift or layer meets design requirements.

Table 5

REQUIRED 40 MIL TEXTURED PE GEOMEMBRANE PROPERTIES

Material Property	Value	Units	Test Method
Resin – Melt Flow Index	≤1.0	g/10 min.	ASTM D1238
Thickness[1]	40	mil	ASTM D5994
Asperity Height [2] (min. avg.)	10	mil	GRI GM12
Specific Gravity (max.)	0.939	g/ml	ASTM D792 or ASTM D1505
Tensile Properties (each direction)			ASTM D6693 Type IV
1. Tensile Strength at Break (min. avg.)	60	lb/in.	
2. Elongation at Break (min. avg.)	250	percent	
Tear Resistance (min. avg.)	22	lb	ASTM D1004, Die C
Puncture Resistance (min. avg.)	44	lb	ASTM D4833
Carbon Black Content	2-3	percent	ASTM D1603
Carbon Black Dispersion	Category 1 or 2	Rating	ASTM D5596

Notes:

(1) Minimum of ten readings must average specified thickness or greater. No single reading may fall more than 15% below the specified value. The lowest individual reading for 8 of the 10 readings shall not fall more than 10% below the specified value.

(2) Minimum of ten readings must average specified height. Eight of the readings must be ≥ 7 mils, and the lowest reading must be ≥ 5 mils.

(3) Manufacturer's Quality Control testing shall be performed at a frequency of one test per every 100,000 ft^2 or one test per resin lot, whichever is more frequent. Thickness testing shall be performed on each roll.

(4) Asperity Height measurements shall be performed on every roll, alternating between measurements for top of sheet and bottom of sheet.

Table 6

REQUIRED 40 MIL TEXTURED PE GEOMEMBRANE PROPERTIES – CONFORMANCE TESTING

Material Property	Value	Units	Test Method	Frequency
Thickness[1]	40	mil	ASTM D5994	100,000 SF
Specific Gravity (max)	0.939	g/ml	ASTM D792 or ASTM D1505	100,000 SF
Asperity Height [2] (min. avg.)	10	mil	GRI GM12	100,000 SF Top and Bottom
Tensile Properties (each direction)			ASTM D6693 Type IV	100,000 SF
1. Tensile Strength at Break (min. avg.)	60	lb/in.		
2. Elongation at Break (min. avg.)	250	percent		
3. Tear Resistance (min. avg.)	22	lb	ASTM D1004, Die C	100,000 SF
4. Puncture Resistance (min. avg.)	44	lb.	ASTM D4833	100,000 SF
Carbon Black Content	2-3	percent	ASTM D1603	100,000 SF
Carbon Black Dispersion	Category 1 or 2	None	ASTM D5596	100,000 SF

(1) Minimum of ten readings must average specified thickness or greater. No single reading may fall more than 15% below the specified value. The lowest individual for 8 of the 10 readings shall not fall more than 10% below the specified value.

(2) Minimum of ten readings must average specified height. Eight of the readings must be ≥ 7 mils, and the lowest reading must be ≥ 5 mils.

(3) Conformance testing shall be performed by the Certification Engineer or TVA at a minimum frequency of one test per 100,000 ft^2 or one test per resin lot, whichever is more frequent.

Table 7

REQUIRED 40 MIL TEXTURED PE SEAM PROPERTIES

Material Property	Value	Units	Test Method
Shear Strength – Fusion and Extrusion(1)	60	lb/in.	ASTM 6392 Strain rate: 2 in./min. 1 in. strip.
Peel Adhesion			ASTM D6392
Fusion(2)	50	lb/in.	Strain rate: 2 in./min. 1 in.
Extrusion(3)	50	lb/in.	strip.

(1) For Shear Testing of both fusion and extrusion welds, the strength of 4 out of 5 specimens should meet or exceed the given value. The 5th must meet or exceed 48 lb/in.

(2) For Peel Testing of fusion welds the strength of 4 out of 5 specimens should meet or exceed the given value. The fifth must meet or exceed 40 lb/in. All specimens shall fail due to film tear bond or with greater than 25% incursion of the weld (peel).

(3) For Peel Testing of extrusion welds, 1 out of 5 specimens may either achieve <50 lb/in. but be ≥40 lb/in. or exhibit greater than 25% incursion of the weld (peel). The remaining four specimens must meet the specified strength and have a maximum of 25% incursion of the weld (peel).

(4) Required laboratory seam testing shall be performed by a geosynthetics testing laboratory at a frequency of one test per 1,000 linear feet of seam constructed for both extrusion and fusion welding equipment.

Table 8

REQUIRED GEOCOMPOSITE PROPERTIES

Material Property	Value	Units	Test Method	Manufacturers Frequency
Geonet Component:				
Thickness (min.)	200	mil	ASTM D 5199	1/50,000 SF
Specific Gravity (min. avg.)	0.94	gm/cm^3	ASTM D 792 or ASTM D 505	1/50,000 SF
Carbon Black Content	2-3	percent	ASTM D1603	1/50,000 SF
Tensile Strength, MD (Machine Direction)	45	lb/ft	ASTM D 5035	1/50,000 SF
Geotextile Component:				
Polymer Composition (min.)	95	% polypropylene or polyester by weight		
Mass per Unit Area (min.)	7.5	oz/yd^2	ASTM D 5261	1/90,000 SF
Grab Tensile Strength	≥170	lbs	ASTM D 4632	1/50,000 SF
Grab Elongation (min. avg.)	50	percent	ASTM D 4632	1/50,000 SF
Puncture Strength (min.)	90	lbs	ASTM D 4833	1/90,000 SF
Apparent Opening Size	70 – 120	sieve size	ASTM D 4751	1/540,000 SF
Water Flow Rate (min.)	110	gpm/ft^2	ASTM D 4491	1/540,000 SF
Ultraviolet Resistance (min. avg.)	70	percent	ASTM D 4355 (after 500 hours)	1/per lot
Geocomposite:				
Transmissivity at 10,000 psf[(1)] (min.)	5×10^{-4}	m^2/sec	ASTM D 4716	1/540,000 SF
Peel Strength (min.)	1	lb/in	GR1 GC-7	1/500,000 SF

Notes:

(1) Transmissivity measured using water at 20°C with a gradient of 0.10 and normal stress of 10,000 psf between two steel plates, after one hour.

Table 9

REQUIRED GEOCOMPOSITE PROPERTIES- CONFORMANCE TESTING

Material Property	Value	Units	Test Method
Thickness (min.)	0.20	inch	ASTM D 5199
Resin Density (min. avg.)	0.935	gm/cm^3	ASTM D1505
Geocomposite:			
Peel Strength (min.)	1	lb/in.	GRI GC-7
Tensile Strength (min.)	45	lb/in.	ASTM D 5035

(1) Conformance testing shall be performed by the Certification Engineer or TVA at a minimum frequency of one test per 100,000 ft^2 or one test per resin lot, whichever is more frequent.

Table 10

REQUIRED PROPERTIES FOR 10 OZ/YD^2 GEOTEXTILES (FILTER)

Material Property	Value	Units	Test Method
Polymer Composition	95 (min.)	% polypropylene or polyester by weight	
Mass per Unit Area (min. avg.)	10	oz/yd^2	ASTM D5261
Grab Tensile Strength(min. avg.)	230	lbs	ASTM D4632
Grab Elongation (min. avg.)	50	percent	ASTM D4632
Puncture Strength (min. avg.)	120	lbs	ASTM D4833
Trapezoidal Tear Strength (min. avg.)	95	lbs	ASTM D4533
Apparent Opening Size(1) (max. avg.)	70	sieve size	ASTM D4751
Water Permeability	$\geq 5.0 \times 10^{-3}$	cm/sec	ASTM D4491
Ultraviolet Resistance	70 (typical)	percent	ASTM D4355

Notes:

(1) Required only on material which is to be used in filter applications.

(2) Manufacturer's testing for the above properties shall be performed the Certification Engineer or TVA at a frequency of one test per 100,000 ft^2 and each resin lot must be tested.

Table 11

REQUIRED PROPERTIES FOR 10 OZ/YD^2 GEOTEXTILES (FILTER) - CONFORMANCE TESTING

Material Property	Value	Units	Test Method
Mass per Unit Area (min. avg.)	10	oz/yd^2	ASTM D5261
Grab Tensile Strength (min. avg.)	230	lbs	ASTM D4632
Puncture Strength (min. avg.)	120	lbs	ASTM D4833
Trapezoidal Tear Strength (min. avg.)	95	lbs	ASTM D4533
Apparent Opening Size (max. avg.)	70	sieve size	ASTM D4751

Notes:

(1) Conformance testing shall be performed by the Certification Engineer or TVA at a frequency of one test per 100,000 ft^2 and each resin lot must be tested.

Attachment 1 – TVA Vegetation Specification

VEGETATION SPECIFICATIONS

NATIVE GRASSESS - SEEDING AND MULCHING

(SPECIAL FOR WASTE AREAS)

SECTION 582 - Mulching

Refer to FP-96 Section 625. FP-96 Standard Specification for Construction of Roads and Bridges on Federal Highway Projects (US DOT - FHWA)

SECTION 583 - Native Grasses Seeding

583.1 – Description

This specification consists of furnishing and placing native warm season grass seed on waste disposal areas when specified by the plans or the Engineer. The use of these grasses for landfill cover crops is being encouraged by the Tennessee Department of Environment and Conservation Division of Solid Waste Management.

583.2 – Materials

1. Seeds

Seeds shall meet the requirements of applicable seed laws and shall be tested in accordance with the most current edition of the U.S. Department of Agriculture Handbook No. 30, Testing Agricultural and Vegetable Seed. Seeds shall be from the last preceding crop and comply with the requirements outlined below for purity and germination. Each variety of seed shall be furnished in separate, strong bags with each bag being fully tagged or labeled to show the variety, weight, purity, germination, and test data prescribed by law. All test results shall be fully certified by the vendor or by a recognized seed testing agency. TVA reserves the right to require that samples be furnished, and to inspect and test the seeds after delivery. Seeds found not to comply with specification requirements shall be subject to rejection.

When mixing or forming seed mixtures, the seeds shall be carefully and uniformly mixed. Seeds shall not be mixed until each variety of seed to be used in the mix has been inspected and/or tested separately and approved.

583.2 – Materials (Continued)

Seed Varieties	Purity, Minimum %	Germination Minimum %
Sideoasts Gramma (*Bouteloua curtipendula*)	95	85
Little Bluestem (Schizachyrium scoparium)	95	85
Sand Lovegrass (*Eragrostis trichodes*)	95	85
Annual Rye (lolium multiflorum)	90	90

Seeding materials shall be free from seeds or bulbets of Wild Onion (Allium vineale), Canada Thistle (Cirsium arvense), and Johnson Grass (Sorghum halepense).

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Seed species shall not contain more than six seeds per ounce of the seed of any of the following noxious weeds or the seeds of any other weed specifically listed as noxious:

Bindweed (Convolvulus arvensis)
Buckthorn (Plantago lanceolata)
Corncockle (Agrostemmo githago)
Dodder (Cuscuta species)
Oxeyedaisy (Chrysanthemum leucantheumum)
Quackgrass (Agropyron repens)
Sorrel (Rumex acetosella)

Seed species shall not contain an excess of 2 percent by weight of weed seeds, noxious or otherwise.

2. <u>Seed or seed mixtures, rates, and seasons</u>

Seeding mixtures, rates, and seasons shall be those specified herein. The types to be used for each area or project will be specified by the drawing or by memorandum. Mixtures or rates of application other than those specified shall be used only when specified by the plans or the Engineer. Seeding shall be planted during the season and between the dates specified. Note that the pound rates are PLS (pure live seed).

Type 1: Winter seeding ((Plant between November 1 and December 31)

(1) Sideoats Grama	4 pounds per acre
(2) Little Bluestem	5 pounds per acre
(3) Sand Lovegrass	1 pounds per acre
(4) Annual Rye	<u>60 pounds per acre</u>
	70 pounds per acre

Type 2: Spring seeding (Plant between April 15 and July 1).

Mixture:

(1) Sideoats Grama	4 pounds per acre
(2) Little Bluestem	5 pounds per acre
(3) Sand Lovegrass	<u>1 pounds per acre</u>
	10 pounds per acres

Note: All slopes 3:1 or greater shall be seeded with the winter mixture

e. Temporary Cover

Type 3: Temporary winter seeding (Plant between October 15 and March 15).

Annual Ryegrass 80 pounds per acre

583.3– Soil Chemistry Requirements

Soil pH range: 5.0 - 7.8 S.U.

Soil Fertility: Low-Medium for phosphorous and potassium.

583.4 -- Soil Preparation

Areas to be seeded shall have approved cross sections and grades. Objects such as large roots, stones, stumps, coarse vegetation, debris, or any other items that might impede mechanical mowing shall be removed and disposed of satisfactorily.

Seedbeds shall be plowed, disked, harrowed, scarified, or cultivated to the approved depth. In areas where it is practical, this work shall be done with farm-type equipment. On steep slopes, preparation of seedbeds shall be done with the tools and methods specified by the Engineer. It is strongly recommended that scarifying and preparation on cut and fill slopes be accomplished with tools or equipment specially designed for this purpose. Small furrows or grooves formed in the slopes shall be horizontal or as nearly horizontal as practical. The work shall be performed only when the ground is in a workable and tillable condition as determined by good farming practices.

583.5 – Special Hydroseeding Equipment

Equipment to be used for the hydraulic application of planting materials shall be a Finn Hydro-Seeder, Bowie Hydro Mulcher, Toro Environmental Control Unit, or an approved equal. The equipment shall have mixing tanks with built-in agitators having operating capacities sufficient to agitate, suspend, and homogeneously mix slurries of water and planting materials. The slurry distribution lines shall be large enough to prevent clogging or stoppage. Discharge lines shall be equipped with sets of different sized hydraulic spray nozzles capable of providing for even distribution of varying slurry mixtures on areas to be seeded.

583.6 – Seeding Methods

Seeds shall be sown with approved hydroseeding equipment. Rates specified in Section 583.2 shall be maintained in a manner that will guarantee uniform coverage. Seeding operations shall not be performed when drought, high winds, and excessive moisture or other factors may defer satisfactory results. The carrier mix shall be 0-13-13. The area shall be cultipacked immediately after seeding.

583.7 -- Maintenance

Seeded areas shall be maintained until a satisfactory cover of plant material is secured, unless stipulated otherwise. All areas shall be preserved, repaired, and protected as specified for this purpose. Areas having poor stands of plant material shall be seeded again and fertilized at the proper rates.

Watering shall be accomplished during the maintenance period to the extent necessary.

583.8 -- Method of Measurement

Seeded areas will be measured in square yard units and include the seeded areas along slopes.

TENNESSEE DEPARTMENT OF EVIRONMENT AND CONSERVATION

Division of Solid Waste Management

FOSSIL FUEL FLY ASH AND BOTTOM ASH DISPOSAL WITHIN A CLASS II FACILITY

POLICY

The purpose of this policy is to establish the criteria by which fossil fuel fly and bottom ash may be disposed of in a Class II facility:

1. The geologic buffer required will be 3 feet in total thickness with a maximum hydraulic conductivity of 1×10^{-6} cm/sec. The thickness will be measured from the base of the fill to the seasonal high water table of the uppermost unconfined aquifer, or the top of the formation aquifer;

2. No leachate migration control system will be required;

3. No gas migration control system will be required;

4. The final cover shall be 24 inches of compacted soil with a minimum of 6 inches which shall support vegetative cover; and

5. No random inspection program will be required.

Any variance to the Class II facility permit criteria will require the Commissioner's approval.

(Signature on File)
Mike Apple, Director
Division of Solid Waste Management

9-7-01
Date

policy/notebook/pn093
Revision 1: September 2001